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Foreword

The Annual Technical Symposium on Mekong Fisheries has become a central element of the MRC's Fisheries Programme. The 2005 symposium, which was held in Ubon Ratchathani, Thailand, was the seventh the Programme has hosted since 1998. Each year the symposium attracts a larger audience and an increasing number of speakers. The papers included in this volume of proceedings cover subjects as diverse as prawn fisheries in southeast Cambodia and fisheries co-management in the Central Highlands of Viet Nam. They represent the work of over a hundred fisheries experts from the four MRC member countries and from as far afield as Australia and Sweden.

The contributions from overseas are very welcome as they are clear indication of the international recognition the symposium now receives. However, we must not forget the primary reasons for holding the symposium. These are to provide a forum in which fisheries experts from across the region can meet to present and discuss their research and, most importantly, an occasion for young scientists working in the various riparian line agencies to present the results of their efforts to their peers and to an international audience.

Publishing is a vital part of research, for no matter how good or important the research, results have little value unless they are made available for managers and other researchers to use and develop. Furthermore, the process of preparing work for presentation and publication can only improve the quality of research, because it demands discipline of purpose and clarity of thought. The thirty-two papers in these proceedings have, no doubt, cost each of the authors a great deal in both time and energy, and they are all to be applauded warmly for their efforts. The standard of the papers is a testimony to their efforts, and it is very encouraging to see the quality of the submissions improving year-after-year. This is a trend that I am confident will continue through future technical symposiums.

The fisheries of the Mekong River are a vital factor in the lives and livelihoods of millions of people who live in the riparian countries. Sustaining these fisheries requires improved management based on increased knowledge. The body of knowledge included in these proceedings is an important contribution to ensuring that the fisheries of the Mekong River system continue to provide employment, nutrition and income for millions of people in the basin.

Dr Olivier Cogels
Chief Executive Officer
Mekong River Commission Secretariat
October 2006

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The *Dai Bongkong* fishery for giant river prawns, *Macrobrachium rosenbergii*, in southeastern Cambodia

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ABSTRACT

Prey Veng Province is located in the Mekong Delta region of Southeastern Cambodia. In this lowland area, agriculture (especially rice growing) and fisheries are the most important sectors for the livelihoods of people. Prey Veng has many kinds of freshwater fisheries; mainly fishing lots (barrages) and mobile gears typically found in Cambodia. This province also has fisheries for catadromous shrimps or prawns, amongst which the bagnet or *dai* (stationary trawl) fishery for *Bongkong* (*Macrobrachium rosenbergii*) is the largest. The fishery consists of 13 single *Dais* operated in one Mekong tributary, the Tonle Touch. The fishery is aimed at the capture of wild *Bongkong* for sale in markets in Cambodia, but fish are also caught. Little is known about this fishery because no data collection system is in place. The aim of the study was to collect primary data on catches and their monetary value from all *Dais* in the fishery. Primary data are required to establish a reliable and cost-effective data collection scheme in the future, and provide information for management.

This paper reports on the results of a monitoring study over the main fishing season (October to December) in 2004. Data collectors recorded catches and their value based on random sampling of each *Dai*, and recorded sub-samples for assessment of species composition. Prices of each species were also recorded based on information from *Dai* operators. *Dai* owners and provincial fishery officers were interviewed about their operations, and about general aspects of the fishery.

The *Dais* caught a total of about 1.5 tonnes of *Bongkong*, (31-274 kg/*Dai*) over the main fishing season. *Bongkong* sold for about 30,000 Riel per kg on average, making it the most valuable species caught in the inland fishery of Cambodia. *Bongkong* catches have reportedly fallen in recent years and now the *Dais* catch mainly fish, including at least 153 species, amongst which *Labiobarbus kuhlii*, was the most abundant (25% of the total catch). Generally the *Dais* furthest upstream recorded the highest catches. *Dais* were classified into high- or low-catch units for sampling purposes.

The study highlights many issues that should be addressed. The operators do not fully comply with their license conditions relating to *Dai* dimensions and the time of operation. Mobile gear operators ignored rules about fishing near the *Dais*, and so have come into conflict with the *Dai* owners. The high price for *Bongkong* is causing overfishing and a decline in the wild catch, so for this species aquaculture should be promoted in Cambodia as it has been in other countries.

KEY WORDS: Cambodia; Tonle Touch; *Bongong*, *Dai Bongkong*; Catch; Value; Conflict

INTRODUCTION

Prey Veng Province is located in the Mekong Delta region of Southeastern Cambodia. In this lowland area, agriculture (especially rice growing) and fishing, are still considered the most important sectors for supporting rural livelihoods. Prey Veng hosts many kinds of freshwater fisheries; mainly fishing lots (barrages) and mobile gears. It is noteworthy that the province has a fishery for catadromous prawns or shrimps, amongst which *Dai* fishery for *Bongkong* is the largest. The fishery consists of 13 stationary *Dais* and targets *Bongkong*. However, since the total landings

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of *Bongkong* have declined in recent years, the fishery has become diversified to target both *Bongkong* and fish.

Prey Veng is one of the few places in the country where *Bongkong* is available, especially from October to December, but little is known about the fishery. Furthermore, *Bongkong* is economically important locally, and has good consumer acceptance. Due to its high demand, *Bongkong* has gained popularity as a marketable item. This has attracted many people to the fishery resulting in an increase in the numbers of fishing gear in use, particularly hook and lines (*Santouch Bongkong)* and traps (*Lop Bongkong*).

Catch statistics for wild *Bongkong* reported by the Provincial Fisheries Office is unreliable as these are totally dependent on fishers who underreport landings because they are required to pay taxes for exclusive fishing rights. Unreliable statistics, when used for planning, will inevitably create problems in implementing policy for fishery management. There is a requirement for a data collection program to be in place, which is scientifically acceptable in order to produce reliable statistics for national level planning. An intensive data collection process from each fishery station is vitally important to identify its capacity in catching fish and *Bongkong*, that is, the volume of its catch and monetary value. This data will allow a sampling strategy to be implemented at all the *Dai Bongkong* units for the Department of Fisheries, particularly for the Prey Veng Provincial Fisheries Office, which is responsible for annual data collection of the fishery for the Ministry of Agriculture, Forestry and Fisheries.

This study aims to document all relevant information on the *Dai Bongkong* fishery with an emphasis on recording data on catches and monetary values of the fishery so that they can be classified for status and sampling purposes.

DESCRIPTION OF THE FISHERY

Location of the Dai Bongkong Fishery

Tonle Touch is a Mekong tributary and branches away from the Mekong near Kampong Cham Province in a southerly direction towards Viet Nam. At the point near Neak Luong ferry crossing in Prey Veng Province the river divides again into two main branches; the Tonle Touch and Prek Trabek Rivers (see Ngor *et al*., 2005). The *Dai Bongkong* fishery operates along the Tonle Touch River from the point where it branches away from Prek Trabek River down to the Cambodian-Viet Namese border (see Figure 1. and Appendix 1).

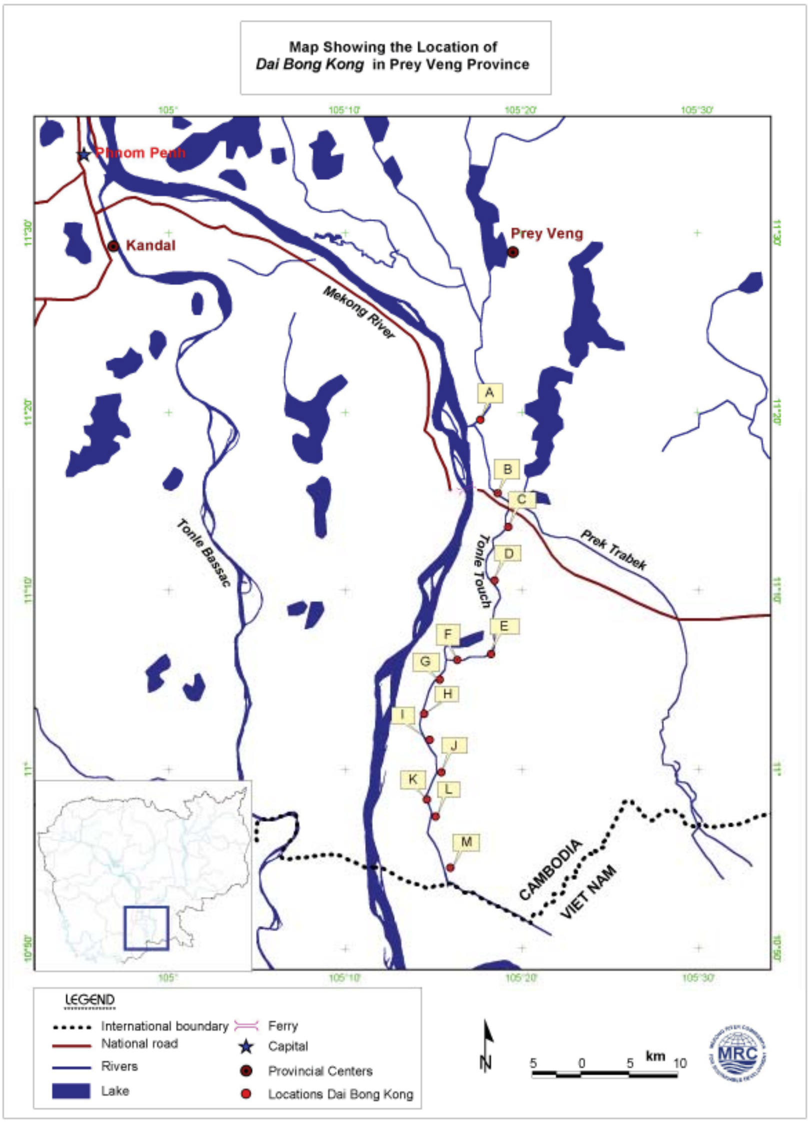


Figure 1. Map showing the location of *Dai Bongkong* fishery in Prey Veng Province

History and Licensing

Similar to the *Dai Trey Linh* fishery (Ngor et al., 2005), the *Dai Bongkong* fishery began operating in 1981. Between 1981 and 1986, the fishery was operated under a solidarity group, and it was privatized as a large-scale fishery in 1987. Normally, exclusive rights for operating each *Dai Bongkong* unit is given to the highest bidder covering a two-year period through auctioning. The official fee of each Dai Bongkong unit varies from about 0.8 to 8.1 million Riels according to locations (see Table 1).

Table 1. *Official auctioning fee for Dai Bongkong*

Dai Bongkong	Auctioning fee (Riel)	Year of operation
1A	5,500,000	2004–2006
1B	5,400,000	2004–2006
1C	4,200,000	2003–2005
1D	1,700,000	2003–2005
1E	4,400,000	2003–2005
1F	4,125,000	2004–2006
1G	8,150,000	2004–2006
1H	810,000	2003–2005
1I	1,800,000	2003–2005
1J	1,820,000	2003–2005
1K	300,000	2003–2005
1L	300,000	2003–2005
1M	4,500,000	2004–2006

Note: Source: Prey Veng Fishery Office

Season of operation

The open season for fishing in Cambodia is from October to June. During this period, all fisheries are allowed to operate under the Cambodian Fishery Law. The operation of most large-scale fisheries takes place over a six to nine month period. For example, the *Dai Trey Linh* fishery in the Tonle Touch (6-7 months), the *Dai* fishery in Tonle Sap River (5-6 months) and the barrage fishery/fishing lot (6-9 months). However, the season of the *Dai Bongkong* fishery takes place over a relatively short period from October to December. Licensing conditions for operation of the fishery are similar to those of other large-scale fisheries in Cambodia.

Recently fishers have tended to start fishing operations in September to target small cyprinids that migrate from surrounding floodplains back to the *Tonle Touch* River. The peak catch of *Bongkong* takes place in November.

Dai Bongkong structure

The *Dai Bongkong* is a stationary bag net positioned in the river to target mainly *Macrobrachium rosenbergii.* Each row of the *Dai Bongkong* allows only one unit, leaving space for navigation. In the past, *Dai Bongkong's* structure was designed to catch only giant river prawns that migrate down the Tonle Rouch River from the surrounding floodplains. However, the fishing gear has recently been modified to target both fish and giant river prawn.

The old *Dai Bongkong* is comparatively shorter, about 8-12 metres long and closed at the bag end. It has a mesh size of 3-4 cm. The mouth of the bag net is rectangular with a width of about 20 to 35 metres and a height of 3-4 metres. It is opened by two bamboo poles, which are tied to small bamboo rafts or 500 litre metal or plastic drums. To prevent the giant river prawns that have entered the bag net from leaving the bag net, curved-backward bamboo stays are used to attach the surrounding ropes, except for the upper rope, to the net. Wooden poles at either sides of the river are fixed and metal wires are used to tie the bag net to the wooden poles in order to make the bag net stationary and stablised. To collect giant river prawns and fish fauna, the bag end of the net needs to be cut open and subsequently repaired when putting back into the river (see figure 2).

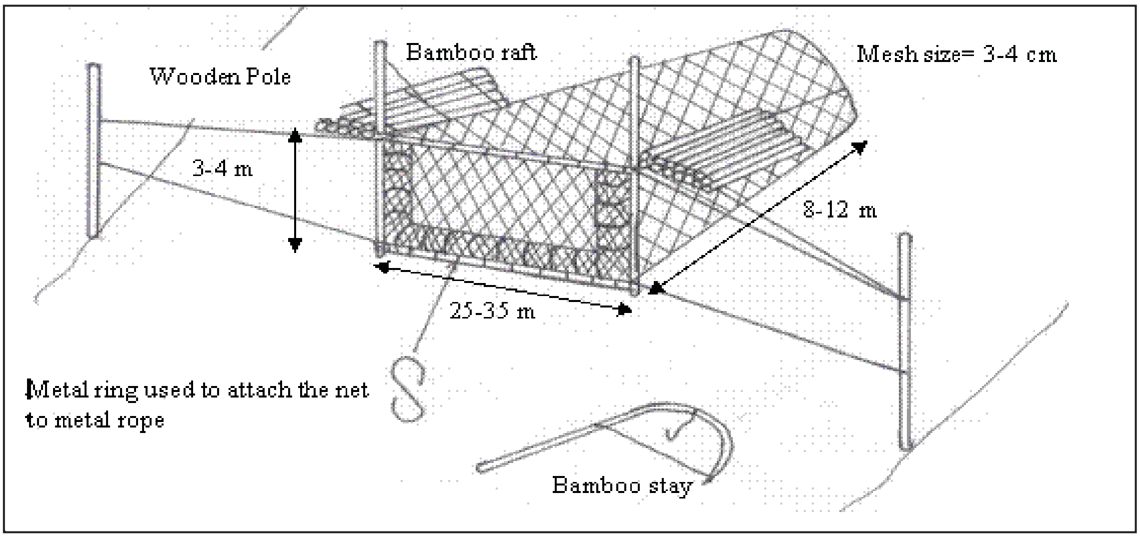


Figure 2. Old design of *Dai Bongkong*

The modern, modified *Dai Bongkong* has the same basic structure as the old one. The difference is that it is about 45 to 50 metres long and the net has a smaller mesh size of about 3 cm at the mouth of the *dai* to only 1.5 cm at the cod-end (Figure 3).

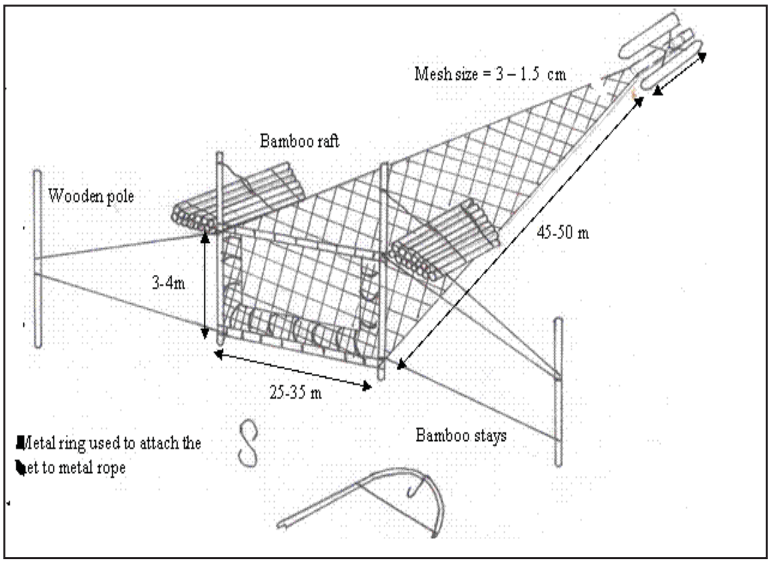


Figure 3. New design of *Dai Bongkong*

In addition, the cod-end of the new bag net is designed in such a way that giant river prawn and fish can easily be removed withouth the need to cut open the dai. The cod-end of the new *Dai Bongkong* is similar to that of the *Dai Trey Linh* fishery (more details see Ngor et al., 2005) and *Dai* fishery in the Tonle Sap River (more details see Deap *et al*., 2003).

Old structure *Dai Bongkong* was designed for the situation when wild giant river prawns were still abundant. Since there has been a drastic decline in giant river prawn production, fishers started to modify the fishing gears to be more convenient to operate and highly effective in catching both freshwater prawns and fish. Another benefit of the new *Dai Bongkong* is that fishers can remove the giant river prawn and fish any time they wish to order to keep fish alive and in good quality. This is different from the old *Dai Bongkong* in that fishers collect fish only one time during the night.

Giant River Prawn Fisheries

Giant river prawns are popularly captured by several fishing gears including hook and lines, traps, *Dai Bongkong* fishery and the barrage fishery or fishing lots.

Hook and lines

Hook and line fishing occur in July and August and from January to May. In July and August, the fishing gears are operated only at night in floodplains when sediment and debris are settled down and the flood waters become less turbid; whereas, from January to may, the fishing gears operate only the Cambodian Lower Mekong River. The fishers use nails with 3 cm long as a hook. Coconut is the most usual bait used by fishers to capture giant river prawns. Alternatively, fishers also use crabs, *botia sp.,* boiled pig skin, corns etc. as bait. The giant river prawns captured by hook and lines in July and August often carry eggs while those that are captured from January through May are small size (about finger sizes).

Traps

Traps are the most popular fishing gears used by fishers in Prey Veng Province to catch giant river prawns. It is reported that traps for giant river prawns has dramatically increased. According to fishers, there were about 5,600 traps from 70 boats in operation in commune 2 and about 1,500 traps from 25 boats in operation in commune 3 and 4 of *Peam Ror* district of Prey Veng Province. The season of trap fishing is from July to October, during which traps are operated mainly in the floodplains, and from January to May through which traps are operated only in the main river of the Cambodian Lower Mekong from ferry crossing (*Neak Loung)* down to Cambodian-Viet Namese border (see figure 1). The peak time of trap fishing occurs in September when giant river prawns carry eggs and are ready to migrate to the brackish water for spawning whereas the giant river prawns caught in January through May in the Mekong River are in small size.

***Dai Bongkong* and fishing lots/barrage fisheries**

Dai Bongkong and fishing lots/barrage fishery begin in October and end in December and June respectively. *Dai Bonkong* operates only in the Tonle Rouch River to capture giant river prawns that migrate down the river; whereas, fishing lots or barrage fisheries operate in the floodplains or lakes by blocking canals or streams which connect to rivers to capture all fish fauna including giant river prawns. The catch of giant river prawn from fishing lot or barrage fishery normally end in February. It is generally seen that giant river prawns captured by the large-scale fisheries during these periods are in large size and very few individuals carry eggs.

From hook and lines, trap fishing and *Dai Bongkong* and fishing lots/barrage fishery, it is suggested that the giant river prawns, *Macrobrachium rosenbergii,* may migrate down the river to the brackish water areas for spawning in September. Ngor et al, 2005 monitored *Dai Trey Linh* fishery in the Tonle Touch River along the Cambodian-Viet Namese border. They found out that 268 kg (64kg in September, 50kg in October, 62kg in November and 92kg in December) of *Macrobrachium Rosenbergii* were captured. The giant river prawns migrate back to the Cambodian waters in January as they are captured by traps and hook and lines (with small size) in the Lower Mekong River close to the Cambodian-Viet Namese border. It was also reported by fishers that between January and May, trawls that are operated in the Viet Namese waters captures a comparatively large amount of finger-sized *Macrobrachium rosenbergii.*

METHODOLOGY

The study was conducted over the period from October to December 2004. Data on the fishery was collected on a daily basis for the purpose of understanding catches and values of the fishery. The main data items recorded were catch, price, and species and their length frequency. The main steps in the research process were: (1) designing sample data sheets, (2) training data collectors on data collection methodology, (3) Collecting data from every station of the fishery and (4) analyzing the collected data.

To begin, sample data sheets were designed in order to facilitate the data collection process. Sample data sheets consisted of three types, which were used to record different data sets. The first sample data sheet was used to record catch composition of the fishery; the second was used to record fishing effort which was composed of a number of hauls (times) fishers cleared their bag net, time intervals between successive hauls and the total catch per haul, and the third data sheet was used to record length frequency of Bongkong (prawn) or fish.

Next, before the actual data collection was started, all the data collectors were trained in data collection methodology and on the identification of the fish species. Data collectors were first trained on how to fill in each of the sample data sheets. Then, the training was started with data collection methods which consisted of how to sample the catch from the fishery and sort the sub-sample by species. The methods also included the ways of how to measure the total length of fish and Bongkong. Data collectors were also trained on how to identify fish species before recording onto the sample data sheets. To make it easier for this, a photo flipchart of over 200 species based on Mekong Fish Database (Mekong Fish Database, 2003) was compiled.

The third step was the actual data collection process. In total, there were 13 *Dai Bonkongs*; therefore, 13 data collectors were needed and each of them was stationed at each *Dai* for all weekdays (26 days per month). Sample data sheets were handed out to all the data collectors. To estimate catches of each Dai, the total catch from randomly selected hauls was recorded. Each 24 hours on each Dai, the total catch from 10 daytime hauls and 5 night-time hauls was recorded, and used to estimate total catches for the day. To estimate catch by species of each Dai, samples for analysis of species composition were taken from at least 4 hauls/day. A sub-sample of fish was sorted by species and each species was weighed on calibrated balances. The price of each species was also recorded, based on information from the Dai operators. For some common species, total lengths were measured using a measuring board accurate to 1 mm. To get relevant information on the fishery, Dai owners and provincial fishery officers were interviewed about the operation of their business, and about general aspects of the fishery such as hydrology and biology.

The last step was data entry and analysis. All the sample data sheets were collected back from the data collectors on a monthly basis. These sample data sheets were sorted by date, and coded before the data entry was started. Collected data from the fishery were primarily stored, processed and analyzed using computer software called *Artfish* for Windows (Stamatopoulos and Jarrett, 2000). Later, the data was exported to Electronic Spreadsheet for final analysis.

RESULTS OF THE MONITORING

Appendices 2, 3 and 4 give monthly details of the quantity, total value and unit price of all the species recorded during the survey.

Size of catch

Table 2 shows the catches of *Dai Bongkong* ranked by each unit (station) over a three-month period from October to December 2004 in Prey Veng Province. From this table, it can be seen that giant river prawns contribute only about 1.2 percent (1,531 kg) to the total catch of 125,911 kg. The rest of the catch is fish fauna. Totally, about 88 percent of the catch was taken by *Dai Bongkong* 1A, 1B and 1C, which are the most upstream units. The other units shared between only 0.2 to just over 2.5 percent.

Therefore for the sampling purposes, rather than collecting all the data from each of the stations, it can be suggested that all the stations be divided into two main strata. Stratum1 consists of 1A, 1B and 1C and the rest can be classified as stratum 2. The other option is basing the stratification on the percentage of the catches of each station. Those that contribute approximately between 3 to 71 percent to the total catch can be put in stratum 1, between 1 and 2.99 percent in 2 and the other will be in stratum 3.

Table 2. *Monthly and annual Dai Bongkong catch in 2004*

Station	Catch of giant river prawn (kg)	Catch of fish (kg)	Total (kg)	%
1A	113	89,350	89,463	71.05%
1C	228	17,045	17,273	13.72%
1B	274	3,820	4,094	3.25%
1M	148	3,076	3,224	2.56%
1I	74	2,155	2,229	1.77%
1J	39	2,049	2,088	1.66%
1H	91	1,870	1,961	1.56%
1E	125	1,343	1,468	1.17%
1G	79	1,070	1,149	0.91%
1D	142	981	1,123	0.89%
1F	137	827	964	0.77%
1K	50	570	620	0.49%
1L	31	224	255	0.20%
Total	1,531	124,380	125,911	100.00%

Composition of catch

Table 3. *Catch composition giving total weight (kg) of the ten most abundant species*

Khmer name	Scientific name	Oct	Nov.	Dec.	Catch	%
Khnang veng	*Labiobarbus kuhli*	30,560	61	18	30,639	24.33
Khlang hai	*Belodontichthys truncatus*	10,121	1,467	101	11,689	9.28
Pruol/kralang	*Cirrhinus microlepis*	7,984	118	11	8,113	6.44
Chra keng	*Puntioplites waandersi*	4,661	715	134	5,510	4.38
Kaek	*Labeo chrysophekadion*	4,434	549	77	5,060	4.02
Sanday	*Wallago attu*	3,210	989	56	4,255	3.38
Kanhchrouk chhnot	*Botia helodes*	3,928	293	4	4,225	3.36
Riel awng kam	*Cirrhinus lobatus*	3,894	48	9	3,951	3.14
Krom	*Osteochilus melanopleura*	3,164	487	25	3,676	2.92
Chhkok	*Cyclocheilichthys enoplos*	3,227	390	23	3,640	2.89
Other (144 species)		29,231	13,977	1,945	45,153	35.86
Total (all species)		104,414	19,094	2,403	125,911	100.00

There were 154 species recorded in the catch of *Dai Bongkong* (see Appendix 2), including the giant river prawn. The top ten species that made up almost 65% of the total catch are listed in Table 3. A small cyprinid, *Labiobarbus kuhli,* was the most abundant species, accounting for around 24 percent in the catch composition of *Dai Bongkokg*. It is interesting to note that although the fishery is operated under the name of giant river prawn fishery, this species was not one amongst the top ten.

Value of catch

Table 4. *Monthly and annual Dai Bongkong total value (R1000s) in 2004*

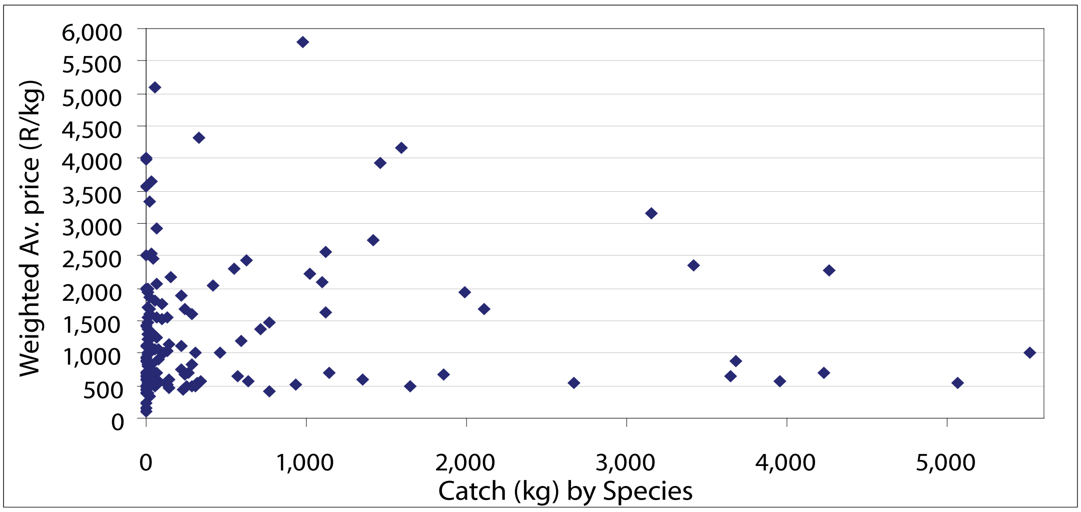
Station	Value of giant river prawn	Value of Fish	Total	Percentage
1A	4,920	116,737	121,657	58.54%
1C	2,577	23,515	26,092	12.56%
1B	9,698	3,131	12,829	6.17%
1M	4,440	4,454	8,894	4.28%
1E	3,868	2,734	6,602	3.18%
1D	4,726	860	5,586	2.69%
1F	4,310	1,308	5,618	2.70%
1H	2,584	2,713	5,296	2.55%
1I	1,983	3,098	5,081	2.45%
1G	2,403	1,356	3,759	1.81%
1J	718	2,700	3,418	1.64%
1K	1,132	750	1,882	0.91%
1L	723	368	1,091	0.53%
Total	44,083	163,722	207,805	100.00%

The total value, which is given in table 4, provides a corresponding answer to what has been found in the total catch. The most upstream *Dai Bongkong* units (1A, 1B and 1C) are the most productive, forming substantially about 77 % of the total sale value; while, the others add up to only about 23 percent (Table 4). Almost 80% of the total sales were from 153 non-prawn species combined.

Table 5. *Total value of catches (R1000s), showing the ten most valuable species (by total value) from October. to December 2004.*

Khmer name	Scientific name	Oct.	Nov.	Dec.	Total	%
Bongkong	*Macrobrachium rosenbergii*	19,819	21,385	2,879	44,083	21.21
Khlang hai	*Belodontichthys truncatus*	29,528	3,054	211	32,793	15.78
Khnang veng	*Labiobarbus kuhli*	15,440	39	10	15,489	7.45
Ros/ptuok	*Channa triata*	1,352	7,567	1,042	9,961	4.79
Sanday	*Wallago attu*	7,152	2,410	152	9,713	4.67
Chhpin	*Hypsibarbus lagleri*	6,974	986	74	8,033	3.87
Pruol/kralang	*Cirrhinus microlepis*	7,695	129	8	7,832	3.77
Khchoueng	*Macrognathus maculatus*	3,434	2,852	374	6,660	3.20
Kes prak	*Kryptopterus limpok*	5,600	123	12	5,735	2.76
Kray	*Chitala blanci*	528	4,551	554	5,633	2.71
Other (144 species)		42,035	17,316	2,520	61,872	29.77
Total		139,558	60,410	7,837	207,805	100.00

Even though giant river prawn production contributed only 1.2 percent to the total catch, its total sale value at the *Dai Bongkong* formed a large proportion of just over 21% (44,083,000 Riels) of the total sale (see Table 5), which was 207,805,000 Riels. The second most valuable species was *Belodontichthys truncatus,* which accounted for almost 16% of the total sales; the remaining 144 taxa combined contributed only about 30%.



Note: Three species are excluded from this graph for clarity, as their weighted average price and catches are off-scale

Figure 4. Weighted average price (R/kg) versus total catch (by species).

Figure 4 shows the weighted average price of each species plotted against total catch of each species. The weighted average price of *Macrobrachium rosenbergii* and the total catches of *Belodontichthys truncatus* and *Cirrhinus microlepis* are excluded from the graph for clarity as they are off-scale. The weighted average price and catches of these species are given in detail in appendices 2 and 4.

Table 6. *The ten most valuable species in the Dai Bongkong fishery*

Khmer name	Scientific name	Catch (kg)	Price (Riel/kg)
Bongkong	*Macrobrachium rosenbergii*	1,531	28,793
Kray	*Chitala blanci*	973	5,789
Khchoueng	*Macrognathus taeniagaster*	56	5,090
Khchoueng	*Mastacembelus favus*	329	4,306
Khchoueng	*Macrognathus maculatus*	1,596	4,173
Chhpin krahorm	*Hypsibarbus wetmorei*	2	4,000
Antong	*Monopterus albus*	3	3,993
Kes prak	*Kryptopterus limpok*	1,462	3,923
Carp sor	*Silver carp*	31	3,648
Antong	*Ophisternon bengalense*	23	3,327

It can be seen from Figure 2 that most of the species caught at *Dai Bongkong* fishery were sold at between 100 and 2,500 Riels per kg. In contrast, few species could be sold at between 3,000 and 6,000 Riels per kg.

Table 6 shows that the price of giant river prawn ranked first, sold at about 29,000 Riels per kg (or about US$7/kg) on average. The second most expensive was *Chitala blanci*, which could be sold at about 5,800 Riels per kg at the *Dai* sites. *Macrognathus spp.* came to the third place sold at between 4000-5000 Riels per kg, and followed by the price of *Monopterus spp.* at 3-4000 Riels per kg. It is noteworthy that *Macrobrachium rosenbergii, Macrognathus spp.,* and *Kryptopterus limpok* were the most abundant amongst the top ten most valuable species.

Practically, when sold, giant river prawns were classified into three grades (see Table 7).

Table 7. *Local price of giant river prawn classified by grades*

Grade	Weight (g)	Price at the landing site (Riel/kg)	Local price sold by middlemen (Riel/kg)
1	≥150	40,000	42,000
2	100 - 150	30,000	34,000
3	< 100	20,000	24,000

This data was a result of the interview with local middlemen who bought and sold giant river prawns in the fishing season of 2004. Giant river prawns were kept alive in basket. Their price of giant river prawns was even higher and could be sold at between US$15 to 20 per kg when transported alive to Phnom Penh.

Table 8. *Monthly weighted average prices (Riel/kg) for the ten species which made up the highest proportion of the total sale value.*

Khmer name	Scientific name	Weighted average price			
		Oct	Nov	Dec	Overall
Bongkong	*Macrobrachium rosenbergii*	25,344	32,352	32,713	28,793
Kray	*Chitala blanci*	6,359	5,710	5,960	5,789
Khchoueng	*Macrognathus maculatus*	3,551	5,120	5,199	4,173
Kes prak	*Kryptopterus limpok*	3,972	2,560	3,000	3,923
Ros/ptuok	*Channa striata*	2,523	3,240	3,708	3,160
Khlang hai	*Belodontichthys truncatus*	2,917	2,082	2,089	2,805
Chhpin	*Hypsibarbus lagleri*	2,340	2,482	2,054	2,354
Sanday	*Wallago attu*	2,228	2,437	2,705	2,283
Pruol/kralang	*Cirrhinus microlepis*	964	1,091	753	965
Khnang veng	*Labiobarbus kuhli*	505	632	567	506
Weighted average price for all species		1,314	1,696	1,925	1,455

Table 8 shows that the prices did not change much between months. From the data in this table, it suggested that a large proportion of giant river prawn captured were Grade 1 and 2.

Size of Giant River Prawn

Appendix 5 provides details of frequencies, mean length, variance and standard deviation of 31 common species captured at the *Dai Bongkong* fishery.

It can bee seen from the graph that most of giant river prawns were caught at the length 12 cm over a three-month period from October to December, 2004. On average, giant river prawns were captured at 14.5 cm with standard deviation ±3.2.

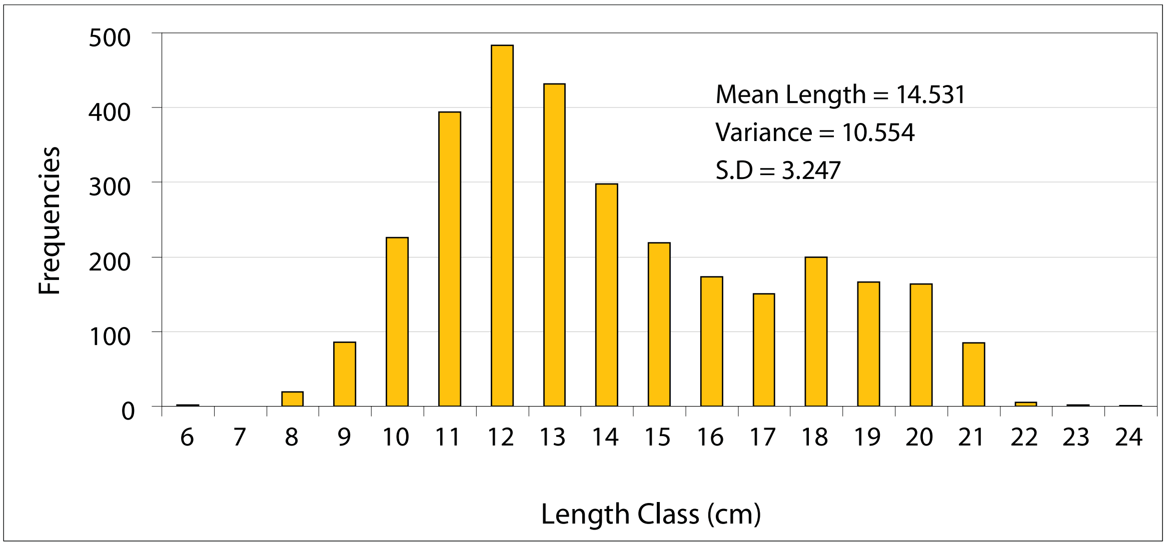


Figure 5: Frequencies versus length classes of giant river prawn (October to December, 2004)

Conflicts in the Dai Bongkong fishery

Several conflicts may occur in every fishing season of *Dai Bongkong*. The conflicts often occurred amongst *Dai Bongkong* operators, *Dai Trey Linh* operators and mobile gear operators.

Dai Bongkong owners: since the production of wild giant river prawn has remarkably declined, some *Dai Bongkong* operators, especially the most upstream ones, tend to start installing the bag net (newly introduced ones) in September, which is the peak time of *Dai Trey Linh* fishery, to capture small cyprinids that are forced to leave the floodplains as the water quality deteriorates (Welcomme, 1985 and Ngor et al., 2005). There are 5 units of *Dai Trey Linh* legally in operation in the Tonle Touch River from July to December; therefore, when *Dai Bongkong* operators begin their fishing before October, conflicts may arise. This is because certain quantities of fish that are supposed to migrate downstream are taken by *Dai Bongkong* upstream. Sometimes, the problems can be solved through oral agreement between the *Dai Trey Linh* and *Dai Bongkong* operators.

In addition, according to anecdotal evidence, there were cases that *Dai Bongkong* operators confiscated villagers' boats and fishing gears and destroyed when those villagers operated those fishing gears nearby or inside the *Dai Bongkong* sites, especially during the peak period, without any cooperation from fishery officers. There were also cases that *Dai Bongkong* operators arrested mobile gear fishers outside their exclusive exploitation area (200 metres up- and downstream from the location of the each *Dai Bongkong*). Furthermore, there was also a requirement of payment for those who want to operate mobile gears such as drift gillnets, giant cast net etc. These activities caused serious conflicts among them.

Mobile gear operators: as there were cases villagers being violated by *Dai Bongkong* owners, some villagers took chance to revenge. Moreover, since there has been a policy reform, mobile gear operators' rights are better aware of and protected. Some villagers seem to use their rights inappropriately to fish in the areas of *Dai Bongkong* fishery. These create conflicts between the mobile gear operators and the *Dai Bongkong* owners.

DISCUSSION AND CONCLUSIONS

The catch of *Dai Bongkong* is much smaller than that of the other *Dai* fisheries such as *Dai* fishery in the Tonle Sap River and *Dai Trey Linh* fishery in the Tonle Touch River. This is because the fishing season occurs in a relatively short period and the fishery operates only in a Mekong tributary. For instance, in the fishing season of 2004-5, the *Dai* fishery's production in the Tonle Sap River was 16,207 tonnes (MRC/DoF monitoring data); whereas, the production of *Dai Bongkong* in 2004 was only 125 tonnes. However, the *Dai Bongkong* fishery is unique in that it captures giant river prawn the most. In 2004 fishing season, giant river prawn contributed to about 1.22 (1,531 kg) and 21.21 percent (R 44,083,000) to the total catch and value respectively. Almost none of the giant river prawns are captured at the *Dai* fishery in the Tonle Sap River. As with other fisheries, except for the *Dai Trey Linh* fishery, *Dai Bongkong* catch is mainly 1+ fish and 1+ giant river prawn (see appendix 5). Apart from catching by the *Dai Bongkong*, considerable quantities of wild giant river prawns are usually taken by barrage/fishing lot fisheries, mobile gear fisheries (traps and hooks and lines) in the Mekong Delta in Prey Veng and Takeo Provinces.

Catch of wild giant river prawn has dramatically declined. It is reported that each unit of *Dai Bongkong* could catch up to 4 or 5 tonnes of giant river prawn per night during the peak period in 1980s. *Dai Bongkong* operators purely targeted only on giant river prawns, not fish. During that period, it was quite common that wild giant river prawns were captured by the *Dai* fishery or barrage fishery in the Tonle Sap River or they were caught by other mobile gear fisheries in the Cambodian upper Mekong in Kratie Province. According to group discussion with trap fishers for giant river prawn in Prey Veng Province, if 40-50 traps were used, they could capture 4-5 kg of giant river prawns per day in 1980s. The production of giant river prawns showed sign of decrease in 1996, when they could capture 1-2 kg per day per 100 traps. In 2004, most fishers could capture less than 1 kg per day per 100 traps. The main reasons behind this decline may be the result of dramatic increase in fishing efforts especially traps, hooks and lines, and other illegal fishing practices. Environmental degradation also plays a part to this decline, for example, hectares of inundated forest in Mekong Delta has been cleared for agriculture purposes. More importantly, it is a trans-boundary issue, when giant river prawns have to migrate to brackish water for spawning, where they pass through Viet Nam and migrate back to Cambodian floodplains for sheltering, feeding, and growing.

To conserve the fishery and to reduce conflicts, a number of measures should be taken. Firstly, traps and hook and lines should not be operated in the closing fishing season, giving chance to giant river prawns to spawn. Secondly, both *Dai Bongkong* operators and villagers have to follow the fishing regulations, in particular, conditions in the burden books and logbooks. Thirdly, the artificial breeding and culturing of giant river prawns (*Macrobrachium rosenbergii)* are successful in other countries than in Cambodia; thus, introducing such technology and re-stocking the species into the wild may help recover the national stock. Fourthly, it is a trans-boundary issue, which needs international cooperation to conserve this species. Finally, the quantities of wild giant river prawns captured by other fisheries such as traps, hook and lines, and fishing lots are not reliably known. The study of these fisheries may be important to understand the status of giant river prawn fishery countrywide. The data and information from this study may be important to suggest intervention measures for the management of the fishery.

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APPENDICES

Appendix 1: *Coordinates of Dai Bongkong location*

Location	North end	East end
1A	N11°19.623’	E105°17.671’
1B	N11°15.488’	E105°18.646’
1C	N11°13.596’	E105°19.251’
1D	N11°10.597’	E105°18.465’
1E	N11°06.496’	E105°18.261’
1F	N11°06.166’	E105°16.346’
1G	N11°05.057’	E105°15.361’
1H	N11°03.148’	E105°14.478’
1I	N11°01.707’	E105°14.778’
1J	N10°59.900’	E105°15.451’
1K	N10°58.377’	E105°14.634’
1L	N10°57.422’	E105°15.118’
1M	N10°54.562’	E105°15.952’

Appendix 2: *Total catch (Kg) by species by months for Dai Bongkong fishery Prey Veng Province (October to December, 2004)*

No	Khmer name	Scientific name	Month			Total	
			Oct	Nov.	Dec.	Catch	%
1	*Khnang veng*	*Labiobarbus kuhli*	30,560	61	18	30,639	24.33
2	*Khlang hai*	*Belodontichthys truncatus*	10,121	1,467	101	11,689	9.28
3	*Pruol/kralang*	*Cirrhinus microlepis*	7,984	118	11	8,113	6.44
4	*Chra keng*	*Puntioplites waandersi*	4,661	715	134	5,510	4.38
5	*Kaek*	*Labeo chrysophekadion*	4,434	549	77	5,060	4.02
6	*Sanday*	*Wallago attu*	3,210	989	56	4,255	3.38
7	*Kanhchrouk chhnot*	*Botia helodes*	3,928	293	4	4,225	3.36
8	*Riel awng kam*	*Cirrhinus lobatus*	3,894	48	9	3,951	3.14
9	*Krom*	*Osteochilus melanopleura*	3,164	487	25	3,676	2.92
10	*Chhkok*	*Cyclocheilichthys enoplos*	3,227	390	23	3,640	2.89
11	*Chhpin*	*Hypsibarbus lagleri*	2,980	397	36	3,413	2.71
12	*Ros/ptuok*	*Channa triata*	536	2,335	281	3,152	2.50
13	*Arch kok*	*Labiobarbus siamensis*	2,521	137	8	2,666	2.12
14	*Chhlanhg*	*Hemibagrus spilopterus*	1,060	926	127	2,113	1.68
15	*Andat chhke*	*Cynoglossus feldmanni*	1,015	799	168	1,982	1.57
16	*Kanhchrouk*	*Botia morleti*	1,848	3	1	1,852	1.47
17	*Changwa chunchuok*	*Crossocheilus reticulatus*	1,397	253	1	1,651	1.31
18	*Khchoueng*	*Macrognathus maculatus*	967	557	72	1,596	1.27
19	*Bongkong*	*Macrobrachium rosenbergii*	782	661	88	1,531	1.22
20	*Kes prak*	*Kryptopterus limpok*	1,410	48	4	1,462	1.16
21	*Kray*	*Chitala ornata*	1,147	260	9	1,416	1.12
22	*Riel tob*	*Cirrhinus siamensis*	1,279	50	20	1,349	1.07
23	*Kampoul bay*	*Cosmochilus harmandi*	272	742	126	1,140	0.91
24	*Kes*	*Micronema apogon*	452	594	79	1,125	0.89
25	*Kampot*	*Tetraodontidae* sp.	642	457	20	1,119	0.89
26	*Pra*	*Pangasianodon hypophthalmus*	1,075	16	4	1,095	0.87
27	*Ruschek*	*Acantopsis* sp.	886	114	16	1,016	0.81
28	*Kray*	*Chitala blanci*	83	797	93	973	0.77
29	*Sloeuk russey*	*Paralaubuca typus*	927	9	1	937	0.74
30	*Po*	*Pangasius larnaudii*	632	132	7	771	0.61
31	*Bandol ampoav*	*Clupeichthys* sp.	166	525	78	769	0.61
32	*Ampil tum*	*Systomus orphoides*	449	210	60	719	0.57
33	*Kulreang/kahor*	*Catlocarpio siamensis*	636	1	1	638	0.51
34	*Slat*	*Notopterus notopterus*	427	170	33	630	0.50
35	*Chra keng*	*Puntioplites falcifer*	45	493	50	588	0.47
36	*KAHe loeung*	*Barbodes schwanenfeldii*	472	85	19	576	0.46
37	*Kes*	*Kryptopterus micronema*	97	351	96	544	0.43
38	*Chhveat*	*Pangasius macronema*	179	275	9	463	0.37
39	*ANDAt chhke*	*Cynoglossus punticeps*	179	204	32	415	0.33
40	*Changwa moul*	*Rasbora aurotaenia*	332	9	1	342	0.27
41	*Khchoueng*	*Mastaecembelus favus*	275	52	2	329	0.26
42	*Linh*	*Thynnichthys thynnoides*	202	120	1	323	0.26
43	*Sloeuk russey*	*Oxygaster anomalura*	311	0	0	311	0.25
44	*Kros*	*Osteochilus hasseltii*	219	83	1	303	0.24
45	*KANTROrb*	*Pristolepis fasciata*	37	243	10	290	0.23

No	Khmer name	Scientific name	Month			Total	
			Oct	Nov.	Dec.	Catch	%
46	*Kahe krorhorm*	*Barbodes altus*	99	174	12	285	0.23
47	*Phkar kor*	*Cirrhinus prosemion*	266	17	1	284	0.23
48	*Lolork sor*	*Osteochilus schlegeli*	266	0	0	266	0.21
49	*Khman*	*Hampala macrolepidota*	216	19	13	248	0.20
50	*Chhpin*	*Hypsibarbus malcolmi*	207	21	9	237	0.19
51	*Dang khteng*	*Macrochirichthys macrochirus*	207	21	9	237	0.19
52	*Kanhchos*	*Mystus wolffi*	229	1	1	231	0.18
53	*Kranh*	*Anabas testudineus*	201	16	3	220	0.17
54	*Andat chhke*	*Achiroides leucorhynchos*	1	181	33	215	0.17
55	*Kamphliev*	*Kryptopterus hexapterus*	34	176	5	215	0.17
56	*Andat chhke*	*Synaptura marginata*	58	59	39	156	0.12
57	*Kambot chramos*	*Amblyrhynchichthys truncatus*	49	90	5	144	0.11
58	*Kamphleanh phluk*	*Trichogaster microlepis*	143	0	0	143	0.11
59	*Chhdor/diep*	*Channa micropeltes*	127	12	0	139	0.11
60	*Kanhchrouk loeung*	*Botia lecontei*	60	71	0	131	0.10
61	*Chun chouk dai /smok*	*Gyrinocheilus* spp.	74	53	2	129	0.10
62	*Chhveat*	*Pangasius polyuranodon*	62	55	10	127	0.10
63	*Chhpin prak*	*Barbodes gonionotus*	107	1	0	108	0.09
64	*Khman*	*Hampala dispar*	74	10	13	97	0.08
65	*Kanhchrouk krahorm*	*Botia modesta*	14	79	3	96	0.08
66	*Chanteas phluk*	*Parachela williaminae*	71	4	1	76	0.06
67	*KANHCHOs kdaong*	*Heterobagrus bocourti*	3	59	13	75	0.06
68	*Kantrang preng*	*Parambassis wolffii*	30	38	5	73	0.06
69	*Chhlonh*	*Macrognathus siamensis*	39	29	2	70	0.06
70	*Changwa nonong*	*Lobocheilos quadrilineatus*	17	51	0	68	0.05
71	*Kes*	*Micronema bleekeri*	44	19	4	67	0.05
72	*Kul chek*	*Epalzeorhynchos frenatum*	67	0	0	67	0.05
73	*Andeng tun*	*Clarias meladerma*	45	18	1	64	0.05
74	*Kanhchos bay*	*Mystus albolineatus*	1	42	19	62	0.05
75	*Andeng tun*	*Clarias macrocephalus*	13	40	6	59	0.05
76	*Kanhchrouk*	*Botia beauforti*	10	40	6	56	0.04
77	*Khchoueng*	*Macrognathus taeniagaster*	37	7	12	56	0.04
78	*Sraka kdam*	*Cyclocheilichthys lagleri*	6	29	16	51	0.04
79	*Kamphliev stoeung*	*Kryptopterus cheveyi*	47	1	0	48	0.04
80	*Damrey*	*Oxyeleotris marmorata*	7	27	8	42	0.03
81	*Kaok*	*Hemipimelodus bicolor*	14	19	6	39	0.03
82	*Kamphliev*	*Kryptopterus moorei*	34	2	1	37	0.03
83	*Chanteas phluk*	*Parachela siamensis*	28	6	0	34	0.03
84	*Carp sor*	Silver carp	10	20	1	31	0.02
85	*Andat chhke*	*Brachirus panoides*	24	5	1	30	0.02
86	*Andeng roeung*	*Clarias batrachus*	0	10	20	30	0.02
87	*Kanhchos chhnot*	*Mystus mysticetus*	2	27	1	30	0.02
88	*Pra khchoa*	*Pangasius bocourti*	17	8	3	28	0.02
89	*Andat chhke*	*Brachirus harmandi*	6	15	4	25	0.02
90	*Khsan*	*Channa gachua*	9	14	2	25	0.02
91	*Kanh chanh chras thom*	*Parambassis apogonoides*	4	12	8	24	0.02
92	*Kanhchos*	*Mystus singaringan*	2	15	7	24	0.02

No	Khmer name	Scientific name	Month			Total	
			Oct	Nov.	Dec.	Catch	%
93	*Kanhchos chhnot*	*Mystus atrifasciatus*	8	14	2	24	0.02
94	*Antong*	*Ophisternon bengalense*	0	10	13	23	0.02
95	*Kanhchos krawbey*	*Glyptothorax fuscus*	0	16	7	23	0.02
96	*Kanhchos thmor*	*Leiocassis siamensis*	3	16	4	23	0.02
97	*Prama*	*Boesemania microlepis*	14	9	0	23	0.02
98	*Kampeus*	*Caridea* spp.	4	12	4	20	0.02
99	*Chanteas phluk*	*Parachela maculicauda*	3	16	0	19	0.02
100	*Kanhchos chhnot*	*Mystus multiradiatus*	8	10	1	19	0.02
101	*Chek tum*	*Bagrichthys macracanthus*	12	5	1	18	0.01
102	*Kaok*	*Hemipimelodus borneensis*	2	13	2	17	0.01
103	*Kros*	*Osteochilus lini*	3	11	3	17	0.01
104	*Pava mokmuoy*	*Labeo dyocheilus*	1	15	1	17	0.01
105	*Chhkok tituy*	*Albulichthys albuloides*	16	0	0	16	0.01
106	*Kros*	*Osteochilus waandersii*	0	4	12	16	0.01
107	*Phtinh*	*Hyporhamphus limbatus*	16	0	0	16	0.01
108	*Changwa chhnot*	*Rasbora espei*	0	14	0	14	0.01
109	*Khla /bey kamnat*	*Systomus partipentazona*	14	0	0	14	0.01
110	*Pra /bonglao*	*Pangasius krempfi*	1	12	1	14	0.01
111	*Trasork*	*Probarbus jullieni*	14	0	0	14	0.01
112	*Pra kandol*	*Helicophagus waandersi*	2	7	4	13	0.01
113	*Ta aun*	*Ompok hypophthalmus*	3	2	8	13	0.01
114	*Changwa chhnot*	*Boraras urophthalmoides*	7	4	1	12	0.01
115	*Andat chhke*	*Brachirus orientalis*	4	3	4	11	0.01
116	*Phkar kor/chhnot*	*Cirrhinus molitorella*	10	0	0	10	0.01
117	*Carp samanh*	*Cyprinus carpio*	6	2	1	9	0.01
118	*Kbork*	*Tenualosa thibaudeaui*	4	3	1	8	0.01
119	*Pror lung/chrawlang*	*Leptobarbus hoevenii*	8	0	0	8	0.01
120	*Andeng tunle*	*Plotosus canius*	6	0	1	7	0.01
121	*Changwa chhnot*	*Rasbora paviei*	6	0	1	7	0.01
122	*Changwa phlieng*	*Esomus longimana*	0	7	0	7	0.01
123	*Chhmar*	*Setipinna melanochir*	1	6	0	7	0.01
124	*Krormorm*	*Ompok bimaculatus*	2	4	1	7	0.01
125	*Kamphliev*	*Kryptopterus schilbeides*	4	2	0	6	0.00
126	*Kampream*	*Polynemus multifilis*	4	2	0	6	0.00
127	*Phtong*	*Xenentodon cancila*	0	6	0	6	0.00
128	*Po pruy*	*Pangasius sanitwongsei*	5	1	0	6	0.00
129	*Sloeuk russey*	*Paralaubuca barroni*	0	5	1	6	0.00
130	*Bang kuoy*	*Luciosoma bleekeri*	3	2	0	5	0.00
131	*Chhkok phleung*	*Cyclocheilichthys furcatus*	3	2	0	5	0.00
132	*Kamphliev khlanh*	*Kryptopterus cryptopterus*	0	5	0	5	0.00
133	*Angkat prak*	*Puntius aurotaeniatus*	4	0	0	4	0.00
134	*Changwa nonong*	*Lobocheilos davisi*	3	1	0	4	0.00
135	*Angkat prak*	*Puntius brevis*	0	0	3	3	0.00
136	*Antong*	*Monopterus albus*	1	1	1	3	0.00
137	*Changwa*	*Rasbora hobelmani*	1	2	0	3	0.00
138	*Sloeuk russey*	*Paralaubuca harmandi*	1	2	0	3	0.00
139	*Sraka kdam*	*Cyclocheilichthys apogon*	0	1	2	3	0.00

No	Khmer name	Scientific name	Month			Total	
			Oct	Nov.	Dec.	Catch	%
140	*Andeng ngaing*	*Clarias nieuhofi*	0	0	2	2	0.00
141	*Chhpin*	*Hypsibarbus pierrei*	0	2	0	2	0.00
142	*Chhpin krahorm*	*Hypsibarbus wetmorei*	0	0	2	2	0.00
143	*Kanhcheak sla*	*Toxotes chatareus*	1	1	0	2	0.00
144	*Kaok*	*Arius caelatus*	1	1	0	2	0.00
145	*Keat srorng*	*Balantiocheilos melanopterus*	0	0	2	2	0.00
146	*Chanluon moan*	*Coilia lindmani*	0	1	0	1	0.00
147	*Chhkok pokmoat bey*	*Cyclocheilichthys heteronema*	1	0	0	1	0.00
148	*Kamphleanh samrei*	*Trichogaster trichopterus*	0	1	0	1	0.00
149	*Kanhchorn chey*	*Channa lucius*	1	0	0	1	0.00
150	*Khya*	*Mystus wycki*	0	1	0	1	0.00
151	*Kros*	*Osteochilus microcephalus*	0	1	0	1	0.00
152	*Sloeuk russey*	*Paralaubuca riveroi*	1	0	0	1	0.00
153	*Sraka kdam*	*Cyclocheilichthys repasson*	1	0	0	1	0.00
154	*Trasork sor*	*Probarbus labeamajor*	0	1	0	1	0.00
	Total		104,414	19,094	2,403	125,911	100.00

Appendix 3: *Total sale price (R1000s) by species by months for Dai Bangkong fishery Prey Veng Province (October to Dec, 2004)*

No	Khmer name	Scientific name	Months			Total	
			Oct.	Nov.	Dec.	Value	%
1	*Bongkong*	*Macrobrachium rosenbergii*	19,819	21,385	2,879	44,083	21.21
2	*Khlang hai*	*Belodontichthys truncatus*	29,528	3,054	211	32,793	15.78
3	*Khnang veng*	*Labiobarbus kuhli*	15,440	39	10	15,489	7.45
4	*Ros/ptuok*	*Channa triata*	1,352	7,567	1,042	9,961	4.79
5	*Sanday*	*Wallago attu*	7,152	2,410	152	9,713	4.67
6	*Chhpin*	*Hypsibarbus lagleri*	6,974	986	74	8,033	3.87
7	*Pruol/kralang*	*Cirrhinus microlepis*	7,695	129	8	7,832	3.77
8	*Khchoueng*	*Macrognathus maculatus*	3,434	2,852	374	6,660	3.20
9	*Kes prak*	*Kryptopterus limpok*	5,600	123	12	5,735	2.76
10	*KRAY*	*Chitala blanci*	528	4,551	554	5,633	2.71
11	*Chra keng*	*Puntioplites waandersi*	5,008	497	78	5,583	2.69
12	*Kray*	*Chitala ornata*	3,074	792	14	3,880	1.87
13	*Andat chhke*	*Cynoglossus feldmanni*	1,584	1,861	383	3,828	1.84
14	*Chhlanhg*	*Hemibagrus spilopterus*	1,532	1,799	231	3,563	1.71
15	*Krom*	*Osteochilus melanopleura*	2,320	849	23	3,191	1.54
16	*Kanhchrouk chhnot*	*Botia helodes*	2,558	378	5	2,940	1.42
17	*Kes*	*Micronema apogon*	1,163	1,511	218	2,892	1.39
18	*Kaek*	*Labeo chrysophekadion*	2,342	357	55	2,754	1.33
19	*Chhkok*	*Cyclocheilichthys enoplos*	1,911	399	18	2,329	1.12
20	*Pra*	*Pangasianodon hypophthalmus*	2,267	16	3	2,286	1.10
21	*Ruschek*	*Acantopsis sp.*	1,960	246	50	2,255	1.09
22	*Riel awng kam*	*Cirrhinus lobatus*	2,192	24	9	2,225	1.07
23	*Kampot*	*Tetraodontidae sp*	861	925	36	1,822	0.88
24	*Slat*	*Notopterus notopterus*	916	542	75	1,532	0.74
25	*Arch kok*	*Labiobarbus siamensis*	1,296	155	2	1,453	0.70
26	*Khchoueng*	*Mastaecembelus favus*	1,172	235	10	1,417	0.68
27	*Kes*	*Kryptopterus micronema*	356	669	231	1,255	0.60
28	*Kanhchrouk*	*Botia morleti*	1,220	4	1	1,226	0.59
29	*Po*	*Pangasius larnaudii*	881	238	9	1,128	0.54
30	*Ampil tum*	*Systomus orphoides*	618	324	45	987	0.47
31	*Andat chhke*	*Cynoglossus punticeps*	323	451	75	850	0.41
32	*Changwa chunchuok*	*Crossocheilus reticulatus*	703	117	0	820	0.39
33	*Riel tob*	*Cirrhinus siamensis*	663	115	12	790	0.38
34	*Kampoul bay*	*Cosmochilus harmandi*	164	549	75	788	0.38
35	*Chra keng*	*Puntioplites falcifer*	46	537	121	704	0.34
36	*Sloeuk russey*	*Paralaubuca typus*	479	5	1	484	0.23
37	*Chhveat*	*Pangasius macronema*	94	369	9	471	0.23
38	*Kantrorb*	*Pristolepis fasciata*	53	397	14	463	0.22
39	*Andat chhke*	*Achiroides leucorhynchos*	0	335	68	403	0.19
40	*Chhpin*	*Hypsibarbus malcolmi*	360	30	11	401	0.19
41	*Kahe loeung*	*Barbodes schwanenfeldii*	297	69	11	377	0.18
42	*Kulreang/kahor*	*Catlocarpio siamensis*	361	0	1	362	0.17
43	*Andat chhke*	*Synaptura marginata*	111	124	106	341	0.16
44	*Bandol ampoav*	*Clupeichthys Sp.*	94	215	12	322	0.15
45	*Kros*	*Osteochilus hasseltii*	192	116	1	308	0.15

No	Khmer name	Scientific name	Months			Total	
			Oct.	Nov.	Dec.	Value	%
46	*Khchoueng*	*Macrognathus taeniagaster*	179	34	72	285	0.14
47	*Kamphliev*	*Kryptopterus hexapterus*	30	200	10	240	0.12
48	*Kahe krorhorm*	*Barbodes altus*	81	140	15	236	0.11
49	*Kanhchrouk loeung*	*Botia lecontei*	68	135	0	203	0.10
50	*Kes*	*Micronema bleekeri*	112	71	13	196	0.09
51	*Changwa moul*	*Rasbora aurotaenia*	190	4	2	196	0.09
52	*Lolork sor*	*Osteochilus schlegeli*	189	0	0	189	0.09
53	*Linh*	*Thynnichthys thynnoides*	97	78	2	177	0.08
54	*Khman*	*Hampala dispar*	117	16	39	172	0.08
55	*Kranh*	*Anabas testudineus*	144	16	4	163	0.08
56	*Dang khteng*	*Macrochirichthys macrochirus*	139	14	7	160	0.08
57	*Chhdor/diep*	*Channa micropeltes*	103	54	0	157	0.08
58	*Sloeuk russey*	*Oxygaster anomalura*	150	0	0	150	0.07
59	*Kanhchrouk krahorm*	*Botia modesta*	10	132	4	147	0.07
60	*Chhlonh*	*Macrognathus siamensis*	61	78	5	144	0.07
61	*Phkar kor*	*Cirrhinus prosemion*	133	7	1	141	0.07
62	*Chhveat*	*Pangasius polyuranodon*	60	57	14	130	0.06
63	*Khman*	*Hampala macrolepidota*	86	27	8	121	0.06
64	*Carp sor*	*Silver carp*	46	66	1	113	0.05
65	*Chhpin prak*	*Barbodes gonionotus*	109	0	0	109	0.05
66	*Andeng tun*	*Clarias macrocephalus*	10	83	14	106	0.05
67	*Damrey*	*Oxyeleotris marmorata*	9	72	22	103	0.05
68	*Kanhchos*	*Mystus wolffi*	101	1	1	102	0.05
69	*Andeng tun*	*Clarias meladerma*	48	51	1	100	0.05
70	*Kambot chramos*	*Amblyrhynchichthys truncatus*	26	51	8	85	0.04
71	*Kul chek*	*Epalzeorhynchos frenatum*	83	0	0	83	0.04
72	*Kantrang preng*	*Parambassis wolffii*	29	42	5	77	0.04
73	*Antong*	*Ophisternon bengalense*	0	38	38	77	0.04
74	*Andeng roeung*	*Clarias batrachus*	0	21	55	76	0.04
75	*Kamphleanh phluk*	*Trichogaster microlepis*	68	0	0	68	0.03
76	*Kanhchos kdaong*	*Heterobagrus bocourti*	2	53	13	67	0.03
77	*Chun chouk dai /smok*	*Gyrinocheilus spp.*	34	32	1	66	0.03
78	*Kanhchrouk*	*Botia beauforti*	9	36	15	60	0.03
79	*Andat chhke*	*Brachirus harmandi*	18	19	9	47	0.02
80	*Chanteas phluk*	*Parachela siamensis*	20	25	0	45	0.02
81	*Chanteas phluk*	*Parachela williaminae*	38	3	3	44	0.02
82	*Kanhchos bay*	*Mystus albolineatus*	1	32	10	43	0.02
83	*Changwa nonong*	*Lobocheilos quadrilineatus*	7	28	0	35	0.02
84	*Kampeus*	*Caridea*	2	26	6	34	0.02
85	*Andat chhke*	*Brachirus panoides*	21	9	3	33	0.02
86	*Chanteas phluk*	*Parachela maculicauda*	1	29	0	31	0.01
87	*Khla /bey kamnat*	*Systomus partipentazona*	28	0	0	28	0.01
88	*Prama*	*Boesemania microlepis*	13	15	0	28	0.01
89	*Sraka kdam*	*Cyclocheilichthys lagleri*	3	15	8	26	0.01
90	*Kamphliev stoeung*	*Kryptopterus cheveyi*	24	1	0	25	0.01
91	*Kamphliev*	*Kryptopterus moorei*	21	1	2	24	0.01
92	*Pra khchoa*	*Pangasius bocourti*	9	11	3	23	0.01
93	*Kaok*	*Hemipimelodus bicolor*	7	10	3	20	0.01

No	Khmer name	Scientific name	Months			Total	
			Oct.	Nov.	Dec.	Value	%
94	*Kanhchos chhnot*	*Mystus mysticetus*	1	18	1	20	0.01
95	*Pava mokmuoy*	*Labeo dyocheilus*	1	17	1	18	0.01
96	*Pra /bonglao*	*Pangasius krempfi*	1	17	1	18	0.01
97	*Kanhchos thmor*	*Leiocassis siamensis*	1	11	6	18	0.01
98	*Andat chhke*	*Brachirus orientalis*	6	5	6	17	0.01
99	*Kaok*	*Hemipimelodus borneensis*	1	12	4	17	0.01
100	*Kanhchos krawbey*	*Glyptothorax fuscus*	0	9	8	17	0.01
101	*Phtinh*	*Hyporhamphus limbatus sp*	16	0	0	16	0.01
102	*Ta aun*	*Ompok hypophthalmus*	3	3	10	15	0.01
103	*Kanhchos chhnot*	*Mystus atrifasciatus*	4	10	1	14	0.01
104	*Chhmar*	*Setipinna melanochir*	2	12	0	14	0.01
105	*Khsan*	*Channa gachua*	4	7	1	12	0.01
106	*Kanhchos*	*Mystus singaringan*	1	8	4	12	0.01
107	*Antong*	*Monopterus albus*	4	3	5	12	0.01
108	*Krormorm*	*Ompok bimaculatus*	5	6	1	12	0.01
109	*Phtong*	*Xenentodon cancila sp*	0	12	0	12	0.01
110	*Chek tum*	*Bagrichthys macracanthus*	6	4	1	11	0.01
111	*Kamphliev khlanh*	*Kryptopterus cryptopterus*	0	10	0	10	0.00
112	*Kros*	*Osteochilus lini*	1	6	2	10	0.00
113	*Kanhchos chhnot*	*Mystus multiradiatus*	3	5	2	9	0.00
114	*Carp samanh*	*Cyprinus carpio*	6	2	1	9	0.00
115	*Changwa chhnot*	*Rasbora espei*	0	9	0	9	0.00
116	*Andeng tunle*	*Plotosus canius*	6	0	3	9	0.00
117	*Po pruy*	*Pangasius sanitwongsei*	5	2	2	9	0.00
118	*Pra kandol*	*Helicophagus waandersi*	1	4	4	9	0.00
119	*Changwa phlieng*	*Esomus longimana*	0	8	0	8	0.00
120	*Kros*	*Osteochilus waandersii*	0	2	6	8	0.00
121	*Sloeuk russey*	*Paralaubuca barroni*	0	6	2	8	0.00
122	*Chhpin krahorm*	*Hypsibarbus wetmorei*	0	0	8	8	0.00
123	*Chhkok tituy*	*Albulichthys albuloides*	8	0	0	8	0.00
124	*Kanh chanh chras thom*	*Parambassis apogonoides*	2	4	2	8	0.00
125	*Changwa chhnot*	*Boraras urophthalmoides*	4	2	1	6	0.00
126	*Kbork*	*Tenualosa thibaudeaui*	2	3	1	6	0.00
127	*Changwa chhnot*	*Rasbora paviei*	4	0	2	6	0.00
128	*Trasork*	*Probarbus jullieni*	6	0	0	6	0.00
129	*Kamphliev*	*Kryptopterus schilbeides*	2	3	0	5	0.00
130	*Keat srorng*	*Balantiocheilos melanopterus*	0	0	5	5	0.00
131	*Phkar kor/chhnot*	*Cirrhinus molitorella*	5	0	0	5	0.00
132	*Changwa nonong*	*Lobocheilos davisi*	2	3	0	5	0.00
133	*Pror lung/chrawlang*	*Leptobarbus hoevenii*	4	0	0	4	0.00
134	*Andeng ngaing*	*Clarias nieuhofi*	0	0	4	4	0.00
135	*Kampream*	*Polynemus multifilis spp.*	2	1	0	3	0.00
136	*Kaok*	*Arius caelatus*	1	2	0	3	0.00
137	*Angkat prak*	*Puntius brevis Sp.*	0	0	3	3	0.00
138	*Sraka kdam*	*Cyclocheilichthys apogon*	0	1	2	3	0.00
139	*Bang kuoy*	*Luciosoma bleekeri*	2	1	0	3	0.00
140	*Chhkok phleung*	*Cyclocheilichthys furcatus*	1	1	0	2	0.00
141	*Angkat prak*	*Puntius aurotaeniatus*	2	0	0	2	0.00

No	Khmer name	Scientific name	Months			Total	
			Oct.	Nov.	Dec.	Value	%
142	*Sloeuk russey*	*Paralaubuca harmandi*	1	1	0	2	0.00
143	*Changwa*	*Rasbora hobelmani*	0	1	0	1	0.00
144	*Kanhcheak sla*	*Toxotes chatareus*	1	1	0	1	0.00
145	*Chhpin*	*Hypsibarbus pierrei*	0	1	0	1	0.00
146	*Chhkok pokmoat bey*	*Cyclocheilichthys heteronema*	1	0	0	1	0.00
147	*Kanhchorn chey*	*Channa lucius*	1	0	0	1	0.00
148	*Trasork sor*	*Probarbus labeamajor*	0	1	0	1	0.00
149	*Sraka kdam*	*Cyclocheilichthys repasson*	1	0	0	1	0.00
150	*Kamphleanh samrei*	*Trichogaster trichopterus*	0	1	0	1	0.00
151	*Sloeuk russey*	*Paralaubuca riveroi*	0	0	0	0	0.00
152	*Chanluon moan*	*Coilia lindmani*	0	0	0	0	0.00
153	*Khya*	*Mystus wycki*	0	0	0	0	0.00
154	*Kros*	*Osteochilus microcephalus*	0	0	0	0	0.00
	Total				7,837	207,805	100.00

Appendix 4: *Monthly average price (R/Kg) by species by months for Dai Bongkong fishery Prey Veng Province (October to December, 2004)*

Nº	Khmer name	Scientific name	Weighted Average			
			Oct	Nov	Dec	Overall
1	*Bongkong*	*Macrobrachium rosenbergii*	25,344	32,352	32,713	28,793
2	*Kray*	*Chitala blanci*	6,359	5,710	5,960	5,789
3	*Khchoueng*	*Macrognathus taeniagaster*	4,839	4,857	6,000	5,090
4	*Khchoueng*	*Mastaecembelus favus*	4,261	4,522	5,000	4,306
5	*Khchoueng*	*Macrognathus maculatus*	3,551	5,120	5,199	4,173
6	*Chhpin krahorm*	*Hypsibarbus wetmorei*			4,000	4,000
7	*Antong*	*Monopterus albus*	3,978	3,000	5,000	3,993
8	*Kes prak*	*Kryptopterus limpok*	3,972	2,560	3,000	3,923
9	*Carp sor*	*Silver carp*	4,567	3,321	1,000	3,648
10	*Antong*	*Ophisternon bengalense*		3,830	2,940	3,327
11	*Ros/ptuok*	*Channa triata*	2,523	3,240	3,708	3,160
12	*Kes*	*Micronema bleekeri*	2,544	3,760	3,125	2,924
13	*Khlang hai*	*Belodontichthys truncatus*	2,917	2,082	2,089	2,805
14	*Kray*	*Chitala ornata*	2,680	3,045	1,567	2,740
15	*Kes*	*Micronema apogon*	2,573	2,544	2,761	2,571
16	*Andeng roeung*	*Clarias batrachus*		2,130	2,750	2,543
17	*Keat srorng*	*Balantiocheilos melanopterus*			2,500	2,500
18	*Damrey*	*Oxyeleotris marmorata*	1,307	2,672	2,700	2,450
19	*Slat*	*Notopterus notopterus*	2,144	3,186	2,258	2,431
20	*Chhpin*	*Hypsibarbus lagleri*	2,340	2,482	2,054	2,354
21	*Kes*	*Kryptopterus micronema*	3,673	1,905	2,401	2,308
22	*Sanday*	*Wallago attu*	2,228	2,437	2,705	2,283
23	*Ruschek*	*Acantopsis sp.*	2,212	2,156	3,120	2,220
24	*Andat chhke*	*Synaptura marginata*	1,911	2,106	2,712	2,185
25	*Pra*	*Pangasianodon hypophthalmus*	2,109	1,019	650	2,088
26	*Chhlonh*	*Macrognathus siamensis*	1,572	2,690	2,390	2,058
27	*Andat chhke*	*Cynoglossus punticeps*	1,807	2,213	2,336	2,047
28	*Andeng ngaing*	*Clarias nieuhofi*			2,000	2,000
29	*Kamphliev khlanh*	*Kryptopterus cryptopterus*		2,000		2,000
30	*Khla /bey kamnat*	*Systomus partipentazona*	2,000			2,000
31	*Phtong*	*Xenentodon cancila sp*		1,982		1,982
32	*Andat chhke*	*Cynoglossus feldmanni*	1,561	2,329	2,277	1,931
33	*Chhmar*	*Setipinna melanochir*	1,500	2,000		1,929
34	*Andat chhke*	*Achiroides leucorhynchos*	298	1,852	2,062	1,877
35	*Andat chhke*	*Brachirus harmandi*	3,000	1,295	2,330	1,870
36	*Andeng tun*	*Clarias macrocephalus*	732	2,074	2,300	1,801
37	*Khman*	*Hampala dispar*	1,586	1,578	2,962	1,770
38	*Krormorm*	*Ompok bimaculatus*	2,500	1,425	1,260	1,709
39	*Chhpin*	*Hypsibarbus malcolmi*	1,739	1,441	1,167	1,691
40	*Kampeus*	*Caridea*	500	2,130	1,550	1,688
41	*Chhlanhg*	*Hemibagrus spilopterus*	1,446	1,943	1,820	1,686
42	*Kampot*	*Tetraodontidae sp*	1,341	2,024	1,777	1,628
43	*Chanteas phluk*	*Parachela maculicauda*	398	1,840		1,612
44	*Kantrorb*	*Pristolepis fasciata*	1,420	1,634	1,382	1,598
45	*Andeng tun*	*Clarias meladerma*	1,071	2,812	1,200	1,563

Nº	Khmer name	Scientific name	Weighted Average			
			Oct	Nov	Dec	Overall
46	*Andat chhke*	*Brachirus orientalis*	1,497	1,740	1,490	1,561
47	*Kanhchrouk loeung*	*Botia lecontei*	1,136	1,903		1,551
48	*Kanhchrouk krahorm*	*Botia modesta*	748	1,675	1,403	1,531
49	*Po pruy*	*Pangasius sanitwongsei*	1,000	1,920		1,487
50	*Po*	*Pangasius larnaudii*	1,395	1,801	1,217	1,463
51	*Kaok*	*Arius caelatus*	796	2,060		1,428
52	*Ampil tum*	*Systomus orphoides*	1,377	1,543	747	1,373
53	*Sloeuk russey*	*Paralaubuca barroni*		1,240	2,000	1,367
54	*Chanteas phluk*	*Parachela siamensis*	700	4,210		1,319
55	*Andeng tunle*	*Plotosus canius*	1,000		3,000	1,286
56	*Pra /bonglao*	*Pangasius krempfi*	700	1,389	600	1,284
57	*Kul chek*	*Epalzeorhynchos frenatum*	1,240			1,240
58	*Prama*	*Boesemania microlepis*	920	1,667		1,212
59	*Changwa phlieng*	*Esomus longimana*		1,210		1,210
60	*Chra keng*	*Puntioplites falcifer*	1,019	1,090	2,410	1,197
61	*Ta aun*	*Ompok hypophthalmus*	927	1,250	1,208	1,149
62	*Chhdor/diep*	*Channa micropeltes*	812	4,500		1,130
63	*Changwa nonong*	*Lobocheilos davisi*	500	3,000		1,125
64	*Kamphliev*	*Kryptopterus hexapterus*	887	1,134	1,960	1,114
65	*Andat chhke*	*Brachirus panoides*	877	1,764	3,000	1,095
66	*Pava mokmuoy*	*Labeo dyocheilus*	700	1,138	600	1,081
67	*Kanhchrouk*	*Botia beauforti*	932	890	2,500	1,070
68	*Kantrang preng*	*Parambassis wolffii*	979	1,115	1,098	1,058
69	*Chhveat*	*Pangasius polyuranodon*	968	1,032	1,358	1,026
70	*Chhveat*	*Pangasius macronema*	523	1,342	973	1,018
71	*Kros*	*Osteochilus hasseltii*	875	1,398	860	1,018
72	*Carp samanh*	*Cyprinus carpio*	1,000	1,150	850	1,017
73	*Chra keng*	*Puntioplites waandersi*	1,074	696	583	1,013
74	*Chhpin prak*	*Barbodes gonionotus*	1,016	150		1,008
75	*Kaok*	*Hemipimelodus borneensis*	500	923	2,000	1,000
76	*Phtinh*	*Hyporhamphus limbatus sp*	995			995
77	*Pruol/kralang*	*Cirrhinus microlepis*	964	1,091	753	965
78	*Angkat prak*	*Puntius brevis Sp.*			933	933
79	*Kanhchos kdaong*	*Heterobagrus bocourti*	640	897	964	898
80	*Krom*	*Osteochilus melanopleura*	733	1,743	911	868
81	*Sraka kdam*	*Cyclocheilichthys apogon*		600	1,000	867
82	*Kamphliev*	*Kryptopterus schilbeides*	500	1,500		833
83	*Pra khchoa*	*Pangasius bocourti*	554	1,341	1,033	830
84	*Kahe krorhorm*	*Barbodes altus*	820	804	1,280	830
85	*Changwa chhnot*	*Rasbora paviei*	612		2,000	810
86	*Kanhchos thmor*	*Leiocassis siamensis*	459	658	1,420	765
87	*Kranh*	*Anabas testudineus*	715	973	1,363	742
88	*Kanhchos krawbey*	*Glyptothorax fuscus*		563	1,120	732
89	*Kbork*	*Tenualosa thibaudeaui*	500	960	900	723
90	*Lolork sor*	*Osteochilus schlegeli*	710			710
91	*Chhkok pokmoat bey*	*Cyclocheilichthys heteronema*	700			700
92	*Kanhchorn chey*	*Channa lucius*	700			700

Nº	Khmer name	Scientific name	Weighted Average			
			Oct	Nov	Dec	Overall
93	*Trasork sor*	*Probarbus labeamajor*		700		700
94	*Kanhchrouk chhnot*	*Botia helodes*	651	1,289	1,240	696
95	*Kampoul bay*	*Cosmochilus harmandi*	602	740	598	692
96	*Kanhchos bay*	*Mystus albolineatus*	700	773	500	688
97	*Dang khteng*	*Macrochirichthys macrochirus*	670	690	786	676
98	*Kanhchrouk*	*Botia morleti*	660	1,390	900	662
99	*Pra kandol*	*Helicophagus waandersi*	475	563	925	661
100	*Kahe loeung*	*Barbodes schwanenfeldii*	630	814	583	655
101	*Kanhchos chhnot*	*Mystus mysticetus*	549	650	860	650
102	*Changwa chhnot*	*Rasbora espei*		650		650
103	*Sraka kdam*	*Cyclocheilichthys repasson*	646			646
104	*Chhkok*	*Cyclocheilichthys enoplos*	592	1,024	777	640
105	*Kamphliev*	*Kryptopterus moorei*	628	400	1,500	639
106	*Chek tum*	*Bagrichthys macracanthus*	498	780	1,270	619
107	*Kanhchos chhnot*	*Mystus atrifasciatus*	460	709	420	602
108	*Kanhcheak sla*	*Toxotes chatareus*	597	600		598
109	*Kambot chramos*	*Amblyrhynchichthys truncatus*	529	565	1,682	591
110	*Riel tob*	*Cirrhinus siamensis*	518	2,299	609	585
111	*Kros*	*Osteochilus lini*	432	567	787	582
112	*Chanteas phluk*	*Parachela williaminae*	537	815	2,500	577
113	*Changwa moul*	*Rasbora aurotaenia*	572	400	2,000	572
114	*Kulreang/kahor*	*Catlocarpio siamensis*	568	100	800	568
115	*Sloeuk russey*	*Paralaubuca harmandi*	700	500		567
116	*Riel awng kam*	*Cirrhinus lobatus*	563	497	1,004	563
117	*Pror lung/chrawlang*	*Leptobarbus hoevenii*	551			551
118	*Linh*	*Thynnichthys thynnoides*	482	648	1,500	547
119	*Arch kok*	*Labiobarbus siamensis*	514	1,130	260	545
120	*Kaek*	*Labeo chrysophekadion*	528	650	714	544
121	*Kampream*	*Polynemus multifilis spp.*	500	600		533
122	*Sloeuk russey*	*Paralaubuca typus*	517	511	500	517
123	*Changwa nonong*	*Lobocheilos quadrilineatus*	400	555		516
124	*Chun chouk dai /smok*	*Gyrinocheilus spp.*	453	598	600	515
125	*Kanhchos*	*Mystus singaringan*	600	510	500	515
126	*Kaok*	*Hemipimelodus bicolor*	526	510	500	514
127	*Kros*	*Osteochilus waandersii*		550	500	513
128	*Kamphliev stoeung*	*Kryptopterus cheveyi*	500	1,000		510
129	*Khnang veng*	*Labiobarbus kuhli*	505	632	567	506
130	*Sraka kdam*	*Cyclocheilichthys lagleri*	467	514	500	504
131	*Angkat prak*	*Puntius aurotaeniatus*	500			500
132	*Bang kuoy*	*Luciosoma bleekeri*	500	500		500
133	*Changwa chhnot*	*Boraras urophthalmoides*	500	500	500	500
134	*Chhpin*	*Hypsibarbus pierrei*		500		500
135	*Kamphleanh samrei*	*Trichogaster trichopterus*		500		500
136	*Phkar kor/chhnot*	*Cirrhinus molitorella*	500			500
137	*Changwa*	*Rasbora hobelmani*	199	650		500
138	*Khsan*	*Channa gachua*	458	504	650	499
139	*Chhkok tituy*	*Albulichthys albuloides*	497			497

Nº	Khmer name	Scientific name	Weighted Average			
			Oct	Nov	Dec	Overall
140	*Changwa chunchuok*	*Crossocheilus reticulatus*	503	462	200	497
141	*Phkar kor*	*Cirrhinus prosemion*	500	388	1,200	496
142	*Khman*	*Hampala macrolepidota*	400	1,423	618	490
143	*Kanhchos chhnot*	*Mystus multiradiatus*	398	460	1,500	489
144	*Sloeuk russey*	*Oxygaster anomalura*	482			482
145	*Kamphleanh phluk*	*Trichogaster microlepis*	475			475
146	*Kanhchos*	*Mystus wolffi*	443	500	500	443
147	*Chhkok phleung*	*Cyclocheilichthys furcatus*	300	650		440
148	*Bandol ampoav*	*Clupeichthys Sp.*	568	410	160	419
149	*Sloeuk russey*	*Paralaubuca riveroi*	400			400
150	*Trasork*	*Probarbus jullieni*	398			398
151	*Kanh chanh chras thom*	*Parambassis apogonoides*	543	306	260	330
152	*Chanluon moan*	*Coilia lindmani*		230		230
153	*Khya*	*Mystus wycki*		150		150
154	*Kros*	*Osteochilus microcephalus*		100		100

Appendix 5: *Mean Length (cm.) of Common Species Captured at the Dai Bongkong Fishery,*

No.	Khmer Name	Species Name	Total catch (kg)	October				November				December			
				Freq.	M. Len.	Var	S.D	Freq.	M. Len.	Var	S.D	Freq.	M. Len.	Var	S.D
1	*Ampil tum*	*Systomus orphoides*	719					102	13.97	1.935	1.391	78	14.245	3.905	1.976
2	*Andat chhke*	*Cynoglossus feldmanni*	1,982	498	24.735	17.238	4.152	806	21.08	26.156	5.114	718	16.132	41.322	6.428
3	*Arch kok*	*Labiobarbus siamensis*	2,666	193.0	8.662	7.877	2.807								
4	*Bangkong*	*Macrobrachium rosenbergii*	1,531	1205	14.218	8.755	2.959	1574	14.508	11.203	3.347	327	15.793	12.073	3.475
5	*Chanteas phluk*	*Parachela williaminae*	76	49	10.185	0.574	0.758								
6	*Chhkok*	*Cyclocheilichthys enoplos*	3,640	384	9.015	5.155	2.270	157	14.667	5.568	2.360	65	15.004	7.126	2.669
7	*Chhlang*	*Hemibagrus spilopterus*	2,113	236	15.035	22.959	4.792	246	18.206	8.324	2.885	129	16.845	5.46	2.337
8	*Chhpin*	*Hypsibarbus malcolmi*	237	92	16.091	6.057	2.461	84	15.236	8.917	2.986	38	15.555	7.286	2.699
9	*Chra keng*	*Puntioplites falcifer*	588	629	9.692	5.225	2.286	1016	10.974	3.326	1.824	561	9.728	5.683	2.384
10	*Kaek*	*Labeo chrysophekadion*	5,060	192	12.138	13.179	3.63	558	13.463	10.045	3.169	199	14.249	10.091	3.177
11	*Kahe loeung*	*Barbodes schwanenfeldii*	576	16	10.825	5.183	2.277	31	12.579	1.583	1.258	40	11.825	2.907	1.705
12	*Kambot chramos*	*Amblyrhynchichthys truncatus*	144	41	8.523	6.820	2.611								
13	*Kampoul bai*	*Cosmochilus harmandi*	1,140	213	13.53	5.744	2.397	702	14.004	13.725	3.705	190	15.924	6.441	2.538
14	*Kanhchos*	*Mystus singaringan*	24	9	11.894	3.023	1.74	88	13.609	2.756	1.66	98	13.379	2.191	1.48
15	*Kes*	*Pangasius larnaudii*	771	558	19.219	11.417	3.379	873	18.045	10.652	3.264	403	18.172	10.241	3.2
16	*Khchoueng*	*Macrognathus taeniagaster*	56	22	39.723	19.541	4.421	6	46.283	2.167	1.472				
17	*Khlang hai*	*Belodontichthys truncatus*	11,689	644	24.556	9.538	3.088	515	24.712	6.462	2.542	73	23.957	23.476	4.845
18	*Khnang veng*	*Labiobarbus kuhli*	30,639	769	7.274	0.916	0.957	37	15.639	1.935	1.391	47	14.982	3.863	1.965
19	*Kray*	*Chitala ornata*	1,416	10	36.45	7.111	2.667	6	36.617	25.367	5.037				
20	*Krom*	*Osteochilus melanopleura*	3,676	99	11.652	7.979	2.825	109	14.551	4.980	2.232	28	13.45	2.296	1.515
21	*Linh*	*Thynnichthys thynnoides*	323	8	8.95	1.429	1.195								
22	*Phkar kor*	*Cirrhinus prosemion*	284	37	11.099	0.401	0.633	46	12.080	1.305	1.142				
23	*Po*	*Pangasius larnaudii*	771	110	20.723	8.549	2.924	35	22.107	7.938	2.817				
24	*Pra*	*Pangasianodon hypophthalmus*	1,095	16	14.575	9.317	3.052	16	14.950	3.467	1.862				
25	*Pruol/kralang*	*Cirrhinus microlepis*	8,113	171	14.093	3.290	1.814	56	16.325	3.493	1.869	18	16.672	1.359	1.166
26	*Riel awngkam*	*Cirrhinus lobatus*	3,951	278	7.515	2.465	1.570	17	13.685	0.941	0.970	85	13.238	1.264	1.124

No.	Khmer Name	Species Name	Total catch (kg)	October				November				December			
				Freq.	M. Len.	Var	S.D	Freq.	M. Len.	Var	S.D	Freq.	M. Len.	Var	S.D
27	*Riel top*	*Cirrhinus siamensis*	1,349	87	9.439	2.825	1.681	21	13.545	1.89	1.375	68	13.082	1.102	1.05
28	*Ros/ptuok*	*Channa triata*	3,152	170	25.709	14.761	3.842	133	26.533	15.531	3.941	17	24.803	20.993	4.582
29	*Sandai/kraport*	*Wallago attu*	4,255	153	28.143	25.188	5.019	86	31.252	44.866	6.698	17	33.391	30.184	5.494
30	*Slat*	*Notopterus notopterus*	630					23	19.015	16.348	4.043	11	20.45	13.2	3.633
31	*Sloeuk russey*	*Paralaubuca typus*	937	47	7.259	2.419	1.555	8	12.825	0.268	0.518				

Standing crop and fish species association in Cambodian floodplains

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ABSTRACT

Cambodia has a diverse range of aquatic habitat ranging from small lakes, dikes, swamps, marshes, grasslands, flooded forests, shrub-land, rice fields, streams, rivers, ponds and canals. Some of these habitats are flooded on a seasonal basis, but to differing degrees. Habitats that are subject to seasonal flooding in Northeast Cambodia, close to the border with the Lao PDR, are important fish habitats and where many 'white' (migratory) fish species spawn. Young fish resulting from spawning activities in these areas contribute greatly to floodplain fish production further downstream. Larvae and fry of at least 130 species of fish drift from upper Cambodia down the Mekong to floodplains, where they feed and grow. These migratory species (white fish) and the floodplain-resident 'black' fish species are generally associated with different kinds of habitat, although some species from both general categories occur in all types of habitats.

Standing crop varies between habitats, depending on their quality, the extent and duration of inundation, and the species present. Several studies on standing crop in representative habitats in Cambodia have attempted to quantify these differences between habitat type. For example, the standing crop from an area of flooded forest near the Tonle Sap Lake was found to be around 95 kg/ha. The standing crop of fish and other aquatic animal from rice fields was found to be approximately 90 kg/ha and the standing crop of fish and other aquatic animal from grasslands, swamps and deep pool/small lake habitats were estimated at about 113 kg/ha, 84 kg/ha and 2,525 kg/ha respectively. The data from deep pools and small lakes included fish and other aquatic animal from a larger surrounding area. In general, species diversity was found to be higher in habitats that were more diverse. The data and information obtained during this study, carried out from March to June 2004, may be of use for estimating standing crop, and its monetary value, from the Tonle Sap system, but data were gathered over a limited time period. The data and information obtained may also be useful for management planning regarding both habitat type and species.

KEYWORDS: Fish, Standing Crop, OAAs, Grassland, Marsh, Deep Pools, Small Lakes, Tonle Sap Floodplain, Cambodia

INTRODUCTION

Studies on the functioning of river-floodplain systems (ecosystem services) that address issues concerning the maintenance of naturally productive habitats have received attention (Bayley, in press). In addition, other types of habitat should also be maintained for the conservation of species diversity. Information on fish standing crops and overall production from different floodplain habitats may be useful in forming the basis of a management tool, and may ultimately help to protect both habitats and species (Bayley, in press). According to a land-use study conducted by the Mekong Secretariat Project CMB/92/005 of UNDP/LUMO/FAO in 1992, the habitat types found in Cambodian Mekong floodplains can be categorised as permanent water (rivers, lakes, ponds, etc), flooded forests, flooded secondary forests, flooded grasslands, receding and floating rice fields, seasonally flooded crop fields and swamps or marshes.

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This study of standing crop by habitat in flooded forest areas of Battambang, Pursat and Prey Veng Provinces was carried out during the period from March to June 2004. The study focussed on two types of flooded forest area. Firstly, those areas where the forest was intact and in good condition, and secondly, those areas where the forest had been cleared.

Studies on fish standing crop from other types of aquatic habitat such as marshes, swamps, rice fields, flooded grass land, small lakes, and flooded shrub-land, where different fish species may be resident, have never been carried out so far. Standing crops for fish and other aquatic animal from these other habitats may very well be different from the flooded forest habitats. Therefore, this study was required to fill in the data gaps on various types of aquatic habitat to provides an estimation of the standing crop of fish and OAAs found in marshes, swamps, flooded grassland, and in deep pools/small lakes in Kampong Chhnang Province. Kampong Chhang Province is located within the floodplain area of the Tonle Sap Lake where various aquatic species are found.

OBJECTIVES

The study was aimed at achieving the following objectives:

- To identify aquatic fauna and estimate their standing crop in marshes, swamps, flooded grassland, and deep pools/small lakes in a target area of Kampong Chhnang Province over a period from March to June 2004.
- To determine aquatic species composition, species occurrence and their association with different types of habitat over a period from March to June 2004.

METHODS

The area of marshes/swamps, flooded grassland, deep pools/small lakes in the Kampong Chhnang Province floodplain were selected using a map from the Ministry of Public Works (Figure 1). In total, 46 sites were sampled during the study. These included 13 flooded grassland sites, 20 flooded marshland sites, and 13 sites where deep pools or small lakes were located. At the flooded grassland sites, nets or bamboo fences were used to capture all fishes and OAAs using the knowledge and experience of local fishers. All aquatic fauna in the selected area was caught as far as was possible. Each area was measured in square meters (m^{-2}) and later converted to hectares. Standing crop (kg/ha) was calculated using the following formula; [Standing crop = total catch in kg/area (ha)]. Fish species were identified using the guidebook *Fishes of the Cambodian Mekong* (Rainboth, 1996) and other reliable sources of literature. Fish or other aquatic species from each habitat type was recorded.

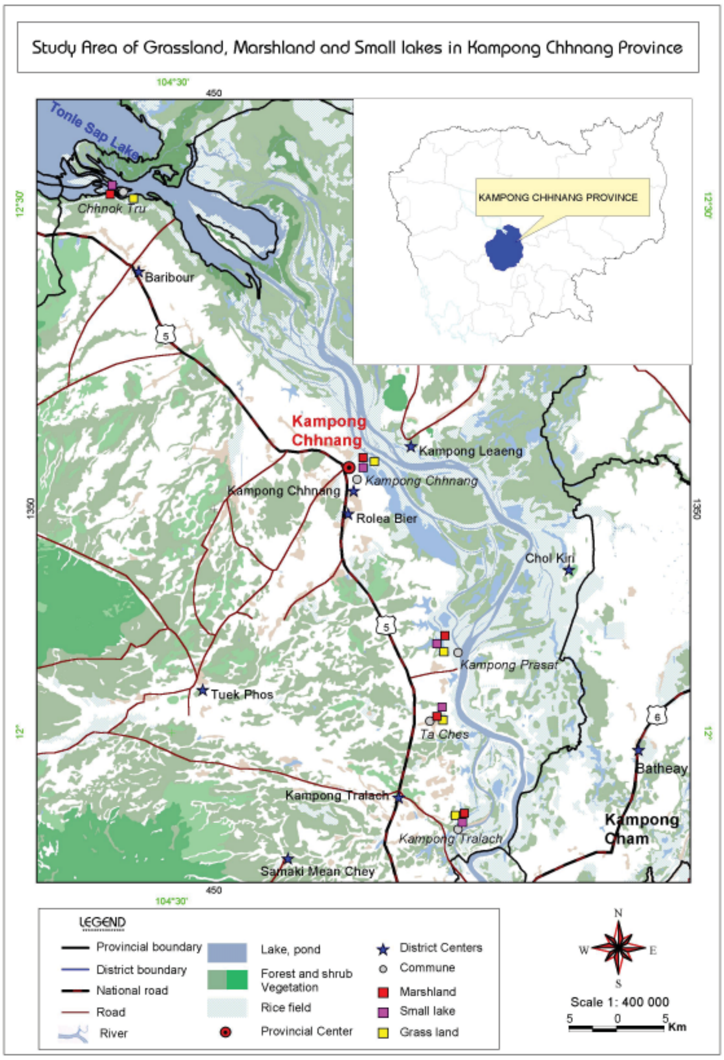


Figure 1. Study Sites in Kampong Chhnang Province, Tonle Sap floodplain, Cambodia

RESULTS

Occurrence of fish species and OAAs

At least 63 species of fish were encountered together with other aquatic animals such as crabs, clams, snakes, shellfish and shrimps. These were found in flooded grasslands, marshes and deep pool/small lake habitats. Abundance of aquatic fauna varied between each habitat type (Annex 1).

Most of the animals found in grassland, marsh and deep pool/small lake habitats are fish. OAAs represent only a small percentage of the total weight of all animals captured (Table 1). Most of the fish caught fall into the broad category of 'white' fish, and represent about 46 per cent to 74 per cent of the total catch (Table 2). Some estuarine fish were also found in the catch. Estuarine fish species formed approximately ten per cent of the total catch in grassland and marsh habitats, but only about two per cent of the total catch from deep pools/small lakes (Table 2). At least 50 per cent of the total catch of fish from deep pools/small lakes can be described as 'black' fish species. (Table 2). Carnivorous fish species represent about half of the total catch in all habitats investigated, and most of the remaining species are either omnivorous or herbivorous (Table 3). OAAs, whose mode of nutrition is not known, only represent a small percentage of the total catch. Herbivorous fish species represent about 20 per cent of the total catch in grassland habitats, but less in marsh and pools habitats (Table 3). Omnivorous fish species make up about 20 to 35 per cent of total catch in all habitats investigated (Table 3).

Table 1. *Standing crop percentages of fish and OAAs (kg/ha)*

	Kg/ha			Per cent		
	Grassland	Marsh	Pool	Grassland	Marsh	Pool
Fish	106.6	75.5	2,458.7	94.9%	89.7%	97.6%
OAA	2.3	2.4	28.0	2.0%	2.9%	1.1%
Other*	3.4	6.2	32.3	3.0%	7.4%	1.3%
Total	112.3	84.1	2,519.0	100.0%	100.0%	100.0%

* 'Other' refers to small fish species and OAAs that could not be identified. These species amounted to about ten aquatic animals in total.

Table 2. *Categories of fish species and OAAs*

	Kg/ha			Per cent		
	Grassland	Marsh	Pool	Grassland	Marsh	Pool
Black	12.7	14.0	1,259.7	11.3%	16.6%	50.0%
White	83.5	53.7	1,158.7	74.3%	63.9%	46.0%
Estuarine	10.5	7.8	40.3	9.3%	9.2%	1.6%
Mixed	3.4	6.2	32.3	3.0%	7.4%	1.3%
OAA	2.3	2.4	28.0	2.0%	2.9%	1.1%
Total	112.3	84.1	2,519.0	100.0%	100.0%	100.0%

Table 3. *Fish species classified by dietary category.*

	Kg/ha			Per cent		
Diet	Grassland	Marsh	Pool	Grassland	Marsh	Pool
Carnivorous	55.8	45.6	1,486.4	50.8%	55.9%	59.7%
Herbivorous	20.9	11.3	137.4	19.0%	13.8%	5.5%
Omnivorous	29.8	18.6	834.9	27.1%	22.8%	33.5%
Mixed species	3.4	6.2	32.3	3.1%	7.6%	1.3%
Total	110.0	81.6	2,491.0	100.0%	100.0%	100.0%

Important species in the total catch from grassland habitats

Fifty-three fish species were found in grassland habitats during the sampling period in the floodplain of the Tonle Sap Lake. The ten most common species appearing in total catch are shown in Figure 2. These ten species represented 67 per cent of the total catch, and the remaining 43 species contributed to 33 per cent of the total catch (Figure 2).

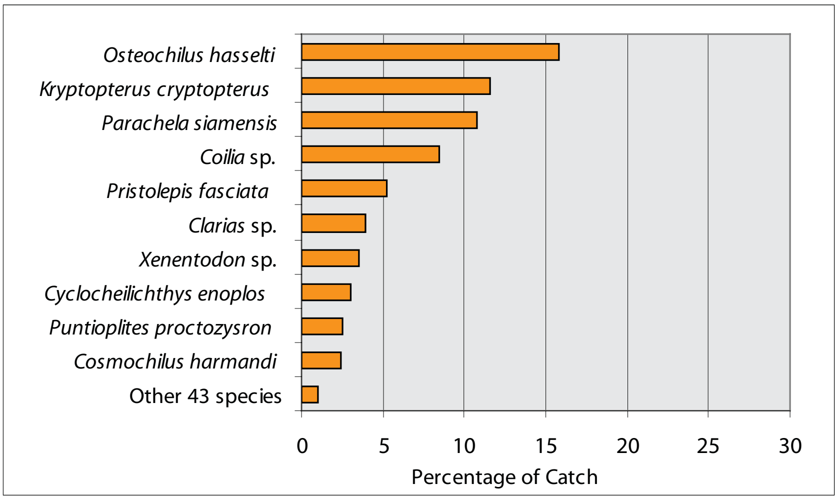


Figure 2. The percentage of fish-catch by species in flooded grassland habitat

Important species in the total catch from flooded marshland habitats

Fifty fish species were found in marshland habitats during the sampling period in the floodplain of the Tonle Sap Lake. The ten most common species appearing in total catch are shown in Figure 3. These ten species represented 62 per cent of the total catch, and the remaining 44 species contributed to 38 per cent of the total catch (Figure 3).

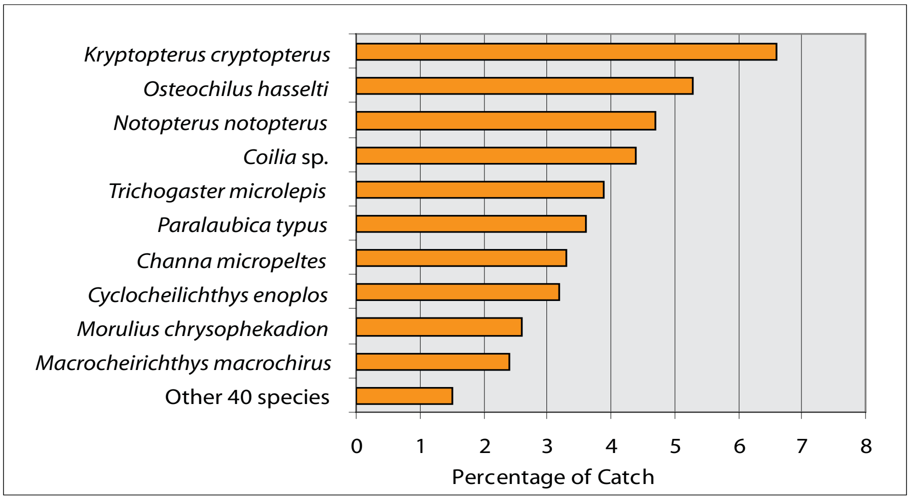


Figure 3. The percentage of fish-catch by species in marshland habitats

Important species in the total catch from deep pools and small lake habitats

Fifty-seven fish species were found in deep pool/small lake habitats during the sampling period in the floodplain of the Tonle Sap Lake. The ten most common species appearing in total catch are shown in Figure 4. These ten species represent 74 per cent of the total catch, and the remaining 47 species contributed to 36 per cent of the total catch (Figure 4).

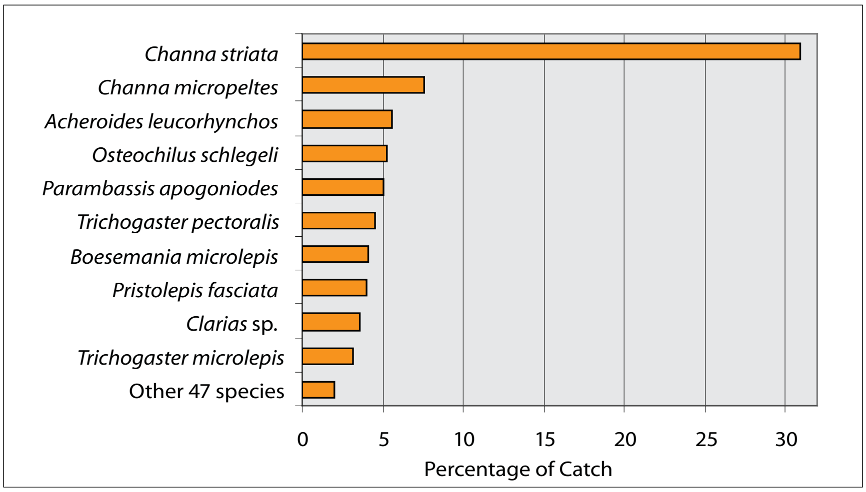


Figure 4. The percentage of fish-catch by species in deep pools/small lake habitats

In total 64 species, including OAAs, were recorded in the three different types of fish habitat. Most of them were found in all habitat types. However, 16 species were only found in either one or two of the habitat types under investigation (Table 4).

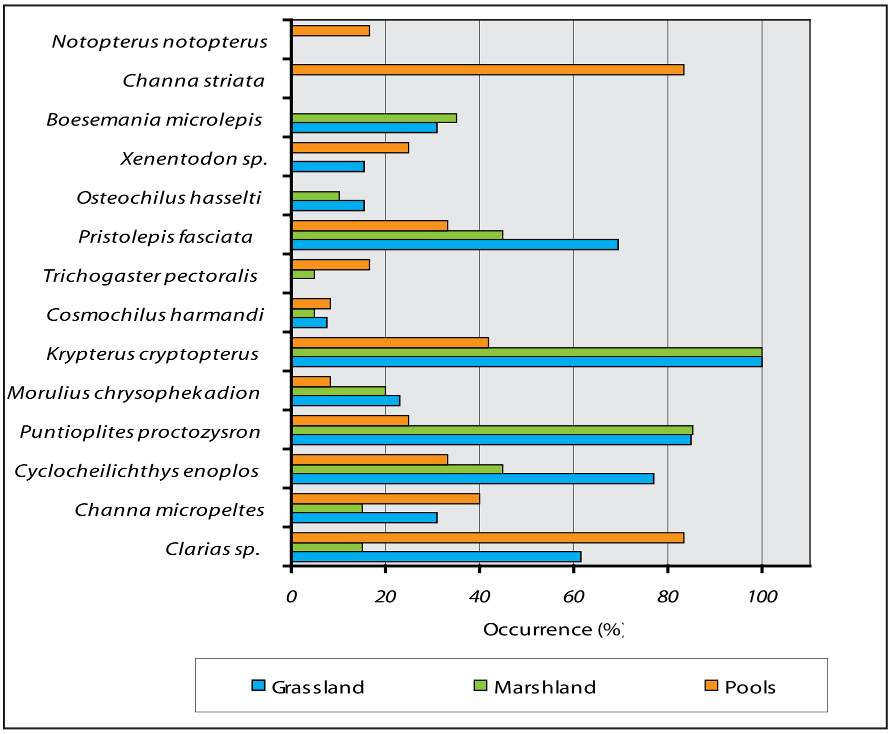
Table 4. *The occurrence of fish species in grassland, marsh and deep pool/small lake habitat types*

No	Scientific names	Khmer names	Grassland	Marshland	Small lake
1	*Achiroides leucorhynchos*	trey andat chhke	√	√	-
2	*Amblyrhynchichthys truncatus*	Kam But Chramos	√	√	-
3	*Mystus nemurus*	trey Chhlang	-	√	-
4	*Setipinna melanochir*	trey chhmar	√	√	-
5	*Pangasius pleurotaenia*	trey chhwiet	√	√	-
6	*Oxyeleotris mamorata*	trey damrey	√	-	√
7	*Barbonymus altus*	trey kahe kra horm	-	√	-
8	*Kryptopterus cryptopterus*	trey kamphliev khlanh	√	√	-
9	*Channa lucius*	trey kanh chorn chey	-	-	√
10	*Hampala dispar*	trey khman	-	√	√
11	*Anabas testudineus*	trey kranh	-	-	√
12	*Ompok bimaculatus*	trey krormom	-	√	√
13	*Glossogobius aureus*	trey khsan	√	√	-
14	*Pangasius sp.*	trey pra	√	√	-
15	*Boesemania microlepis*	trey prama	√	√	-
16	*Acantopsis sp.*	trey ruschek	√	√	-

Notes: sign ‘ √ ‘ = presence of the species in the habitat type and sign ‘ – ‘ = the absence of the fish species in the habitat type.

General abundance of fish species in grassland, marsh and deep pool/small lake habitats

Fourteen fish species, amongst a total 64 recorded, were found in all three types of habitat studied. These species are of importance in the diet of people living in the Mekong region. They are commercially important, and some are exported to neighboring countries.



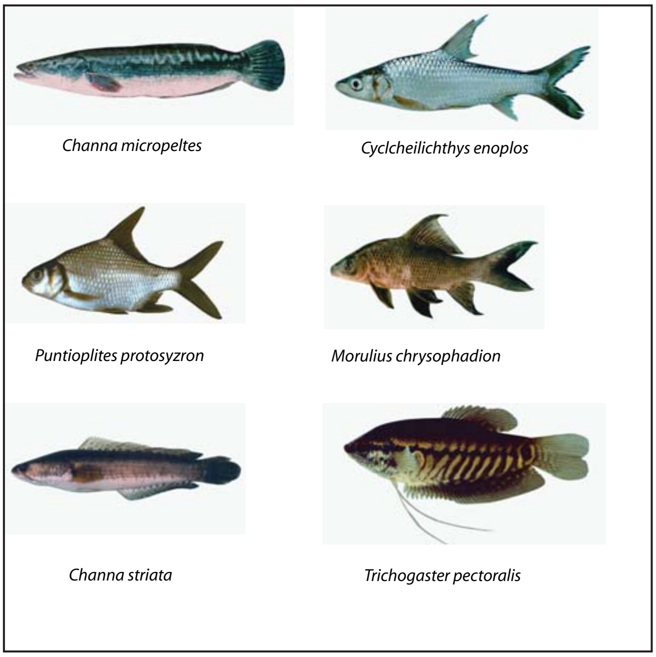


Figure 5. Some of the most abundant species found in grassland, marsh and deep pool/small lake habitats

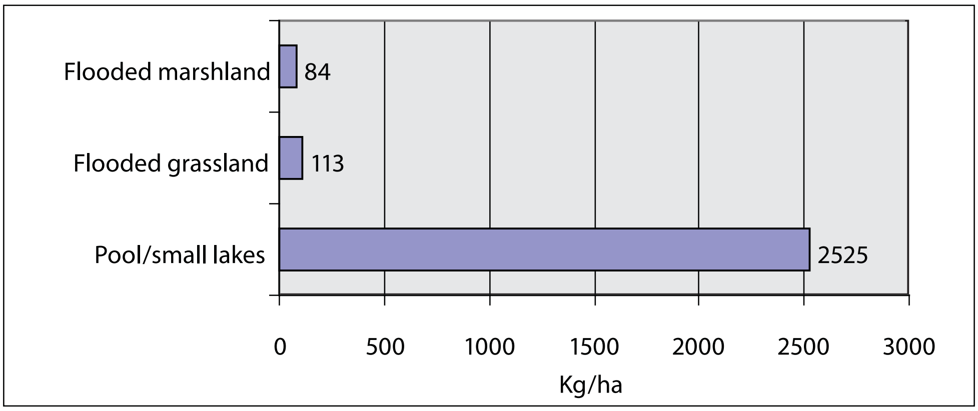


Figure 6. Standing crop of fish and other aquatic animal (kg/ha) in different types of habitat

Standing crop

Standing crop and OAAs were found to be 113 kg/ha in grassland habitats, 84 kg/ha in marshlands and 2,525 kg/ha in deep pool/small lake habitats. The standing crop in grasslands and marshland habitats were recorded in a defined area over one specific time period. The catch from pools/small lakes was also recorded over a specific time period. Sampling during other times of the year may have produced different results. The standing crop of fish and OAAs in deep pools and small lakes was gathered from surrounding areas when floodplain waters were receding late in the year from December to April.

DISCUSSION

Fish and other aquatic animal recorded during this study were found to be similar to the species encountered in the Dai and middle-scale fisheries operating in the Mekong and elsewhere in Cambodia as reported by Diep *et al*., 1998. Diep *et al*. (1998) reported on 75 species and, or, genera occurring in the other fisheries mentioned above. However, the total number of species recorded during this investigation is comparatively small compared to the total number fish species known to exist in the Tonle Sap floodplain; estimated at around 300. A recent report on the Dai fisheries indicated that there were about 150 species caught in the Tonle Sap River (Pengbun, pers.comm., 2005). The report concluded that species diversity in the Tonle Sap River was less than that in the flooded forest areas around the Tonle Sap Lake. For example, 83 species were encountered in Battampbang Province and 179 species and 171 species were recorded from two different fishing lots in Prey Veng Province (Troeung *et al*., 2003). However, species diversity in the Tonle Sap River was considered to be higher than that found in rice-fields (35 species reported) on the Tonle Sap floodplain. Correct identification of fish species, or species groups, together with a comparatively short study period may mean that complete species inventories were not recorded in these rice-field habitats. During the time that this study was carried out (March to June 2004) it is highly likely that many 'white' fish species would have returned to the Mekong mainstream. In addition, fish species inventories may be difficult to obtain because standing water bodies are dominated by 'black' fish species during this period.

The standing crop of fish and OAAs in the flooded grassland habitat was recorded at around 113 kg/ha and was higher than the standing crop from the flooded forest habitats found to be at around 95 kg/ha. The flooded forest area in Battambang Province where part of this study was carried out is reported to be in good condition (Troeung *et al*., 2003). By comparison, it is similar to conditions found in some floodplain areas of Bangladesh (Eric Baran 2005 after Hoggarth and Halls 1997). The report of Eric Baran *et al*. (2000) on fish and other aquatic animal production in the Tonle Sap Lake floodplains from 1994 to 1997 was higher than the 95kg/ha in this study. Lieng *et al*. (2001) reported that the average standing crops of fish and other aquatic animal in the floodplain fisheries around the Tonle Sap Lake from 1995 to 1999 ranged between about 130 to 190kg/ha.

The standing crop estimates of fish and other aquatic animal from two fishing lots in Prey Veng Province were found to be 55 kg/ha and 92 kg/ha respectively as reported by Troeung *et al*., (2003). Troeung *et al*. (2003) found that the standing crop in flooded marshlands at 84kg/ha was lower than that for flooded grasslands. Troeung *et al*. (2003) reported that the standing crop in deep pools or small lakes was high at around 2,525 kg/ha. However, it should be mentioned that this standing crop estimate was based on data from surrounding areas close to the Tonle Sap Lake and included OAAs also.

CONCLUSIONS

At least 64 fish species were encountered in flooded grassland, marshland and deep pool or small lake habitats in the Tonle Sap Floodplain during the months of March to June in 2004. It is important to notice that the standing crop is very high in deep pools or small lakes. The fish species diversity is also comparatively high in these habitat types. During the period from March to June, fish populations in deep pools and small lakes are dominated by 'black' fish species. These species were also commonly found in flooded rice fields and flooded grassland habitats. Many fish species associated with these kinds of habitat contribute significantly to food security for rural fishers, farmers and their families. Some of the most important species in this category are: *Achiroides leucorhynchos, Amblyrhynchichthys trunctaus, Mystus nemurus, Setipinna melanochir, Pangasius pleurotaenia, Oxyeleotris mamorata, Barbonymus altus*, *Kryptopterus cryptopterus, Channa lucius, Hampala dispar, Anabas testudineus, Ompok bimaculatus, Pangasius* sp., and *Boesemania microlepis.* Not all species are common.

In order to maintain fish bio-diversity and food security for the rural people in Cambodia, management should focus on protection of critical habitats and the most important fish species identified in this study.

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No.	Species	Black/ White	Diet	Fish OAA	Khmer	Grassland	Marsh	Pool
1	*Acantopsis spp.*	White	Carnivorous	Fish	trey reus chek	0.47		
2	*Achiroides leucorhynchos*	White	Carnivorous	Fish	trey andat chhke			133.79
3	*Amblyrhynchichthys truncates*	White	Herbivorous	Fish	trey kambut chramoh	0.51		
4	*Anabas testudineus*	Black	Carniverous	Fish	trey kranh	1.13	0.63	36.52
5	*Barbodes gonionotus*	White	Omnivorous	Fish	trey chhpin		0.04	0.04
6	*Barbonymus altus*	White	Omnivorous	Fish	trey kahe	0.94		
7	*Belodontichthys dinema*	White	Carnivorous	Fish	trey khlang hai	1.80	1.11	3.89
8	*Boesemania microlepis*	White	Carniverous	Fish	trey prama			97.24
9	*Botia* spp.	White	Carnivorous	Fish	trey kanh chrouk	1.56	1.39	1.39
10	*Channa lucius*	Black	Carnivorous	Fish	trey kanh chorn chey	0.55	0.72	0.91
11	*Channa micropeltes*	Black	Carnivorous	Fish	trey chhdoar/diep	0.60	3.26	182.20
12	*Channa striata*	Black	Carnivorous	Fish	trey ras/phtuok	1.34	0.68	737.00
13	*Cirrhinus microlepis*	White	Omnivorous	Fish	trey kralang	1.45	0.77	19.78
14	*Clarias* sp.	Black	Carniverous	Fish	trey andeng	3.59	2.21	86.50
15	*Clupeoides borneensis*	White	Carnivorous	Fish	trey bandoul ampov	1.02	0.35	0.35
16	*Coilia macrognathos*	Estuarine	Carnivorous	Fish	trey chunluon moan	7.80	4.36	4.36
17	*Cosmochilus harmandi*	White	Omnivorous	Fish	trey kampoulbai	2.21	2.01	10.40
18	Crab	OAA	Omnivorous	OAA	kdam			0.13
19	*Cyclocheilichthys enoplus*	White	Omnivorous	Fish	trey chhkok	2.77	3.23	28.40
20	*Cyclocheilichthys repasson*	White	Omnivorous	Fish	trey srawkar kdam	1.61	0.93	69.80
21	*Glossogobius aureus*	Estuarine	Carnivorous	Fish	trey khsan	0.63	1.95	1.95
22	*Hampala dispar*	White	Carnivorous	Fish	trey khman	1.17	0.55	27.96
23	*Henicorhynchus siamensis*	White	Herbivorous	Fish	trey riel	1.45	0.77	19.78
24	*Indostomus/Doryichthys/Hippichthys*	Estuarine	Carnivorous	Fish	trey chai krapoeu	1.46	0.13	16.91
25	*Kryptopterus apogon*	White	Carnivorous	Fish	trey kes	1.37	1.44	1.44
26	*Kryptopterus cryptopterus*	White	Carnivorous	Fish	trey kampliev	10.63	6.62	6.62
27	*Labeo chrysophekadion*	White	Herbivorous	Fish	trey kaek	1.73	2.55	9.42
28	*Labiobarbus lineatus*	White	Omnivorous	Fish	trey khnang veng	1.69	1.54	11.16

No.	Species	Black/ White	Diet	Fish OAA	Khmer	Grassland	Marsh	Pool
29	*Macrochirichthys macrochirus*	White	Carnivorous	Fish	trey dangkhteng	2.00	2.40	2.40
30	*Macrognathus taeniagaster*	White	Carnivorous	Fish	trey khchoeung	1.37	1.44	1.44
31	*Macrognathus siamensis*	White	Carnivorous	Fish	trey chhlonh	1.05	0.64	36.16
32	*Macrognathus spp.*	White	Carnivorous	Fish	trey khchoeung	0.72	1.90	38.85
33	Clam A	OAA	Herbivorous	OAA	leas	0.08		9.32
34	Clam B	OAA	Herbivorous	OAA	khchao	0.65	2.16	2.16
35	*Monopterus albus*	Black	Carnivorous	Fish	trey antong	0.41		
36	*Monotretus sp.*	Estuarine	Omnivorous	Fish	trey kampot		0.19	20.30
37	*Mystus nemurus*	White	Carniverous	Fish	trey chhlang		0.78	0.78
38	*Mystus* sp.	White	Carniverous	Fish	trey kanh chos	1.98	0.92	32.58
39	*Notopterus notopterus*	White	Carnivorous	Fish	trey slat	2.14	4.67	23.97
40	*Osteochilus hasselti*	White	Herbivorous	Fish	trey kros	14.49	5.26	58.77
41	*Osteochilus melanopleurus*	White	Herbivorous	Fish	trey krum	1.01	1.51	12.46
42	*Oxyeleotris marmorata*	White	Carnivorous	Fish	trey damrey	0.48		
43	*Pangasius pleurotaenia*	White	Omnivorous	Fish	trey chhwiet	0.83	0.30	0.30
44	*Pangasius* sp.	White	Carnivorous	Fish	trey pra		0.22	0.22
45	*Parachela siamensis*	White	Carnivorous	Fish	trey chanteas phluk	9.92		
46	*Paralaubuca typus*	White	Carnivorous	Fish	trey sloeuk russey	1.52	3.61	34.95
47	*Parambassis wolffii*	White	Carnivorous	Fish	trey kantrang preng	0.38	0.77	33.72
48	*Pseudambassis notatus*	White	Carnivorous	Fish	trey kanh chanh chras			119.63
49	*Polynemus multifilis*	Estuarine	Carnivorous	Fish	trey kampream	0.45	1.13	1.13
50	*Poropuntius deauratus*	White	Omnivorous	Fish	trey loloksor			127.00
51	*Pristolepis fasciata*	White	Omnivorous	Fish	trey kantrawb	4.77	1.01	95.60
52	*Puntioplites falcifer*	White	Omnivorous	Fish	trey chrakeng	2.30	1.07	58.67
53	*Rasbora* spp.	Black	Omnivorous	Fish	trey changwa	1.44		
54	*Setipinna melanochir*	Estuarine	Carnivorous	Fish	trey chhmar	0.13		
55	*Small freshwater shrimp*	OAA	Omnivorous	OAA	kampoeuh			16.07

No.	Species	Black/ White	Diet	Fish OAA	Khmer	Grassland	Marsh	Pool
56	Snake	OAA	Carnivorous	OAA	puoh chhoeu	1.54	0.28	0.28
57	*Thynnichthys thynnoides*	White	Herbivorous	Fish	trey linh	1.71	0.94	0.94
58	*Toxotes microlepis*	White	Carniverous	Fish	trey kancheaksla	1.11	0.36	0.36
59	*Trichogaster microlepis*	Black	Carnivorous	Fish	trey kamphleanh	1.61	3.87	77.08
60	*Trichogaster pectoralis*	Black	Omnivorous	Fish	trey kanthor	2.00	1.47	108.07
61	*Trichopsis pumila*	Black	Carniverous	Fish	trey kreoum tunsay		1.13	31.40
62	*Xenentodon cancila*	White	Carnivorous	Fish	trey phtong	3.25	2.40	2.40
63	*Other**	Mixed	Mixed	Mixed	Mixed	3.40	6.18	32.34

Monitoring of fish markets in Vientiane and Luang Prabang Province, Lao PDR, using logbooks

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ABSTRACT

This paper presents some of the results from fish trade monitoring in both Vientiane and in Luang Prabang Province carried out by the Assessment of Mekong Fisheries Component (AMFC) from 2004 to 2005. The results show that *Pangasianodon hypophthalmus Wallago leerii*, *Channa micropeltes Bagarius bagarius*), *Pangasius conchophilus* and *Wallago attu* are some of the most commercially important Mekong fish species found in fish markets in Vientiane. *Oreochromis niloticus*, *Mystus nemurus*, *Hypophthalmichthys molitrix*, and *Pangasius* spp. are amongst the most commonly cultured species selling in Vientiane markets. Selling prices of wild fish captured from the Mekong, its tributaries and other natural water bodies, appear to be around double the price of cultured fish. High prices of wild-captured fish may result from greater demand for fish in urban areas. Of significance is that the prices of Mekong fish species seem to be constant over a year at city markets whilst the prices of Mekong fish at the landing sites fluctuate with regard to the quantity of fish supply.

In contrast, the price of fish captured from the Mekong and its tributaries in Luang Prabang Province is less than that in Vientiane. The close proximity to fisheries resources, and lower demand for fish, may explain this finding.

KEY WORDS: Lao PDR, Mekong, fish, OAAs, fisheries, markets

INTRODUCTION

Fish is one of the most vital sources of nutrition in the diets of the people in the Lao PDR. Consumers mainly purchase fish from markets and culture ponds. The population of Vientiane increased from 381,000 in 1985, to about 583,000 in 1999 (DOS, 2000). This population expansion led to an increase in demand for basic food items such as rice, meat and also fish. As a result, fish is now brought in from many places outside of Vientiane to fill this increased demand. Transportation and road access are very important as they provide more access to fish sources. In the last decade, transportation systems and main roads have been improved. As a result, it is now more convenient to transport fish to the cities. Many markets now have access to public transportation. This enables many small traders in rural areas to get their fish products to major city markets.

Luang Prabang is a province in the northern part of the Lao PDR, and within the Mekong River watershed. There are two markets where fish can be purchased in the city of Luang Prabang, but only one (Phosy market), that supplies fish on a regular basis.

This paper presents the results from two monitoring surveys carried out in fish markets during 2004; one in Vientiane City, and the other in Luang Prabang City. Thongkhankham and Thatluang markets

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were selected for monitoring in Vientiane because they appeared to be the two largest fish markets in the city. Luang Prabang main market was selected for monitoring in Luang Prabang Province).

Figure 1. Location map

Structure of the markets

The marketing operations of all three locations being monitored appeared to be well organized. Market administration units are primarily responsible for allocating places for fish sales, collecting fees and providing security (Phonvisay, 2001). People interested in selling fish are able to approach the unit for renting a place to sell. They are able to pay market fees on a daily, monthly or annual basis. Therefore, it was easy to spot differences between the types of fish vendors operating at the market. Small or rural fish vendors are likely to have to pay fees on a daily basis, because they usually only come to sell their fish when they have caught enough fish to sell in the market and cover transport costs. In contrast, large-scale fish vendors, who have more capital than the small vendors, usually have larger selling places and pay rent on a monthly or annual basis.

Monitoring fish sales

There has never been a full study of fish market monitoring in the Lao PDR. Phonvisay (2001) conducted an initial fish marketing survey in Thongkhankham and Thatluang Markets, but it only took place over one day, and was very general in nature. Interviews did not include all fish vendors in the markets. Phonvisay (2003) made a study of fish marketing operations in Luang Prabang Province, but again, this was just a ‘snap shot’ survey. Attempts to identify the quantities of fish sales covering periods of weeks, months or years were made on that day, but they failed to obtain accurate data on fish sales. This study was aimed at a more systematic approach. That is, the monitoring of fish sales at the three markets in Vientiane and Luang Prabang in 2004.

Figure 2. Mekong fish displayed for sale by a fish vendor in Thongkhankham Market (left) and a fish vendor who sells live tilapias in Thatluang Market (right)

Methods of trial monitoring

During 2004, we decided to carry out two types of survey in these markets. The completed surveys included:

Five-day interview survey

The survey teams carried out five-day surveys of the three markets during 2004. These surveys were an attempt to estimate the type and amount of fish products sold within a five-day period. During the five-day survey period, interviews were conducted four times at the two markets in Vientiane, and twice at the market in Luang Prabang. Interviews were carried out during morning periods, and included all vendors who sold fish products in the markets. The survey team conducted interviews on five consecutive days. This type of monitoring took place every three months in Vientiane, and twice in Luang Prabang in 2004.

Logbook survey

Together with the five-day surveys, we conducted fish market monitoring using logbooks. The purpose of this survey was to obtain data on daily fish sales from individual vendors within a period of one year. Prices and quantities of fish fluctuated throughout the year. We selected three vendors in each market in Vientiane and six vendors in Luang Prabang to record data in logbooks. Each fish vendor sold fish that were obtained from different sources; mainly aquaculture and capture fisheries. Data recorded were primarily concerned species, quantities of sale, prices and sources of fish. Each month, the survey team collected data from each logbook vendor. Data were stored in Microsoft Access prior to analysis.

RESULTS

Sources of aquatic products in Vientiane markets

Sources of aquatic products were classified into three main types in Vientiane. These three main sources were:

1. Cultured fish sold in Thongkhankham and Thatluang markets mainly imported from Thailand and from fish farms in Vientiane Province. Thailand supplied a large number of cultured fish to the Vientiane markets. Large fish vendors appeared to have more access to these sources of fish, especially those fish from Thailand.

2. Wild captured fish from rural areas throughout Vientiane Province were found to be the most important in the markets being studied. The fish were mainly captured from natural ponds, swamps, rice fields and small rivers. A large number of fish vendors selling these fish appeared to be small or part-time fish vendors. These part-time vendors usually bought fish from the main bus stations in Vientiane. Some vendors were from rural areas and had collected enough fish to sell in the markets and spent only a few hours at the markets. Some fish traders collected fish from many different villages in rural areas, and sold these to part-time vendors at the bus stations.

3. A large number of wild captured fish from Champasack Province, in the south of the country, were also found in the markets in Vientiane. Most of these fish were from the Mekong River in the Siphandone area, famous for its highly productive fisheries (Bush, 1999). Buses and private vehicles were found to be the main forms of transportation for bringing fish to the markets in Vientiane, a distance of some 800 kilometers or more. Mekong fish from Champasack Province were mostly found in the Thongkhankham Market.

Fresh fish products from aquacultural operations accounted for approximately 61 and 60 per cent of total sales in the Thongkhankham and Thatluang Markets respectively (Table 1). In contrast, fresh fish products from wild capture fisheries accounted for almost 40 per cent of the total fresh fish products in both markets. High levels of purchase of cultured fish may be partly due to the lower prices paid compared to wild captured fish. All processed fish products found during the five-day surveys originated from wild captured fish.

Sources of *aquatic products in Luang Prabang*

Local wild captured fish supplied to Luang Prabang Markets are mainly caught from the Mekong River and its tributaries such as Ou, Xieung and Khan Rivers. These fish are collected by fish traders from fish landing sites along the rivers, and sold directly to restaurants and markets in Luang Prabang. Some fish are also from Vientiane Province and Vientiane City (Phonvisay, 2003).

Table 1. *Sources of fish at Thongkhankham (ML1) and Thatluang (ML2) Markets during the five-day survey from 12 to 16 January 2000*

		Product name			
Market	Source	Fresh fish (kg)	%	Processed fish (kg)	%
ML1	Aquaculture	2,865	61.1%	0	0%
	Capture	1,826	38.9%	1,219	100%
	Total	4,691	100.0%	1,219	100%
ML2	Aquaculture	2,000	60.3%	0	0%
	Capture	1,316	39.7%	236	100%
	Total	3,316	100.0%	236	100%

Note: Data collected between 12-16 Jan 2004 ML1: Thongkhankham; ML2: Thatluang

Fish market monitoring at Vientiane and Luang Prabang

Fish market monitoring provided an understanding of the daily consumption level of fish on selected days at markets. Table 2 shows the total numbers of fish vendors during the five-day surveys at the three markets. Thirty-four, and 22 fish vendors were present at the Thongkhankham and Thatluang Markets respectively in January 2004. Twenty-six fish vendors were active at the Luang Prabang Market in March 2004. About 15 per cent of the total numbers of fish vendors operating within the three markets studied used logbooks to record data during the monitoring process

Table 2. *Number of fish vendors at the three markets selected for monitoring. Data from Vientiane were collected from 12 to 16 January 2004, and from Luang Prabang from March 2 to 6 2004.*

		Thongkhankham	Thatluang	Luangprabang	Total	%
Vendor	Logbook	3	3	6	12	14.6%
	Interview	31	19	20	70	85.4%
	Total	34	22	26	82	100.0%

Note: Data collected between 12-16 Jan 2004 for the markets in Vientiane; Data collected between 2-6 Mar 2004 for the markets in Luangprabang

A summary of the five-day monitoring survey of fish and other aquatic animals (OAAs) sold in the two markets in Vientiane is shown in Table 3. Data were collected between January 12 and 16 2004. During the five-day survey, almost six tons of aquatic products were sold at Thongkhankham Market. This was valued at approximately US$ 9,000. At this market, fresh fish accounted for almost 79 per cent, whilst processed fish and other aquatic animals accounted for 20.6 per cent and 0.7 per cent respectively.

In Thatluang Market, the amount of fish and OAAs sold within the five-day survey period was just over half of that sold in Thongkhankham Market. Fresh fish accounted for about 85 per cent of total aquatic products sold at Thatluang Market. More OAAs were sold in Thatluang Market compared to that sold in Thongkhankham Market. Overall, Table 3 shows some level of the importance of aquatic animals for protein consumption of people living in the in the capital city of the Lao PDR, but these figures need to compared with the consumption of other protein food sources.

Figure 3. Fermented fish on sale at Thongkhankham Market

Table 3. *A summary of the data collected during a five-day survey on the sale of fish and OAAs at the two main markets in Vientiane from January 12 to 16 2004.*

Market	Sub-category	Total (kg)	%	Value (Kip)	Value (US$)	%	Mean (US$/kg)
Thongkhankham	Fresh fish	4,649	78.7%	81,275,000	7,525	83.4%	1.6
	OAA	42	0.7%	960,000	89	1.0%	2.1
	Processed fish	1,219	20.6%	15,244,000	1,411	15.6%	1.2
	Total	5,910	100%	97,479,000	9,026	100%	1.5
Thatluang	Fresh fish	3,027	85.2%	44,418,000	4,113	73.1%	1.4
	OAAs	289	8.1%	2,753,000	255	4.5%	0.9
	Processed fish	236	6.6%	13,555,000	1,255	22.3%	5.3
	Total	3,552	100%	60,726,000	5,623	100%	1.6

Notes: Data collected between 12-16 Jan 2004. US$ 1.00 = Kip 10,800; OAA – other aquatic animals

Figure 4 displays the total sales of aquatic animal products during the five-day surveys in Thongkhankham and Thatluang Markets in Vientiane. The surveys were carried out within a series of five-day periods in January, April, August and November 2004. Figure 4 shows that total sales of aquatic animal products in Thongkhankham Market varied from about 4.7 tons to 6.3 tons, whilst the total sales in Thatluang Market varied between approximately 2 to 3.5 tons.

In Luang Prabang Market, total sales of fresh fish within a five-day period was almost 3.8 tons and valued at $US 5,331. During the monitoring period, there were no other aquatic animals sold in the market. Fresh fish products were most important at 98 per cent of total sales (Table 4).

Logbook analysis

Logbooks have provided interesting information and data on fish sales obtained from fish vendor’s records throughout one year. Analysis of logbooks has revealed information on the sales of different fish species and their total composition regarding sales, and the variety of fish sold by the vendors.

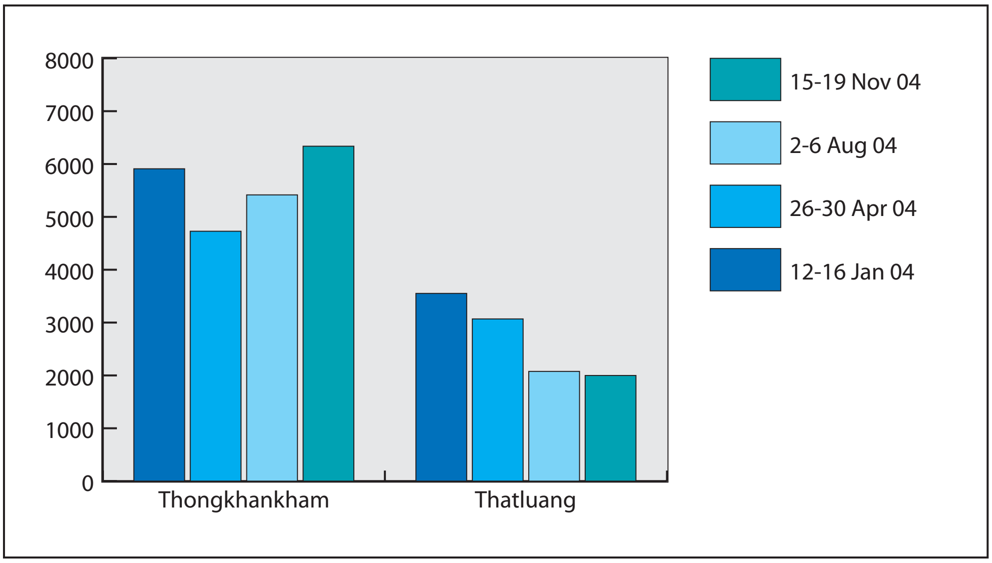

Figure 4. Total weight of fish and OAAs during the five-day monitoring periods at the Thongkhankham and Thatluang Markets in Vientiane in 2004.

Table 4. *A summary of a five-day survey of fresh fish and processed fish on sale at Luang Prabang Market between March 2 and 6 2004*

Market	Sub-category	Total (kg)	%	Value (Kip)	Value (US$)	%	Mean (US$/kg)
Luangprabang	Fresh fish	3,720	98.0%	55,093,000	5,101	95.7%	1.4
	Processed fish	76	2.0%	2,480,000	230	4.3%	3.0
	Total	3,796	100%	57,573,000	5,331	100%	1.4

Notes: Data collected between 2-6 Mar 2004. US$1.00 = Kip 10,800

Sales of Mekong wild fish

In Vientiane, the Mekong fish sold in markets were mostly from the Siphandone area in Champasack Province. According to the survey, these fish were sold almost exclusively at Thongkhankham Market. There were only two vendors in this market that sold Mekong fish from Champasack Province (Table 5). Table 5 shows the average weight of fish sold daily by Vendor 1-8. The average weight of fish sold each day by this vendor was almost 70 kg. Range divided by daily average of fish sold provided an estimate of error.

P. hypophthalmus (Pa Souay) was the most important species, and represented about 17 per cent of total sales. This was followed by *W. leeri* (Pa Khoun) at around 16 per cent and *C. micropeltes* (Pa Doh) at around 15 per cent (Table 5). Other important species not shown in Table 5 were *H. wyckioides* (Pa Kheung), *B. truncates* (Pa Khob), *C. harmandi* (Pa Jok) and *N. notopterus* (Pa Tong).

Table 5. *Average weight of fish sold daily by vendor 1-8 at Thongkhankham Market based on data recorded from logbooks.*

Scientific Name	Weight (kg/day) from all sampling on days								Percent of total	Range	Error
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	All days			
Pangasianodon hypophthalmus	13.0	11.5	11.8	10.0	12.9	11.7	13.0	12.0	17.15%	3.1	25.68%
Wallago leerii	11.6	9.0	10.6	10.8	13.5	12.3	13.1	11.6	16.56%	4.5	38.64%
Channa micropeltes	11.4	9.3	9.5	9.5	13.9	10.7	12.5	11.0	15.73%	4.6	41.85%
Bagarius bagarius	6.2	8.5	8.2	10.2	8.9	7.3	8.0	8.2	11.69%	4.0	48.73%
Pangasius conchophilus	8.2	6.0	4.2	2.9	6.7	6.1	5.3	5.6	8.05%	5.4	95.37%
Wallago attu	4.4	4.7	5.6	4.9	4.9	4.3	5.8	4.9	7.07%	1.4	28.55%
Others	16.6	21.1	17.6	14.6	16.9	14.7	14.7	16.6	23.74%	6.5	39.30%
Grand Total	71.4	70.1	67.4	62.7	77.8	67.1	72.4	69.9	100.00%	15.0	21.50%
No. of days	52	52	52	52	53	53	52	366			

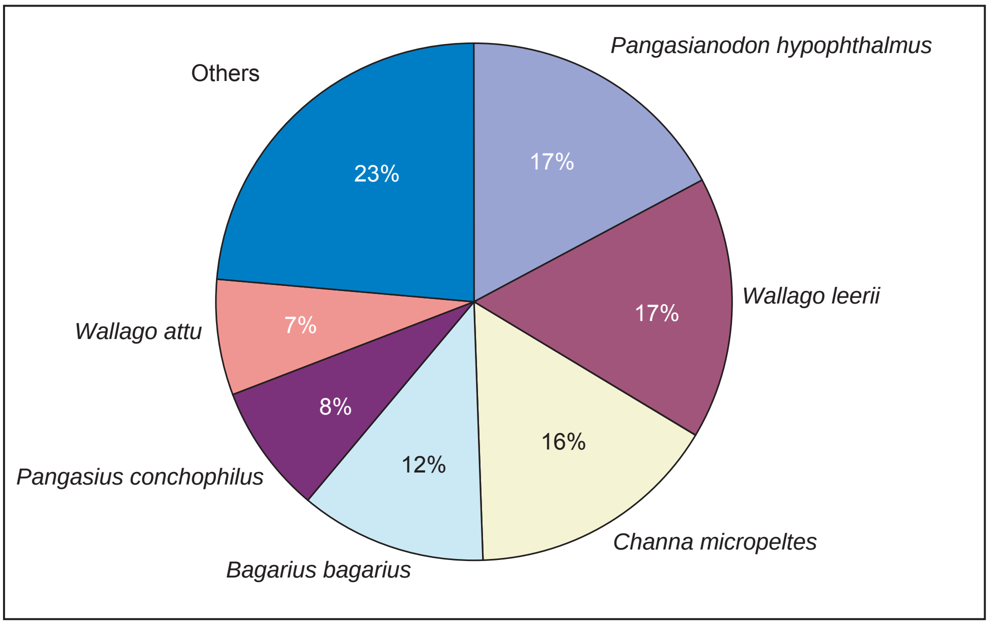

Figure 5. Fish composition sold by Vendor 1-8

From the logbook analysis, we looked at the most important species (*P. hypophthalmus*) sold by a vendor throughout the study year. It can be seen that the price of *P. hypophthalmus* varied from 21,000 Kip/kg to 30,000 Kip/kg. Weight of fish sold by Vendor 1-8 seemed to fluctuate highly throughout the year. The highest weight of *P. hypophthalmus* sold by this vendor was 639 kg in June. This is at a time when fish are migrating upstream in the Mekong from Cambodia to Lao PDR.

Sales of cultured fish

There are a large number of cultured fish sold in the markets in Vientiane. These fish are mainly from aquaculture farms close to the city or imported from Thailand. Vendor 1-19 at Thongkhankham Market was a vendor who sells cultured fish. From Table 6, it can be seen that Vendor 1-19 sold almost 83 kg of fish per day of which 28.6k g was *Oreochromis niloticus* (Pa Nin).

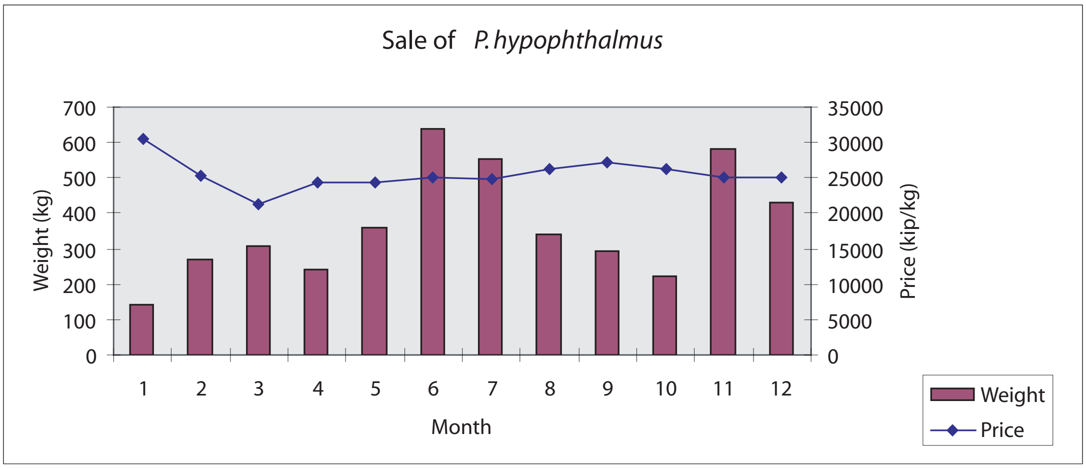

Figure 6. Sale of *P. hypophthalmus* by Vendor 1-8

Table 6. *Average weight of cultured fish (and wild caught marine species) sold daily by Vendor 1-19 at Thongkhankham Market*

Scientific Name	Weight (kg/day) from all sampling on day								Percent of total	Range	Error
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	All days			
Oreochromis niloticus	28.3	27.7	29.9	27.7	27.9	29.2	29.2	28.6	34.4%	2.21	7.7%
Cirrhinus cirrhosus	17.0	13.2	15.3	16.5	14.8	19.1	17.4	16.2	19.5%	5.88	36.3%
Mystus nemurus	14.0	16.1	16.8	16.6	14.3	17.5	17.1	16.0	19.3%	3.49	21.8%
Tuna sp.	13.6	13.3	13.0	14.2	11.4	14.3	14.6	13.5	16.3%	3.20	23.7%
Pangasius spp.	10.1	7.6	7.3	9.4	7.6	9.0	8.8	8.5	10.3%	2.79	32.6%
Other	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.1	0.1%	0.38	394.6%
Grand Total	83.0	77.8	82.4	84.7	76.4	89.1	87.2	82.9	100.00%	12.64	15.2%
No. of days	52	52	52	52	53	53	52	366			

Figure 7 presents fish composition sold by Vendor 1-19. The most important species sold by Vendor 1-19 was *O. niloticus* (Pa Nin) at about 34 per cent. This was followed by *C. mrigala* (Pa Regal, or Pa Nuan Jan) at about 20 per cent and *M. nemurus* also at about 20 per cent. A small species of Tuna (Pa Tu) represented about 16 per cent of sales and *Pangasius* spp. about 10 per cent of sales

Figure 8 shows the sale of O. niloticus by Vendor 1-19 in 2004. The price of *O. niloticus* varied from about 14,000 Kip/kg to 16,000 Kip/kg. The weight of this fish sold by the vendor appeared to be low during the first few months of the year, but it started to increase to around 400 kg in

February to about 1,000kg in May. After this time, the sales weight of this fish seemed to be constant. It can be seen that price and weight of this species do not seem to be related.

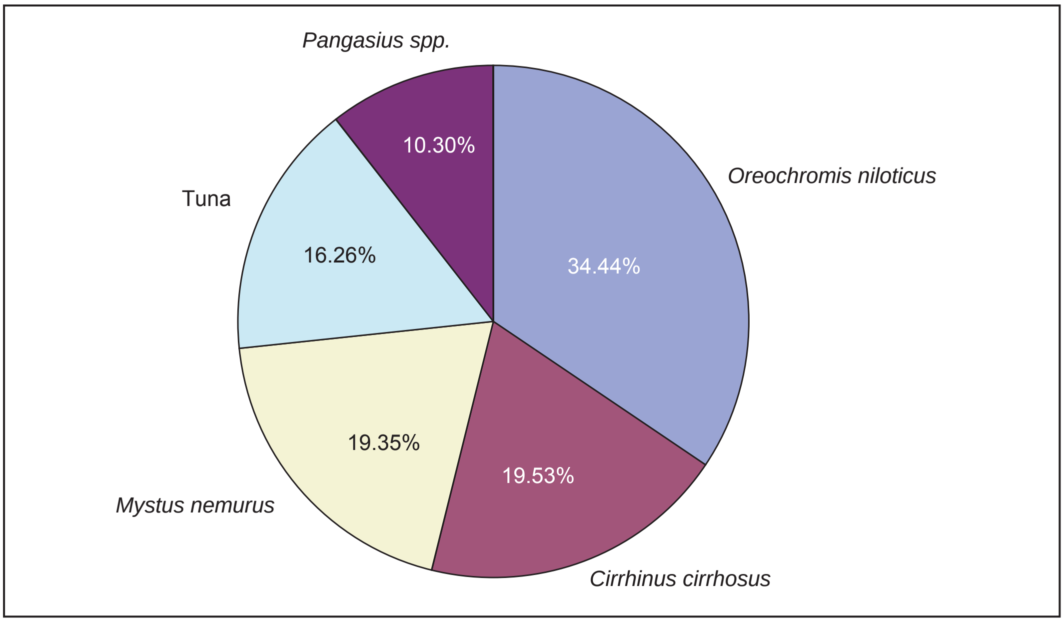

Figure 7. Fish composition sold by Vendor 9–19

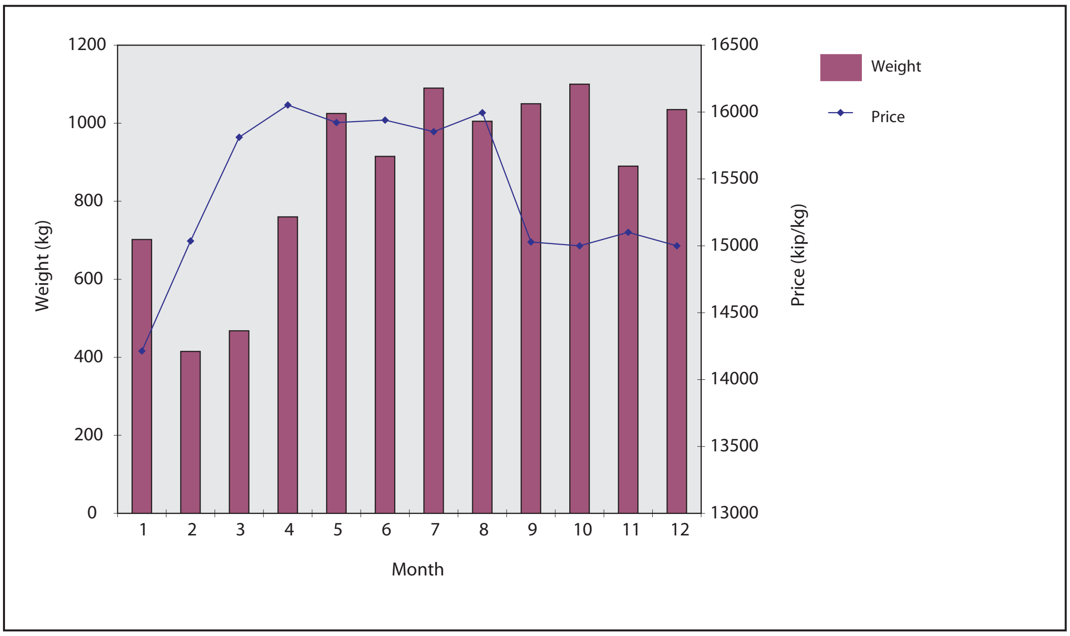

Figure 8. Sale of *O. niloticus* by Vendor 1–19

Sales of wild captured fish from rural areas

A large number of wild captured fish from rural areas close to the cities of Vientiane and Luang Prabang are also sold in major markets. Fish are mainly sold from small or part-time vendors. Table 7 shows the average weight of fish sold daily by Vendor 2-3 at Thatluang Market. The average daily sale of fish from this vendor was about 17 kg. Important fish species include *Hemibagrus* sp., *N. notopterus* and *Hypsibarbus lagleri.*

Table 7. *Average weight of fish sold daily by vendor 2-3 at Thatluang Market*

Scientific Name	Weight (kg/day) from all sampling on days:								Percent of total
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	All days	
Hemibagrus sp.	2.75	3.08	3.33	2.67	2.79	3.32	3.15	3.01	18.01%
Notopterus notopterus	2.71	2.69	2.77	2.27	2.87	3.11	2.98	2.77	16.57%
Hypsibarbus lagleri	2.94	2.37	3.77	2.81	1.45	2.57	2.63	2.64	15.80%
Cyprinus carpio	1.83	1.92	1.62	1.31	1.70	1.40	1.52	1.61	9.63%
Labeo chrysophekadion	1.37	0.90	1.35	1.27	1.51	2.04	1.58	1.43	8.55%
Pangasianodon hypophthalmus	1.17	0.71	1.02	1.00	1.38	1.51	1.06	1.12	6.71%
Cirrhinus microlepis	0.94	0.71	1.33	1.33	0.85	1.28	1.04	1.07	6.38%
Others	2.52	2.62	3.69	3.17	3.70	3.38	2.40	3.07	18.35%
Grand Total	16.23	15.00	18.87	15.83	16.25	18.60	16.37	16.74	100.00%
No. of days	52	52	52	52	53	53	52	366	

DISCUSSIONS AND CONCLUSIONS

Fish are one of the main sources of protein, not only for rural consumption, but also for urban consumption. The fish sold in the city markets come from different sources Some sources are close to the city but others are considerably distant. In markets, fresh fish products are the most important. The main source of these fish is from rural areas close to the cities, fish from Mekong and its tributaries, and cultured fish imported from Thailand.

During this survey, it was found that fresh fish from aquaculture were considerably more important in the urban markets than wild captured fish from rural areas and the Mekong River. However, wild captured fish are still preferred to cultured fish, as is shown by the higher price of these fish in urban markets. Wild captured fish also generate significant income for rural people, many of them poor, who have less opportunity to invest in aquaculture.

P. hypophthalmus, *W. leerii*, *C. micropeltes*, *B. bagarius*, *P. conchophilus*, and *W. attu* are the most common Mekong fish found in fish markets in Vientiane.

O. niloticus, *C. mrigala*, *M. nemurus*, *H. molitrix*, and *Pangasius* spp., are the most common cultured species in the markets. Selling prices of wild capture fish from the Mekong, its tributaries and other natural ponds appear to be double the prices of cultured species. High prices of capture fish may result from greater demand for fish in the urban areas. One interesting point is that the prices of Mekong fish species seem to be constant over a year at the urban markets while the prices of Mekong fish at the landing sites fluctuated with regard to the quantity of the fish supply (Phonvisay and Bush, 2001). In contrast, the prices of the wild capture fish from the Mekong and its tributaries in the markets in Luangprabang Province are cheaper than those in Vientiane Capital. The proximity to the fisheries resources and low demand for fish may be the explanation of this.

The survey of the whole market provides general information of fish sales. It presents types and prices of fish products and geographical sources of fish. In addition, total quantity of fish sold in the interviewed days can be estimated. This provides a view the level of fish consumption of that particular location.

In contrast, logbook analysis of specific vendors provides insightful details of the trend of fish sales within months and a year. We also obtain species composition of fish sold in the markets, prices information and sources of fish. In this study, it is found that a presence of wild capture fish in the urban markets may be related to seasonality and water levels of the rivers where they influence a migration and spawning of particular fish species. This specially occurs with wild capture fish from the Mekong.

Measurement of fisheries resources

Measurement of resource scarcity is the main concern in the point of view of the fisheries management. One of the market signals of scarcity of the natural resource is market information, especially market price (Simon, 1996). The price of fish in the final market, for example, the markets in Vientiane Capital, may be one of the most important factors in determining the demand for (or value of) the fisheries resource in Mekong River in the Siphandone area which is hundred miles away from the city. It maybe argued that the demand for fish at the fish landing sites in this area is significantly influenced by the demand for fish in the final markets. The final markets are either in the country itself or outside the country. Phonvisay and Bush (2001) found that there have been illegal trades of wild Mekong fish from the Siphandone area to Ubon Ratchathani, Thailand. These fish are mainly big fish with high value prices. In addition, some amounts of wild Mekong fish from Cambodia are also traded legally through Champasack Province to the final markets in Ubon Ratchathani, and possibly also Vientiane. This highlights the influence of demand for fish in the final markets to the level of exploitation of fisheries resources. Access to transportation and improvement of roads are also important factors facilitating high mobilization of fish trade from the resource base to the final market.

Market study may also involve systematic identification of the key variables influencing the supply for the resource. The factors that affect the supply of a natural resource can be divided into two broad categories i.e. one pertaining to nature, and the other pertaining to technology including infrastructure. In economic perspective, although nature plays a role in determining the availability of natural resources, technology may be a key factor in determining the supply of natural resources. Technology of harvesting such as fishing gears and improvement of roads, for example, need particular attention because technology change can affect the supply of the resources.

onstant monitoring of the fish market, in a form of time-series data can provide valuable data for future research. It is argued that under ideal market settings and where resources have clearly defined ownership rights, the long-run equilibrium price of a natural resource measures the marginal social opportunity cost of bringing that resource onto the market. Under this condition, a positive price trend for the resource over a long period of time signals emerging resource scarcity (Hussen, 2000). This concept may be well applied to reservoir fisheries or aquaculture where ownership rights are clearly defined. Nevertheless, time-series data of price of fish from other inland fisheries, especially Mekong fisheries are very important for the future market research.In addition, monitoring of the fish market may involve in the activities of other government institutions like the National Statistic Center. Such data of fish sales would be definitely valuable for future research and management planning of fisheries resources.

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Trial monitoring of fishers in the Mekong Delta, Viet Nam

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ABSTRACT

The Mekong Delta in Viet Nam supports large capture fisheries, but catches have not been accurately documented. Official statistics cover large commercial gears, for which catches may be under-reported. Some socioeconomic surveys of households provide better coverage, but results from questionnaires are of unknown accuracy. This is because respondents may be unable to recall details of fishing activity and catches, or may be unwilling to report accurately. This paper reports on the results of monitoring the catches of 13 fishers, carried out as a trial over a one-year period from key sites in the delta. Full-time professional fishers were selected who mostly used larger gears, including *Days* (stationary trawls or *Dais*), trawls, push nets, traps and gill nets. The objective was to document the daily and seasonal variation in catches and to make recommendations for long-term monitoring. The fishers filled in logbooks on a daily basis concerning their catches noting species, total weight and size range. They were also interviewed after the study about their recall of catches over the period of the study.

The fishers caught between 0.9 and 30 tones/year; the highest annual catch was from one fisher who used a push-net; other trawlers or push-netters caught 2.5 to 6 tones/year, and fishers who used *Days* caught 0.8 to2.4 tones/year. All catches showed seasonal peaks, the timing of which varied with gear type. Dominant species included large predators like *Wallago attu* and *Micronema* spp., smaller cyprinids, estuary fish such as threadfins (Polynemidae) and shrimps (*Macrobrachium* spp.).

Based on our data, individual fisher's catches recorded at weekly intervals provided estimates of their annual catches within - at worst - 28% of the true values. There was no particular day of the week that gave high or low estimates, so systematic (rather than random) sampling over time was considered acceptable. However if sampled at 14 or 28-day intervals, annual estimates may have been up to 80% and 110% different from true values. For total catches from these 13 fishers monthly sampling provided an estimate to within 23% of true value, as individual high or low estimates tended to cancel each other.

During interviews, the fishers who had lower catches tended to underestimate their catches, whilst the fishers who caught the most tended to overestimate their catches. Summed over the 13 fishers the estimate of total catch was approximately twice the actual catch. Surveys should include both interviews and follow-up monitoring for accurate estimates of quantities.

KEYWORDS: Mekong Delta, Viet Nam, catch assessment, white fish, and black fish

INTRODUCTION

The Mekong River enters Vietnamese territory through two branches (at this point it is called the Cuulong River). These two branches of the Mekong River are known as the Tien River and the Bassac River or Hau River. Both these rivers are approximately 230km in length. Both rivers create a large delta with an area of approximately 39,000km^2 that covers over 13 provinces in Southern Viet Nam. Two mainstreams enter the sea after passing through nine estuaries that are linked to a complex network of canals that regulate flooding and drainage.

Annual flood flows from the Mekong River are usually highest in September and October and are about the order of 25,500 m^3/s in total. When the floodwaters reach a certain volume, water spills

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over the banks. This creates an immense area of floodplain along the lower mainstream estimated to cover about 1,400,000 ha to 1,900,000 ha (depending on the annual flood level). Eighty per cent of the Mekong's average annual runoff enters the delta, whereas the Bassac River contributes only about 20 per cent of its average annual runoff. Floodplains in this region are considered to be very important areas for feeding and growth for a large number of fish species in the Mekong River. These areas are highly productive for fisheries and are strongly affected by the annual flood pulse of the Mekong River system.

The water current in the Mekong Delta is affected by the tidal regime of the Eastern Sea and the Western Sea (Thailand Gulf) and cause water to flow upstream during high tides. The tide of East Sea is strong with an amplitude of about 3.5 to 4.0 m and occurs on a semi-diurnal basis. The tide from the West Sea is smaller with an amplitude about 0.8 to 1.0 m and takes place under an irregular diurnal regime. Tides in the East Sea strongly influence the dry season flow and salinity levels in the Mekong River. Tides in the West Sea influence the dry season flow and salinity levels in the channels of the Ca Mau Peninsular. Because of the topography of river bases, and channels with low slopes, the tide comes far into inland water. The 4g/l saline level typically penetrates 40 to 45 km upstream along main rivers in the Mekong Delta

The Fish Catch Monitoring Study in the Mekong Delta was started in July 2003. This paper reports the results of monitoring catches of 13 fishers, carried out as a trial over a full one-year period from key sites in the delta. The fishers selected were full-time professional fishers who mostly used larger gears, including *Days* (stationary trawls or *dais*), trawls, push nets, traps and gill nets.

The general objective of the study was to obtain information on Lower Mekong Basin (LMB) countries to act as an input to management. The specific objectives of the study were to: 1) Use fishers as indicators of trends in fisheries of the LMB countries, and 2) Identify the best ways to collect data in a long-term monitoring programme. There were three goals to the study. These were: 1) To collect accurate data from fishers using logbooks and by interviewing, 2) To determine the extent of short-term and long-term, and 3) To determine species composition in some catches.

METHODS AND MATERIALS

Log books and the use of local ecological knowledge (LEK)

A workshop was held on 28 July 2003 in Cantho Province, Viet Nam. All fishers recruited for the study were selected by local government officials. The objectives of the Catch Monitoring Study were explained to the fishers, and they were shown how to fill out blank forms. Each person was supplied with one Fish Photo Flip Chart, one 2 kg-scale, one 30cm ruler, one notebook, one ball point pen and blank data sheets. Fishers started the work on the following day after returning home from the workshop.

Monitoring stations

Initially, 18 stations were chosen for monitoring along the Mekong and Bassac Rivers, and also in the Plain of Reeds and at Long Xuyen. Thirty-three professional fishers, operating various kinds of fishing gears along the rivers were recruited for the study. However, 20 fishers were eliminated during the study because their data were not considered reliable.

All 13 monitoring stations along the Mekong Rivers were located from upstream areas down to the estuaries.

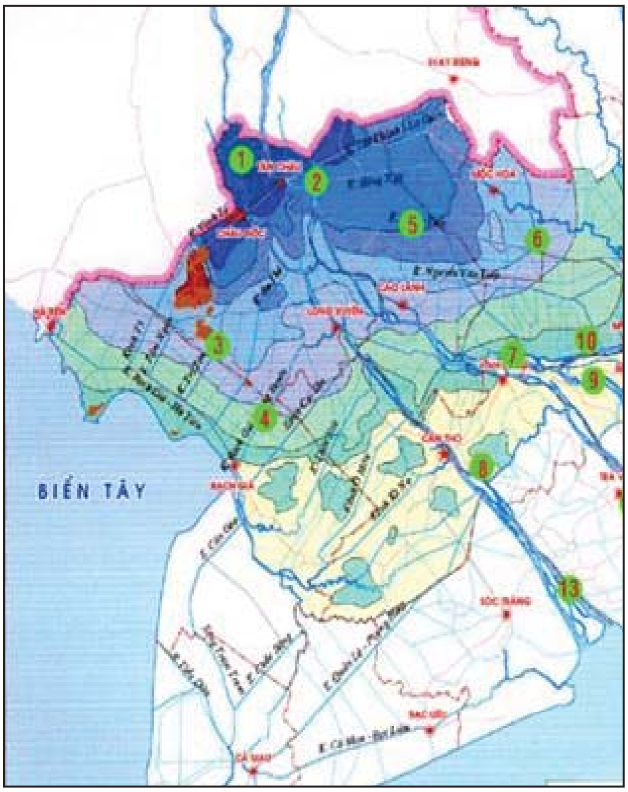

Figure 1: Map of the monitoring stations in the Mekong Delta

RESULTS

Fisher information (by interview)

Personal and family data:

Viet Nam educational system as follows:

Level 1 = Primary school (from grade 1 – 5)

Level 2 = Secondary school (from grade 6 – 9)

Level 3 = High school (from grade 10 – 12)

University (4 years more)

Schooling level of fishers: Secondary school 69.23 per cent. Primary school 23.08 per cent, High school 7.69 per cent Very few fishers had received training in aquaculture (15.38 per cent) or fisheries (7.69 per cent)

Most fishers had gained their fishing knowledge having been taught by their parents. Number of years of fishing experience: 12 – 51 years; average 28 years. All fishers were married and have 1 to 4 children. Children were fishers to at 53.8 per cent. Fisher wife job: housewife 92.3 per cent; housewife – fish seller 15.38 per cent

Property ownership and other personal information (Non fishery)

House size average: 70 m^{2}.. Wood and tin roof 69.23 per cent; thatch 23.08 per cent; brick-cement 7.69 per cent. Electricity 84.62 per cent. Road Type: Dirt 46.2 per cent; gravel 15.4 per cent; bitumen 38.5 per cent. Fishers have motorcycle: 53.84 per cent, television: 84.62 per cent. Fishers with no land 53.85 per cent. Average area of land owned average 0.4 ha.

Fishing gears

Boat length: 6 – 12 m, engine power: 4 – 24 HP. Only Mr. Nguyen Van Ro (Tam Nong, Dong Thap) has a larger engine at 120 HP for push net, so his catch is the highest in the area.

No license for aquaculture. 15.38 per cent of fishers have a fishing license and pay annual tax (US$6 to 10/gear/year).

Fishing history

Income mainly from fishing 85 per cent, from others 15 per cent (aquaculture, agriculture, fruit garden, animal farming). Fish catch: sold 90 per cent, eaten 5.5 per cent; aquaculture feed 4 per cent and other animal 0.5 per cent.

Best catch in the year (kg/year): 300 to 18,250 kg/year; average 5,561 kg/year. Fishing worse now: 76.9 per cent. Very bad: 15.4 per cent Normal 7.7 per cent. The reasons causing changes in fishing: by pollution: 53.8 per cent; more fishers, illegal fishing gears: 50 per cent.

The environment changed in their lifetime: worse: 76.9 per cent; better 23.1 per cent (because widening and deepening of irrigation canals has created better habitat for fish). Main environmental reasons: pesticides from rice field, dike, salinity affected, toxic pollutant from agriculture, canal development, canal system releases acid sulphate soil, canals, processing waste product, waste from poultry, cattle, human activities.

Fishing occurred nearly all year round. The scale and intensity changed with seasons and the fishing gears. The main catch season is from the rainy season to beginning of the dry season. Fishing scale is greatest in the flood season. Fishing took place everywhere in the flooded areas with all kinds of fishing gears. Whereas, fishing in the dry season occurred only in river and deep channels

According to the local fishers, fish catch in the Mekong Delta currently has a tendency to decrease to about 50 per cent less than that during the past 15 years.

Fish species during the study

Two hundred and forty species were identified from all stations during the 12-month monitoring period. Dominant species included large predators belong to Bagridae, Siluridae, Polynemidae, smaller cyprinids, and shrimps. Table 5.2.1 showed 10 dominant species with high total weight.

Table 1. *The weight of dominant species*

No	Vietnamese name	Taxa	Sum of Total Weight (tonnes)
1	Tren	*Micronema apogon*	4.98
2	Me vinh	*Barbonymus gonionotus*	4.09
3	Linh	*Henicorhynchus* spp.2	3.83
4	Tom	*Macrobrachium* sp.	3.69
5	Phen	*Polynemus longipectoralis*	3.64
6	Thieu	*Paralaubuca typus*	3.2
7	Lang	*Hemibagrus* spp.3	3.03
8	Danh	*Puntioplites* spp.4	2.73
9	Leo	*Wallago attu*	2.11
10	Chot	*Mystus* spp.5	2.02

Total weight by habitat

In terms of ecological characteristics, these fish can be divided into 3 groups:

- White fishes (migratory species)
- Black fishes (swamp fishes group)
- Brackish water fishes group

White fish dominated in all water bodies, particularly in the rivers. Black fish are mainly found in rice-fields and canals. Some marine and estuary fish migrate into river and canal.

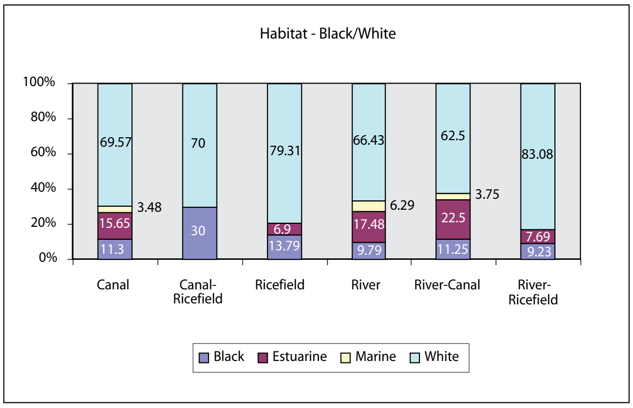

Figure 2. Habitat use for black, white, estuarine and marine fish shown as per cent by weight in fishers catches.

Total catch of inland fish is highest, then estuary fish and marine fish is least (Figure 2). The indigenous species were highest by weight in the total catch (Figure 3).

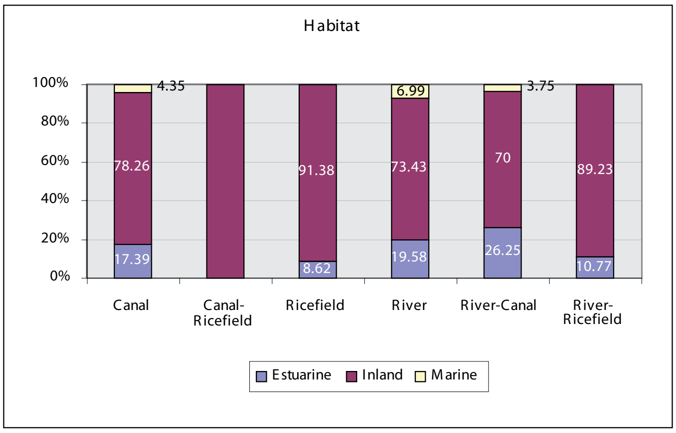

Figure 3. Habitat use for inland, estuarine and marine fish shown as per cent by weight in fishers catches

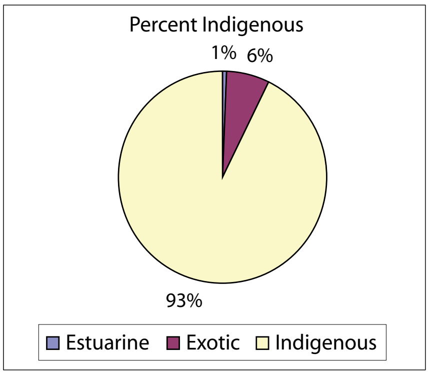

Figure 4. Percentage of estuarine, exotic and other species

Total catch by feeding type

Carnivorous species are dominant in all water bodies. Omnivorous species are also important and herbivorous species less so (Figure 5)

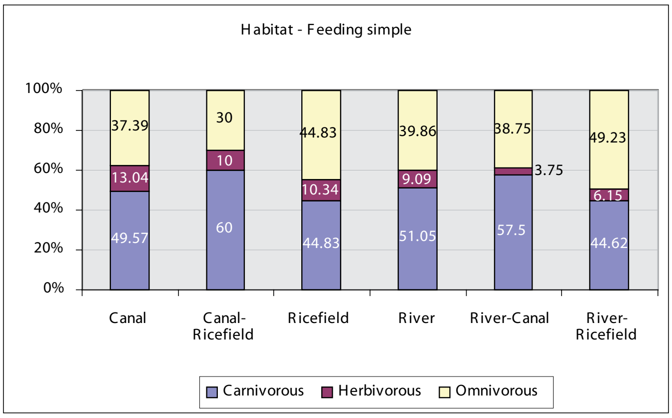

Figure 5. Habitat by type of feeding

Total catch per hour by habitat

Total catch per hour was always high in canals and rivers (Figure 6).

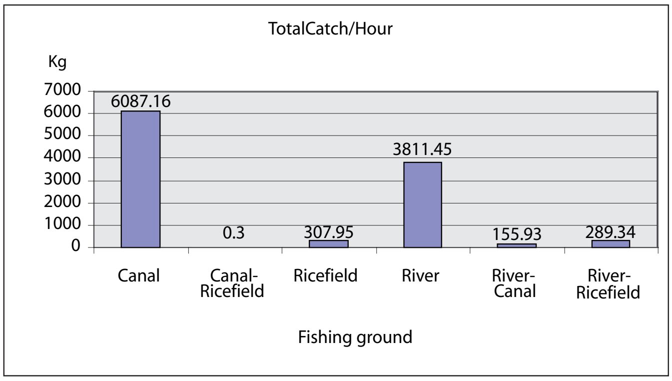

Figure 6. Total catch by fishing ground

Sum of the total catch per year for all fishers

The fishers caught between 0.89 to 29.6 tonnes/year. The highest annual catch was from one fisher who used a push net. Other trawlers or push-netters caught 2.5 to 6 tonnes/year, and fishers that used *Days* caught 0.8 to 2.4 tonnes/year (Table 2).

Table 2. *Sum of total catch by the gear for each fisher*

No	Fisher Name	Gear	Sum of Total Catch (g)
1	Nguyen Van Ro	Push net	29.65
2	Nguyen Van Hanh	Push net, trap net	12.18
3	Nguyen Van Viet	Frame trawl	6.34
4	Le Van Rong	Frame trawl	3.82
5	Cao Van Nam	Frame trawl	3.01
6	Vo Van Hoa	Frame trawl	2.85
7	Pham Hong Quon	Frame trawl	2.55
8	Tran Thanh Sang	Day	2.40
9	Nguyen Van Lam	Day	1.27
10	Pham Van Mat	Gill net, trammel	1.20
11	Nguyen Huu Loi	Trap net, push trawl	1.20
12	Nguyen Van Thong	Day	0.93
13	Nguyen Van Quyt	Day	0.89

Catch by fishing time

The timing of fishing varied with gear type. In general:

- Push net and trawl net: 5 - 7 fishing hours per day
- *Day*: 3 – 6 hrs per day
- Gill net: 1 – 12 hrs per day
- Trap net: 12 – 24 hrs per day

Total catch by fishing gear/day

Total catch by push net is highest, followed by trawl, Day, and trap net. Gill net is least (Figure 7)

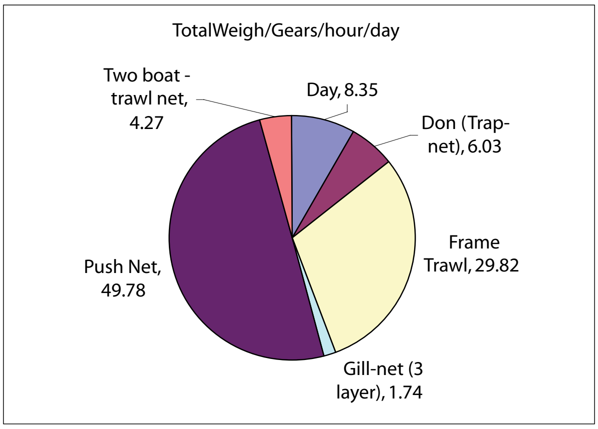

Figure 7. Total catch by fishing gear/day

Total weight per fishing gear/hour

Total weight caught by push net per hour is highest. Frame trawl high also. Others are less. (Figure 8).

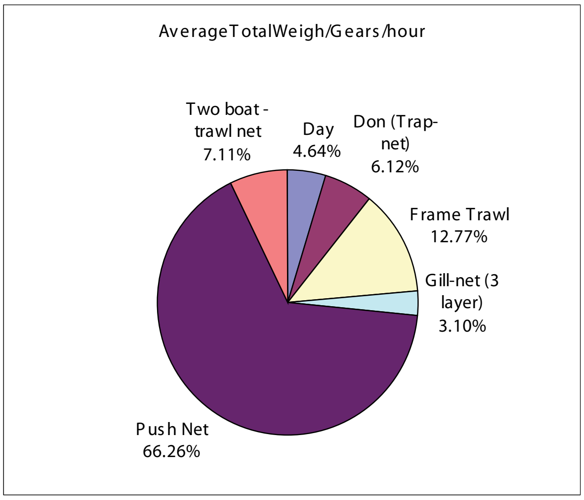

Figure 8. Total weight of catch per hour by different fishing gears

DISCUSSION

1. There was no particular day of the week which would give high or low estimates, so systematic (rather than random) sampling over time would be acceptable. Annual estimates using sampling intervals of 14- or 28-day may be up to 80% and 110% different from true values. Monthly sampling would give an estimate of total catches within 23% of true value, as individual high or low estimates tend to cancel each other. Reducing sampling frequency from daily to weekly has little effect on the estimate of the annual mean
2. The Fish Photo Flipchart used for LEK for Mekong Delta lacked many kinds of fish in the Mekong Delta, Viet Nam. Besides, it had many errors, such as no name (local, scientific), no size, false colour caused incorrect identification.
3. Sampling technique actually not represent for the total catch. Too large or too small fish are not recorded. For future study, the sub sample need to establish as follows:
4. Select the large and small fish to analyse and record first.
5. Separate each group to weigh, then take 10% randomly each group
6. Analysis the sub sample (combine all groups)

CONCLUSIONS

There were 240 species (172 taxa) identified at all stations during the 12 month monitoring in Mekong Delta, Viet Nam. Of these, 10 species were dominant—*Micronema apogon, Barbonymus gonionotus, Henicorhynchus* spp.2, *Macrobrachium* sp., *Polynemus longipectoralis, Paralaubuca typus, Hemibagrus* spp.3, *Puntioplites* spp.4, *Wallago attu*, *Mystus* spp.5.

White fish are dominant in river and flooded rice fields. Black are found fish mainly in rice fields and canals. Some marine and estuary fishes migrate into rivers and canals during the dry season. Carnivorous species are dominant in all water bodies. Omnivorous the next most numerous, followed by herbivorous. Inland fisheries recorded the greatest total catch, followed by then estuarine and then marine species.

The total catch per year in Mekong Delta was 0.89 - 29.6 tonnes/year. The fishing gears recovering the largest annual catches were push-netters and trawlers. The small mesh size of these fishing gears killed a large amount of small fish and other aquatic organisms. In addition they damage the benthic fauna living at the river bottom.

The fish catch monitoring study in Mekong Delta was carried out a few years ago and needs to be undertaken more regularly. Results of these studies could be used to assess and to protect the natural fisheries resources.

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Monitoring of fish larvae during the annual flood of the Mekong and Bassac rivers, Mekong Delta, Viet Nam

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Assessment of Mekong Capture Fisheries Component Mekong River Commission and Research Institute for Aquaculture No. 2.

ABSTRACT

Many Mekong fish species spawn in Cambodia at the beginning of the annual flood, after which their fry drift down the Mekong and its tributary rivers into the Mekong Delta. During the flood, fish fry move from the main rivers to flooded areas where they can feed and grow, and as flood levels fall they move back to the main river systems. Pangasiid catfish are a particularly important component of the fry drift, as they were the target of a large stationary bagnet (Dai) fishery along the Mekong and Bassac Rivers in Cambodia and Viet Nam. The fry were sold to aquaculturists, but the fishery was outlawed in Viet Nam in 2000 when fry from hatcheries became available.

In 1999 and 2000, catches by the Dai fishery were studied, and later on samples (up until 2003) were taken with Bongo nets to monitor fry as a general indicator of the status of fish stocks. Samples were taken in the Mekong and Bassac Rivers in Viet Nam close to the border with Cambodia. A total of 4,535 samples have been taken and processed: 3,018 samples from Vinh Xuong (Mekong River) and 1,517 samples from Quoc Thai station (Bassac River). A total of 201 fish species were identified.

The highest numbers of fish larvae occurred in 2000 when 148 species were recorded, and the lowest catches were in 2002 when only 59 species were recorded. The hydrological regime of the Mekong River profoundly influences the distribution of fish larvae and juveniles. The fry samples confirmed that most Mekong River fish spawn at the beginning of the flood season and fewer fish spawn during or after peak water levels. Fish larvae/fry in samples are derived from spawning several days or weeks before they are caught; highest densities were 0.98 individuals/m3 in the early flood season, 1.2 individuals/m3 in the mid-flood season, and 0.09 individuals/m3 at the end of the flood season. Water levels fluctuated by about 3m during a large flood in 2000, from June (1.77m) to September (4.78m) at Tan Chau.

The studies show that water management in the delta could be improved to allow better recruitment of fry to seasonally flooded areas to support fisheries production. Monitoring of fry drift should continue as a useful general indicator of the status of the fishery.

INTRODUCTION

Many fish species of the Mekong River migrate upstream for spawning during the flood season. However, the exact spawning sites of most fish species has yet to be determined. For some inland freshwater species, some knowledge of spawning sites is available, such as in shallow rice fields or similar flooded areas. Some of species of the Pangasiidae family, such as *Pangasius hypophthalmus* and *Pangasius bocourti* are thought to spawn somewhere in the mainstream of the river. However, this is still not clear due to strong flows and turbidity during the flood season, making research difficult. From the spawning grounds, larvae drift into flooded areas of the lower basin, and fish larvae develop there in inundated swamps and other wetland areas until the end of flood season. When floodwaters recede, fish migrate back to the mainstreams via small rivers or canals.

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Very few studies have been completed on the larval stages of Mekong fishes due to difficulties in sampling, and also the technical problem involved with identifying fish larvae looking at morphological and meristic characteristics. So far, most studies and documents on fish taxonomy in the Mekong in general have dealt with adult fish.

The migratory behaviour of most fish species are in tune with annual flood patterns, but not always so for all species. Many egg-laying fish species spawn in the main flows of Northern Cambodia and Southern Laos and fish larvae are then carried into Southern Cambodia or into the Mekong Delta in Viet Nam up to distances of 500km away. If spawning is delayed late into the wet season, fish larvae may not reach Tonle Sap Lake due to back flows coming from the Great Lake. Under these conditions fish larvae may therefore drift into the lower Mekong Basin of Viet Nam. So, the stages of the flood cycle, and the timing of spawning, regulate what actually happens in any one given year. Environmental changes, such as alterations to the beginning of the time of the flood cycle and its duration, together with total annual flow volume of the Mekong River are of major importance and ultimately have consequences for fisheries.

Submerged areas in the Mekong Delta of Viet Nam and the areas surrounding the Tonle Sap Lake are very important nursery sites for fish. Many commercially important fish species migrate hundreds of kilometres across international borders from the Mekong Delta of Viet Nam up to Cambodia, Thailand and Laos via the Mekong mainstream channel. Fish larvae of some fish species drift several hundred kilometres from spawning grounds in upstream areas back downstream into inundated areas where they grow and develop. Some other fish species migrate only short distances into nearby flooded areas, and it is there that they reproduce and the young fish develop.

MATERIALS AND METHODS

Study sites

Two study sites were chosen, just about 1km away from the border with Cambodia. One was at the Hau River located at Hamlet 1, Quoc Thai village, An Phu district at 177^{o}5’49,2’’E and 10^{o}55’13,2’N, and the second one was at the Tien River located at Hamlet 1, Vinh Xuong village, Tan Chau district, at 177^{o}10’52,4’ E and 10 ^{o}54’11.9’N (Figure 1).

Sampling methods

Sampling nets used during the study

Three types of nets were used for sampling. The first type was a simple bag net (called ‘*Dai*’ for larvae sampling). It is a traditional fishing gear used by farmers when they want to collect fish larvae (*Pangasius hypophthalmus*) in An Giang and Dong Thap Provinces. The objective of using (Figure 2).

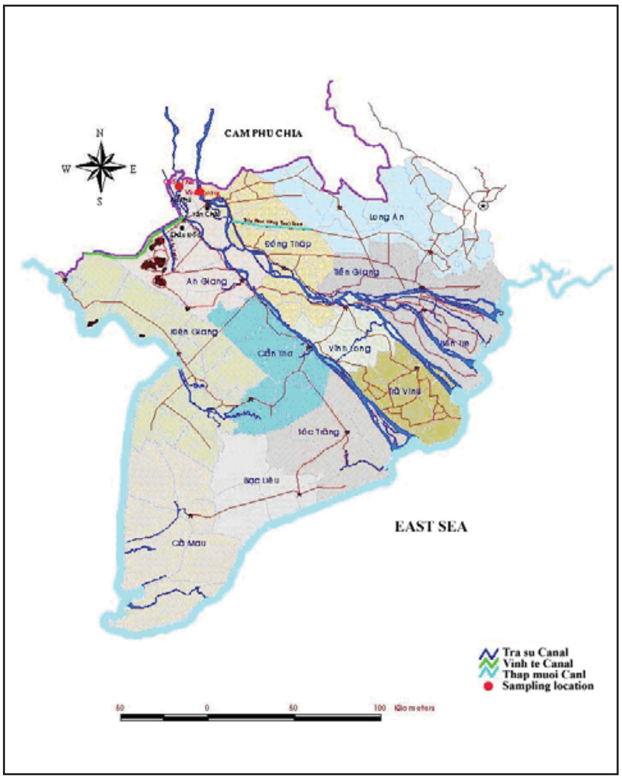

Figure 1. Map of sampling sites

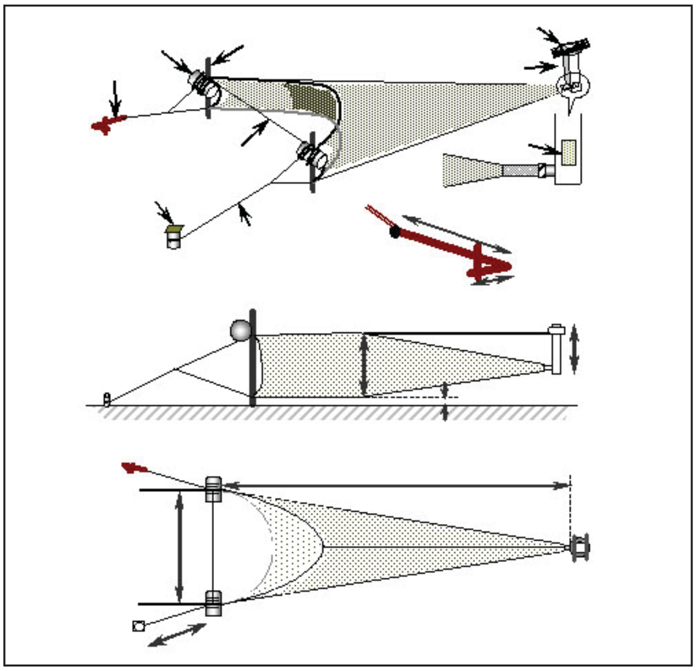

Figure 2. Nets used for sampling.

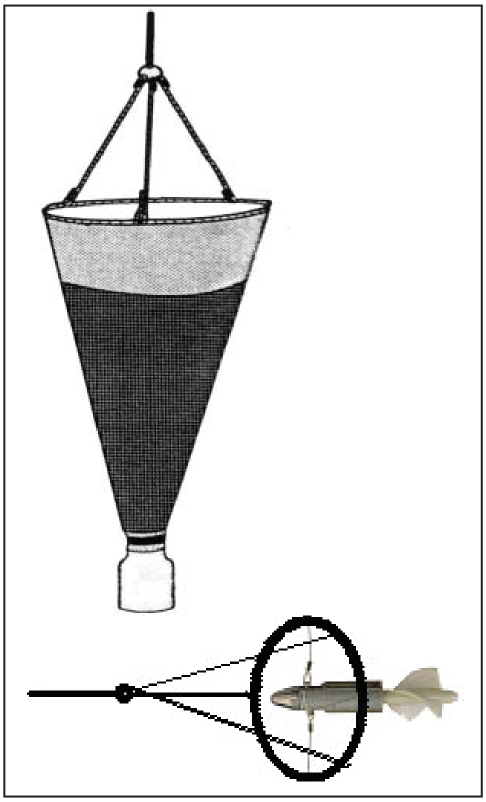

Figure 3. A second type of sampling net.

this sampling net was to qualitatively sample fish species and to identify them to genus or species. The second type of gear used for sampling was to determine species composition and density of fish larvae and juveniles at different sampling sites (Figure 3).

Sampling methods

- Regular samplings. Four samplings per month. Samples collected on two days with an interval of three hours between sampling.
- Other sampling techniques. Samplings over almost one complete day. Sampling began at 6:00am in the morning and continued until 5:00am the next morning. The duration of sampling was over a time period of 60 minutes. This took place during every hour, on one day each week. Samples were immediately fixed in 5 per cent formalin solution.
- Sampling took place during the main spawning period from May to September in the Mekong mainstream.

Number of samples

From 1999 to 2003, a total of 5,498 samples were collected (3,501 samples from Mekong River and 1,997 samples from the Bassac River).

Methods of sample analysis and taxonomy

Fish classification

Fish were classified using published literature by Rainboth (1996), Termvidchakorn (2003) and Pinder (2001).

All samples were deposited at the Division of Fisheries Resource, Research Institute for Aquaculture No.2, Ministry of Fishery, 116 Nguyen Dinh Chieu Street, District 1, Ho Chi Minh City.

Quantity of species composition

All fish species present in the samples were separated and counted by species type. In some cases there were thousands of fish larvae mixed with organic debris in samples. In these cases we took sub-samples using the following steps:

- Total weight of main sample (original sample) was measured
- Take out 3 sub-samples from different sampling sites
- Weight of sub-sample was measured
- Identifying species and counting number of larvae in each sub-sample
- Number of fish species is calculated by using following formula:

$$N_{tot} = \left(\frac{N_1}{W_1} + \frac{N_2}{W_2} + \frac{N_3}{W_3} \right) \times \frac{W_{tot}}{3}$$

Where:

N_{total} = number of larvae in the sample

W_{total} = total weight of main sample

N_1 = number of larvae in sub-sample1 W_1 = weight of sub-sample 1

N_2 =: number of larvae in sub-sample 2 W_2 = weight of sub-sample 2

N_3 = number of larvae in sub-sample 3 W_3 = weight of sub-sample

Data storage and analysis

All data were stored in MS Access and analyzed using Excel software.

Data on relationship of individual and species composition depends on different times in samplings. All data is converted by sampling or fishing time based on the formula:

Formula 1: *Identical- Index Jaccards*

J percentage of identical level, a similar number of fish in two different environments , b number of fish in environment 1 and c number of fish in environment 2.

$$J = \frac{a}{a+b+c} * 1($$

Formula 2: *Biological diversifying Index Shannon – Wiener*

H' = diversity of species composition P: probability of species I (abundant relationship) and S: total number of species.

$$H^{'} = -\sum_{i=1}^{S_{obs}} p_i \, \mathrm{h} \;\; p_i$$

Where: CSC : later measuring value
CSD: previous measuring value
t : measuring time (unit: second)

RESULTS AND DISCUSSION

Species composition of fish larvae and juveniles and fluctuation of their production.

Species composition

During 1999 to 2003 a total of 5,948 samples were collected (3,501 samples collected at Vinh Xuong in the Mekong River, and 1,997 samples at Quoc Thai in The Bassac River). One hundred and thirty fish species belonging to 31 families and 11 orders were found. One hundred and thirty species were found in the Tien River and 125 species were found in the Hau River. The majority of the fish species were from Cyprinidae (actually occupying about one third of the total number of species). This family was the most diverse of all the families encountered in the in the Mekong Delta.

Results from Figure 6 showed that three orders have the largest number of species. These were Cypriniformes (53 species, and representing 40 per cent of the total), Siluriformes (27 species and representing 20 per cent of the total), and Perciformes (23 species and representing 17 per cent of the total). Other orders included Clupeiformes (6 species and representing 5 per cent of the total), Pleuronectiformes (6 species and representing 5 per cent of the total), and Synbranchiformes

(5 species and representing 4 per cent of the total). Four orders (Anguilliformes, Beloniformes, Tetraodontiformes and Osteoglossiformes) each had 3 species, and each represented 2 per cent of the total. Lastly, there was the order Syngnathiformes and species in this order represented only 1 per cent of the total.

In terms of orders, Perciformes had the highest number (9 families, 30 per cent), followed by Siluriformes (6 families, 20 per cent), and then Cypriniformes (4 families, 13 per cent). The family *Cyprinidae* had the highest number of species (44 species, 35 per cent), followed by the families of *Siluridae* (8 species, 6 per cent), *Gobiidae* (8 species, 6 per cent), *Pangasiidae* (8 species, 6 per cent), *Bagridae* (7 species, 5 per cent), and *Cobitidae* (6 species, 4 per cent). Four species in both the *Belontiidae* and *Clupeidae* (3 per cent). Three species in both the *Mastacembelidae* and *Cynoglossidae* (2 per cent). Thirty-two species were found in other families (25 per cent).

Our results on species composition are similar to previous studies on fish species composition in the Mekong Delta.

Several species found in the Mekong Delta are important for inland fish culture. Two of the most important of all are *Pangasius hypophthalmus* and *Pangasius bocourti*. Commercial export of several fish species from An Giang Province reached 100,000 tons in 2002 and 130,000 tons in 2003. From Dong Thap Province 30 tons were exported in 2002 and 33,000 tons in 2003. These two provinces border the Mekong and Bassac rivers providing good advantages for cage-culture activities. Recently, several provinces without the right conditions for cage-culture have developed river-catfish / pond-culture with very high yields of up to 200-300 tons/ha/crop on average. Other fish species used in aquaculture are also of high economic value and include: P*angasius larnaudii, Pangasius conchophilus, Labeo chrysophekadion, Osteochilus melanopleurus*, *Cyclocheilichthys enoplus, Silver barb Barbodes gonionotus, Barbodes altus, Micronema bleekeri*, *Anabas testudineus,* Sand goby *Oxyeleotris marmorata, Channa micropeltes, Channa striata, Clarias batrachus, Notopterus notopterus, Chitala ornata, Monopterus albus, Mystus filamentus,* and *Catlocarpio siamensis*. Of all the species found in Vinh Xuong and Quoc Thai, there are 19 species that are commonly cultured species in the Mekong Delta, and 6 species are recorded in the Red book of Viet Nam.

Species composition fluctuation of fish larvae and juveniles by years

During our 5-year study (1999 to2003) we found that the highest number of species of all were found in the year 2000 (130 species). This was followed by 125 species in 1999, 92 species in 2003, 77 species in 2002 and the lowest in 2001 (71 species) (Figure 4).

We examined the fluctuation in flooding in the Mekong Delta in relation to species composition. The crest of the flood was highest in 2000, with 490cm of flood water level. Generally, water levels fluctuated between 350 to 447cm in other years. The highest record we obtained was at Chau Doc in 2000 (506 cm), but during other years, the flood water level fluctuated between 406 to 482cm.

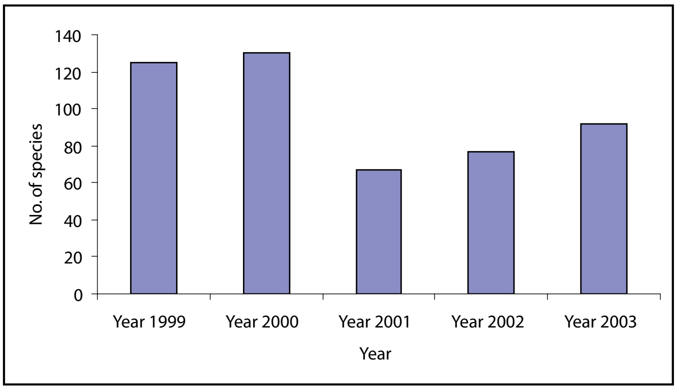

Figure 4. Species composition changes of fish larvae and juveniles by years

It appeared to us that the flood regime significantly influenced both spawning success and species composition in the lower Mekong Basin. In the year 2000 the strongest flood was recorded within 70 years of records being taken. It was also during this year that we found the largest number of species.

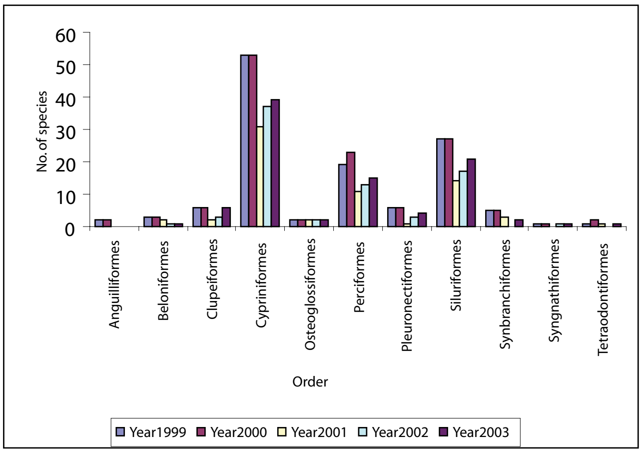

Figure 5. Variation in species composition during the 1999 to 2003 study

Figure 5 shows that the highest number of species appeared in three orders; Cypriniformes, Siluriformes and Perciformes. Previous studies have also confirmed these three orders contain the highest number of species.

Species composition fluctuation of fish larvae and juveniles by seasons

Species composition of fish larvae and juveniles clearly fluctuated during different seasons. At the beginning of the flood season, many species spawned resulting in more species appearing during this time. The number of species decreased at the end of the flood season (Figure 6). The annual flood causes many areas to become submerged. Fish move to these areas to spawn and grow. At the end of flood season they migrate back to canals and rivers.

- Species often appear at high density at the beginning of the flood season such as *Pangasianodon hypophthalmus, Clupeoides borneensis* and other species.

- Some species appear in the middle of the flood season such as *Henicorhynchus siamensis* and *Paralaubuca riveroi*.

- Some species appear at the end of flood season including *Rasbora daniconius* and *Pangasius siamensis*. Certain species often appeared in all samples, and at all times of the year such as *Henicorhynchus siamensis.*

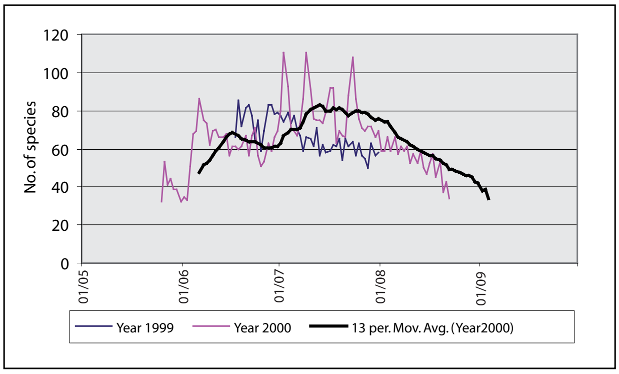

Figure 6. Changes in species composition by sampling period

In general, the number of species appears to be highest at the beginning of June until July.

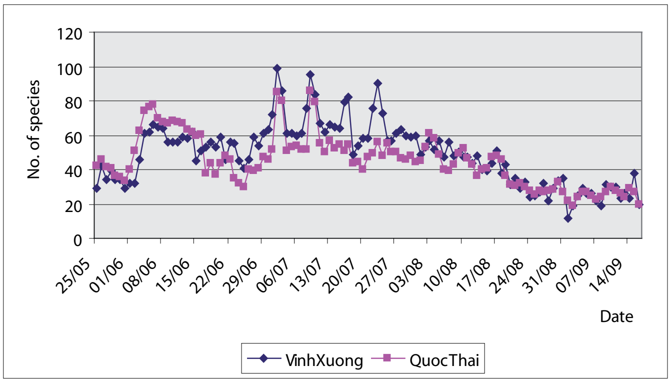

Figure 7. Changes in species fluctuation at two study stations

The fish species composition at two stations where the study took place (Vinh Xuong of Mekong River and Quoc Thai of Bassac River) were found to be similar. That is, more species at the beginning of flood season and then a gradual decline. By the end of the flood season the species composition was the lowest of all. Family composition also varied over the different seasons (Figure 7). This was probably due to the favourable spawning conditions at the start of the flood season in the Mekong Delta.

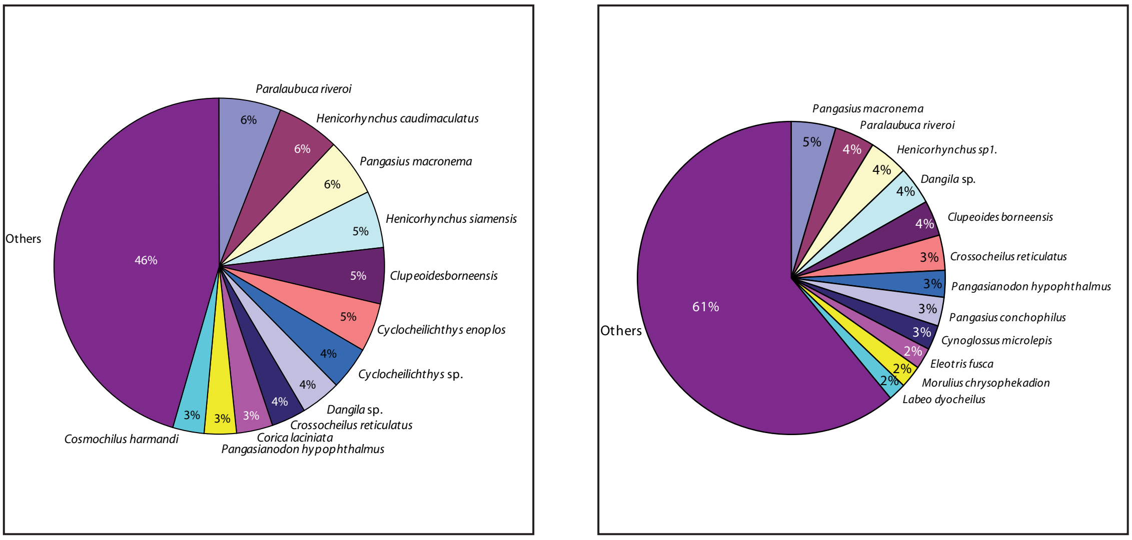

Figure 8. Species fluctuation of fish larvae and juvenile by day and night

Clearly there is a difference in species composition between day and night. Species appearing at night are mainly scale-less fish species and, in contrast, species appearing during the daytime were mainly fish species with scales. Some species show different frequencies of capture between day and night. Species that mainly appeared during the day included *Corica laciniata*, *Paralaubuca riveroi*. Species that mainly appeared during night included *Rasbora daniconius*, *R. myersi*, *Labeo chrysophekadion*, *Pangasius conchophilus*, *Pangasius macronema*, *Mastacembelus favus* and *Eleotris fusca* (Figure 8).

Light intensity also influences the distribution of fish species during day and night. Many catfish species live deep in the water column, coming up to the surface at night. The studies of Paller (1987) and Marchetti and Moyle (2000) also indicated that fish larvae and juveniles often appear more during the night than during the day. They also appear at different depths in the water column. Sheaffer and Nickum (1986) found that near to the water surface of the Mississippi River (America) the numbers of fish larvae and juveniles were as much as four times the number of species at the bottom of the river. Holland (1986) also had the same conclusion on species distribution of fish larvae and juveniles during day and night.

Frequency of species appearing

Of all the samples made, only very few samples with over 100 species appeared. Most samples contained 8 to 22 species but higher frequency of appearance, from 20 to more than 60 per cent (Figure 9). The species with frequency of appearance of more than 60 per cent are mostly common species cultured in the Mekong Delta.

The results of study showed that 34 species often appear within 60 to 90 days during the flood season; these species may be multiple-spawners or species that spawn at intervals during the flood season (Table 1).

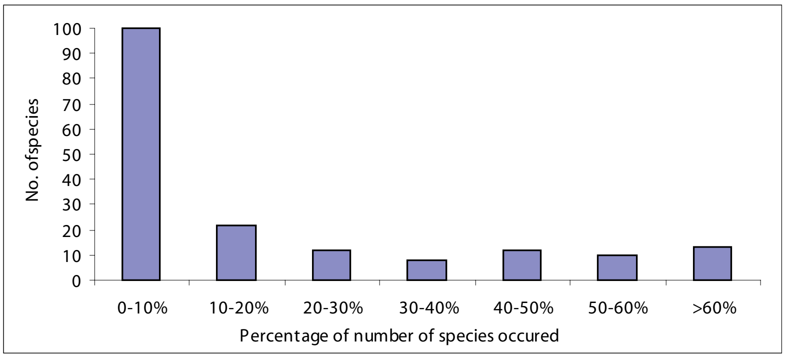

Figure 9. Frequency of appearance (%) of fish species

Table 1. *Relationship between number of species and days appearing*

Number of appearing days	Number of species
1 - 29	68
30 - 59	42
60 - 90	34

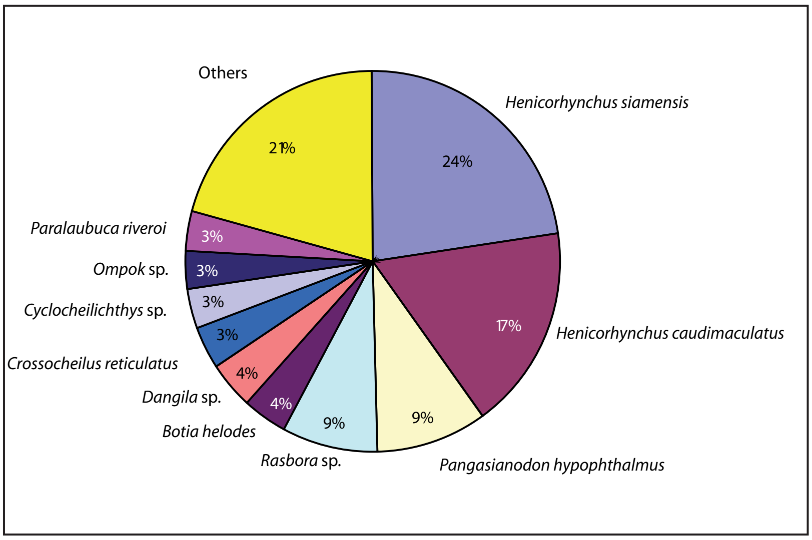

Figure 10. Main species in samplings (Per cent of species number)

Figure 10 indicates that the genus appearing most often with the highest number is *Henicorhynchus* (at around 40 per cent). *Henicorhynchus lobatus* occupies 17 per cent and *Henicorhynchus siamensis* occupies 23 per cent. *Pangasianodon hypophthalmus* occupies 9 per cent, *Rasbora myersi* (9 per cent), *Botia helodes* (4 per cent), *Cyclocheilichthys enoplus* (3 per cent), *Paralaubuca riveroi* (3 per cent), *Ompok hypophthalmus* (3 per cent).

Changes in abundance of fish larvae and juvenile

Abundance

There were five peaks of the number of individuals per hour linked to 5 peaks of the number of species. The first peak, with 354 individuals/hour, was recorded on 29/05/2000 and there was a second peak with 288 individuals/hour, recorded on 07/06/2000. A third peak with 916 individuals/hour was recorded 21/06/2000, and a fourth peak was recorded with 1,229 individuals on 25/06/1999 (Figure 11). (There was an earlier peak with 282 individuals/hour found on 19/07/1999.)

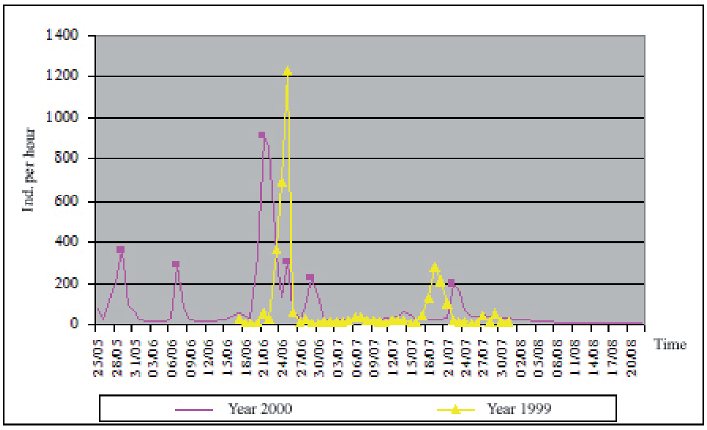

Figure 11. Variation of fish larvae in numbers in year 1999 and 2000

Number of individuals that produced the first peak mainly came from the following species: *Corica laciniata* (size range 12.8 to 16.0 mm in length) with 64 individuals per day. Other important species were *Clupeoides borneensis* (size range 10.6 to 12.3 mm), with 264 individuals/day, *Pangasianodon hypophthalmus*, (size range 11.6 to 17.69 mm) with 4,584 individuals/day; and *Eleotris fusca*, (size range 30.0 to 67.4 mm), with 114 individuals/day.

Number of individuals producing the second peak mainly came from the following species: *Henicorhynchus siamensis*, (size range 12.5 to 19.5 mm), with 1,686 individuals/day; *Pangasianodon hypophthalmus*, (size range 13.3 to18.3 mm), with 1,683 individuals/day, and *Rasbora daniconius*, (size range 8.6 to 11.0 mm), with 9,119 individuals/day.

Number of individuals producing the third peak mainly came from the following species: *Pangasius siamensis* (size range 16.4 to 29.8 mm), with 1,502 individuals/day, *Pangasianodon hypophthalmus* (size range 33.1 to 48.0 mm), with 152 individuals/day, *Paralaubuca riveroi* (size range 16.5 to 30.9 mm), with 588 individuals/day, *Dangila*, or *Labiobarbus* spp., (size range 17.7 to 28.0 mm), with 1,680 individuals/day; *Crossocheilus reticulatus* (size range 15.0 to17.1mm), with 964 individuals/day, and *Cyclocheilichthys enoplus* (size range 13.1 to 8.9mm), with 674 individuals/day.

Number of individuals producing the fourth peak mainly came from the following species: *Henicorhynchus siamensis* (size range 18.5 to 35.0 mm), with 2,011 individuals/day; *Paralaubuca* *riveroi* (size range 20.3 to 20.8 mm), with 415 individuals/day; *Botia modesta* (size range 17.8 to 25.7 mm), with 735 individuals/day; *Cyclocheilichthys enoplus* (size range 14.3 to 21.8 mm), with 69 individuals/day; *Dangila* or *Labiobarbus* spp. (size range 25.0 to 39.1mm), with 512 individuals/day, and *Mystus filamentus* (size range 14.8 to 30.7 mm), with 181 individuals/day.

Number of individuals producing the fifth peak mainly came from the following species: *Henicorhynchus siamensis* and *Botia modesta*.

From the results we can estimate (or guess at) some of the most important species contributing to the 'peaks' mentioned above, and that may also be important in overall production of fish total catch in the Mekong Delta.

Diurnal changes

Figure 12 showed fluctuations and some production peaks during day and night. The highest was 1,007 individuals/hour at 07:00 hours and the lowest was 33 individuals/hour at 16:00 hours. In consideration of the diurnal cycle, the highest number of individuals appears at 07:00 hours, 11:00 hours, 19:00 hours and at 23:00 hours. The lowest number of individuals appears at 13:00 hours, 16:00 hours, 01:00 hours and at 04:00 hours. Many fish species spawn at different times during the diurnal cycle, and this may explain some of our findings.

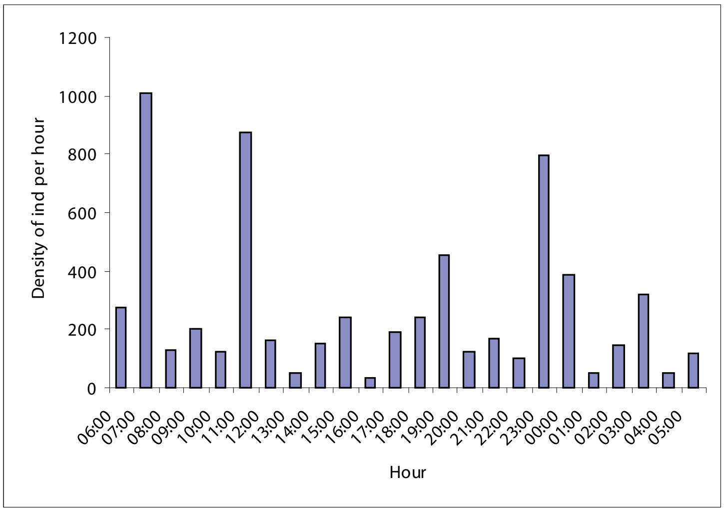

Figure 12. Diurnal capture of individual species (individuals/hour)

Density of larvae during the 1999-2003 study

Together with high individual numbers at the beginning of the flood season, due to many fish species spawning as described above, it may be possible to explain the variation in production peaks produced during this period. For instance, the sudden high number of individuals (reaching 1,229 individuals/hour) found on 25/06/1999. However, we have to look at average density over the five years of study. The density reached 0.98 individuals/m^3 at the beginning of the flood season, 1.2

individuals/m^3 in the middle of the flood season, and clearly decreased to 0.09 individuals/m^3 at the end of flood season (Figure 13).

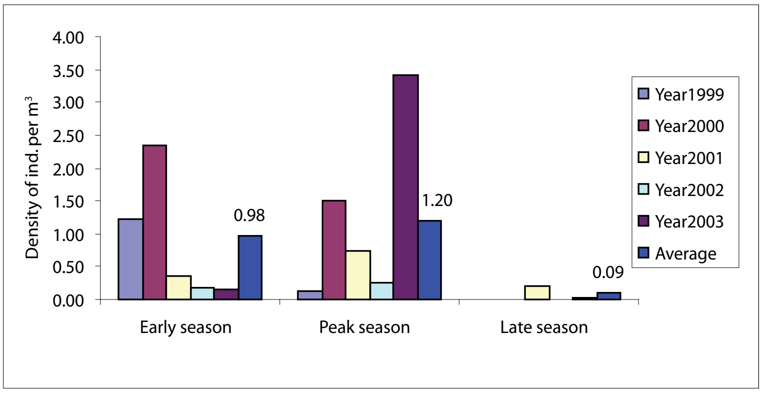

Figure 13. Changes in species (individuals/m^3) by season

Relationship between individual numbers of larvae and water flow

The amount of water in the Mekong Delta changes by season, from about 8,500 m^3/s at the beginning of the flood season, to about 30,650 m^3 at the end of July. This characteristic almost certainly influences the ecological conditions of fauna in the lower Mekong Basin, especially when these coincide with the spawning season of many species. Most species of fish spawn during the time at the beginning of the flood season due to changes in environmental conditions. Many of these changes are stimulated by floodwaters, and the areas that become inundated at this time.

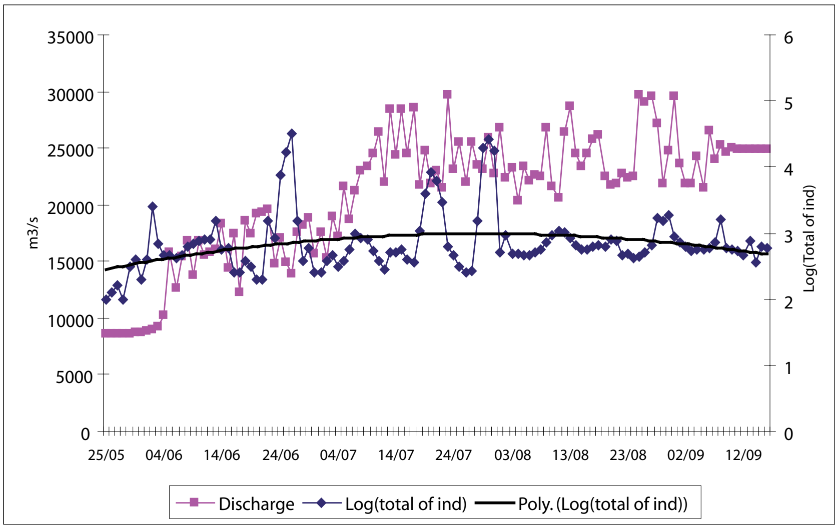

Figure 14. Relationship between water flows and number of individuals

At the beginning of the flood season, many fish species migrate to spawning areas. We estimate from our studies that at least 75 species do this, whilst only 12 species appeared at the end of the rainy season. Fish larvae and juvenile fish collected during our study were also recorded as changing from 31,789 individuals/day at the beginning of the season, to 195 individuals/day at the end of the flood season. This phenomenon may be due to their own adaptation to environmental conditions as well as flows. These adaptations are also important for maintaining lifecycles and their offspring, because floods create spawning and feeding grounds for their development and growth. One of our main conclusions is that the spawning season coincides with the beginning of flood season, although for some species, spawning lasts for several months after this time for some tropical fish species (Figure 14).

Fish density (individuals/m^3) appearing in different river sections

There are clearly differences in the density of fish larvae and juveniles between different river sections. The highest densities we recorded close to the riverbank was 9 individualsds/m^3 or slightly further away from the bank was 4 individualsds/m^3. The lowest density was found in the middle of the river with 2 individuals/m^3. Thus, the migration of larvae, and juveniles appears to depend on water flows, and appear to be sustained by slow flow rate. In the middle of the river, flow rate is strongest at around 0.82 m/s. Fish density is therefore highest when fish larvae are near to the riverbank where the flow rate is around 0.58 m/s resulting in high fish larvae densities (Figure 15).

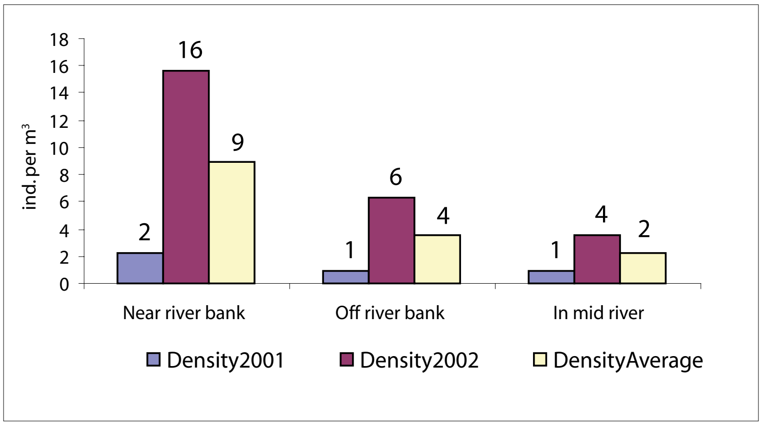

Figure 15. Fish density (individuals/m^3) at different river sections

CONCLUSIONS

1. After a 5-year study (1999-2003), fish larvae and juveniles at the two study sites in the lower Mekong Basin, it was determined that at least 130 species in 31 families and 11 different orders of fish were identified. Of all the species identified, 19 species are known to be commonly cultured species in the Mekong Delta (aquaculture), as well as valuable for export markets to several countries in the region.

2. Species composition, and the numbers of fish larvae and juveniles species clearly change with season, and are influenced by the annual flood cycle in the Mekong Delta.

3. Spawning season mainly takes place in the flood season from June to August. Larval densities decrease at the end of the of the flood season.

4. Density of larvae and juveniles along both sides of the river is higher than that in the central parts of the river. Density of larvae and juveniles is around 9 individuals/m^3 and 4 individuals/m^3 respectively, while only about 2 individuals/m^3 were found in the in central parts of rivers.

SUGGESTIONS AND RECOMMENDATIONS:

1. Biological and ecological characteristics of fish larvae and juveniles should be studied for the identification of new candidates of economic species for fish culture, or as subjects for research into river fisheries.

2. The study of natural species, their distribution and their spawning grounds for economic species should be continued with a view to their conservation and protection.

3. Studies involving the artificial propagation of indigenous species for inland aquaculture, and restocking into rivers should be encouraged, but with some caution.

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Section 2. Management of River and Reservoir Fisheries

Streamlining community fisheries plans into commune plans, Cambodia

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ABSTRACT

There are several steps and activities in the process of Community Fisheries establishment and development. Community Fisheries plan is an important guidance for Community Fisheries management and development in order to achieve the goal of natural fisheries resources conservation and management in a sustainable way. Once, the CFs in MRRF target areas were completely established, and then the next step is the planning step.

The CF plan is the action plan for a year implementation and it is made by CF committee members in consultation with all relevant stakeholders in the areas, especially local authorities. The CF plan is reviewed every year and updated for next year. It is important that CF plan is submitted to Commune Council, so that it could be streamlined into Commune plan and it is recognized at the district and provincial level in Siela program and especially the share responsibility of Commune Council in decentralization approach to be good governance in fisheries conservation and management.

KEY WORDS: Community Fisheries; Cambodia

INTRODUCTION

Most of CFs, in MRRF target areas, have been arranged and established since 2001, immediately after the Cambodia Government had reformed the fisheries management policy using a decentralization approach through having fisheries co-management with sharing responsibilities of local resource users. Presently there are more than 400 CFs in Cambodia, and most of them did not have CF action plan and CF fishing ground 's management plan.

The CF plan is the action plan for a year implementation and it is set up by CF committee members in consultation with all relevant stakeholders in the areas, including local authorities. This was done with the help of fisheries technical facilitators from Department of Fisheries, who are the counterparts of MRRF project who work in close collaboration with Community Fisheries Development Office (CFDO) of DoF. In the process of Community Fisheries establishment and development, there are several steps and activities. Community Fisheries plan is one of those steps and it is important guidance for yearly Community Fisheries management and development in order to achieve the goal of natural fisheries resources conservation and management in a sustainable way. While commune plan is the annual action plan of each commune, which combines all village plans within a commune and is submitted to district level and presented at the District Integration Workshop.

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CF action plan or CF annual plan was initiated by CFs in MRRF target areas with help and support by MRRF-Cambodia sub-component. The main idea of having CF action plan is to solve the problems of fisheries resources faced by Community Fisheries, which have been addressed by CF members during the process of Participatory Rural Appraisal (PRA) in CF village.

In order to be recognized by the commune and district levels, the needs at village levels have to put in the annual commune plan. Therefore, CF action plans of MRRF target areas were introduced and submitted by CF committee members to commune council and put together in the annual commune plan as one of the priority activities in the commune.

It is important to write up the lessons learned and experiences of streamlining Community Fisheries Plan into Commune Plan based on MRRF practices in Cambodia. The paper will present the ideas and concepts of why and how the Plans of Community Fisheries streamline into the commune plan, and what are the benefits are from that, based on local perceptions and practices.

Why streamlining CF plan into commune plan?

After the first year of implementation of CF action plans in MRRF-target areas, and based on its evaluation, results by CF committee members with help by MRRF counterparts, one of the main recommendations was on CF action plan streamline into commune plan for the next year. This idea was strongly addressed by most of CF committee members, some other active CF members and other related stakeholders in the CF areas, during the participatory evaluation process on the effectiveness of CF action plan implementation. The main reasons of its streaming are illustrated as follows:

- CF annual plan is the action plan for fisheries management and development purpose at the village level. While commune plan has to combine all village plans within a commune with all sectors of villagers' needs as well as commune as a whole. Fisheries sector is one of those priority sectors in CF villages. So, it is important to streamline CF activities which has been addressed in CF action plan together with commune activities or commune annual plan. This could help the commune council to see and understand deeply on the importance of fisheries natural resources management for people livelihoods in their communes. Usually, the main activities presented in the annual commune plan, are emphasis on rural infrastructure and rice farm activities, where CF villages are not located fully at fishing ground or fishing village. Fisheries management and development activities are sometime ignored or bias during the process of villages planning. It is probably because of missed or low participation of fishermen during villages planning due to they were busy with fishing activities;
- Once the CF action plan has been placed in the commune plan, the CF activities are clearly presented at commune and district level as well as national level. This provides for a wider recognition by stakeholders at all levels on the importance of participatory

fisheries resources management through Community Fisheries, which is sharing responsibilities by local users and the government;

- Meanwhile, the CF action plan, which is already in the commune action plan is automatically and officially authorized and approved by local government who are the commune council and district. Then their responsibilities and close collaboration are made with CFs and fisheries technical agencies for the purpose of fisheries resources management and development in a sustainable manner. It means that the recognition, authorization and sharing responsibilities of all relevant stakeholders at all levels and are importance, in order to achieve the goal of sustainable fisheries resources uses and management.

- It is necessary to clearly present the CF supported activities by MRRF component to local authorities/commune council. While other CF activities in CF action plan which could not supported by the component, funding can be sought from other sources and donors from the assistance of commune council and during District Integration Workshop for those NGOs or other related agencies, who are interested to support CF activities.

- Moreover in the Article 8 Prakas on commune/Sangkat development planning, MOI and MOP, No 098 PRK, stated that every civil society organization may participate in the commune/sangkat development plan and investment programme preparation, and shall be responsible for:

    - Representing the interests of localized communities and specific stakeholders groups like women, youth, the poor and ethnic groups, as well as Community Fisheries;

    - Contributing knowledge and ideas to the preparation of the commune/sangkat development plan.

The above illustrations of the reasons for streamlining CF action plan into commune plan, by local users, CF members and other stakeholders in CF areas, have contributed to the implementation of the Cambodian decentralization approach. Therefore, it is importance for CFs to have their annual action plans beside CF fishing ground management plan, and streamline into commune annual plan. The CF development and management could become more efficient and sustainable, if they knew what the problems were facing related to the fisheries sector and what needs to be prioritized and especially wider recognition and sharing responsibilities and support.

How to streamline CF plan into commune plan?

Preparation of CF Annual Action Plan

According to the sub-decree of CF management in the article 7 (June 2005), every CF shall have a CF guideline, CF by-laws & internal regulations, management plan of CF fishing areas/ground and agreements recognized by the competent authorities. The CF annual action plan is different from the management plan of CF fishing areas* and it could contribute to the implementation of a longer plan (such as management plan of CF fishing areas).

The CF action plan was initially prepared by CF committee members, after completion of CF establishment, by using PRA results or problem identification. Usually CFs in MRRF target areas, the priority areas have been identified through Participatory Rural Appraisal (PRA) during the earlier steps of CF establishment to see the fisheries situation and problems in the areas.

In the first year, the preparation of CF action plan is based on PRA results, prioritized activities, resources/inputs and means to solve problems (see the format of the CF action plan in Annex 1). The above have been identified by CF committee and members, and other related stakeholders in the CF areas, with the help and support from/by MRRF component. Once the CF annual action plan has been completely finalized, then it is often launched with the participation of CF members, local authorities and other stakeholder in CF areas. Usually, a CF action plan is for a CF federation in one fishing ground, where several CF villages are located.

Figure 1. Participants in the preparation of a Commune Development Plan

The preparation of CF annual action plan for the following year is usually based on the results of the first year of implementation. The CF action plan implementation is evaluated by CF committee members, key CF informants and local authorities, every year, through participatory evaluation approach. The next year of CF action plan is changed accordingly based on the previous experiences and lesson learned. Some activities could not be implemented in the previous year due

* CF Management Plan of Fishing Ground is a longer plan for at least three year to five year plan

to some reasons and then moved to next year. Meanwhile, some new activities have been identified and put in the next year of CF action plan.

The CF annual action plan is submitted to commune council by CF committee members, in order to place it in the commune annual plan. The annual action plan of Community Fisheries should be prepared before the commune plan, which usually takes place at least before October in the every year.

Preparation of Commune Development Plan

The purpose of preparing a commune/sangkat development plan is to help the commune/sangkat council to mobilize resources – both internal and external – and decide on their use to solve local problems and to serve the general interest of the commune/sangkat residents. (Article 1 of Prakas on commune/Sangkat development planning, MOI and MOP, No 098 PRK).

The commune/sangkat development plan is a five year plan and is reviewed every year to update the three-year rolling commune/Sankat investment programme (Article 3 of Prakas on commune/ Sangkat development planning, MOI and MOP, No 098 PRK). As stated in the article 20 of Prakas: "each year the commune/sangkat council must review its development plan, and formulate commune/sangkat investment programme, and complete this process not later than August 31. This review and formulation shall follow the phases and steps outlined in art.12 to 17 of the prakas. This review shall be taken into account to update and form the basis of amendment to the development plan and the investment programme. Amendments of the development plan and investment programme must be approved by the absolute majority of the commune/sangkat council". Therefore, it is good opportunity for CFs to submit their CF annual action plan to commune council every year.

The communes conduct their development planning following the Inter-Ministerial Prakas on Commune Development Planning, and the Guideline on Commune/Sangkat Development Planning Process (April 2002). The commune development planning process has five phases that consists of 11 steps (see Guideline on Commune/Sangkat Development Planning Process, 2002). While the first, second and third steps are in the first phase of analysis (Annex 2) that is similar to the CF action plan preparation process and addressed the issues/problems and needs of local people at village levels through participatory approach. In this phase, the activities from the CF action plan need to be integrated and streamlined and presented during the District Integration Workshop (in the step 8).

Streamlining of CF Annual Action Plan into Commune Plan

As illustrated above, the CF annual action plan is submitted to commune council for approval and streamline into commune plan by commune council in the third step, where priority activities been selected, shorted and combined into related sector, such as fisheries or natural resources management sector etc.

At the end of step 7 in the commune planning process, each commune has a list of priority projects and activities to be discussed at the District Integration Workshop.

In step 8, the commune plan is prepared and presented during the annual district integration workshop by commune chief or/and other commune council members, where the selected activities of CF annual action plan are also represented. The annual district/khan integration workshops is organized by the concerned provincial/municipal Department of Planning to bring together the commune/sangkat councils of the district/khan, the provincial/municipal departments, the non governmental organizations and other national and international agencies, for the purpose of:

- Determining and agreeing on the potential financial and technical support of the above agencies to the formulation and implementation of the commune/Sangkat development plan; and
- Aligning the commune/sangkat council and the provincial/municipal development plans and programmes.

District Integration Workshop is important as it is the key opportunity for the commune representatives to win support from provincial technical agencies and NGO's/IO's for development activities which the communes themselves consider their development priorities for the following year. Meanwhile, a representative from MRRF component was also invited to participate in the District Integration Workshop at our MRRF target districts. Through dialogue and negotiation, the communes, the line departments and the NGO's/IO's seek alliances with each other to obtain more resources for local development, or to increase the potential impact of the resources which each of them allocates to various development activities, by linking them up with the activities of others.

Immediately, after dialogues and negotiations during this District Integration Workshop, the temporary agreement is made for each supported agency who has agreed on the interest and related activities which could be supported by their agencies. Meanwhile, MRRF also could agree on some related activities (related with the prioritized activities in CF action plan) which could be supported and sign the temporary agreement (Annex 3). The rest of CF activities that could not be supported by MRRF, they could be interested and supported by other agencies. The process of streamlining CF action plan into commune plan is illustrated in Figure 2.

Therefore, it is important for CFs to streamline their action plan into commune plan, so that the needs and priority activities for CF management and development could be widely understood, given recognition and provided with transparency at higher levels.

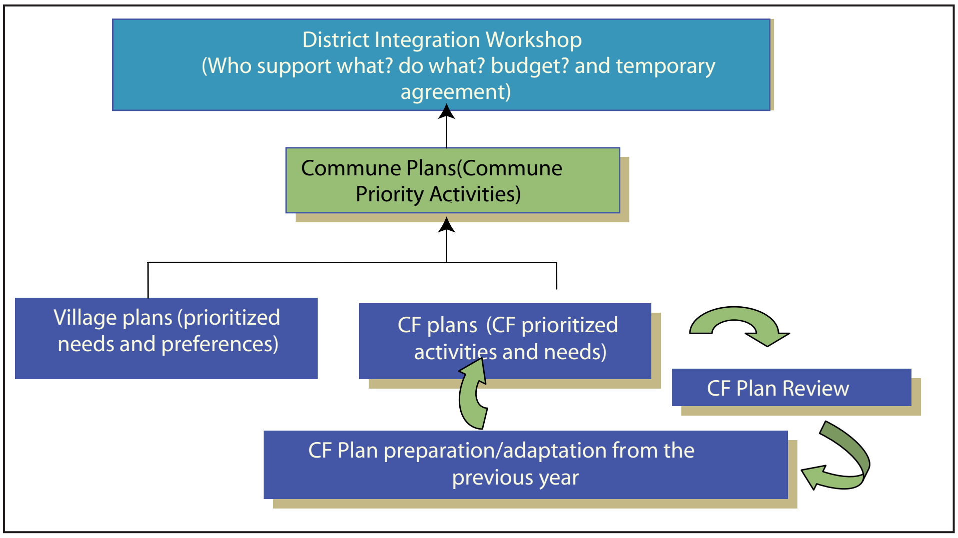

Figure 2. Process of Streamlining CF Plan into Commune Plan

ADVANTAGES OF CF PLAN STREAMLINING INTO COMMUNE PLAN

The CF annual action plan as well as CF's fishing ground management plan streamlining into commune plan is necessary and important, not only for CFs themselves but also for local authorities (communes), for provincial technical line departments, and for all those who take part in it.

- **Community Fisheries**: It is important for CFs as it is the key opportunity for CFs to present their voices and needs at higher levels and to show the importance of having CFs in their villages where fishing grounds are present. Greater understanding, recognition and interest on Community Fisheries management and development could be made in wider and larger circles from grass roots to national levels. All relevant agencies could share their roles and responsibilities in supporting CFs for both technical and financial supports. Moreover, it is necessary incentive and encouragement for Community Fisheries themselves from getting this recognition and official approval, so that other CF members and CF non members who usually have participated less and did not; could understand more and see how important all stakeholders are in participating in CF activities. This could make them have self-confidence and empowerment, in order to participate higher, active and share their responsibilities in a more effective way, especially in complying with CF by-law and regulation. From those advantages, the achievement of CF action plan implementation as well as the implementation of management plan of CF fishing ground could be made.

- **Communes**: It is an important key opportunity for the commune to see and understand their groups of interested people such CFs in their commune come up with their prioritized needs and problems, so that Communes could help make the correct decisions for their people. Commune council could not become good governors unless they could understand clearly what are the problems of their people facing all aspects and people needs and come up with all priority activities (such including CF priority activities from CF action plan) in all aspects in their commune plan. In this respect, the communes could share their responsibilities and support much better the Community Fisheries and be confident on how they could help and support CFs by not ignoring CF activities in the commune plan for the following year.

- **Provincial Technical Line Departments**: They have similar advantages to the communes as well. Moreover it is important for two reasons. First, it helps the line departments, especially provincial fisheries technical agencies to see and understand what and how they could help CFs in their provinces. Also to identify where to implement local development activities with development funds they have already secured (e.g. from centrally funded sectoral development programs, or from donor projects administered nationally). Secondly, it allows the line departments to compete for extra resources made available through the Provincial Investment Fund (PIF) facility. The PIF enables line departments to respond to local development priority requests from the communes, including CF priority activities, and to link these with sectoral priorities, or to seek acceptance and endorsement of the activities that they themselves propose for PIF funding.

- **NGO's/IO's**: It is an opportunity to better integrate their program activities with the proposals that come from the communes and in order to avoid the overlap activities with other projects and programs, especially deal with CFs. It also could show what, and how much each NGO/IO could help and support local communities, including CFs activities in the following year.

THE PROBLEMS BEING FACED

Even though, there are lots of advantages of CF plan streamlining into commune plan, however, based on previous year experiences, there are some problems facing during process of streamlining. The main problem occurring is on the timing of CF plan preparation. Some CFs have prepared their action plan too late. This could lead to the problem that commune could not put CF priority activities in proper way in the commune plan. However, even though it was a bit late, CF committee members have tried their best to give main points of CF needs, to be done in the following year. Once CF plan has been completely made and then the revision could be made by commune council before District Integration Workshop.

The other main problem is on the limitation of donors supporting CF activities in most of MRRF target areas. Even though, CF priority activities have been presented together with commune priority activities and all representatives of donors and line departments have participated in process of District Integration Workshop and see the needs of CFs in the commune priority activities. However, most of them do not work and deal with the field of natural resources management and environment, including CF development activities. On the other hand, some other agencies do not take the first priority to CFs, due to it is not in the main purpose of their project and program. This made difficulty for CFs to get more/extra funding from other donors to implement their CF action plan completely and successfully. Mostly CFs in MRRF target areas could receive only support from MRRF. Some priority activities in CF action plan could be done successfully by receiving MRRF support, and some are not due to funds not being available from MRRF and from other donors too.

CONCLUSIONS AND RECOMMENDATIONS

Community Fisheries annual action plan as well as CF management plan of fishing ground is an important guide for Community Fisheries management and development in order to achieve the goal of natural fisheries resources conservation and management in a sustainable way. Moreover, the streamlining of those plans into a commune plan is much needed to provided key opportunities and advantages for not only CFs themselves, but also crucial important for local authorities (especially commune council), technical line departments and NGOs/Ios. In addition, to see and understand the real needs and problems of the grass roots groups/local communities. CFs, could help keep on the correct track for both technical and financial supports to CFs in more sufficient and effective way. This led to the achievement of the implementation of government decentralization approach, in terms of good governance, especially for the commune council.

Therefore, every CF in Cambodia should have a yearly plan or CF annual action plan and it is necessary to streamline it into commune plan for the successful implementation of management plan of CF fishing ground, for wider recognition, approval and authorization, transparency of donor supported activities and interest, empowerment of CF and higher participation of all stakeholders at all levels. These issues contribute to success of fisheries conservation and management in a sustainable way, as well as sustainable Community Fisheries management in the long run and future.

CF plan has to be prepared before the commune plan, so that the streaming process could be carried out in the proper way. The implementation of CF plans, both annual and longer plan, should be monitored and evaluated, so that it could give the lesson learned and experiences to be improved in the follow year and plans.

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Annex 1: *Format of CF Annual Action Plan*

Problem	Causes	Proposed solutions or	Specific task	Resources needed		Person in charge	Target date
				Internal	External		

Annex 2: *Format tables for the analysis phase of Commune Development Process*

Form 1 (in step 2): Identified and prioritized village needs and problems

Activities	Description	Output	Materials needed	Participants

Form 2 (in step 2): Village identified prioritized issues and preference in [village name] in 200...

Village issues/ preferences	Priority by number	Proposed solution and available resources

Form 3 (in Step 3): Lists of commune/sangkat prioritized problems or needs

Activities	Description	Output	Materials needed	Participants	Facilitators

Form 4 (in step 3): Commune/Sankat wide prioritized problems/preference in [name of C/S] in [year]

Problems/Preference	From village priority list					C/S Wide*	Priority
	....	....	....	....	......		
Economic							
Agriculture							
Credit							
Infrastructure							
Others							
Social							
Health							
Education							
Watsan							
Others							
Natural Resources and Environment							
………							
………							
Others							
Administration and security							
………							
Others							
Gender							
……….							
Others							

* If ≥ 50% of villages identify a problem/preference, it will be considered a C/S wide priority.

Annex 3: *Temporary Agreements form*

Kingdom of Cambodia
Nation Religion King

Province [.................]

.... Date: ....200...

Temporary Agreement

At district integration workshop in 200... held at .... district on [insert date.........], commune council of [insert commune name] with (1) .... (2) .... and (3) .... [insert name of agencies] has entered into provisional agreement to cooperate in the implementation of commune projects as follows:

No	C/S Projects	Size	Location	Agency		Local Contribution
				Sector	NGOs	

C/S Chief

[signature]

Agency representatives

1. [name agency] .... [signature] [name]

2. [name agency] .... [signature] [name]

3. [name agency] .... [signature] [name]

Witnessed by District Chief
[signature]

Witnessed by PDoP
[signature]

Nursing of silver barb (*Puntius gonionotus*) in hapas at Huay Siet Reservior Lao PDR

PHOMMACHAN, Khamla* and Vannida BOUALAPHAN

Management of River and Reservoir Fisheries in the Mekong Component

ABSTRACT

In the past, fish stocking at the Huay Siet Reservoir used small fry purchased from local hatcheries, which had low survival rate after stocking because of their relatively small size and predation from natural fish, especially carnivorous species living in the reservoir. Therefore, in order to find a solution to this problem, an experiment was conducted with the objective to study the effectiveness of nursing fry up to fingerling size prior stocking to increase their size and survival rate. The experiment on nursing fry of silver barb (*Puntius gonionotus*) in hapas was conducted from 19th August to 20th October 2004 at the Huay Siet Reservoir located in Paksan District, Bolikhamxay Province. Data on feeds and feeding were gathered in order to identify appropriate feeding regimes for nursing fry of silver barb in hapas in the reservoir.

The experiment was conducted as a Randomized Complete Block Design with three treatments and three replications for each. The size of each hapa was 2 x 5 x 0.9m. Stocking density was 1000 fishes/hapa or 100 fishes/m^2. The initial weight and length of the fish were between 0.49 to 0.53g and 2.52 to 2.54cm. Fish were fed with commercial catfish feed (>30%). Feeding was made twice a day for T1, 3 times/day for T2 and 5 times/day for T3. After the end of the experiment, there was no significant difference among the three treatments (P>0.05). The average total lengths were 7.37, 7.73, and 7.53cm in T1, T2 and T3. For the average weight of fish, there was no significant difference (P>0.05) between T3 (8.42g) and T1 (8.37g). However, T2 (9g) was greater than T3 and T1. Food Conversion Rate was calculated to be 1.68, 1.62 and 1.72 in T1, T2 and T3. Over 73% of the fish in all treatments survived.

Economic analysis indicated that the economic profit of those three treatments were $US 41 for T2, $US 26 for T1 and $US 32 for T3.

KEYWORDS: Stocking, survival rates, growth, length, economic analysis, feeding frequency, treatment, replicates, food conversion

INTRODUCTION

The experiment on nursing of silver barb *(Puntius gonionotus)* fish in hapas was conducted from 19 August to 20 October 2004 at Huay Siet Reservoir, Pakxan District, Bolikhamxay Province. The objective of the study was to evaluate the impact of feeding frequency on length, weight, food conversion rate and survival of silver barb nursed in hapas over a two-month period. To meet these objectives, we looked at appropriate feeding regimes for nursing silver barb in hapas and compared silver barb growth rates by varying the number of times that feeding took place per day. In addition we also determined the profitability of each feeding regime.

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METHODS

Location and duration of study

The study was conducted from 19 August to 20 October 2004 at Huay siet Reservoir Paksan District, Bolikhamxay Province, Lao PDR.

Experimental design

The experiment was designed with 3 treatments (T1, T2, T3),each with 3 replications, The size of each hapa was 2 x 5 x 0.9m

Feed and feeding

Fish were fed with commercial catfish feed (protein >30%). Feed was given twice a day for treatment 1 (T1), at 06:00 hours and 18:00 hours. For treatment 2 (T2), feed was given three times/ day at 06:00 hours, 12:00 hours and 18:00 hours. For treatment 3 (T3), feed was given five times/ day at 06:00 hours, 09:00 hours, 12:00 hours, 15:00 hours and at 18:00 hours.

Local made feed procedure

Percentage of feed given per body weight was 10 per cent for weeks 1 and 2, 8 per cent for weeks 3 and 4, and 6 per cent for weeks 5 to 8.

DESIGN

The experimental design was a Randomized Complete Block Design. Three treatments were applied with three replications for each treatment.

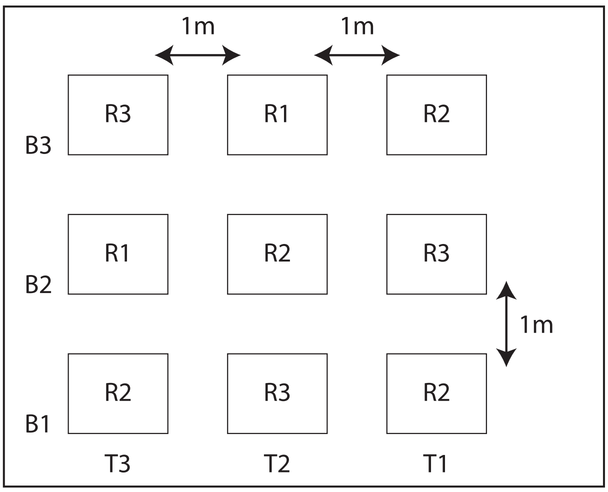

Figure 1: Treatments and three replications

Fish and Stocking density

The stocking density was 1,000 fish/hapa or 100 fish/m^2. Initial weight and length of the fish that were stocked was between 0.49g to 0.53g and 2.52cm to 2.54cm respectively.

Data collection

Weight and length of fish:

- At the start and end of research 20 fish were selected and measured individually for weight and length
- Weight and length of fish was measured twice every month.

Water quality:

- Temperature, Dissolved Oxygen and pH were measured in the hapa once every week.

RESULTS

The growth rate of the fish

Weight and length

Table 1 shows the average weight and length of fish, measured twice per month, across the three treatments. The highest growth rate was found in treatment 2, but with all treatment under test, the fish showed rapid growth in the last two weeks of the experiment. Fish length was found to increase steadily throughout the experiment.

Table 1. *Average weight and length of fish under different treatment during the experimental period*

Treatment	Week II		Week IV		Week VI		Week VIII	
	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)
T1	1.61	3.18	2.78	4.83	3.92	5.60	8.37	7.37
T2	1.71	3.33	3.20	5.60	4.44	6.00	9.00	7.73
T3	1.62	3.27	3.06	5.22	4.22	5.56	8.42	7.53

Note: Initial weight was 0.50 g, 0.52 g and 0.49 g for T1, T2 and T3 respectively. Initial length was 2.50 cm, 2.51 cm and 2.49 for T1, T2 and T3 respectively

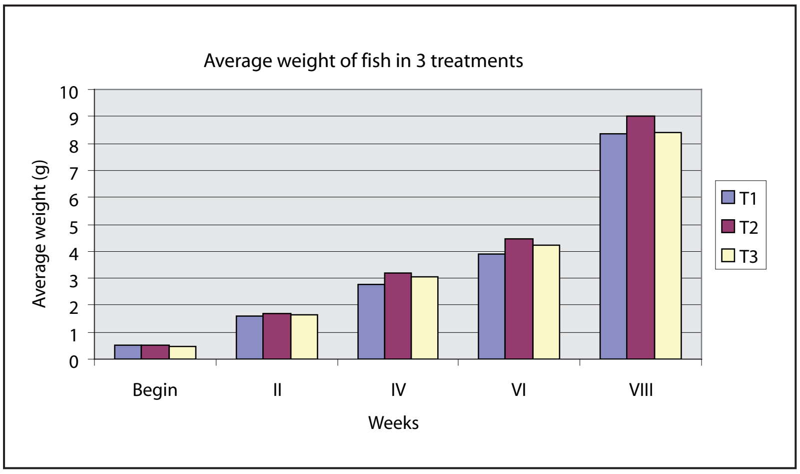

Figure 2. Average weight of fish in three treatments during the experimental period.

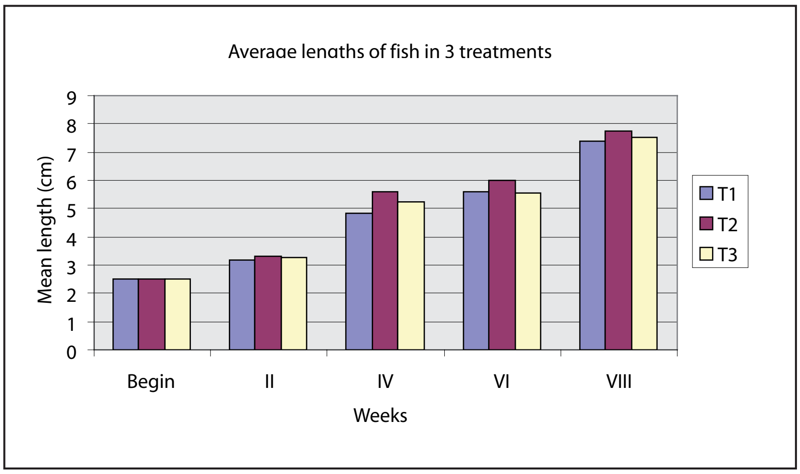

Figure 3. Mean length of fish in three treatments during the experimental period.

Growth performance of the fish

Table 2. *Weight and length measurement of fish in 3 treatments.*

Item	T1	T2	T3
Weight gain (Fish/g)	8.37 (±0.5)	9 (±0.76)	8.42 (±0.3)
Length gain (Fish/cm)	7.37 (±0.133)	7.73 (±0.136)	7.53 (±0.016)
FCR	1.68	1.62	1.72
Survival rate (%)	73.37	78.4	74.27

Table 2 showing weight gain and change in length, with relatively high Food Conversion Ratios (FCRs) and fairly consistent survival rates across all treatments.

Water quality

Water quality data from 19 August to 20 October 2004 are presented in Table 3

Table 3. *Water quality parameters.*

Week	Water Temperature (°c)	DO (ppm)	NH_3 (mg/l)	pH
I	28	5	0.2	6.2
II	29	5	0.2	6.3
III	30	4.5	0.2	6.3
IV	27	4	0.3	7.5
V	28	3	0.4	7.8
VI	30	4.5	0.5	6.5
VII	29	5.2	0.6	6.3
VIII	31	5.3	0.6	6.4

ECONOMIC ANALYSIS

Table 4. *The economics of the three experimental treatments (US$)*

Item	T1	T2	T3
Fixed capital	66.72	66.72	66.72
Revolving capital	16.35	18.32	17.13
Total expenses	83	85	83.85
Income from fish sales	109	126	111.85
Profit	26	41	32

DISCUSSION

The experiment on nursing of silver barb *(Puntius gonionotus)* fish in hapas at Huay Siet Reservoir (size around 150ha). However, it should be noted that the experiment was carried out during the wet-season months. During this time, water level increases and the water becomes turbid. Dissolved Oxygen (DO) levels may have been affected close to the hapas where the experiment took place. Predatory birds were a problem. Covering the hapas with a nylon-net can help to protect fish from predators, especially birds. The fish were fed with a commercial catfish feed (protein >30%) during the experiment. However, the size of the pellet given was quite big, and this may have affected growth rates during the initial period of the experiment (about 2 to 4 weeks after starting the trial). Later on, the fish adapted to this diet, and began feeding well in the hapas.

CONCLUSIONS

- The most economically viable feeding regime in terms of profit was treatment at three times per day (T2).
- Statistically there was no significant difference in weight and length between the three treatments ($P>0.05$).
- Economic analysis showed that the highest profit was T2 at $US 41.

RECOMMENDATIONS

- Nursing of silver barb *(P. gonionotus)* in hapas should be less than two months to avoid over-crowding that may lead to slow growth.
- Hapas should be covered with a nylon-net to protect fish from predators, especially birds.

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Gender in fisheries management in the Lower Songkhram River Basin, in the northeast of Thailand

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ABSTRACT

'Women are important and without them our livelihood would be difficult as well as in the fisheries sector'. This perspective was frequently mentioned by men during the conduction of Participatory Rural Appraisal (PRA) in the Lower Songkhram River Basin (LSRB) in the Northeast of Thailand, to investigate the basic information of communities in particular relation to the fisheries sector. However, why we debate and/or emphasize on gender in the fisheries development in the LSRB, and what women can do for fisheries management, the various reasons are documented in this report. The paper describes gender status toward fisheries management in the LSRB, including fisheries activity profile and how women can participate in fisheries management. Moreover, the situation of gender to gain access to fishery resources is assessed and suggestions are made on how to challenge gender issues in fisheries management is presented in order to ensure equal gender participation in fisheries management, which is considered to lead to more sustainable fisheries management.

Several income-generating activities, such as rice farming, cage culture, livestock etc., and responsibilities towards them have been shared between women and men. In the fisheries sector of the LSRB, women are involved particularly in fish processing and marketing practices, whilst men are involved in direct fishing activities rather than women. However, it seems that woman's activities in the family and other aspects of fisheries are usually unpaid, often unrecognized and sometimes completely ignored. But it is obvious that women are adding value to their importance, particularly in areas such as fish processing. Moreover, women participate particularly at the fisheries management level, and in the government agencies. But the role of women in fisheries in the LSRB is not well defined at the community or local level where a fishery is still considered as a male domain. However, under the leadership of women, their socio-economic conditions have changed and the social capital has increased.

It is essential that the vital role of women in fisheries and integrated community development should be recognized and supported. Women's participation at all levels in decision-making should be promoted in the community and other organizations. Knowledge, and the capacity of women to access information and technologies should be taken into consideration in fisheries management measures in order to encourage women's participation in fisheries sector.

KEYWORDS: Gender, participation, Fisheries, Lower Songkhram River Basin

INTRODUCTION

Culture, social, economic and agro-ecological divisions as well as political structure affect to the allocation of labour and responsibilities between men and women in the household. In fisheries activities, women play a significant role in terms of labor, but there has been no clear about policy on the promotion of women in the fisheries. However, women have been accepted by the community that women are key persons in the development as well as fisheries sectors at the community levels. Obviously, it was frequently mentioned by men during the PRA surveys in the

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Lower Songkhram River Basin (LSRB) that 'Women are important, without them our livelihood would be difficult as well as in the fisheries sector'. Nowadays, Thailand is the biggest exporter of seafood in the world and women play a huge role in the Thai fisheries sector, including holding 33 per cent of professional positions in the central Directorate of Fisheries. According to the Director-General of Fisheries, fishing has long been considered a male occupation, and women were thought to be only involved in post-harvest activities. In recent years, there is a growing recognition of women's contribution in capture fisheries in all activity spheres. In China, rural labour force statistics for 1991 showed that women accounted for 26.3 per cent of rural labour force in fisheries (UNDP/FAO,n.d.quoted in FAO/website 1).

Therefore, the success behind the fisheries and aquaculture development in Asia is a partly due to the direct and indirect contributions of women to fisheries and fisheries-related areas. In many fishing communities, women make and repair nets, and have the primary responsibility for fish marketing. The fisheries sector, women have a high potential in fish processing and in the marketing of fish products. It can be expected that hundreds of thousands of women work in these enterprises. Moreover, at a professional level, women show their talents as fishery researchers, fishery lecturers, and fishery extension officials.

However, woman's activities in the family and in the industry support many aspects of fisheries, and are usually unpaid and often unrecognized. These activities become especially crucial in times of crisis when women are the key people to keeping communities and families together. This is why we must take into account the role of women in studies and management decisions concerning the fishing industry.

This paper describes an overview of current gender status toward fisheries management in the LSRB, including fishery activities, and also shows that women are highly productive and can actively participate in fisheries management. Moreover, the situation of gender to access fisheries resource is assessed and suggestions are made on how to challenge gender issues in fisheries management is presented in order to ensure equal gender participation in fisheries management, which is believed that it could lead to more sustainable fisheries management.

OBJECTIVES

This study describes how women's participation in the fisheries sector, including the division of labor and decision making, can influence gender relation in households and in the fisheries sector in the Lower Songklram River Basin. The specific objectives of this study are:

1. To describe the gender role in the overall functioning of fisheries
2. To describe the gender role in fisheries sector
3. To identify problems or constraints facing and related to gender in fisheries development

4. To provide recommendations and outline the formulation strategies to encourage gender perspectives in fisheries development

METHODOLOGY

All data were obtained mainly from PRA, which was conducted in 14 villages of two provinces; Sakhon Nakorn and Nakorn Phanom in the Lower Songkhram River Basin. Focus group discussions were carried out with men and women. All groups were asked what are their perception, roles and responsibility about the fisheries activities and constraints for women's participation in the fisheries sector. The information of women's participation in the fisheries sector at the management level was obtained during a fisheries management stakeholder workshop held in Lower Songkhram River Basin held in Sakhon Nakorn Province. Moreover, women activities in the fisheries sector and their participation in fish processing, aquaculture activities, and in social and culture activities of women's income generation group were discussed. The role of women in the training program was also observed and analysed.

GENDER INVOLVEMENT STATUS IN FISHERIES IN THE LSRB

The productive role involved both men and women for payment in cash. It includes not only market production with a monetary value, but also subsistence or home production with an actual use value, but also covers those with a potential to earn income (Moser, 1993). In the case of the fisheries sector in the LSRB, women play an important role in generating income in the same capacity of males. The average percentages of participation of men and women in fisheries activities are shown in Figure 1.

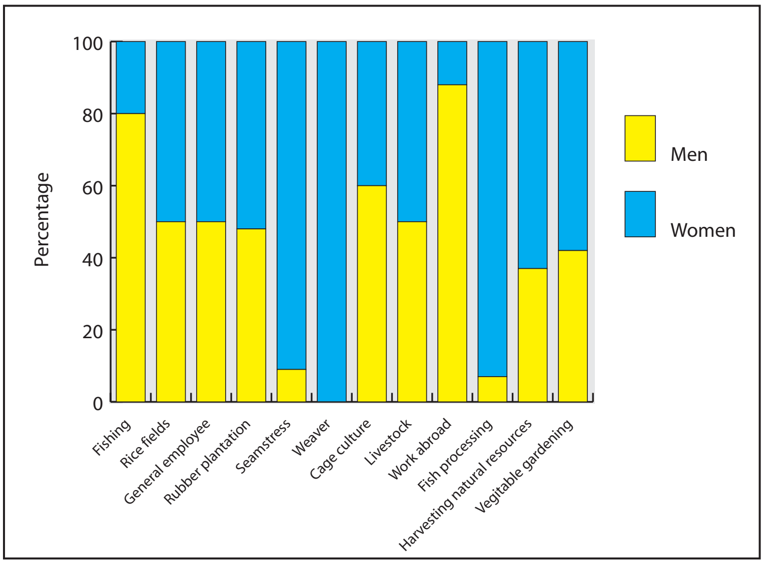

Figure 1. Gender involvement in the income generating activities in the LSRB

The figure shows that women engage more than men in such activities as weaving, food processing and garment production due to the fact that it involves elaborate work, and does not required heavy labor. It also shows that men are involved mainly in fishing activities and work abroad. However, both men and women share responsibly for some other important activities such as rice field farming, rubber crop, livestock and horticulture. Family members share responsibility for this type of work. Labour and security for these activities are important for the whole family. For example, in rice farming, plowing and land preparation require heavy labor usually done by men. However, the whole rice-growing cycle and eventual harvest requires both women and men for a successful outcome.

GENDER ROLES IN THE FISHERIES SECTOR OF THE LSRB

Gender division of labor in fisheries activity in LSRB

There are different levels of involvement in inland fisheries, especially around large lakes and reservoirs involving capture fisheries as a primary source of income. In many areas, inland capture fisheries are a secondary income or supplementary sources of protein for food consumption as in the case of the Lower Songhram River Basin. The gender division of labor also has important implications for fisheries development, division of labor applies to who does what activity in the fisheries activity. In the LSRB women and men are engaged in complementary activities in fisheries.

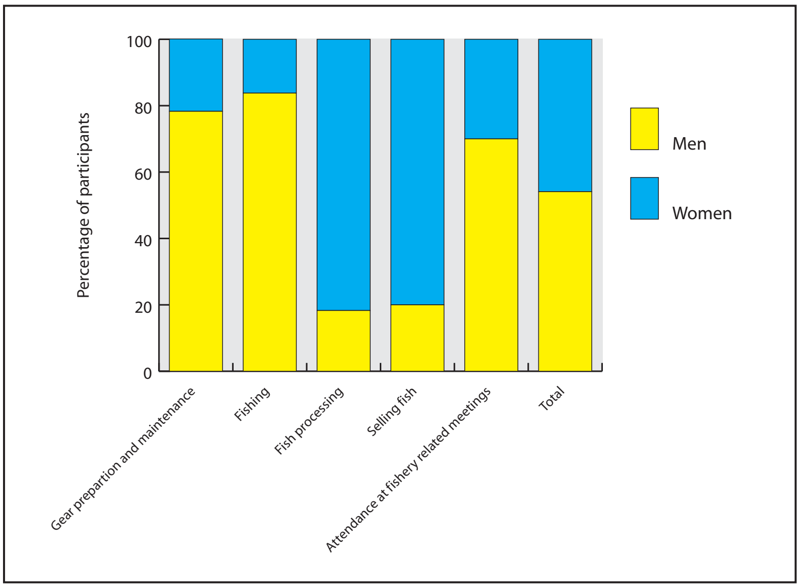

Figure 2. Gender division of labour in fisheries activity in LSRB

Figure 2 shows the gender division of labour in fisheries activity, the fishermen being preparing and maintenance the fishing gears by mainly men (78.3 per cent) while 21.8 per cent of women also involved. Fishing practices is a relatively more risky activity and required physical labor engaged mainly by men (83.8 per cent). However, there are some women that can fish if they have no men in the family but although there is a strong perception that women are not suited for fishing and cannot go far and fish on their own. Importantly, women are actively involved in the processing of fish catch (81.7 per cent). This involves sun drying, salting, smoking and Pha la production. Women are also normally the ones who subsequently sell the fish products (80 per cent). Concerning the ratio of access to the meeting relating to fisheries between men and women, it is seems that men more attended than women. However, an overview of the gender division of labor in fisheries shows that responsibilities of fishery activities between men and women is 54.1 per cent and 45.9 per cent respectively.

In many countries of the world, many women are engaged in inland fishing. In Africa, they fish from the rivers and ponds. In Asia, where fish is an integral part of the diet of many cultures, women are active in both artisanal and commercial fisheries. In parts of India, women net prawns from backwaters. In Laos, they fish in canals. In the Philippines, they fish by using canoes in coastal lagoons. In artisanal fishing communities, in addition, women are mainly responsible for performing the skilled and time-consuming jobs that take place on-shore, such as net making and mending, processing the catch and marketing it. Moreover, in some developing regions women have become important fish entrepreneurs. Women earn, administer and control significant sums of money, financing a variety of fish-based enterprises and generating substantial returns for their household as well as the community.

Gender division of labour in cage culture in the LSRB

Cage culture in Thailand was promoted 10 years ago in central part of Thailand. In the Lower Songkkram River, cage culture is one alternative activity that provides income for many families. There are two types of cage culture in the LSRB; cage culture of Tilapia and cage culture and collection of ornamental fish (mostly indigenous fish species) from the river. Women sell fish to the middlemen. Concerning gender division of labor in cage culture, women have assumed a leading role in the cage culture as well as men. They often perform work of feeding and rearing fish that can be carried out by both men and women (50 per cent and 50 per cent). Men are more engaged in the cage preparation (72 per cent) while women participate in selling fish more than men (75 per cent). However, both men and women (49 per cent and 51 per cent) share responsibilities and decision making on cage culture activity (Figure. 3)

In term of the gender division of labor in collection of ornamental fish, women are more involved in selling fish, while men are engaged mainly in cage preparation and fish collection (Figure 4).

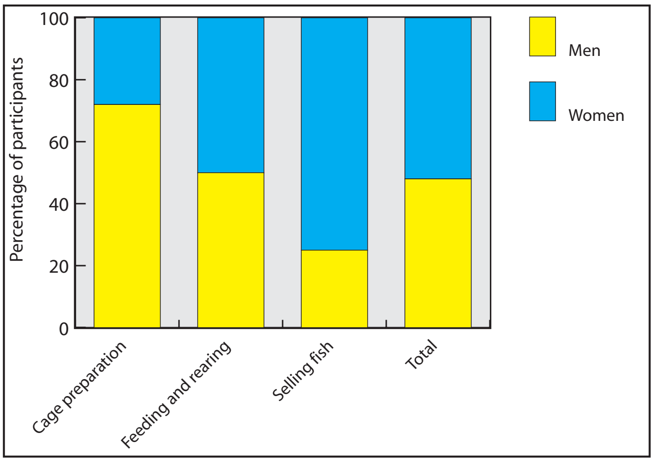

Figure 3. Gender division of labour in cage culture in LSRB

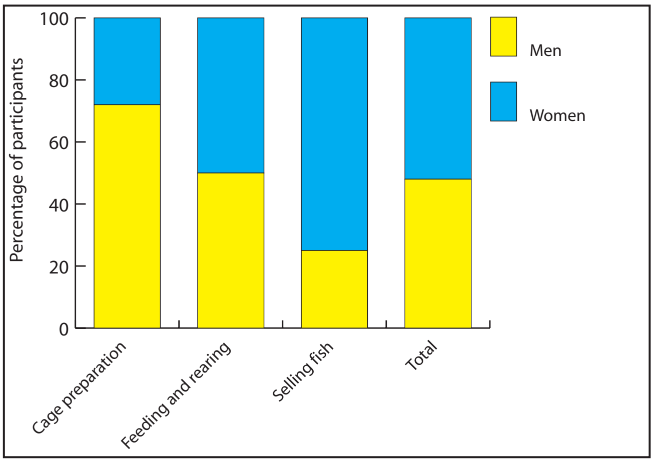

Figure 4. Gender division of labour in collection of aquarium fish

Women normally have to integrate their aquaculture activity with household chores. Thus, they will attend to fish raising later than their husbands. Even though the intensity of their input is the same, women and men might consider women as secondary workers because men do more physically demanding jobs. Men might be seen as the main workers (Kusakabe, 2003). However, the technologies in agriculture, including aquaculture, are commonly transferred directly to men who are supposed to relay the knowledge to their women, specially in the case if the technologies are considered to be difficult to understand (Korsieporn, 2003). This may be a major point to be overcome in gender issues in aquaculture as well as cage culture.

Gender's participation in fisheries management

According to the number of the participants attending the PRA in LSRB, women are the important people providing the information. Figure 5 shows the women's participation in PRA in LSRB that have participated in the group discussion. Men participated more than women (69.1 per cent), while 30 per cent of the participants were women. Most of women who participated provided information about the activities of women groups in the communities. Women participated in the fisheries management level, as indicated by the number of women attending the stakeholder workshop in LSRB. There were no women in the local community leader and Tambon Administrative Organisation officers group. While women were participating in the group of facilitators, fishers and government and NGOs the numbers of women were less than men. This indicates that women's involvement in fisheries is mainly towards the contribution of labour, but not at the management level, as well as for decision making at both community and higher levels (Figure 6).

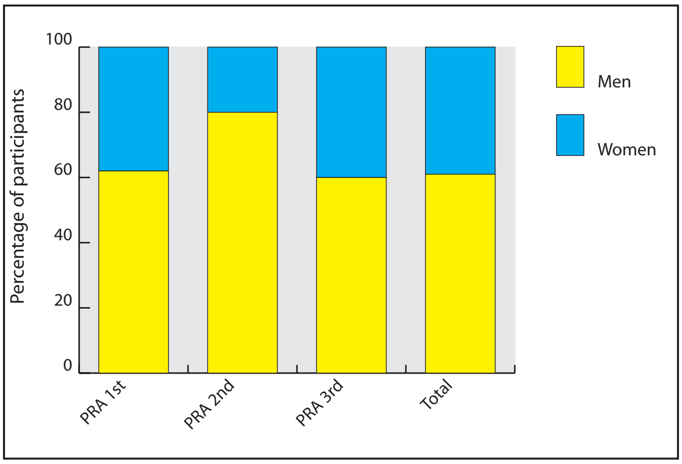

Figure 5. Women's participation in the PRA in LSRB

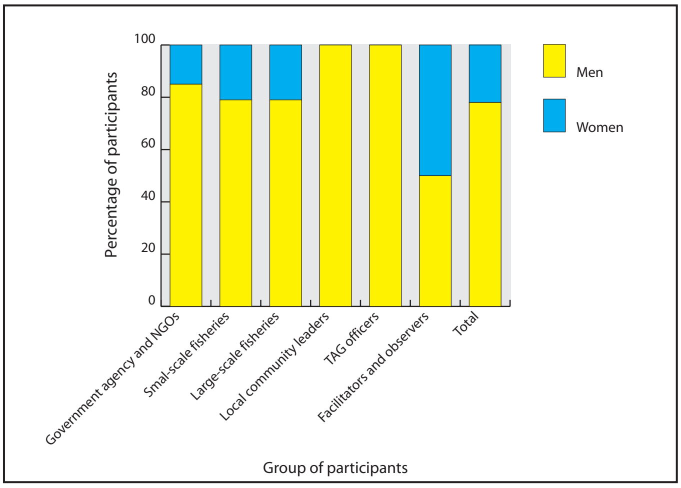

Figure 6. Women's participation in fisheries stakeholder workshop in LSRB

ACCESS STATUS TO TECHNOLOGY AND CONTROL RESOURCES

Due to women have less time available to adjust to take advantage of the growing opportunities, women's time is less flexible because of their reproductive responsibilities (Elson, 1992). This means that most women involved in fishing lack access to tools and credit, a voice in decision making, and opportunities to receive training. Compared to the case of the Lower Sonkhram River

Basin women's access to resources and decision making is less. It is a well established fact that women are not represented in community fishing management committees as well as other issues within the community.

Women's time constraints and their decision making power in the household indicates that a household decision-making is not equally shared. For example, improved technology can increase the catch and benefit the household income. However, it is not clear whether the increased catch would result only in increasing the workloads of women, or would increase women's independent income (Kusakae, 2003).

DISCUSSION AND RECOMMENDATIONS

The role of women in fisheries today, there is little knowledge of women's role in fisheries and of the ways it could be enhanced. In Lower Songkhram River Basin, women are involved in fisheries not only in fish processing and marketing but also they can also catch fish as well as men, when no men in the family or men needs them for assistant. Consistently, in the Nam Ngum Reservoir in Lao PDR both women and men go fishing by motorized boats and use gill nets. Women control the boats, pull nets and get fish from the nets while the men dive. If there is no women control the boats and pull nets, men will hire someone to do the job (Viravongsa, 2000).

Gender may also affect the roles that men and women play in the community. For example, men and women may not have the same participation in patrolling, fishing, or marketing activities, access to decision making as they are differently represented in management organization. It is a fact that there are no women in the group of local community leader and Tambon Administrative Organization officers, which considers the decision making at management level. Consequently, the benefits from different gender roles may differ between men and women.

However, over the years, women involved in fisheries are becoming more visible to policy-makers and the general public alike. In the past most people tended to overlook the fact that women are fully involved in fish processing, marketing and selling aquatic products. Only recently have decision-markers become aware that women actually play a crucial role in the nutrition, health and well being of rural families in the Mekong Basin. Greater recognition by the general public is also emerging. Moreover, women continue to improve the quality of life in rural communities and they want to participate fully in the planning of future development initiatives that will affect them and their families. They especially want to contribute in tandem with men to develop the fisheries of the region. By realizing their potential, society as a whole will benefit

Therefore, in order to increase women's participation in decision making in the community and other organizations should promote the gender mainstreaming in fisheries (Figure 6). For example MRC can provide the opportunity for conducing research activities and exchanging information on women in fisheries among riparian countries by drawing up policies which increase awareness on women in fisheries and exchange information among relevant agencies within and outside the region. With this wider perception and information, the fisheries line agencies can help each respective government to introduce policies for women in fisheries.

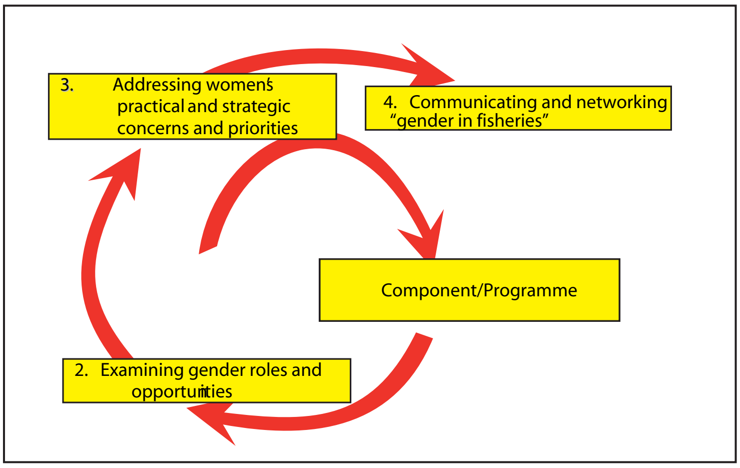

Figure 7. Entry point for gender mainstreaming

These policies can be actualized in programs that meet the needs of women in the fisheries sector, be they in remote rural areas or large-scale commercial enterprises. We need better recognition and enhancement of women's role in the fisheries sector. The examine gender roles and opportunities needs to be analyzed- the recognition of women's labour and knowledge should be monitored. How much of women's work is reported by men? Are women's contribution to fisheries seen as important by other member of the family? How much do men think women know about fisheries and identify the strategic concerns and priorities through the communication and networking gender and women in fisheries?

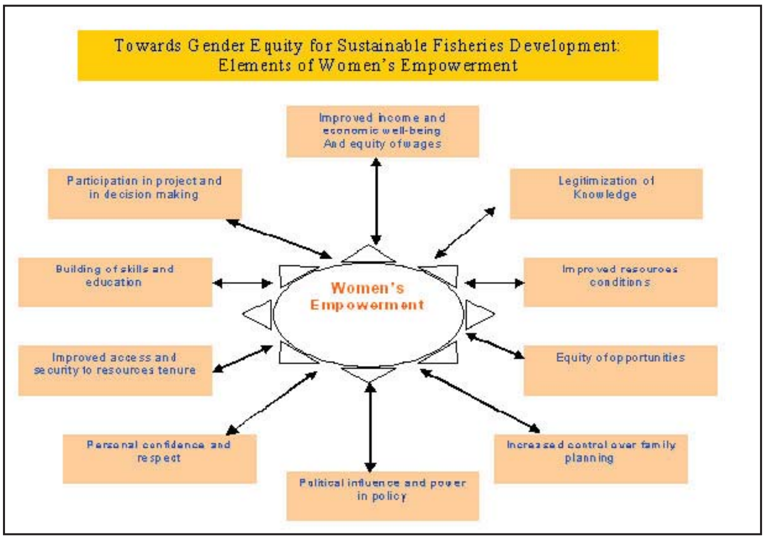

Figure 8. Towards Gender Equity for Sustainable Fisheries Development Elements of Women's Empowerment

However, we must particularly emphasize professional training for women who want to become involved in accounting or management activities. Support should also be directed to women wishing to bring greater added value to fish production and to those wishing to become involved in alternative economic activities whether inside or outside the fisheries sector.

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Fisheries co-management in Lower Songkhram River Basin: problems and challenges

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ABSTRACT

The current crisis in resource management is caused, to some degree, by a lack of legitimacy of management regimes. Legitimacy can be improved by co-management, which has been applied in many countries and it is believed that it could lead to more sustainable fisheries management. Main issues/problems and suggestions relating to fisheries activities in the Lower Songkhram River Basin (LSRB) have been identified during a Stakeholder Workshop on Fisheries management in the LSRB, which was carried out in early August 2005.

LSRB is a part of the Mekong River Basin. It covers 33 districts across four provinces in the Northeast of Thailand: Udonthani, Nong Khai, Sahkon Nakon and Nakon Phanom provinces; with a total area of approximately 3,451 km^2. The LSRB is the most fertile river basin in Thailand, due to a variety of ecosystems with large flood plains. It is the lifeblood of the region, supporting the livelihood of the people within the basin. Most people living in the LSRB are still heavily dependent on natural resources from the basin, as well as fishing activities, which play an important economic role.

The LSRB is a topographically flat basin and due to its flood pulse pattern, experiences heavy flooding. As a result of the geo-physical features of the basin, coupled with its severe seasons of flood and drought, land is mostly unsuitable for general agricultural extension practices.

It would be expected that fishing activities support a great deal of the basins economy. The results from the workshop confirmed that the fisheries sector plays a highly significant role in the LSRB. The fisheries resource has been exceptionally productive and as a result, has been heavily utilized for many decades, the main problems now being faced include illegal fishing, decreasing catch, degradation of habitat and demand from markets . The lack of alternative economic activities has not only been attributed to the exploitation of the fisheries sector, but also the level of poverty in the basin.

Appropriate fisheries management measures are urgently needed to secure the sustainability of the resource. There are numerous suggestions in order to overcome these issues which were provided by participants. For example, laws and legislation should be reviewed and/or revised, occupational opportunities/alternatives should be developed and relevant research is needed to support the formulation of sustainable fisheries management. Nevertheless, this will not work unless implemented in collaboration with all relevant stakeholders, which would be encouraged and supported to reach an integrated, holistic and joint management, leading to sustainable outcomes. How to facilitate these management measures to be more practical will be a major challenge for fisheries management in LSRB.

KEYWORDS: Fisheries co-management, fisheries resources, Songkhram River Basin, problems, challenges, way forward, workshop

INTRODUCTION

Songkhram River Basin is a part of the Mekong River Basin. It covers 33 districts of four provinces in the Northeast of Thailand: Udonthani, Nong Khai, Sahkon Nakon and Nakon Phanom; with a total area of approximately 3,451 km^2 (Khon Khen University, 1997). Songkhram River Basin is considered the most fertile river basin in Thailand due to a variety of ecosystems with large flood plains, particularly from the river mouth to Klam Taka District of Udonthani Province, which stretches over a total of 170 kilometers (Mari et al., 2001)

The Songkhram River is vital, just like an artery in the sense that it provides support to the people's livelihoods throughout the basin. Most people living in the basin are still heavily dependent on the natural resources from the seasonally flooded forest and wild plants, as well as fishing activities that play an important economic role in people's livelihoods. Fishing not only provides and ensures food security for the communities in the basin as the most important single source of animal protein, but also offers important sources of income. The current fishing activity in the Songkhram River is conducted throughout the year. The common fishing gears used in the Songkhram River Basin are gill nets, fish traps, stationary trawl nets, hook, long-line and cast nets. Moreover, some of those are illegal fishing gears, according to the fisheries regulations. Some of these include push nets, big fish traps and stationary trawl nets. The operation of illegal fishing gears would negatively affect the fisheries resources.

Increasing population in the existing socio-economic environment is placing huge pressure on this unstable fisheries resource; a situation that has already occurred in the Lower Songkhram River Basin. Most fishers in the Lower Songkhram River Basin have extensive experience in fishing, and have developed fishing gear to improve its efficiency in catch per unit of effort. However, such modified fishing gears are illegal according to fisheries regulation. In contrast to this, degradation of the seasonally flooded forest is becoming serious due to expansion of land use for agricultural activities, which remain unregulated and unchecked.

The problem related to fisheries resources in the Lower Songkhram River Basin becomes more complicated, while the actual problem in terms of the low compliance of fisheries regulation together with conflict between the government sector and fisher community on illegal fishing are still occurring. In addition, there are several organizations interested in carrying out overlapping activities in terms of different project implementation in the same area without the presence of co-management. Consequently, fisheries resources are declining which will eventually affects people's livelihood.

Therefore, in order to overcome this problem and to improve the fisheries management system, the collaboration from all relevant stakeholders on fisheries co-management is encouraged and supported to reach the integrated and holistic management approach for sustainable development. The stakeholder workshop on fisheries co-management will be held in order to facilitate the joint fisheries management process between users and government agencies. In addition, these workshops are aimed at implementing management strategies, which remain unclear, and will attempt to identify possible solutions by involving users and other stakeholders in fisheries management.

OBJECTIVES

1. To identify main issues/problems related to the fisheries sector
2. To identify possible solutions to solve fisheries management problems
3. To identify and analyze existing institutions and processes that could lead to effective co-management systems

METHODOLOGY

All data was obtained from the stakeholder workshop on fisheries management in the Lower Songkhram River Basin, which was held at the Mekong River Grand View Hotel**,** Nakon Phanom Province from August 1 to 3 2005. The objectives of the workshop were:

1. To discuss the results of research related to fisheries management in the Lower Songkhram River Basin
2. To identify main issues regarding the problems/constraints of fisheries management
3. To provide suggestions and recommendations on possible solutions to the problems of fisheries management
4. To ascertain alternative occupations in non-fisheries practices
5. To provide guidelines on research necessary to fisheries management in the Lower Songkhram River Basin.

A total of 86 participants were divided into 5 stakeholder groups. These were a) Government Agencies and Non-Government Organisations; b) Small-scale fishers; c) Large-scale fishers; d) Local community leaders; and e) Tambon Administrative Organisation (TAO). Representatives from International Organisations, Department of Fisheries and others participated as observers. Workshop activities included a brief presentation related to fisheries management in the LSRB, group discussion on the main problems and identification of strategies to solve these problems.

RESULTS

The main issues raised at the workshop can be summarised as follows:

- Fisheries sector is considered as a highly significant issue in the Lower Songkhram River Basin as a major source of income and livelihoods for its inhabitants. The resource has been exceptionally productive and heavily utilised for many decades. Appropriate fisheries management measures are urgently needed to secure the sustainability of the resource.

- The characteristic of the Lower Songkhram River Basin, however, may not be physically appropriate for agricultural practices mainly due to the flood pulse pattern in the basin. General agricultural extension practices in the basin are, therefore, unsuitable due to natural flood and drought conditions.
- Household income of most small-scale fishers is under the poverty line. Their livelihoods are in poor condition, education of young children is not favoured, and occupation alternatives are currently scarce.
- Fisheries legislation understanding of local communities is limited. Some poor fishers performed illegal fishing activities because they had no better occupational alternatives. Some fishers ignored fisheries laws and regulations these were seen to limit profits.
- Illegal fishing practices generally found in the basin are mostly large-scale fishing gears, electro-fishing, fishing with explosives and poisoning. These activities, as well as over-fishing, have led to degraded fisheries resources in the basin.
- The fishing grounds and habitats, particularly flooded-forest, are reduced and deteriorated due to illegal encroachment. Clear boundary and management measures should be identified in order to conserve these critical areas.
- Fisheries information in the basin is deficient and outdated. Present communication channels are unsuitable and ineffective. Conflicts among fisheries beneficiaries were evident.
- Coordination and cooperation among parties concerned are inadequate. Integrated planning approach was recently introduced without being fully implemented. Communications among fishery officers, local fishers, local administration staff and others is insufficient, partly due to limited man-power and budget.
- Marketing of fisheries products in the basin is uncertain due to seasonal fluctuation of fish production, product quality and quantity, price negotiation power, etc.

Suggestions and recommendations related to fisheries activities provided by participants can be summarised as follows:

- Fisheries laws and legislations should be reviewed and/or revised (if appropriate) to reduce conflicts of fisheries resource utilisation in the basin. Effective communication on fisheries laws and legislation should be strengthened accordingly to ensure full understanding and compliance with laws and legislations of local communities and parties concerned.
- Sustainable fisheries resources management measures should be formulated with full participation of stakeholders concerned. Gender issue should be fully considered. The

formulation should integrate all scientific, social, economic and local knowledge/information.

Occupation opportunities and alternatives should be developed. Due to various constraints in the basin, the appropriate occupation opportunities and alternatives should focus on:

- Non-agricultural practices, such as small-scale entrepreneurs, handicrafts, cottage industry, etc.
- Services, such as beauty salon, repair and maintenance, tailor, etc.
- Value-added activities, such as food processing and preservation, packaging, etc.
- Eco-tourism on fisheries activities, flooded-forest ecosystem, etc.
- Aquaculture, such as cage culture of indigenous species, breeding and nursing of indigenous species, etc.

However, in the case of the Songkhram River Basin, the relevant research and activities needed to support the Lower Songkhram River Basin sustainable fisheries management measures need to be formulated.. Therefore, identification of guidelines required for fisheries management was prepared during the workshop. The results showed that the relevant research for fisheries management should include:

1. Fisheries laws and legislations as tools for conflict resolution.
2. Assessment of fisheries resources in the Lower Songkhram River Basin.
3. Fisheries related occupation development.
4. Flooded-forest ecosystem rehabilitation and conservation.
5. Fisheries marketing system and marketing channel development.
6. Sustainable fisheries resources and co-management process enhancement.
7. Fisheries information and communication system improvement.

CONCLUSIONS

The current problem related to fisheries resources in the Lower Songkhram River Basin is (Figure 1). Therefore, in order to overcome the problems there needs to be a co-management approach. The key-findings from the stakeholder workshop on fisheries management in the LSRB are used to guide further implementation of the "Project for the Sustainable Fisheries Management in the Lower Songkhram River Basin". However, the stakeholder workshop on fisheries management is an initial step in cooperative management; it needs support from all interested parties to sustain this participatory process in fisheries management measures, not only in the Lower Songkhram River Basin, but also in all basins within the region.

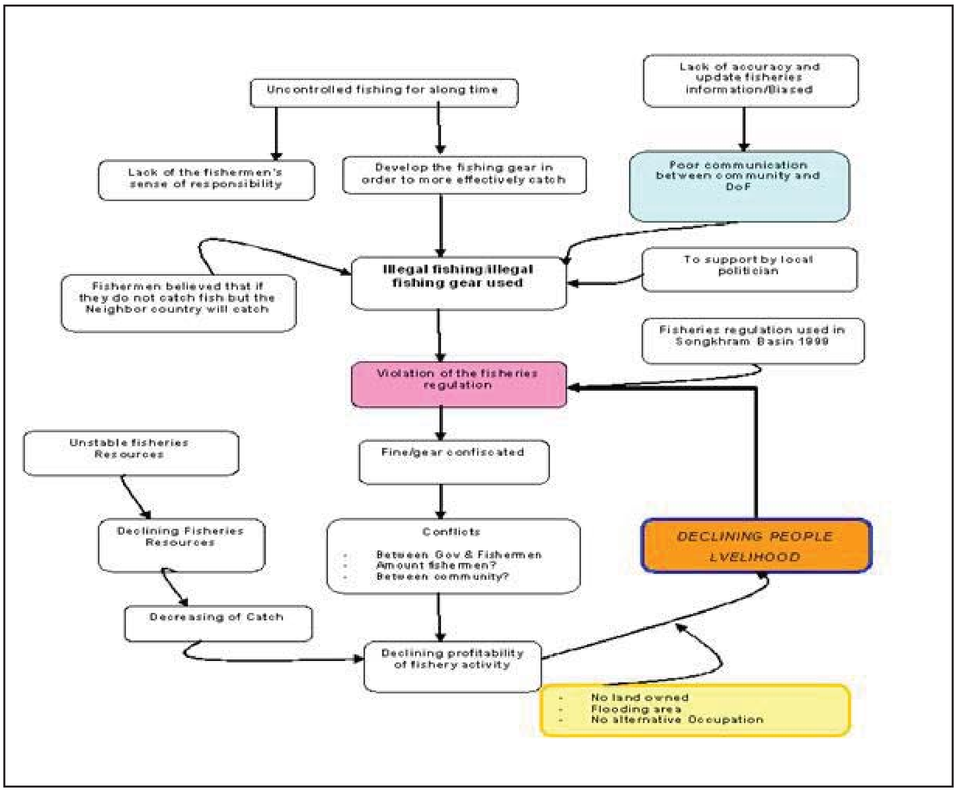

Figure 1. Problem statements in the Songkhram River Basin

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Strengthening co-management of water resources for rice-shrimp farming in Soc Trang Province—Viet Nam

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ABSTRACT

A project aimed at strengthening co-management of water resources for rice-shrimp farming in Soc Trang province, Viet Nam has been in operation for almost two years and will be finalised by the end of 2005. The immediate objective of this project is 'Aquatic resource stakeholders (rice-shrimp farmers and staff from concerned government organisations) focus on communal issues and apply participatory mechanisms in the management of rice-shrimp culture in Hoa Tu 1 Commune, My Xuyen district'. Three outputs were identified in order to achieve the immediate objective: 1) A structure for the participatory preparation and implementation of management plans is developed, tested, and strengthened for selected farmers' organisations and functioning; 2) The management capacity of all participating organisations and resource users is developed and strengthened; 3) A network for communication between all crucial stakeholders is established and functioning.

The results of surveys to assess the progress of strengthening co-management are presented. Surveys were conducted to assess the application of good shrimp culture techniques by farmers, the status of co-management between local government and farmers' groups, the progress of collaboration between farmers in terms of environment management, how farmers share their knowledge and experience of shrimp culture, and the status of household debt in 2005.

The results from interviews with farmers showed that farmers who applied good techniques in pond preparation, shrimp seed checking and pond care made more profit. Interviews with stakeholders from the local government and farmers' groups and with individual farmers showed that collaboration in management was strengthened during the project as shown by an improved understanding of the club/co-operative plans and training courses improved level of compliance with local government regulations, and improved responsiveness from organisation executives and commune authorities. Farmers preferred to use face-to-face communication when sharing their knowledge and experiences of shrimp culture. Household debt increased overall during the project, although farmer incomes also increased.

The project has seen an improvement in communication between stakeholders and a more formal structure for co-management has been implemented in Hoa Tu 1 Commune.

KEY WORDS: Co-management; Rice-shrimp farming; Viet Nam

INTRODUCTION

My Xuyen District is in the coastal province of Soc Trang, in the Mekong Delta. The proximity of this district to the ocean and the tropical monsoon climate results in the area being seasonally inundated with brackish water during the dry season and fresh water during the wet season. For over 10 years farmers in My Xuyen district have undertaken shrimp farming in the dry season when the water is too saline to grow rice. The high value of shrimp and this additional means of agricultural income has resulted in higher household incomes and reduced poverty for farmers who have successfully applied this system. However, rapid development and a tendency to replace rice with

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a second shrimp crop have resulted in changes in water usage patterns and other farming practices. Conflicts over water use have increased and shrimp farming has affected water quality throughout the district.

Farmers' organisations are being established in My Xuyen District; however, their effectiveness is so far variable and limited. Farmers had previously worked individually with little consultation with neighbours in respect to intake and discharge of pond water and disease management. This has resulted in problems in communal water usage such as the pumping of mud and diseased water into canals, which adversely affects farmers who intake water downstream. The need for communication and co-management of water resources is therefore apparent.

The shift in reliance on shrimp culture as the main source of income and the high initial outlay means that crop failure as a result of disease or pond condition results in high debt and increased poverty. This reinforces the need for education in sustainable farming practices and co-management of water resources.

In late 2003, a project aimed at strengthening co-management of water resources for rice-shrimp farming in Soc Trang Province was initiated with funding from the Management of River and Reservoir Fisheries component of the Mekong River Commission. The project has been in operation for two years and will be finalised by the end of 2005.

Objectives and outputs

The development objective of this project is:

> *'Co-ordinated and participatory management by aquatic resource managers contributes to improved household productivity and economics from rice/shrimp culture in Soc Trang Province.'*

The immediate objective of this project is:

> *'Aquatic resource stakeholders (rice-shrimp farmers and staff from concerned government organisations) focus on communal issues and apply participatory mechanisms in the management of rice-shrimp culture in Hoa Tu 1 Commune, My Xuyen district'.*

Three outputs were identified in order to achieve the immediate objective:

1. A structure for the participatory preparation and implementation of management plans is developed, tested, and strengthened for selected farmers' organisations and functioning;

2. The management capacity of all participating organisations and resource users is developed and strengthened;

3. A network for communication between all crucial stakeholders is established and functioning.

It is hoped that the achievement of these three outputs will lead to an improvement in co-management structures and mechanisms, resource sharing and household economics. This is illustrated in Figure 1.

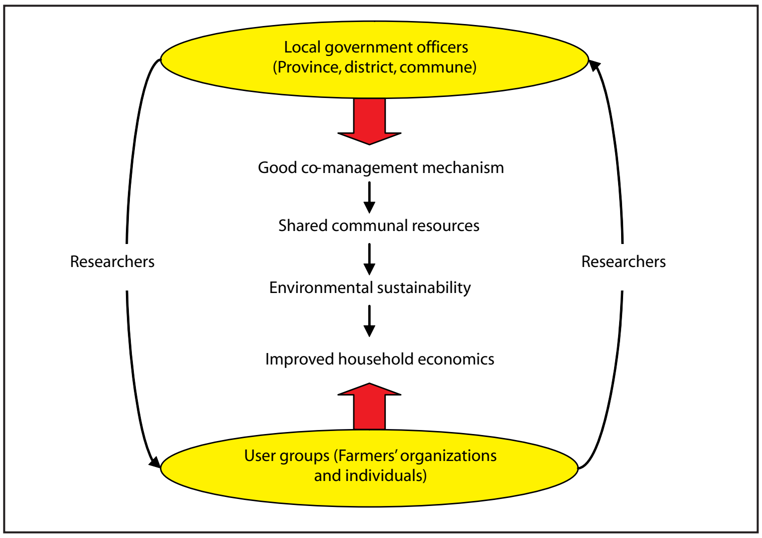

Figure 1. Strengthening co-management of water resources in Soc Trang Province

Study area

Hoa Tu 1 commune in My Xuyen District (Figure 2) was selected as the focal commune for this project. The commune is located at the centre of rice/shrimp farming in My Xuyen District and experiences the same climatic conditions as the entire district with a brackish intrusion during the dry season and freshwater conditions during the wet season.

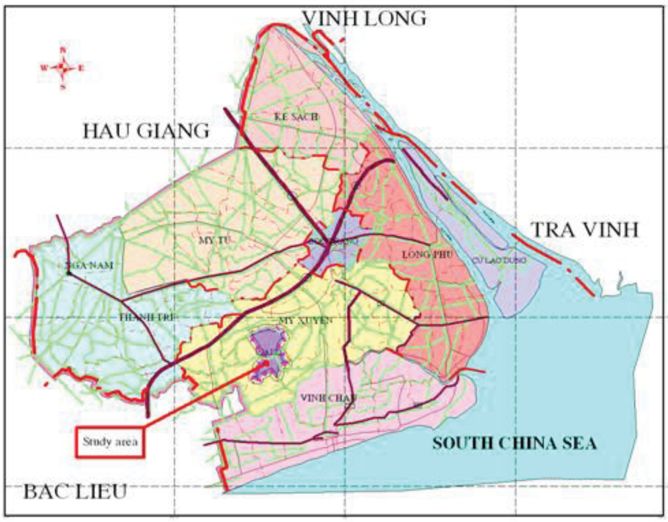

Figure 2. Location of Hoa Tu 1 commune in the lower Mekong Delta

Basic co-management structures, for example farmer's clubs and co-operatives already existed within this commune. However many of these were very weak. Hoa Tu 1 Commune was chosen as a suitable case study for capacity building for farmers through these existing groups and acting as a model for improved co-management of resources in a rice/shrimp culture region of the Mekong Delta. Two farmers' organisations: Club 4 in Hoa Truc and Phu Loi Co-operative in Hoa Trung, were selected as focal farmers' organisations for this project.

METHODS OF DATA COLLECTION

Data for assessment were collected from three sources during the project:

1. Existing information in the form of reports and regulations was collected from local government officers at the province, district and commune level;
2. Reports prepared by project staff during the monthly farmers' organisation meetings; and
3. Questionnaires based on project outputs collected at various stages of the project. Results from these questionnaires provide valuable information on the progress of the project and the status of participatory management in the project site. Methods for these questionnaires are outlined below in this document.

The information collected from these sources was used to plan, implement and review project activities.

Baseline survey

In May 2004, a baseline survey was carried out prior to the implementation of the project to report on the status of collaboration between local government, farmer's organisations and individual farmers, as well as household debt and shrimp culture performance. A total of 74 rice/shrimp farmers were interviewed comprising 23 from Club 4, 31 from Phu Loi Co-operative and 20 from outside either of the farmers' organisations. The data were analysed using MS Excel and the results are presented in Nguyen Minh Nien *et. al.* (2004).

Monitoring surveys

In April and October to November 2005, monitoring surveys were carried out to assess the progress of collaboration between local government, farmers' organisations and individual farmers as well as the progress of the project against its indicators. A total of 71 rice/shrimp farmers were interviewed during the April survey comprising 23 from Club 4, 31 from Phu Loi Co-operative and 17 from outside either of the farmers' organisations. A total of 79 farmers were interviewed during the October survey comprising 24 from Club 4, 25 from Phu Loi Co-operative and 30 from outside either of the farmers' organisations. The data from these surveys was analysed using MS Excel and the results from the April survey are presented in Sollows (2005).

Technical evaluation survey

In September 2005, a technical evaluation survey was carried out to investigate the links between shrimp culture performance (including shrimp yield, profit and debt) with the implementation of good shrimp culture techniques and co-management of water resources. A total of 89 farmers were interviewed comprising 24 from Club 4, 29 from Phu Loi Co-operative and 36 from outside either of the farmers' organisations. The data were analysed using MS Excel and divided into those farmers who made a profit, those that broke even and those that lost money.

PROJECT IMPLEMENTATION METHODS

Output one

> *'A structure for the participatory preparation and implementation of management plans is developed, tested, and strengthened for selected farmers' organisations and functioning.'*

Participatory Structures

A structure for management of water resources in Hoa Tu 1 commune already existed prior to the implementation of this project, however there was a need to build upon and strengthen the existing mechanisms and to focus on participatory structures. As such, Club 4 and Phu Loi Co-operative were divided into four subgroups each for easier management. Each subgroup elected a Head who would be responsible for management of the subgroup group and liaison with the Heads of the other subgroups. It was arranged that the Heads of the subgroups would meet on a weekly basis and Club 4and Phu Loi Co-operative would meet monthly.

Farmers manage their own operations, guided by decisions and regulations of the farmers' organisation. The organisations co-ordinate the efforts of their members, make joint plans, decisions and regulations, and communicate with the Commune office. The Commune communicates regulations, environmental information, and other advice to the farmers' groups, gives some support to enforcement, and provides higher levels of government with feedback. The District level provides advice, training, and in some cases, material inputs. The Provincial level regulates, enforces, and supports training efforts. All levels of government develop plans. Project staff from the Research Insitute for Aquaculture No. 2 (RIA 2) provide and organise training, assist the farmers' groups in developing their plans and structures, and liase with all other stakeholders on issues affecting the participating farmers' organisations. The Project has also contracted one staff at the commune level to monitor and support the activities of the farmers' organisations.

Club/Co-operative plans

During the monthly meetings of Club 4 and the Phu Loi Co-operative members developed monthly plans, which guided the Club/Co-operative activities. These plans were evaluated and reviewed during the next monthly meeting. Issues about water quality management, disease management, training needs and communication networks were discussed during the meetings and activities were planned for the next month if necessary. Club 4 and the Phu Loi Co-operative also held annual reviews of the effectiveness of their plans and activities.

Notebooks and logbooks were provided to farmers to help them record monthly meeting information and water quality monitoring information. This assisted the farmers to share and discuss shrimp technique information and review their plans with each other.

RIA 2 staff and local officers of Hoa Tu 1 commune frequently attended the monthly and annual meetings to provide a facilitation role and assist in discussions on the development, implementation and review of the organisation plans.

Training needs

Training needs of local government staff, farmers' organisations and individual farmers were identified in training needs assessments, which were conducted periodically. RIA 2 organised the following training activities:

- training in shrimp culture techniques for all members of Club 4 and the Phu Loi Co-operative;
- on-site follow-up training for individual farmers on shrimp culture techniques;
- training in low-cost water quality monitoring and management for commune officers and target organisations;
- training in other livelihoods for all members of Club 4, Phui Loi Cooperative and farmers outside these clubs;
- training in post-larvae checking for all members of Club 4 and Phu Loi Cooperative;
- training in rice-fish culture and pond fish culture for all members of Club 4 and Phu Loi Cooperative.

In addition, low-cost water quality monitoring equipment was provided to each subgroup.

Output two

> *'The management capacity of all participating organisations and resource users is developed and strengthened.'*

RIA 2 organised the following training activities in respect to management capacity of all participating organisations and resource users:

- Training in organisation skills for the Chair of all clubs in Hoa Tu 1 commune and other co-ordinated organisations, particularly for all executives of Phu Loi Co-operative and Club 4.
- Training in financial management for all members of Club 4, Phu Loi Co-operative and farmers outside these clubs.

The training courses listed in Section 3.1 also contribute towards improved management capacity. Good shrimp farm management should lead to fewer economic problems and increased ability to focus on communal issues.

Output three

> *'A network for communication between all crucial stakeholders is established and functioning.'*

As stated above a communication network already existed in Hoa Tu 1 commune. However this network needed strengthening at three levels including the farmers' organisation level, commune level and district/provincial level.

Each participating farmers' organisation was divided into four subgroups. This improved communications within each organisation. A set of loud speakers was provided to each subgroup to help the members in each subgroup easily to communicate each other to announce environmental issues as well as meetings.

At the commune level, the commune office has monthly meetings to discuss and plan, and to pass along new regulations to the heads of villages and clubs. The project has supplemented this with a number of relevant training courses, of which courses on fisheries regulations, financial management, and livelihood alternatives have already been given. Training courses in disease management and environmental issues/water management are also proposed at the commune level.

A contract for one collaborator (Chairman of Hoa Tu 1 commune) was signed to monitor and support project activities.

The commune is affected by conditions outside its boundaries, and communications with authorities at district and province level exist. The My Xuyen Fisheries Extension Officer and Vice Head of the My Xuyen Agriculture and Rural Development Office have supported and given advice on project activities.

RESULTS AND DISCUSSION

Development objective and factors affecting success in shrimp culture

The development objective of this project is:

> *'Co-ordinated and participatory management by aquatic resource managers contributes to improved household productivity and economics from rice/shrimp culture in Soc Trang Province.'*

The premise of this project is that if co-management of aquatic resources is strengthened including participatory institutional structures, management capacity of all stakeholders and communication networks then this will lead to better management of communal resources and an improvement in household economics (previously illustrated in Figure 1).

Figures for 2005 are not yet final, but between 2003 and 2005 mean shrimp yields increased in both participating farmers' groups (Figure 3), although the increase in 2005 appears very slight in Phu Loi Co-operative. Four Co-operative farmers who were very successful in 2004 reported much lower yields in 2005.

Net income from shrimp increased steadily in Club 4, but dropped in Phu Loi Co-operative (Figure 4). In 2004, many Co-operative members dug ponds and in 2005, shrimp selling prices were low, particularly for Co-operative farmers. Still, compared to the control group, incomes appeared more stable.

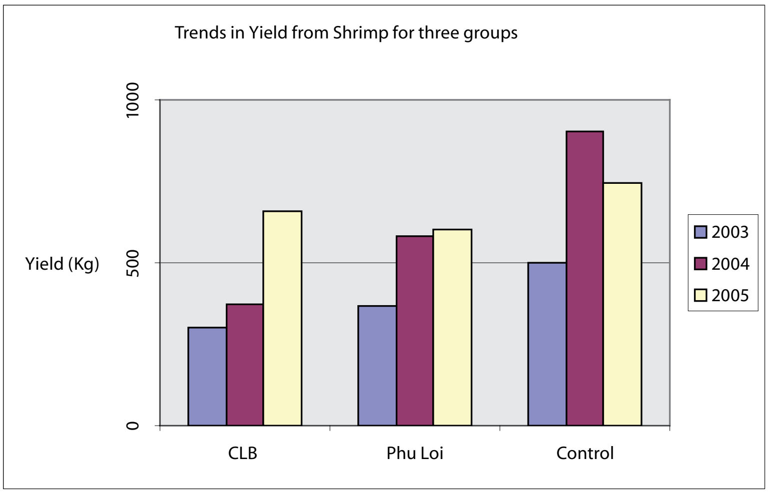

Figure 3. Mean shrimp yield per household.

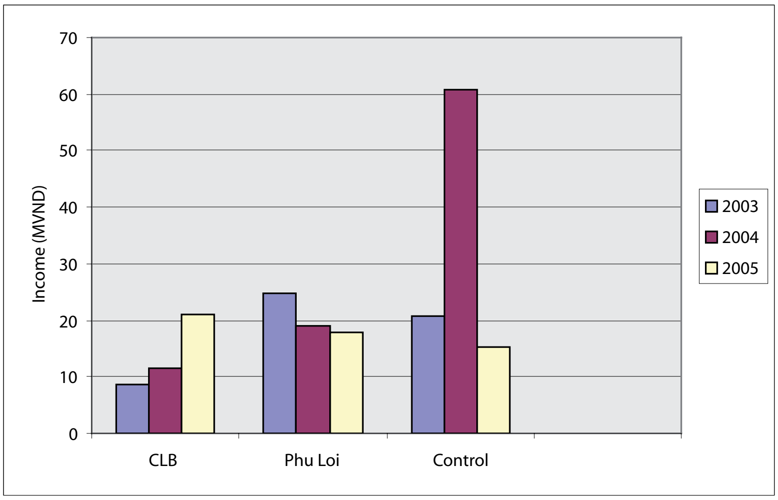

Figure 4. Mean net household income from shrimp farming

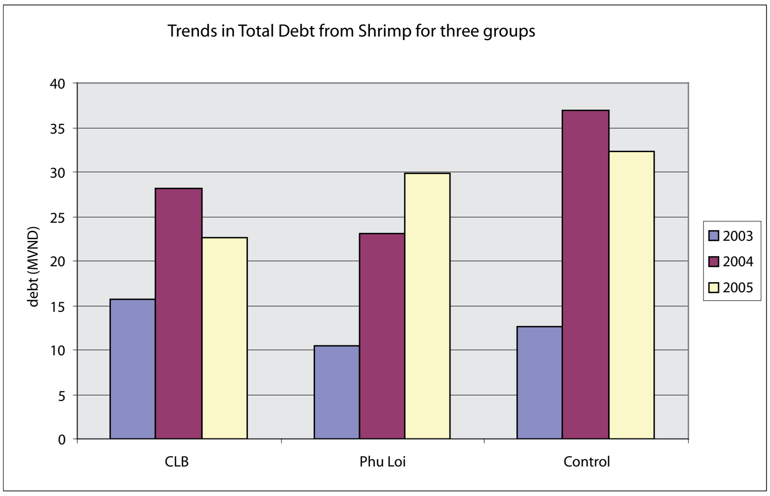

Figure 5. Mean household debt during 2003, 2004 and 2005.

Credit was not easily available in 2005, so household debt (Figure 5) peaked in 2004, except in Phu Loi Co-operative, where a couple of successful farmers took out sizeable loans this year and have not yet repaid their debts. Most farmers this year were able to pay their interest charges, and a few made payments against their principal. However, immediate needs usually take priority. Many farmers need money for family expenses and for maintaining shrimp culture operations, and some farmers have difficulty making long-term plans. Otherwise, between 2004 and 2005, income increased more rapidly than debt in Club 4 but not in Phu Loi Co-operative nor in the control group.

The number of debt-free households in Club 4 increased from 2 to 5, or from 8.3 to 20.8 per cent of the membership. While data are missing for a few farmers in Phu Loi Co-operative, at least two more farmers took out loans in 2005, and the percentage of debt-fee farmers has dropped from 28 per cent to an estimated 20 per cent. Similarly, in the control group, the percentage of debt-free farmers dropped from about 24 per cent to an estimated 20 per cent.

The project has not yet reached its development objective, but the news from Club 4 is very encouraging.

Success in shrimp culture is influenced by many factors, and cannot be guaranteed. However, a technical evaluation survey indicated a few ways in which farmers could increase the likelihood of success. In general farmers who made a profit tended to stock at lower densities (Figure 6).

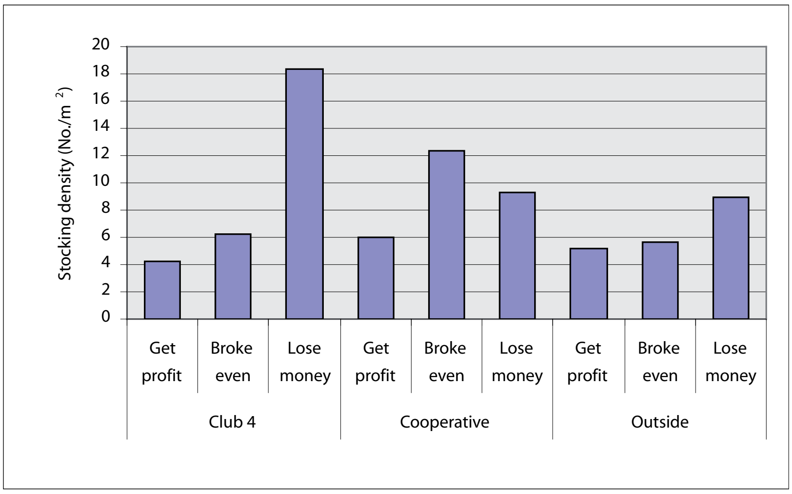

Figure 6. Densities of shrimp stocked.

Farmers who made profits in Club 4 and Phu Loi Co-operative tended to have more family members involved in shrimp operations and to culture larger areas, but this trend was not reflected by outside farmers. However, the number of outside farmers who broke even or who failed was very small.

Most farmers who made a profit had a reservoir to hold water prior to letting it into the culture pond (Figure 7). Most farmers who lost money did not.

Similarly, farmers who lost money were more likely to use the same channel for water drainage and intake; successful farmers more often had separate channels (Figure 8).

Getting information on water quality prior to intake is also advisable (Figure 9).

Farmers who got information could still lose money, but not getting information before intake increases the chances of loss.

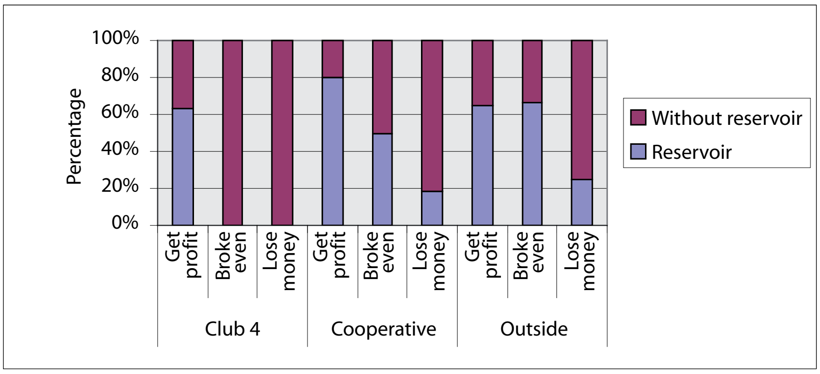

Figure 7. Use of a holding reservoir

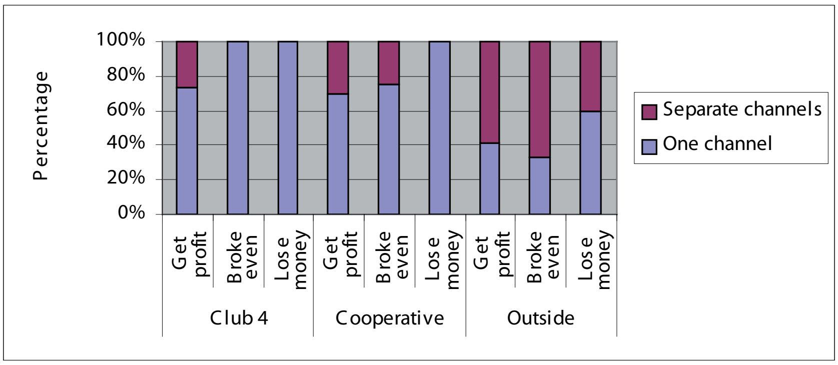

Figure 8. Separation of intake and drainage channels

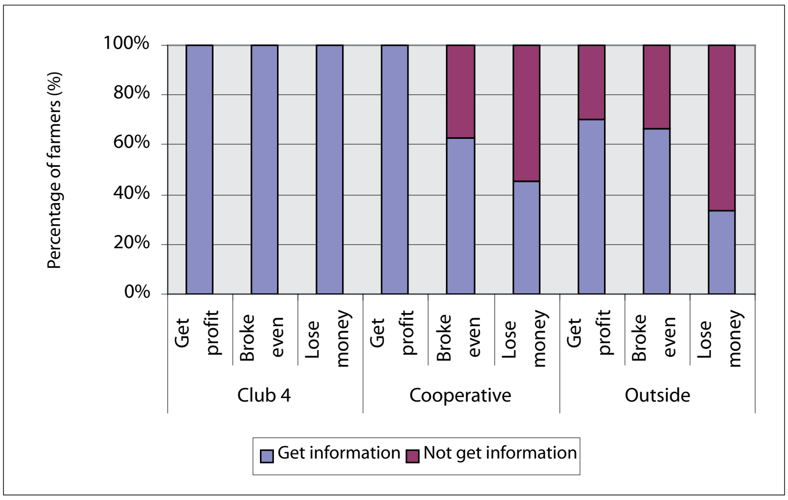

Figure 9. Information on water quality prior to intake.

A good technique in *shrimp seed checking* is to employ a variety of methods including microscope checks, chemical checks, visual observation and recommendations from the seller (Figure 10). The more types of post-larvae checking methods used the better.

Most outside farmers did not check their post-larvae. Many succeeded in spite of this, but it is prudent to take precautions.

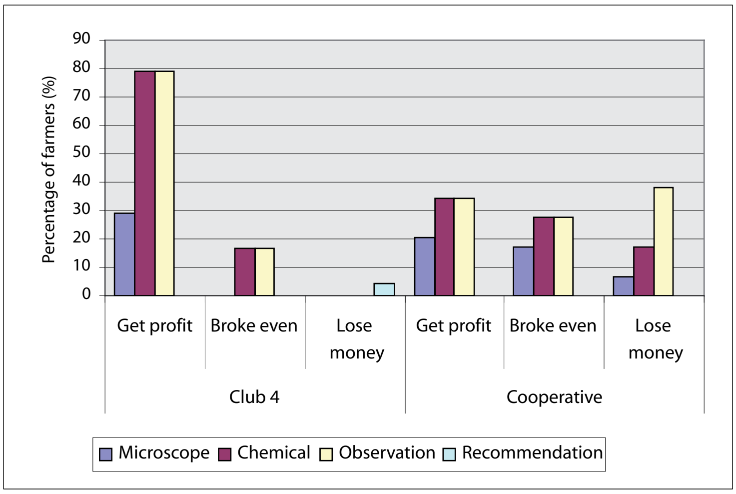

Figure 10. Percentage of farmers that applied a variety of shrimp seed checking methods.

Notwithstanding the occurrence of shrimp disease, data collected during the technical evaluation survey reveals that households that made a profit had, to a greater extent, applied good techniques in pond preparation, shrimp seed checking and pond care. Alone, no one technique will ensure a successful shrimp crop, application of several good techniques in pond preparation, seed checking and pond care may lead to higher shrimp yields.

Immediate objective

The immediate objective of this project is:

> *'Aquatic resources stakeholders (rice-shrimp farmers and staff from concerned government organizations) focus on communal issues and apply participatory mechanisms in the management of rice-shrimp culture in Hoa Tu 1 Commune, My Xuyen District.'*

The commune has already established a network at its level with monthly meetings of village, club, and co-operative heads. The work of the project is to strengthen this. With the agreement of the Commune and the two participating farmers' organizations, Club 4 and Phu Loi Co-operative were divided into four sub-groups from an existing two, and project staff have been working closely with these subgroups.

The performance of this network, particularly at the Commune level, is assessed in detail under Output 3. Between the Commune and higher levels, more work remains to be done, and is likely to be a focus of the work in Phase II.

In general, farmers reported increased satisfaction with responses of their leaders to the concerns they raise, although the improvement among outside farmers was very slight. Both inside participating organizations and at the Commune level, there is plenty of room for improvement in two-way communication.

Problems from beyond the farms of club and cooperative members remain a problem. If this initiative is to succeed, efforts are needed commune-wide to increase awareness of the need for sound environmental management and sustainable farming practices. Since pollution can come from outside the commune, enhancement of communications beyond the commune level also appears needed.

Farmers' groups also developed schedules for pond preparation, stocking, and harvest, designated communications channels within their organisations, and issues regulations banning pumping of mud into waterways and unnecessary use of chemicals.

Output one

> *'A structure for the participatory preparation and implementation of management plans is developed, tested, and strengthened for selected farmers' organizations and functioning'*

The structure for participatory planning and management was strengthened during the project. The division of Club 4 and the Phu Loi Co-operative into smaller subgroups meant that communication was easier between individual farmers and between the two farmers' organisations. Monthly plans reflected the concerns of the farmers and were adapted to include relevant issues. Participating farmers reported an improved understanding of the Club and Co-operative plans and training as compared to outside farmers, indicating that the project has had an effect here. (Table 1).

Table 1. *Percentage of farmers with an improved understanding of the plan and training course.*

Farmers' organisation	Farmers with improved understanding of plan	Farmers with improved understanding of training
Club 4	75%	92%
Phu Loi Cooperative	81%	94%
Outside farmers' organisation	30%	73%

In respect to co-management of water resources, farmers previously worked individually with little consultation with neighbours in respect to intake and discharge of pond water and disease management. This resulted in problems in communal water usage such as the pumping of mud and diseased water into canals, which adversely affected farmers who intake water downstream.

It is believed that the improved participatory management structure implemented, training and communication network through this project has resulted in better communication between farmers and better co-management of communal water resources. The results from the monitoring surveys indicate that when farmers experienced shrimp disease they prefer to discuss the problem with their neighbours rather than deal with it by themselves (Table 2).

Table 2. *Method of dealing with shrimp disease problems*

Method	Percentage of farmers from Club 4	Percentage of Farmers from Phu Loi Cooperative
Discuss with neighbours	70%	57%
Do it themselves	30%	39%
Discuss at monthly meeting	0%	4%

Most farmers within Club 4 (81 per cent) and the Phu Loi Co-operative (91 per cent) made announcements when they were pumping water from their ponds into the canals. This has important implications for limiting the spread of shrimp disease.

Most farmers within Club 4 (88 per cent) and the Phu Loi Co-operative (67 per cent) stated that they shared their experiences of shrimp culture including, shrimp disease stock and shrimp status, water quality and food with their neighbours. The most important method of sharing experiences was informal: on the farm often while working or over drinking tea followed by discussions during the monthly meetings (Table 3). This has important implications for communications with farmers that are further away. Communications with outside farmers is needed, if problems are to be minimised effectively. Arranging opportunities for different farmers' groups to meet and discuss is advisable.

Table 3. *Method of sharing experience of shrimp culture.*

Method of discussion	Percentage of farmers from Club 4	Percentage of farmers from Phu Loi Cooperative
On the farm while working or drinking tea	62%	69%
During monthly meetings	19%	6%
During monthly meetings and on the farm while working or drinking tea	14%	19%
Discussion with more experienced farmers	5%	0%
During monthly meetings and discussion with more experienced farmers	0%	6%

Another indicator used for this output was attendance at meetings (Table 4).

Table 4. *Attendance at monthly meetings*

Method of discussion	Percentage of farmers from Club 4	Percentage of farmers from Phu Loi Cooperative
On the farm while working or drinking tea	62%	69%
During monthly meetings	19%	6%
During monthly meetings and on the farm while working or drinking tea	14%	19%
Discussion with more experienced farmers	5%	0%
During monthly meetings and discussion with more experienced farmers	0%	6%

Attendance has dropped off in recent months. The most recent months reported are in the off-season for shrimp, but more effort in encouraging attendance may also be needed.

Output two

> *'The management capacity of all participating organizations and resource users is developed and strengthened'*

As stated above, farmers reported an increased understanding of the plan and training courses, which has resulted in increased management capacity of farmers. Most farmers within Club 4 (65 per cent) and the Phu Loi Co-operative (87 per cent) reported that their compliance with the plans had improved. Only 50 per cent of farmers outside these farmers' organisations reported an improvement in plan compliance. In respect to regulations, almost all of the farmers within Club 4 (92 per cent) and all of the farmers within the Phu Loi Co-operative stated that they followed at least one regulation. The most common regulation followed by farmers was the shrimp stocking time followed by the regulation about not pumping mud into the canal.

Six of the Club 4 members and six from Phu Loi Co-operative indicated difficulties in following the set schedule for stocking. When everyone stocks at the same time, post-larvae prices can be high, and because of the high demand, quality may be low. Environmental conditions in some ponds may not be ideal for stocking on the set day. Finally, stocking at the same time leads to harvesting at the same time, so a low selling price results.

Eleven outside farmers, or 45 per cent of those who responded to the question, made the same comment.

Uncoordinated stocking can lead to chronic disease problems, but a solution to this problem is needed.

Most farmers within Club 4 (88 per cent) and the Phu Loi Co-operative (83 per cent) checked the quality (primarily pH, NH_3 and salinity) of source water prior to taking it into their ponds, which indicates an understanding of the importance of water quality to shrimp culture and of the techniques in monitoring water quality.

Management capacity of farmers is further demonstrated by the information on pond preparation, seed checking and pond care, which is outlined above. This information also concludes that farmers that applied good techniques made more profit.

Increased management capacity may also be reflected by level of material well-being among participating farmers. Hence, 75 per cent of the Club 4 members, and two-thirds (15/24) of the farmers from Phu Loi Co-operative reported higher shrimp yields in 2005, relative to 2004. In terms of total family income, seventeen farmers in Club 4 (71 per cent of the total) and eleven of twenty-five (44 per cent of the total) in Phu Loi Co-operative reported increased total income in 2005, compared to 2004.

Output three

Local government staff at the province, district and commune level, farmers' organisations and individual farmers were involved in the planning and decision making processes. It is believed that this has led to an improvement in communication among all levels. Farmers reported improved satisfaction with the responses of commune leaders to their concerns. There was also a reduction in the incidences of external undesirable practices reported by farmers with Club 4 and the Phu Loi Co-operative (75 per cent and 50 per cent of farmers reporting a reduction in incidences from 2004, respectively). Most of the problems noted in the co-operative were the result of increased turbidity due to construction of the Thanh My Canal, and are expected to be temporary. Two to three farmers in each group also indicated that uncontrolled drainage and pumping of mud remain problems.

Seventy-one percent of outside farmers reported more frequent communications from the commune. However, there was still more room for improvement with response to farmers' concerns. Only 28 per cent of the outside farmers interviewed indicated an improvement in satisfaction with responses to their concerns, in contrast to 77 per cent from Club 4 and 50 per cent from Phu Loi Co-operative. On the positive side, no farmer indicated a worsening of responsiveness.

In Club 4, 65 per cent of the respondents were aware of initiatives the Commune has taken to improve the situation of farmers in the commune, as were 47 per cent of the respondents in Phu Loi Co-operative. Among outside farmers, 55 per cent indicated similar awareness. Initiatives mentioned included provision of cattle to poor farmers, improved enforcement against polluters, provision of technical training, facilitating access to loans, and in Club 4 and Phu Loi Co-operative, increased participation in meetings of the two organisations.

Commune officials indicate that more support is needed from district and provincial levels to assure the health of farmers' organisations.

CONCLUSIONS AND RECOMMENDATIONS

A structure for participatory management of water resources in Hoa Tu 1 commune was strengthened during the project, but the job is not complete, particularly in Phu Loi Co-operative. Formal co-management mechanisms including the formation of subgroups, regular meetings and planned activities have been implemented and stakeholders provided with training to ensure that they have the capacity to work together. The results show that communication networks have improved. However there is still much room for improvement particularly at the commune level and above.

Co-management takes time and patience on all sides. Disappointments and unwanted surprises are a normal part of the process. Despite this, all concerned must keep in mind the need to work together. Shrimp farmers in My Xuyen District unavoidably affect one another. Governments at various levels realise the need to assist farmers in co-ordinating and controlling activities in order to assure environmental health and sustainable livelihoods for all. Co-management is recognised on all sides as essential; the big question is not 'if,' but 'how?'

Similarly, two years has not been long enough to complete the job we set for ourselves at the beginning of the project. Results from Club 4 are very promising, but more work is needed there, and considerably more with Phu Loi Co-operative, as well as at the commune level.

Good, frequent communications among all stakeholders is essential to success. Hence, project staff need to try to understand the perspectives and circumstances of participating farmers and of their colleagues. The greater this level of mutual understanding, the better equipped all will be to address problems and issues effectively.

Training and organising events need supportive follow-up if they are to be effective. Farmers have identified this need repeatedly. Many identified repeated visits as crucial to the effectiveness of the shrimp culture courses given in 2005, and members of failing organisations identified the lack of follow-up as an important factor in their decline.

Monitoring should be used, not only to assess the progress of the project against stated indicators, but also to indicate how activities should be adapted to serve the needs of the farmers more effectively. Some interviewing of farmers may be unavoidable, but these should be a short and as interesting for the farmer as possible. Unexpected information from such conversations should be put to use, as appropriate.

To the extent possible, monitoring (data-collecting) and supportive follow-up exercises should coincide. One visit should serve both purposes.

The project has met some challenges:

- Farmers have limited education and understanding of the reasons for fisheries regulations and co-management.
- Farmer's primary focus is to escape poverty, which means that environmental sustainability is a secondary focus. Their difficult economic circumstances often force them to put family and immediate concerns ahead of longer-term and communal ones.
- The project has had considerable, and unavoidable, turnover in staff.
- Implementing the project has been a learning experience for all concerned. All concerned stakeholders have limited expertise in establishing co-management. Competing work

priorities and geographical distance have also limited the efforts various concerned agencies have been able to put into the project.

- In general, the project has made more progress with Club 4 that with the Phu Loi Co-operative. The Co-operative members, in general, are wealthier than club members, and many had already converted their rice fields to ponds. Construction of the Thanh My canal eliminated the land of some members, and made access to and by one subgroup much more difficult. Hence, there may be more limits on ways that the project can help the co-operative.

RECOMMENDATIONS FOR FUTURE WORK

- Project activities need to continue with more emphasis on the commune and higher levels. Requested courses on disease management and environmental issues/water management should be conducted at the commune level, after confirmation, and subsequent training needs should be investigated.
- Training in other livelihoods can be continued. So far, the emphasis has been on various forms of aquaculture. There is interest in raising a variety of livestock, as well.
- Concerted attention is needed at the district and provincial level, as well as at the commune level. Discussions with all concerned should clarify what should be done in order to assure sustainable management of water resources for shrimp culture beyond the boundaries of the participating farmers' organisations and Hoa Tu 1 Commune.
- Changes in management capacity of local government officers have not been studied yet during this project. This could be a focus of future projects.
- As attention shifts to new target areas and farmers, it is advisable to keep in touch with the two initial target organisations, in order to assess how sustainable the contribution of the project has been and to make corrections to implementation in order to assure sustainability.
- Co-management is our target, but immediate needs often keep farmers from focusing on this. Hence, if the project is to succeed in encouraging co-management, it must also help farmers address their immediate needs to the extent possible. Hence, the technical training courses in shrimp culture and other livelihoods.
- 'How can we do better?' is a question all stakeholders and staff need to be asking one another, as a continuous part of the process.

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Is there fisheries co-management in Daklak province, Central Highlands of Viet Nam?

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Management of River and Reservoir Fisheries (MRRF), Viet Nam

ABSTRACT

Phase II of Management of River and Reservoir Fisheries (MRRF) Component in the Lower Mekong Basin has focused on establishing fisheries co-management in six selected water bodies in Daklak province, Central Highlands of Viet Nam from March 2000.

The Component is now focusing on three water bodies: Lak lake, Easoup and Buon Tria reservoirs. The MRRF organised meetings, training sessions and workshops with local authorities and fishers, to discuss and come to an agreement on, the setting up of fisheries management systems suited to the actual fishing communities in Daklak province.

Easoup Fishers Union was established in 1999 with 80 members. In June 2001, the Lak Fishers Union was established in Lak lake with 216 members, and in October 2001 at Buon Tria reservoir the Buon Tria Fishers Group was established with 12 members.

Due to characteristics of the selected water bodies, the organisational and institutional arrangements of the Fishers Groups varied. All Fishers Groups closely cooperated with resource users, local authorities and line agencies to manage the fisheries resources effectively and sustainably.

Since the Fishers Groups were established, the situation in all three selected water bodies has improved. Destructive fishing practices were reduced by over 80% and fishers became more aware of the impact of exploiting fisheries resources. In addition, the groups monitored fishing activities around the Lake and reservoirs, collected taxes, patrolled, and organised a fund for stocking fish in order to increase and replace lost fish resources. Training courses were held, and credit and savings groups were established; all these activities supported better management of the water bodies. Furthermore, the environment and resources in the reservoir are being maintained and the livelihood of fishers around the reservoirs is improving.

INTRODUCTION

Daklak is one of five provinces in the Central Highlands of Viet Nam with around 500 reservoirs totaling an estimated area of 10,500 ha. While the construction of reservoirs in this Province was primarily for the purpose of agricultural development, irrigation and hydroelectricity, fishing also contributes the local economy. Annual average yield of fish varies greatly among reservoirs, with a median figure of approximately 300 to 350 kg/ha/year. While there has been little investment from government and resource users, interest in the development of reservoir fisheries has increased in recent years.

The population of Daklak province has grown from around 1,798,000 in 1999 to 2,054,000 in 2004 (Daklak Statistical Office, 2004). Fish is the cheapest source of animal protein for this rapidly growing population, and local authorities estimate that approximately 70% of fish consumed in the province is of marine origin.

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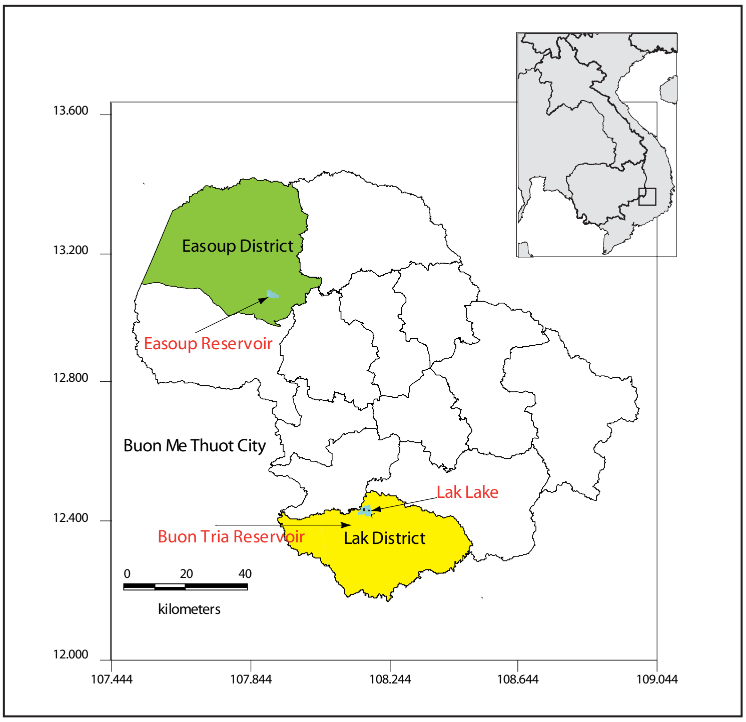

Figure 1 Map of Daklak province and selected water bodies

The supply of marine fish cannot be expected to keep up with this growing demand. Hence, the demand for fresh water fish is likely to increase greatly. As a result, Provincial authorities are beginning to recognise the importance of, and focus on, reservoir fisheries development.

The fisheries in selected water bodies in Daklak have been open access for a long time and have considerable fishery potential. However, numbers of resource users are increasing, and the use of destructive fishing methods such as electro-fishing, blasting, and using nets with small mesh sizes continues, resulting in a detrimental impact on fisheries in the region.

To solve this situation, MRRF helped local authorities, line agencies and fishers arrange numerous meetings and workshops to identify options for managing the fisheries in Lak Lake, Easoup and Buon Tria reservoirs, effectively. Consequently, fisheries Co-management was accepted and applied to all three water bodies.

From 1999 to 2001, Fishers Unions were established in Lak Lake, Easoup and Buon Tria reservoirs. Since the new fisheries management models have been set up, the livelihood of fishers living around the reservoirs has improved, resources are used effectively and local authorities can share rights and responsibilities with users, to manage the fisheries sustainably.

This paper will consider the management systems in three selected water bodies and characteristics of governments, line agencies and user interactions in managing the resources.

DEFINITION OF CO-MANAGEMENT

There are many definitions of co-management. In order to address the question raised in this paper, we have used two.

The Management of River and Reservoir Fisheries Viet Nam subcomponent has used as its working definition of co-management the following:

> *An increase in broad-based participation by the resource-user community in managing the resource, which gets formal agreement from all concerned stakeholders.*

Participants at the MRC Fisheries Program First Regional Training Course agreed on the following definition of co-management:

A systematic process of participation

by {
- *affected resource user groups*
- *concerned levels of government, and*
- *any other concerned agencies*

} *in* {
- *planning*
- *making decisions about*
- *regulating and controlling*
- *monitoring and evaluating and/or distributing benefits from*

}

the use of a resource, in a way which gets agreement, if possible, formalised, from all concerned. It requires a sharing and definition of both the power and responsibility for managing the resource.

Controlling: having decision-making power over enforcement
Monitoring: Following up and patrolling (Cowling, 2001)

HISTORY OF MRRF'S ACTIVITIES IN DAKLAK

MRFP Phase I

Current MRC Fisheries Program activities in Daklak began in 1995 with the Management of Reservoir Fisheries Project, implemented and managed, then as now, by the Fisheries Program and the Viet Nam Ministry of Fisheries Research Institute for Aquaculture No.3 (RIA3), in Nha Trang. This project had as its development objective the following:

> *"Sustained, high yields from reservoir fisheries achieved under local community agreement with government."*

It was recognized that this project would be the first phase of a longer-term effort. In the mid-1990s very little was known of the fisheries situation in the Central Highlands and most staff had limited experience with reservoir fisheries, so the immediate objective of Phase I was:

> *"Enhanced capacity of government fisheries agencies to plan and manage reservoir fisheries on a sustainable basis."*

Hence the focus of Phase I, which ran from August 13 1995 to February 28 2000, was on training of project (mainly RIA3) staff and on biological and socio-economic surveys of six selected water bodies in Daklak province.

By 1998, project staff had developed an understanding of the working of fisheries management mechanisms around the six studied water bodies. Mindful of the longer-term aims of the project, attempts began to develop community involvement in reservoir fisheries management.

The first step was to select a target water body, where the project felt there was openness on the part of all local stakeholders to increased involvement on the community in fisheries management and where other circumstances made the probability of success relatively high. At three of the study reservoirs, semi-privatised fisheries management systems were already operating and at a fourth, a well-established management system was running under a cooperative. Lak Lake was already regulated with limited effectiveness, however it was a relatively large fishery whose management was made considerably more complex by divisions between two major ethnic groups. Therefore, the project focused its efforts on Ea Soup reservoir, where local authorities saw the need for more effective fisheries management. The fishing community saw that it needed to be involved in fisheries management, and local authorities concurred.

After an introductory workshop held with district and commune authorities and local line agency representatives in June 1998, a training course in environmental awareness was provided to members of the Ea Soup fishing community. Four similar sessions were held for fishers from different locations, between July and November 1998. Representatives of Ea Soup district, Ea Soup Commune and local line agencies usually joined for a concluding discussion. The basic conclusion of every session was similar: Fishers wanted their children to be able to catch fish from the reservoir, and therefore saw the need for sustainable management. To achieve this, they saw their involvement in management as essential.

Project staff identified interested community members and mobilised them to discuss with their colleagues and local officials over the next few months, and the Ea Soup Fishers Union was officially established in August 1999.

Preliminary workshops were also begun with officials and fishers at Lak Lake with a view to developing involvement of the fishing community in fisheries management.

MRRF Phase II

The objectives of Phase II were redefined late in 1998, as was the project, which became the Management of Reservoir Fisheries Component of the MRC Fisheries Program. As such, the development objective of the Component became that of the program:

> *"co-ordinated and sustainable management, use, and development of the economic and nutritional potential of the inland living aquatic resources in the Mekong River Basin."*

The component focused on achieving its new immediate objective:

> *"Sustainable co-management models for optimal fish production developed, implemented, and disseminated".*

The emphasis on establishing co-management systems should be noted. In Phase I, more attention was paid to community-based models. Strictly community-based fisheries management is rarely workable. In practice, concerned government agencies and other stakeholders also have to be involved in the management process. The emphasis on co-management allows the Component to encourage development of systems that involve all crucial stakeholders in managing the resource, based on their mutual agreement as to roles and responsibilities.

Of the six reservoirs studied in Phase I, three had to be dropped. Two had semi-privatised fisheries management systems and the likelihood of developing a broader base to community involvement in fisheries management was very low. The reservoir managed by the cooperative was too small for consideration, given our selection criteria. Work continued at Ea Soup, Lak Lake and Yang Re reservoir, where the fisheries contractor and commune officials indicated the need for a more broad-based community role in management of the reservoir. Three "new" reservoirs were subsequently added: Buon Tria, Nam Nung, and Krong Buk Ha.

The process followed was similar in each water body. Initial discussions were held with authorities to discuss initial plans. A participatory rural appraisal session was held to identify problems faced by the community, their possible causes and potential solutions. The next step was a training course in environmental awareness, to focus on fisheries issues. Through cooperation with the authorities, locally contracted collaborators from line agencies and members of the fishing communities, fishers groups were organised around each water body. Each group drew up a constitution and with component staff, developed plans to address their problems. Various training courses were organised to help them address issues of importance.

Details were reservoir-specific, but the basic objectives of every fishers group were similar, focusing on achieving the highest possible sustainable fisheries yields from their reservoirs, developing mutual welfare mechanisms, and developing smooth relations with local authorities.

Regulation, enforcement, taxation, and stocking were common fisheries issues of interest. Authorities commonly advised on drafting fisheries regulations. Authorities and police were often asked to provide the enforcement of regulations, and taxing of fishing activities by fishers groups was authorised by local authorities. Training of various sorts was provided by concerned line agencies, as well as by component staff.

The time and energy required to maintain these organisations was considerable, and all felt that in addition to fisheries management, other community issues needed to be addressed, especially those related to mutual welfare. Credit and savings groups were therefore set up by each organisation.

Training in alternate livelihoods was also widely popular. This gave participants a chance to try new economic activities to enhance family income and reduce dependence on the fishery.

Funding for organisational activities tended to come from the membership, but usually was not enough. Governments at all levels were not in a position to offer assistance aside from allowing fishers groups to keep part or all of the tax money collected. As a stopgap measure, the Australian Embassy provided modest funding for some activities, mainly material inputs under credit and savings programs.

In general, local authorities tended to delegate as much of the fisheries management responsibilities as possible to the concerned fishers groups, once they were organised with the approval of the authorities.

Funding cuts in 2002 forced the component to scale back its work, as a result three reservoirs were dropped. The Fishers Groups in Nam Nung and Krong Buk Ha were ready and willing to have a hand in managing their fisheries, but in each case a crucial stakeholder (the irrigation manager in Krong Buk Ha and the fisheries contractor in Nam Nung) were unwilling to allow the fishers groups to have any meaningful role in fisheries management, contrary to their initial indications of support. In Yang Re, the fisheries contract expired in 2002 and the commune awarded the contract to the highest bidder, one whose bid was so high that he would have to "mine" the fishery in order to pay the amount he bid. Hence, the commune opted for maximum immediate income from the fishery, rather than a benefit more equitably and sustainably distributed throughout the fishing community. Again, this was in contrast to their initial expressions of support for community involvement in fisheries management.

PRESENT MANAGEMENT SITUATION AT TARGET WATER BODIES

At all three water bodies, fishers groups were established with the approval of concerned local authorities at various levels, and their establishment was facilitated by concerned line agencies. In all three cases, day-to-day management of the fisheries was primarily the responsibility of the fishers groups, and the authority concerned delegated this task to them.

Lak Fishers Union

In all cases, local authorities have delegated the bulk of the day-to-day management responsibilities to the fishers groups. Fishers groups draft regulations are modified as needed and approved by the authorities. Authorities provide police support, where possible, to assist enforcement efforts by fishers groups, and often allow fishers groups to tax fishing effort. Authorities also provide advice and guidance, and can help liaise with other agencies on behalf of the fishers groups who report to the authorities on a regular basis.

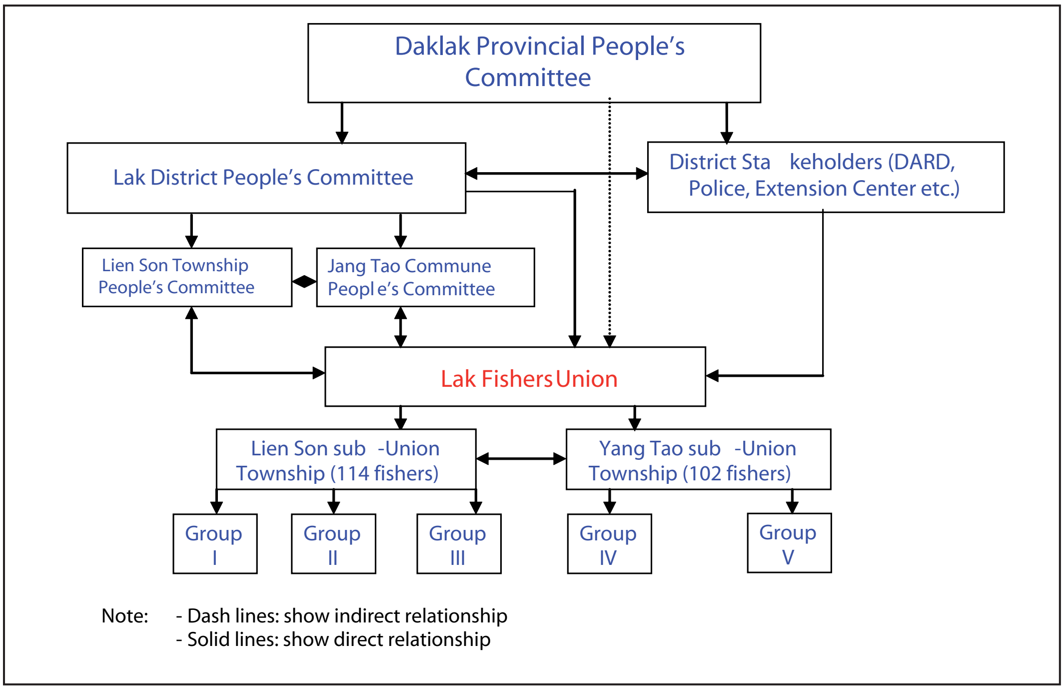

Figure 2. Activities, responsibility and right of stakeholders of Lak Fishers' Union in Lak district

Local authorities: Monitoring and responsibility for administration activities of the fisheries Union such as: drafting and enacting the regulations, finalise and approve fisheries regulations, penalising violators, cooperating with the Fishers Union on patrolling in the lake, and supporting capital to stock the lake in order to rehabilitate the resource.

Line agencies: Department of economics, Agriculture Extension Center, Board of forestry-history-culture-environment in Lak district, all have responsibility for supporting technical aspects, management and cooperating with Lak Fishers Union in relation to various fishery activities including, fish culture in fence net pens , stocking, and patrolling. In addition, line agencies have helped the Union hold training sessions, search for alternate livelihoods for users who use destructive fishing methods, and support and share with the fishers the right and responsibility to manage the resource.

Fishers Union activities: Cooperation with local authorities, line agencies and stakeholders in order to carry out activities: drafting fishing regulations, finding orientation to develop the fishery, collecting fishing tax from members of the Union, patrolling to protect the resources, and stocking to rehabilitate resources. The Union has encouraged and mobilised fishers to not use destructive fishing methods in order to protect resources. The Fishers Union also submits quarterly and annual reports to the local authorities.

In addition, the Union established credit and savings groups to help members have the capital to buy fishing gears or invest in farming activities.

5.2. Easoup Fishers Union

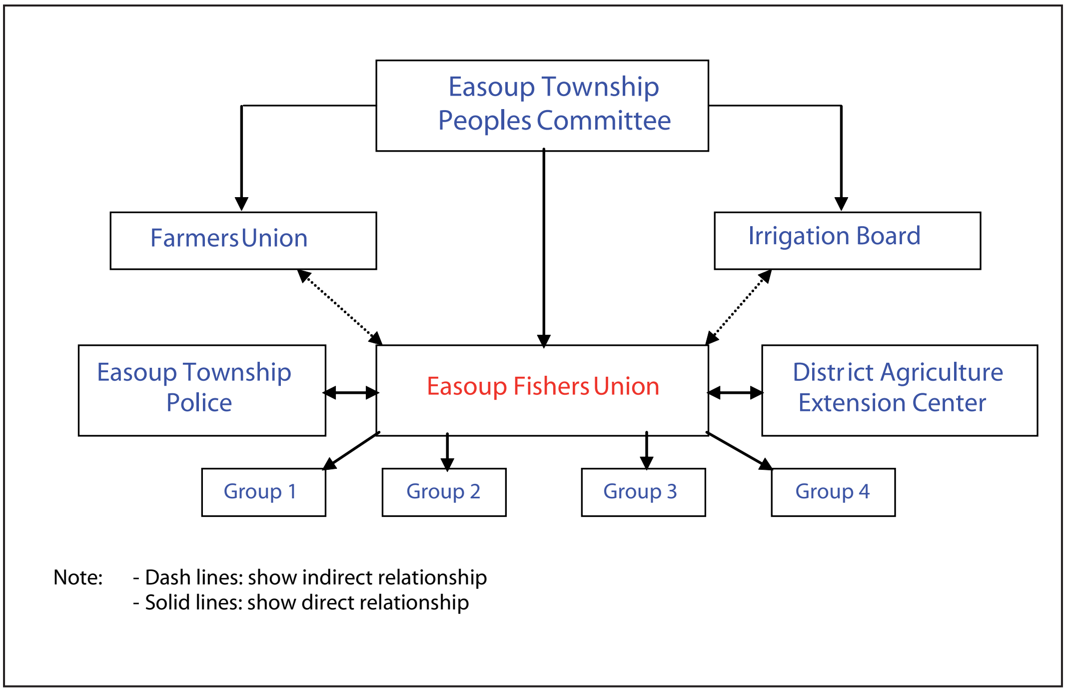

Figure 3. The structure of the fisheries management model in Easoup reservoir

Easoup township authorities play an important advisory role in supporting the Union to make plans and carry out activities.

Local government: Monitoring Union activities, determining fisheries regulations, contacting other agencies for funding and support, and cooperating with the Union in managing the fishery.

Line agencies: The Farmers Union and the Irrigation team of the township are responsible for seeking technical support and cooperation with the Irrigation Office of the District, to ensure appropriate water levels in the reservoir for fisheries management. They also cooperate with the Agriculture Extension Center to introduce fishers to alternative livelihoods in order to decrease the pressure on the fishery, improve livelihoods and to help share benefits equitably.

Easoup Fishers Union: Members of Union cooperate with police to protect the resources and plan activities in such areas as fishing regulations, stocking, patrolling, and training needs of Union members. The Union also mobilised members to establish credit and savings groups, an activity that was very effective. Fishers were able to help each other in fishing and other economic activities, the group also built on relationships between members and developed solidarity. The Union President reports activities of the Fishers Union bi-monthly and submits a report to the Farmers Union and Easoup township.

Buon Tria Fishers Group

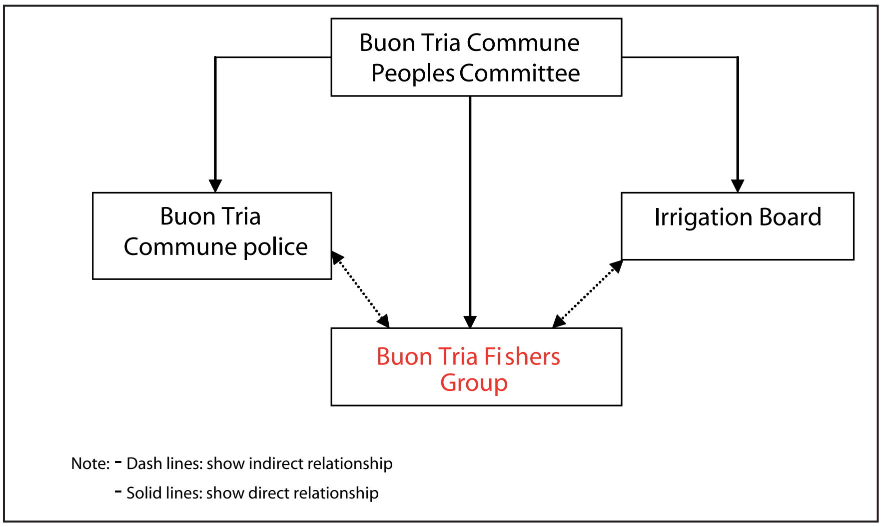

Figure 4. The structure of the fisheries management model in Buon Tria reservoir

Local government: Monitors the activities of the group, determines fisheries regulations, contacts other agencies for funding and other support, and cooperates with the group in managing the fishery.

Line agencies: The Commune police and the Irrigation Board of the Commune are responsible for seeking technical support and cooperating with the Irrigation Office of the Commune to ensure appropriate water levels in the reservoir for fisheries management. They also cooperate with the Agriculture Extension Center to introduce the fishers to alternative livelihoods in order to decrease pressure on the fishery, improve their life and help them to share benefits equitably.

Buon Tria Fishers' Group: Members of the group cooperate with the police to protect the resources and to plan activities in such areas as fishing regulations, stocking, patrolling, and training needs of group members. The group also mobilised members to establish credit and savings groups. This activity proved to be effective and practical as fishers could help each other with fishing activities and there is more cohesion between members. The group leader reports activities of the group annually to the Buon Tria commune.

SOME RESULTS OF FISHERIES CO-MANAGEMENT IN DAKLAK PROVINCE:

- Environment and resources in the reservoirs are being maintained
- Destructive fishing practices were reduced by over 80%
- Knowledge of users on using resources changed
- Livelihood of fishers living around the reservoirs is improving
- closer relationships between local government, line agencies and users.

ROLES OF MRRF:

- An agent to help local authorities, line agencies and users in managing and using the resources sustainably
- Impact on many aspects to the fisheries management in the Province
- Support Fishers Unions to plan and implement activities

CONCLUSION

Is there fisheries Co-management in Daklak province?

The concept of Co-management is not new to Viet Nam, but its application in the fisheries sector in Daklak province, Central Highlands, Viet Nam is a recent development. However, natural resources co-management has been encouraged by other projects in the province, and the Ministry of Fisheries is interested in co-management as one way of achieving high, sustainable yields, and alleviating poverty (MOFI and SUMA, 2001).

Let us return to our two definitions:

> *(1) An increase in broad-based participation by the resource-user community in managing the resource, which gets formal agreement from all concerned stakeholders.*

Prior to the work done by the MRRF, there was effectively no fisheries management in Ea Soup or Buon Tria. District police regulate the fishery in Lak until 1997, when it was handed over to the board for the Preservation of the History, Culture and Environment of Lak. In both cases, the responsible agencies issued regulations with no involvement by the fishing community, and were unable to manage effectively.

Now, at each of the three water bodies, a fishers group, which represents the entire fishing community adjacent to the water body, has direct responsibility for managing the resource, with roles and a constitution approved and effectively supported by the concerned local authorities.

By this definition, fisheries co-management is operating at each water body.

(2) A systematic process of participation

by { *affected resource user groups*; *concerned levels of government, and*; *any other concerned agencies* } *in* { *planning*; *making decisions about*; *regulating and controlling*; *monitoring and evaluating and/or distributing benefits from* }

> *the use of a resource, in a way which gets agreement, if possible, formalised, from all concerned. It requires a sharing and definition of both the power and responsibility for managing the resource.*

Is the process systematic? All crucial stakeholders have agreed to roles, and these have been adjusted with experience. Planning, deciding about, regulating and controlling, monitoring, evaluating, and benefit distribution from the resource are all addressed by user groups, local authorities, and other concerned agencies in mutually-agreed capacities. Again, the constitutions and regulations governing the groups are drafted by the groups and finalised by the authorities. Power and responsibility for management are shared, primarily, by the user groups and concerned local authorities.

So again, by this definition, fisheries co-management is operating at each water body.

Are the systems established sustainable?

Probably, since they carry out many of their functions without external support. However, only after the project finishes can we be sure, as the project provides various kinds of support. Quite likely, activities will change considerably after the project ends, but given the benefits from the activities of the fishers groups, they are expected to adapt to the change and continue.

Relations between the fishers groups and local authorities have been strengthened over the years, and both sides will have to continue to make efforts to communicate and respond to issues promptly, in order to assure continuation of co-management. The systems established will have to remain adaptable to changing circumstances.

Fishers groups have to generate as much benefit as possible for their members, since the time, energy and money these poor villagers invest is considerable. Therefore, they cannot limit their activities to only fisheries management.

Governments at the appropriate level or levels may have to look for modest financial support for these user groups. The sums involved are small, but important to the group members, whose resources, both in terms of time and money, are very limited.

RECOMMENDATIONS

1. All stakeholders with responsibility for managing a resource need to communicate frequently and openly in order to assure effective management.
2. Roles, responsibilities, regulations, and activities need to be responsive to changing circumstances.

3. Governments need to provide appropriate enabling conditions to user groups involved in co-management, in order to assure that the users can afford to give management of the resource the attention it needs. "Enabling conditions" may include modest financial support in some or most cases.

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Section 3. Aquaculture of Indigenous Mekong Species

Economic evaluation of small-scale aquaculture of indigenous fish in Cambodia

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ABSTRACT

The study on economic evaluation of indigenous fish in small-scale culture system has been conducted from 2001 to 2005 in Takeo, Prev Veng, Kompomg Cham and Kompomg Thom Provinces. The total number of farmers involved in this study was 181.

The objective of the study was to evaluate the popularity and the economic aspect of indigenous fish species in small- scale aquaculture system.

Results from the data analysis show an average fish production of 36.4 kg/100m^2/8 months. Our results agree with those of with Kaing Khim (2001) on exotic species (41.2kg/100m^2/8 months). Based on economic analysis the total expense for fish culture is US$5.1/100m^2 /8 months with a high contribution from seed (32%) and feed (38%). The analysis has found that the net profit from fish culture is US$23.4/100m^2 /8 months (60.9 %). Most of the farmers are satisfied (81% including 12% strongly satisfied), however 1% were dissatisfied. The main constraints faced by farmers are stocking late due to climatic conditions, small fish at stocking and a high mortality, and short culture periods.

This study confirms the importance of maintaining indigenous fish species culture. Indeed indigenous fish species for small-scale aquaculture system are suitable in terms of production, market demand and economic benefits.

KEYWORDS: Economic evaluation, Indigenous fish, small-scale aquaculture, farmer attitude

INTRODUCTION

Presently, small-scale aquaculture is being developed rapidly in Cambodia. Most farmers generally prefer to culture introduced species such as Chinese carp, Indian carp and Tilapia. These species can adapt well to new environments. Their adaptation includes their feeding habit and growth. However, exotic species impact natural resources in Cambodia, as some rural areas are covered by flood which allows these species, especially Tilapia reared in the farmer's pond, to move into the natural water bodies. This may affect indigenous species through disease transmission, feeding and habitat competition, and genetic effects (FAO, 1997).

In response to environmental issues arising from the aquaculture of exotic species, the Ministry of Agriculture, Forestry and Fishery, in collaboration with Department of Fisheries and national and international projects, especially AIMS project of MRC, has conducted research on indigenous species to promote their culture and reduce negative impacts on the environment through the escape of exotic species. To address this problem, the AIMS project has conducted research on the evaluation of small-scale aquaculture of indigenous Mekong fish species in three provinces of Takeo, Prey Veng, Kampung Thum and Kampong Cham from 2001 to 2005. The research survey was to evaluate some indigenous species, which grew well and were accepted by farmers,

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in order to encourage farmers to rear them and replace exotic species in small-scale aquaculture development.

The objectives of our survey were to evaluate the popularity and the economic aspect of indigenous fish species in small-scale aquaculture system in Cambodia.

RESEARCH METHOD

The survey was conducted every year from 2001-2005 in four provinces of Takeo, Prey Veng, Kampong Ckam and Kampong Thum (Figure 1).

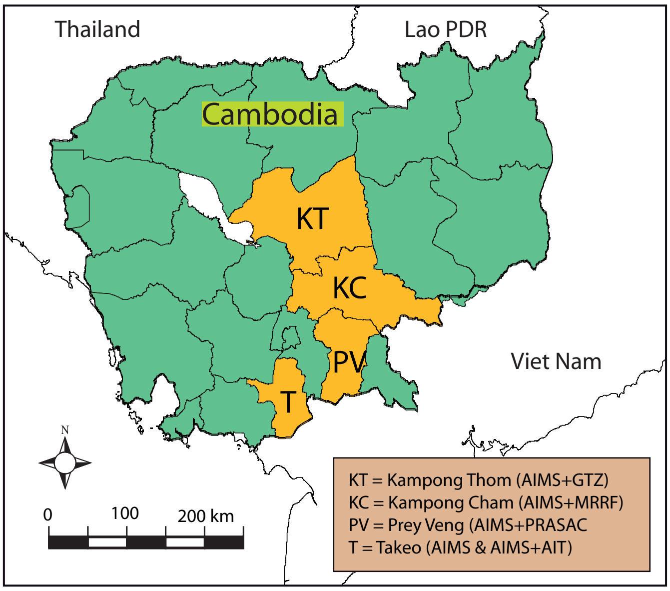

Figure 1. Survey locations

The survey was conducted with 181 farmers in total from 2002 to 2005. Some farmers joined fish culture of indigenous for 1, 2, 3 or 4 years and some grew polyculture of indigenous species only and some grew mixed polyculture of indigenous and exotic species (Table 1).

Table 1. *Number of fish farmers involved in fish culture of indigenous fish species*

Type of culture	Number of fish farmers				
	2002	2003	2004	2005	Total
Indigenous	28	31	45	49	153
Mixed	13	5		10	28
Total	41	36	45	59	181

The stock was composed of five indigenous fish species for polyculture system while a mixture of two indigenous and three exotic species for mixed polyculture system.

Polyculture with indigenous

- *Pangasianodon hypophthalmus*
- *Barbonymus gonionotus*
- *Leptobarbus hoevenii*
- *Trichogaster pectoralis*
- *Barbonymus altus*

Polyculture with mix species

- *Pangasianodon hypophthalmus*
- *Barbonymus gonionotus*
- *Oreochromis niloticus*
- *Cyprinus carpio*
- *Hypophthalmichthys molitrix*

Data collection was carried out by questionnaires, meeting face-to-face with the farmers, using the existing data in the record books recorded by farmers. There were also surveys on the growth of fish, using questionnaires at harvest.

The survey on the growth of fish was done every 2 months, measuring each species in length and weight, sampling 15-20 of each species. The farmer recorded data in a record book, and at the harvest, another questionnaire was prepared by AIMS staffs, PRASAC staffs and the farmers in order to record data. This questionnaire mainly focused on the social influence on indigenous fish culture, farmer techniques, obtained yield, income, expense and profit on the indigenous aquaculture as well as the farmer's attitude to this activity.

Data were entered in the computer into a table to allow easy analysis. Data was analyzed using Excel program dividing the data in-group, mean, standard deviation, maximum and minimum of each variable. Graphs and tables summarizing the data were then produced.

RESULTS OF THE SURVEY

Evaluation of technical aspect of fish culture of indigenous fish species

Result of pond preparation surveyed from involved fish farmers

In pond preparation, the organic fertilizer, chemical and green maures were applied. Cow manure was popularly used, as it was easily found in their residence and did not need to be bought. According to analysis, the lime was applied 6kg/100m^2, Urea of 1.5kg/100m^2, DAP of 1kg/100m^2, cow manure of 30kg/100m^2 and green fertilizer of 25kg/100m^2. The amount of fertilizer used by farmers was used most in 2002 and then less so continually until 2005. However, it was not different from technical recommendation (Figure 2).

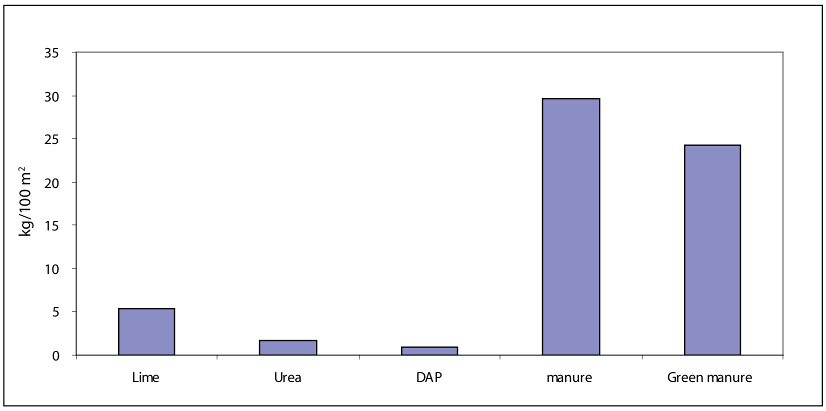

Figure 2. Composition of materials used in pond preparation

Feed and Feeding used by surveyed fish farmers

According to the survey and data analysis, in small-scale aquaculture, feed was generally duckweed, termite and house waste formulated with the supplementary feed of rice bran, broken rice and vegetables bought at the market. The duckweed and termite called natural feed found in nature depended on the weather and location. In fact, duckweed was commonly used in all area and all year, it was the highest amount among feed composition used. High rainfall allowed the duckweed to grow well, however, in Figure 3, it was used less in 2004 and 2005 due to the drought during that period. The supplementary feeds (rice bran and broken rice) were not significantly different from 2002 to 2005 and between indigenous fish and exotic culture system. Based on data analysis the rice brain used ranged from 60 to 80 and broken rice ranged from 5 to 10 kg/8months/100m2.

Feed was applied twice a day, in the morning from 7-9 am and in the evening from 4-5 pm. The feed was usually cooked, especially broken rice and rice bran, before feeding. This is a good practice to stimulate fish growth and help reduce feed loss.

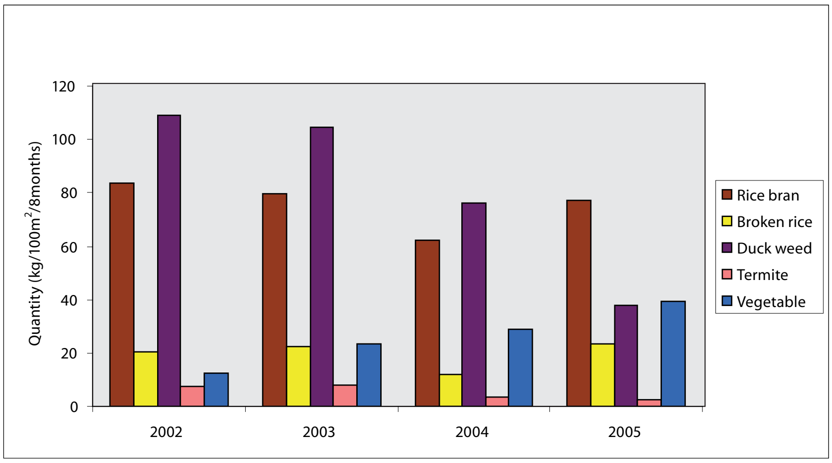

Figure 3. Feed type

Yield obtained

Overall, the total yield of aquaculture was 35kg/100m^2 for 8 months on average; it was not significantly different from 2002 to 2005. Based on the data analysis, the average fish yield from mixed culture system was higher than that from indigenous culture system, but not significantly different. This average yield was reasonable for small small-scale fish culture system and it was found to be not significantly different compared to exotic fish culture.

Among the 4 indigenous fish species, *P. hypophthalmus* gave the highest yield and contributed up to 40 per cent of the total indigenous fish yield, followed by *B. gonionotus* that contributed 27 per cent. *B. altus* gave the lowest yield and contributed only 3 per cent. However, for mixed culture system, when *P. hypophthalmus* and *B. gonionotus* were stocked with exotic species these two indigenous species contributed 18 per cent and 12 per cent only, and Tilapia contributed up to 30 per cent and Silver carp 21 per cent of total fish yield.

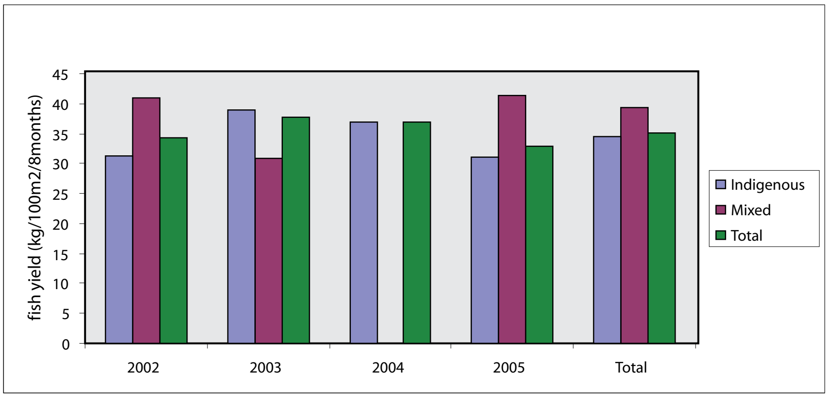

Figure 4. Average fish production by culture system

Fish Survival Rate of Each Species

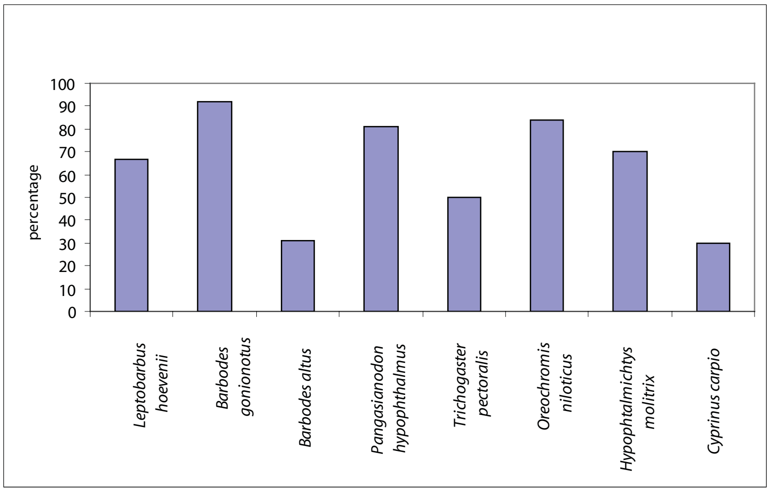

Figure 5. Survival rate

Indigenous fish species reared in the farmer's pond generally had high survival rate. As Figure 5 illustrates, the average survival rate of *P. hypophthalmus* was 80 per cent, *B. gonionotus* was 90 per cent and *L. hoevenii* was 70 per cent. This suggests that indigenous fish species have high potential for productive aquaculture in Cambodia. However, the survival rate of some species such as *B. altus* and *T. pectoralis* were significantly lower.

Daily weight gain

The average growth of *P. hypophthalmus* statistically was the highest. It reached 1.4 gram per day. The second species was the *B. gonionotus* with an average growth that reached up to 0.58 gram per day, followed then by *L. hoeveni*, at 0.44 gram per day and the species with slowest growth was *B. altus* (0.14g/day).

Evaluation of economical aspect of fish culture of indigenous fish species

The total cost of indigenous fish culture per 100 square meters per 8 months includes costs of pond preparation, plastic bags, fish seed, fertilizer, feed, harvesting and labour.

In both culture systems, the cost contribution was the same. Figure 6 below shows that the cost of feed was the highest and contributed 34 per cent, followed by the seed cost that contributed 29 per cent and labour cost contributed about 16 per cent.

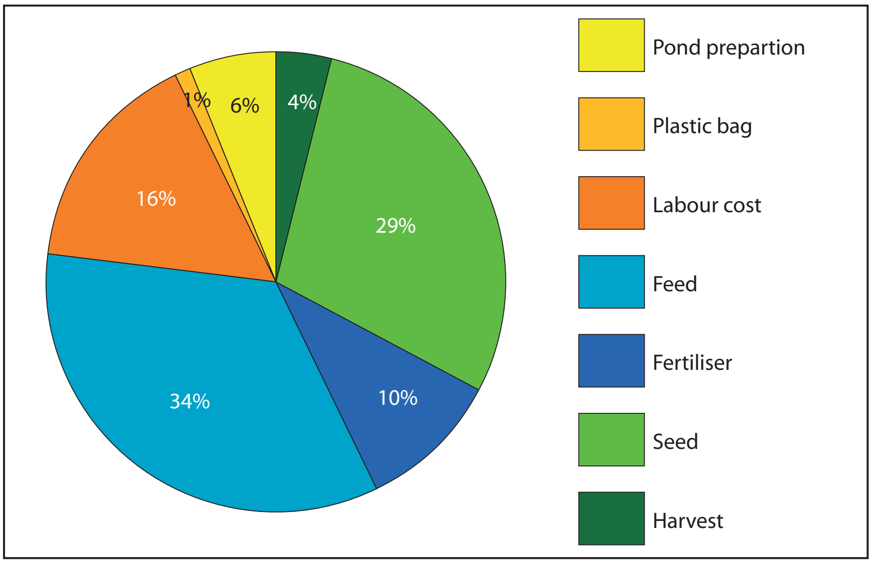

Figure 6. Total expenses for fish culture

The cost contribution for both systems was similar to exotic culture system; however, the cost of labour for indigenous and mixed culture system was significantly lower than exotic culture system. This may due to the fact that most farmers cultured exotic species would spend more time to collect natural food, while most farmers cultured indigenous fish species prefer using natural feed and supplementary feed.

Table 2 shows about the expense, revenue and profit of indigenous fish culture. From this table the average total expense was US$18/100m²/8months. The total expense ranged from US$16 to 20/100m²/8months within 2002-2005 but not significantly different, however the profit significantly increased from 38 per cent in 2002 to 58 per cent in 2005. The increase of profit is due to increasing fish market price of indigenous fish.

Table 2. *Economic analysis of fish production (US$/100m²/ 8 months)*

	2002		2003		2004		2005		Total	
	mean	%	mean	%	mean	%	mean	%	mean	%
Seed	4.75	24	5.74	28	5.93	33	4.8	29	5.31	29
Fertilizer	2.64	14	2.41	12	1.13	6	1.22	7	1.69	9
Feed	5.74	30	6.22	30	6.27	35	7.01	43	6.40	35
Labour cost	3.41	18	4.33	21	2.65	15	1.73	11	2.83	15
Plastic bag	0.2	1	0.38	2	0.28	2	0.24	1	0.27	1
Pond preparation	1.84	10	1.1	5	0.98	5	0.70	4	1.07	6
Harvest	0.83	4	0.63	3	0.74	4	0.66	4	0.71	4
Total expense	19.41	100	20.77	100	17.98	100	16.37	100	18.29	100
Revenue	31.34		38.91		46.11		38.8		39.61	
Production (kg/100m²/8m)	31.3		38.9		36.9		31.0		34.4	
Profit/ lost	11.93		18.14		28.13		22.43		21.32	
Profit %	38		47		61		58		54	

Table 3. *Economic analysis of fish production (US$/100m²/ 8 months)*

	2002		2003		2004		2005		Total	
	mean	%	mean	%	mean	%	mean	%	mean	%
Seed	5.53	27	5.36	28			4.94	31	5.29	28
Fertilizer	1.92	9	4.81	25			1.15	7	2.16	12
Feed	5.93	29	4.32	23			6.48	41	5.84	31
Labour cost	5.5	27	2.95	16			1.84	12	3.73	20
Plastic bag	0.26	1	0.40	2			0.26	2	0.29	2
Pond preparation	0.97	5	0.63	3			0.61	4	0.78	4
Harvest	0.52	3	0.47	2			0.42	3	0.48	3
Total expense	20.63	100	18.95	100			15.7	100	18.57	100
Revenue	38.91		29.38				41.42		38.1	
Production (kg/100m²/8m)	41.0		30.9				41.4		39.3	
Profit/ lost	18.27		10.43				25.72		19.53	
Profit %	47		36				62		51	

Table 3 shows about the average expense, revenue and profit of mix culture system. Compared to indigenous fish culture, even though the total fish production of mix culture was higher than indigenous fish, the average profit was not significantly different.

Evaluation of economical aspect of indigenous fish species

In terms of marketing aspects of indigenous fish species, the analysis found that indigenous fish could be sold at site. As can be seen in the Table 4, up to 80 per cent of farmers could sell their fish at their house during harvesting and only 0.6 per cent farmers brought their fish to sell in the district market. The analysis found that the indigenous fish was very easy to sell and with higher price as well compared to exotic species (Table 5). This indicates that the indigenous fish was very high market potential and preferably consumed by villagers.

Table 4. *The place where indigenous fish were sold (%)*

	2002	2003	2004	2005	Total
Commune	2.8	0.0	2.6	5.4	3.0
Commune and Village	0.0	0.0	2.6	0.0	0.6
District	0.0	0.0	2.6	0.0	0.6
House	91.7	80.6	51.3	94.6	80.8
House and Village	2.8	0.0	38.5	0.0	9.6
Village	2.8	19.4	2.6	0.0	5.4
Total	100.0	100.0	100.0	100.0	100.0

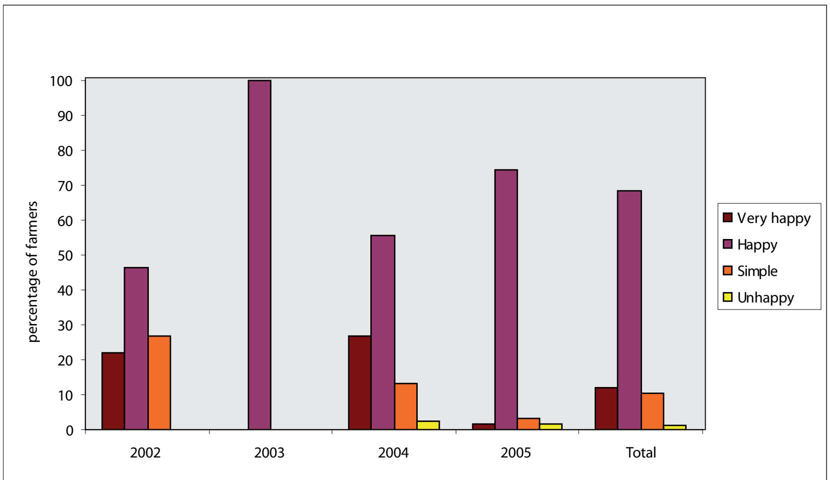

Table 5. *The way indigenous fish were sold*

How to Sold	Total (family)	%
By themselves	165	99
Through middle-man	1	1
Total	166	100

Evaluation of attitudes

In terms of fish farmers' attitude regarding aquaculture of indigenous fish species, the analysis found most farmers were satisfied with the results. Results from 2002 to 2005 showed that 50 to 100 per cent of farmers were content, and only a few were unhappy with the results (Figure 7).

Figure 7. Degree of satisfaction with indigenous aquaculture

Based on the survey, *P. hypophthalmus, B. gonionotus* and *L. hoeveni* were the most popular species and only five per cent of indigenous fish farmers decided to stop because they wanted to change their job. Very few farmers complained about the culture of indigenous fish species in terms of slower growth.

DISCUSSION

Based on the result of Economic Evaluation of Small- Scale Aquaculture of Indigenous Fish in Cambodia we can discuss that most of the people involved in fish culture were rice farmers. Although they were busy with rice cultivation, they could also raise fish because the fish culture did not need much time. Moreover, they could use their own materials such as rice bran and cow manure to assist in the culture.

Compared to small-scale fish culture exotic species, the yield from indigenous fish species was not significantly different. The total yield was mostly obtained from the species of *P. hypophthalmus* because this species grew fast and its survival rate was high. It could be said that the growth of *B. gonionotus* and *L. hoevenii* were not significantly different; however the potential of the indigenous fish culture is significant due to the high survival rate compared to the exotic species. However, indigenous fish culture needs more supplementary feed, using up to 100 kg rice bran per 100m2 per 8 months while the exotic one was only 50 kg (Vibol, 2002)

Because the indigenous fish culture needed more supplementary feed, the expense on feed was also increased (39 to 44 per cent of total expenses) leading to a reduction in the profit. However, the profit rate was still high because the price of the indigenous fish was up to 4000-5000 riels per 1kg while the exotic species could sell only 3500 riels per 1kg. This advantage led the farmers to be interested in indigenous fish species. Moreover, the market, in term of market demand and market price, of indigenous fish species was significantly higher then exotic species.

CONCLUSIONS

Based on the discussion we can conclude that:

- it is not possible, or desirable, to eliminate all alien species in aquaculture;

- use best scientific and cultural information should be used to decide what species to farm—alien or indigenous;
- it is necessary to develop indigenous alternatives fish species to reduce need for alien species. This development should include investigating feasibility from the perspective of culture, markets and economics.

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Artificial reproduction of the carp *Cirrhinus microlepis* performed in the south of Laos by using LHRHa implant

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ABSTRACT

Experiments were carried out with fish breeders raised in ponds; the mean body weight (BW) of the fish was 1.07 kg and 0.85 kg for the females and the males, respectively. Induction of the ovulation was tested with two treatments. The first treatment included two injections given 6.5 hours apart consisting of LHRHa and domperidone both diluted in water; the total dose was 30 µg LHRHa and 10 mg domperidone. For the second treatment, the first injection consisted in a cholesterol-cellulose implant loaded with LHRHa given at the dose of 70 +/- 10 $\mu g.kg^{-1}$; the second injection was given 16 hours apart with LHRHa (30 $\mu g.kg^{-1}$) plus domperidone (10 $mg.kg^{-1}$) both diluted in water. For the two treatments, the Suprefact™ and the Motilium™ were used as source of LHRHa and domperidone, respectively. The rate of good ovulation was 26 % (N = 19) and 92 % (N = 13) for the first and the second treatment, respectively. Females were kept individually in small tanks for the early detection of the release of the ova; otherwise a large amount of ova could be lost. The mean fecundity per kilo of BW was 58.1 10^3 +/- 16.4 10^3 $ova.kg^{-1}$; the effect of the feed on the fecundity is discussed; the comparison with the fecundity of the wild females issued from the Mekong River is presented. The spontaneous production of sperm was low (264 +/- 126 $\mu l.kg^{-1}$) and the volume of sperm was increased (964 +/- 361 $\mu g.kg^{-1}$) after a single injection of LHRHa plus domperidone. Sperm diluted three times in saline solution (NaCl 12 $g.L^{-1}$) can be stored chilled (5-6 °C) for 20 hours while keeping a good motility of the spermatozoa. The conditions of dry fertilization and incubation of the floating eggs are described; the mean fertilization rate was 60.6 %.

KEY WORDS: *Cirrhinus microlepis*; artificial reproduction; LHRHa

INTRODUCTION

Among the native fish of the Mekong River, the 'small scale mud carp' *Cirrhinus microlepis* is one of the most promising for domestication. This migratory fish is indeed well appreciated by fish consumers all along the River and its regime is omnivorous (Rainboth, 1996; internet website Fish Base); the growth might be fast since wild fish can weigh five kilo and even more. Research on the domestication of *C. microlepis* in Laos and at the regional level along the Mekong River is conducted since 1992 mainly through the programme of the Mekong River Commission (MRC) on the Aquaculture of the Indigenous Mekong Species (AIMS). In Lao PDR *C. microlepis* is called 'Pa-phone'; we will use this local name in the present document.

Until now and at least in Laos the reliable reproduction of Pa-phone was performed only with fish breeders captured from the Mekong River. The first reproduction of Pa-phone was obtained by this way in 1991 as mentioned by Somboon (2002); Gorda (2001) has reported details about this practice. Wild fish breeders are usually captured every year within few days in June-July near the Don Den village located in between the Khone waterfalls and the Pakse city. Capture certainly

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occurs on the spawning ground since most of the females are already at the stage of spontaneous ovulation. Therefore ova are easily collected by stripping the ovulated female or after a simple hormonal treatment.

For more convenience the fish seed supply should also rely on the reproduction of fish breeders hold in captivity. By this way the reproduction period could be extended to several months per year. At the aquaculture station of the Km8 in Pakse, breeders of several other species of carps are stocked in ponds and reproduced in the hatchery; those species are mainly the silver barb, the common carp and the mrigal (Indian carp). About 170 breeders of Pa-phone are also stocked in ponds; they are issued from the reproduction of wild fishes in 2001. Three spawnings were obtained for the first time with those fish in 2004. However, the ovulation rate was quite low and the hatching rate was nil or very low (details given by Cacot, 2005). Moreover, most of the fish, both males and females, have died after the treatment due to inappropriate and stressful handling. Consequently, the method remained to be improved. In the present study we have tested again the standard treatment for inducing the ovulation consisting of two injections of LHRHa from Suprefact ™ associated domperidone from Motilium ™. We have also tested a new treatment involving the use of hormonal implant loaded with LHRHa from Suprefact ™. The latest method is quite recent although it is now widely applied for fish propagation, especially for the natural spawning of the marine fish as reviewed by Mylonas and Zohar (2001). Beside, we have also worked on various techniques including the handling and keeping of the fish breeders during the treatment, the management of the sperm and the incubation of the eggs. Experiments were carried out at the Km8 station from 27 June to 17 August 2005 during the natural period of reproduction of Pa-phone.

Data and statistics have been processed with the software SPSS (version 9.0). Average values are mentioned with the associated standard deviation (SD) or, in case of high variability, the min and max values. Significant differences were assessed with the Student test or the ANOVA test or, for the small samples only, with the Mann-Whitney test (non-parametric test). Correlations were assessed with Pearson test.

MATERIALS AND METHODS

Broodstock available at the Km 8 station

The present fish breeders (Figure 1) are issued from the reproduction of wild fish breeders four years ago, in 2001. Larvae were stocked in fertilized pond and then shared into two batches. One batch of fish is fed with extruded pellets (30 % proteins) and the other one is fed with home-made feed (half fish meal and half rice bran). The two batches of fish are kept in two different ponds. Each pond is about 300 m2 and 1.2 m maximum depth; the pond 4 is slightly larger than the pond 3. Permanent water exchange, about one volume per week, is provided continuously from the diversion of a small river. Fishes from the pond 4 are heavier than those from the pond 3 for the females (+ 90 %,

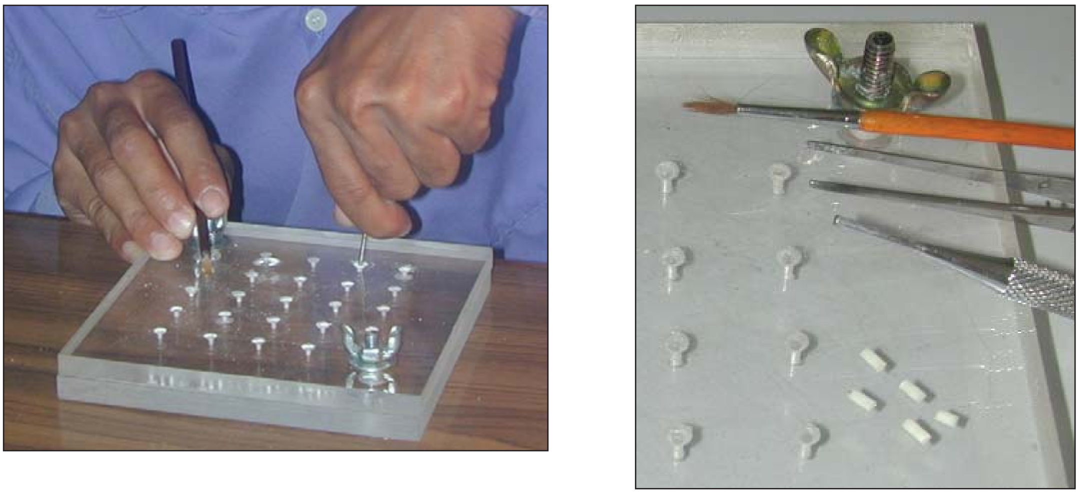


Figure 1. Making of the hormonal implants; the mixture cholesterol-cellulose and LHRHa is pressed in small moulds drilled in a plate of Plexiglas

P < 0.001) as well as for the males (+ 32 %, P < 0.05) (Table 1). This difference is certainly related to the feed; the use of extruded pellets has led to better growth than the home-made feed. Otherwise, females are heavier than the males in the pond 4 (+ 35 %, P < 0.05). Females show higher condition factor (indicator of stoutness) than the males in the pond 3 (+ 16 %, P < 0.01). Beside those differences in weight or stoutness, male can be easily distinguished from the female by the rough pectoral fins, which is smooth in the female.

Table 1. *Biometry of the fish breeders of Pa-phone raised in pond.*

Origin	Sex	BW (kg)			Lf (cm)			Condition factor K		
		N	Average	(SD)	N	Average	(SD)	N	Average	(SD)
Pond N° 3	Male	26	0.78	(0.25)	11	36.5	(1.4)	11	1.47	(0.11)
	Female	16	0.73	(0.10)	3	36.8	(1.9)	3	^{oo} 1.71	(0.06)
Pond N° 4	Male	13	$^{+}$ 1.03	(0.37)	6	$^{+}$ 40.7	(3.5)	6	$^{++}$ 1.65	(0.05)
	Female	17	$^{+++ / o}$ 1.39	(0.52	9	40.6	(4.5)	9	1.72	(0.09)

Note: BW : body weight; Lf : length at fork; Condition factor K = 105 x BW (kg) / Lf (cm)3. Significant differences are mentioned between males and females from the same pond (o : P < 0.05; ^{oo} : P < 0.01) and between the two ponds for the males or the females (+ : P < 0.05; ++ : P < 0.01; +++ : P < 0.001).

Selection of the mature fishes and keeping in tanks

Fishes are caught from pond with a seine net and carry individually in a small tissue stretcher. Mature females have a swollen belly and mature males produce sperm. A biopsy of the ovary was done with a soft catheter (Pipelle de Cormier ™) to take an oocytes sample from most of the selected females. Mature females show grey-green oocytes with a large and homogenous size. Oocytes samples were fixed in the Gilson's solution (composition for one litter: 100 ml ethanol 60 %, 880 ml pure water, 15 ml nitric acid, 9 ml acetic acid, 10 g mercury chloride). The stage of the nucleus (or germinal vesicle) was checked with a binocular lens (x 10-20) after clearing the fresh oocytes (i.e. no fixation in Gilson) with the Serra's solution (40 % ethanol, 40 % formalin, 20% acetic acid). Lastly, the diameter of the oocytes was measured with the same lens to the nearest 0.1 mm.

Mature fishes were transferred to the hatchery and hold in separate tanks for females and males. Fish breeders were kept in two conditions during the treatment: (1) hapas of about 2.2 m^3 (2.5 x 1.5 x 0.6 m) with thin mesh net (0.2 mm) hold in a large concrete tank (Figure 2); (2) small circular tank made of plastic of about 330 L in volume (1 m diameter x 0.4 m height) (Figure 3). Water exchange was done continuously with an open water system for the concrete tanks or through a recycling water system for the plastic tanks. The latest system includes a bio-filter to control the ammonia (0-0.5 $mg.L^{-1}$). Water was aerated with an air pump in both cases. Males were kept together in the same tank. Females were kept together in the concrete tanks or individually in the plastic tanks. In the latest case, a small scoop net with thin mesh was hold in the outlet of each tank in order to indicate the presence of ova released in the tank by the female right after the ovulation. Fishes are caught in the tank with a small scoop net.

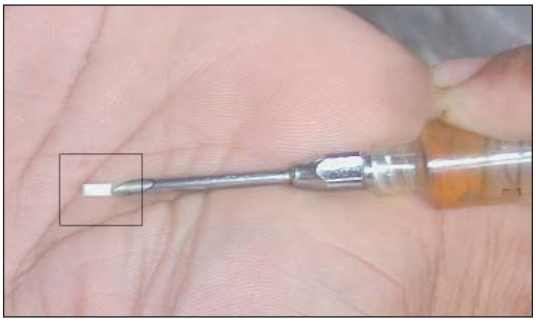


Figure 2. Injection of the hormonal implant in the dorsal musculature of the fish (left); detail of the implant and the needle (right).

It appears that Pa-phone is really a 'jumping fish', as much as the silver carp or even more; jumping out of the tank was the main cause of mortality of the fish during our experiments. Consequently, the fish breeders had to be hold in tanks or containers covered with a net firmly attached to the edge of the tank; hapas completely closed is also useful. Lastly, water had to be aerated while fish are temporarily hold in small container in order to avoid anoxia.

Figure 3. Collection of the sperm of Pa-phone by striping; the sperm is sucked directly in a syringe containing the immo solution; the 'spimmo' (sperm + immo) is stored in a flask.

Hormonal treatment for inducing the ovulation and spermiation

The standard treatment with hormone diluted in water

A standard treatment was tested for the induction of the ovulation, including two successive injections of LHRHa plus domperidone as applied to the Pa-phone in 2004. The Suprefact™ was used as source of LHRHa; it contains a solution of buserelin acetate (d-Ser(Bu^t)$_6$ N-Ethyl amide LHRHa) at the concentration of (1 mg.ml^{-1}). This solution was diluted ten times in pure water for more convenience. The Motilium™ was used as source of domperidone. The dose for the injection 1 and the injection 2 was 5 and 25 µg.kg^{-1} or 10 and 30 µg.kg^{-1} for the LHRHa associated with domperidone (5 and 5 mg.kg^{-1}) both diluted in water. The two injections were given 6:30 apart.

The new treatment involving the hormonal implant

A new treatment was also tested including two different injections: a first injection with an implant loaded with LHRHa (70 +/- 10 µg.kg^{-1}) followed by a second injection with LHRHa (30 µg.kg^{-1}) plus domperidone (10 mg.kg^{-1}) diluted in water. The two injections were given 16:00 apart.

Implants consisted in solid pellets prepared as described by Lee *et al.* (1986) with a matrix made of cholesterol (85 %) and cellulose (15 %). The two powders were mixed during 10 minutes then the suitable volume of *pure* Suprefact™ (LHRHa 1 mg.ml^{-1}) was added. The mixture was dried with a hairdryer at 35-38°C temperature; the mixture was mixed twice during the drying. Drying lasts 0.5-3 hours depending on the quantity of Suprefact™ solution. Margarine was added to the dried mixture (5 % of the total) in order to provide suitable stickiness to the powder. Then the powder was shared in small quantities (17-18 mg) which were pressed into a mould (Figure 1). The mould is made of two plates of Plexiglas fixed together; one plate is pierced with 23 holes (one hole per pellet). Pellets are pressed with a stainless rod adjusted to the diameter of the hole, then the two plates are separated and the pellets are pushed out of the mould. Each pellet weighted about 16 mg and measured 4 mm in length and 2.5 mm in diameter. Three kinds of pellets were prepared containing 25, 50 and 100 µg LHRHa. Part of the implants were prepared three months ago and new ones were prepared few days before use; all of them were stored in the freezer (-20 °C).

The number of solid pellets injected per fish and the dose per pellet was adjusted to apply almost the same dose per kilo of body weight. Injection of a single pellet loaded with 50 µg LHRHa was the most common although two and even three pellets were also used. Fishes were anaesthetized with Phenoxy-2-Ethanol prior the pellet(s) injection (§ 1.4). The pellet(s) was injected a single time in the dorsal musculature with a special syringe (large needle, Figure 2); a small incision was made first on the skin under a scale with a scalpel; Betadine ™ ointment is put on the incision afterwards to prevent the infection.

The male was induced to release sperm mainly by a single injection of LHRHa plus domperidone. Injection of the implant as single injection was also tested in four fishes.

Anaesthesia of the fish

Anaesthesia was used before the stressful operations including the injection of the pellet and the striping for the collection of sperm or ova. Suitable anaesthesia is obtained after few minutes in the solution of Phenoxy-2-Ethanol (0.2 $ml.L^{-1}$). Then fish is handle with care for no longer than one minute; water with anaesthetic can be poured on the gills to prevent anoxia. The fish is revived in pure water before being released in tank or pond. Anaesthesia and reviving are made in two different containers (50-70 L) with good aeration. Anaesthetic solution is kept for no longer than 5 hours and then discarded and renewed.

Collection of the sperm and storage

Sperm was collected from the male by striping after anaesthesia with Phenoxy-2-Ethanol (§ 1.4). Hands of the operator are previously coated with vaseline ointment for a soft striping. The urea is first discarded by gentle striping near the genital papilla and the papilla is dried. Then the belly is striped and the sperm is sucked directly from the papilla into a syringe containing the immobilizing solution 'immo' (salt NaCl 12 $g.L^{-1}$) as illustrated in the Photos 3. By this way, the spermatozoa are kept un-active. A maximum of one volume of sperm is collected for two volumes of immo in each syringe. The syringe is gently checked after each sampling. When the syringe is full, the volume of sperm is recorded and the sperm diluted in the immo, mixture called 'spimmo', is put in a flask kept in icebox. Sperm collected from several males are put together in the same flask. Then the flask is kept open and put in the fridge for optimal storage at 5-6 °C temperature; the spimmo is regularly gently stirred to mix. It can be stored for several hours prior its use for fertilization; fertility of the sperm after 5 h storage was still good. Spermatozoa are still motile after quite long storage duration, up to 55 h but its fertility was not assessed.

It is to notice that the quantity of sperm collected is relatively limited, about 1.1 ml per kilogram of body weight (ml.kg^{-1}) after the fish was induced to release sperm. Moreover, liquid faeces are often squeezed together with the sperm while striping. Consequently, the syringe should be applied right on the genital papilla, just below the anus, in order to avoid any pollution of the sperm by the faeces. A small piece of air pipe (1.5 cm) is bevelled and connected to the syringe to have a better contact with the genital papilla.

Motility of the spermatozoa was checked after the sperm collection and prior its use for fertilization. Spermatozoa are observed in a drop of spimmo put under a microscope (x 160). Motility is triggered by mixing the spimmo to a larger drop of water. Almost all the spermatozoa should be active and the high motility should last about 20-30 seconds.

Conditions of fertilization

Ova were collected from the female by striping after anaesthesia with Phenoxy-2-Ethanol (§ 1.4) as illustrated in the Figure 4. Hands of the operator are previously coated with vaseline ointment for a soft striping. The fish is taken out of the water and dried in order to avoid any contact of the ova with water. The weight of spawn is recorded and a small sample (300-500 mg) of ova is taken to estimate the fecundity.


a


b


c


d

Figure 4. Management of the eggs of Pa-phone: collection of the ova by striping (a) and mixing with the spimmo and water for the fertilization (b), eggs put in the incubator (c), swelled eggs after hydration (d)

The spimmo is added to the ova and both are gently mixed with feathers. Spimmo might be diluted more with one or two volumes of immo solution (NaCl 12 g.L^{-1}) added just before fertilization; the extended volume of spimmo will provide a better contact between the ova and the spermatozoa. Pure water is added to trigger the fertilization; the water volume was equivalent to 50 % to 100 % the weight of ova. Ova, spimmo and water are gently stirred to mix with a soft spatula for one minute. Then the ova are rinsed twice with pure water. At this stage the eggs start to swell and they are put in the incubator.

Conditions of incubation

Three kinds of incubator were tested including one 'Mac Donald's jar' made of stainless steel and two kinds of hapas made of tissue and net. The second model of hapas was the most suitable (Figure 5); its use was already reported by Woynarovitch and Horvath (1980). Its volume was about 200 L including a conic volume on the bottom (65 cm side x 25 cm height) made of tissue topped by a cubic part (65 cm side x 35 cm height) made of net (thin mesh of 0.2 mm). The conic part was connected on the bottom to a small submersible water pump (60 watts) which provided ascendant water current in the incubator. The shape was maintained by a frame made of PVC pipe and by ballast hanged on the bottom. By this way, eggs were maintained in suspension in the incubator. This device was used here to incubate up to 150 g eggs; higher quantity might be used, probably up to 300 g.

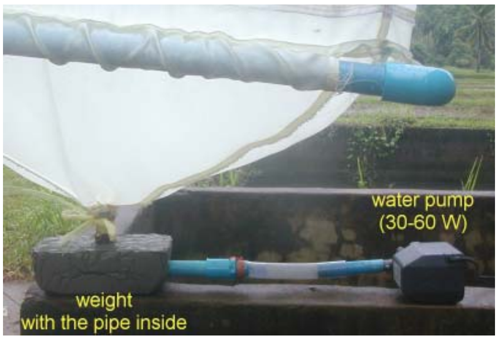


Figure 5. Incubator made of tissue and plankton net for the floating eggs of Pa-phone; the bottom part is connected to a small submersible water pump (right)

The fertilization rate (100 x N good eggs / N total eggs) was determined from a sample of 100-250 eggs taken from the incubator 10-14 h after fertilization. At this stage, the fertilized eggs showed an embryo with head and tail in the transparent membrane (Figure 4) while the non-fertilized eggs have a white colour. Hatched larvae were harvested from the incubator with a scoop net and separated from the eggshell and died eggs in a small container; the larvae settle quickly on the bottom while the waste staying in suspension are discarded. The hatching rate (100 x N total larvae / N total eggs) was determined based on the number of larvae estimated as in the following example. 0.1.

Assessment of the number of larvae (example) :

Larvae are put in a small container with a fixed volume of water (20 L) and aeration. The water is gently stirred to mix and four samples are taken. The number of larvae is counted in each sample and the density of larvae is calculated.

	Sample	volume (ml)	N	larvae density (N larvae.L^{-1})
1	70	130		1857
2	70	109		57
3	67	94		1403
4	70	90		<u>1286</u>
				average1526
			x 20 L	
			= 30 520 larvae total	

The volume of the sample is adapted to the density of larvae, so the amount to count is not too high (about 100 is suitable). Lastly, the number of samples (3 to 5) depends on the variability between the samples (more samples in case of high variability).

The total amount of larvae can be easily shared into several batches by taking a fixed volume of water. Following the same example, 10 000 larvae will correspond to 6.6 L taken from the 20 L containing the larvae (= 10 000 larvae / 1526 larvae. L^{-1}).

Reproduction performed with the wild fish breeders

Spawning was obtained with nine females captured at Don Den on the 2 July 2005. The body weight (BW) of those fishes was 3.4 +/- 1.3 kg, ranging from 2.1 to 6 kg. It is to notice that 6 kg is probably the highest BW ever reported for this species; the largest fish reported so far weighted 5 kg (Source: Fish Base 2005). Seven females shown spontaneous ovulation and ovulation had to be induced in two others. The latests have received two intra-peritoneal injections of LHRHa (5 and 25 µg.kg^{-1}) associated with domperidone (5 and 5 mg.kg^{-1}) diluted in pure water. The delay between the two injections was 6 h. Ovulation was observed 3:45 after the second injection at the water temperature of 25-26°C.

Ova were collected by striping and the weight of spawn was recorded. Sperm was collected by striping from males and directly poured on the ova for fertilization. Fertilization was triggered by adding water (about the same volume as the ova). Eggs were put into a small hapas hold in the river for incubation (about 2.5 x 1.5 x 1 m); the hapas net had thin mesh size (about 0.2 mm); aeration was provided with an air pump.

The males used for the sperm collection for the seven females with spontaneous ovulation did not receive any treatment to enhance the release of sperm. An other male was used for the two induced females; this male had received a single injection of LHRHa (25 µg.kg^{-1}) associated with domperidone (5 mg.kg^{-1}) while females have received the second injection.

RESULTS

Induction of the ovulation

The result obtained with the standard treatment was similar for the two doses of LHRHa; on the whole, only a quarter of the treated females had good ovulation (Table 2).

Table 2 *Ovulation rate with the standard treatment (A) and the new treatment (B).*

Treatment	Ovulation (N females)			
	None	Bad	Good	Total
A) Injection 1 / inj. 2: hormone diluted in water				
LHRHa 5/25 µg.kg^{-1} + domperidone 5/5 mg.kg^{-1}	8	1	3	12
LHRHa 10/30 µg.kg^{-1} + domp. 5/5 mg.kg^{-1}	1	4	2	7
Total	9 (47.4 %)	5 (26.3 %)	5 (26.3 %)	19 (100 %)
B) Injection 1: implant (LHRHa 70 +/- 10 µg.kg^{-1}) inj. 2: LHRHa 30 µg.kg^{-1} + domp. 10 mg.kg^{-1}	1 (7.7 %)	-	12 (92.3 %)	13 (100 %)

Note: Delay between the two injections: 6:30 (treatment A) and 16:00 (treatment B)

An other quarter had a bad ovulation (partial ovulation?) with hard striping of the ova and nearly half of the other females did not ovulate at all. Despite this poor result, it is amazing that all the treated females have shown oocytes at the stage of the germinal vesicle breakdown (GVBD) after the first injection; the GV was in the central part of the oocytes before treatment (Figure 6).

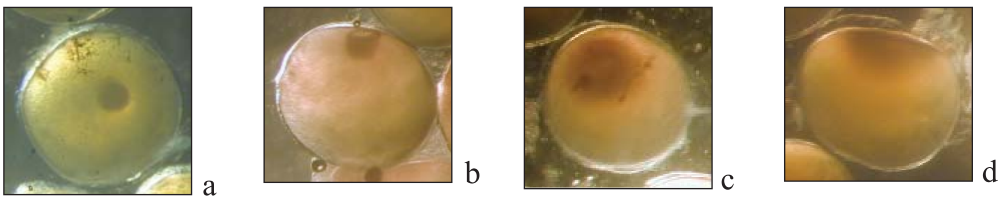


Figure 6. States of the germinal vesicle (GV) in the oocytes of Pa-phone (oocytes cleared with the Serra's solution): GV central (a); GV at the periphery (b); GVBD (germinal vesicle Breakdown), side view (c) and top view (d).

On the opposite, the new treatment has successfully induced the good ovulation in about 90 % of the treated females. It is to notice that the single female which did not respond had certainly an initial a problem to the ovaries as indicated by the presence of blood taken with the oocytes sample. Otherwise, the germinal vesicle has migrated from the central part of the oocytes to the periphery after the injection of the hormonal implant in all the females observed.

The latency period between the second injection and the ovulation was 3:45 and 7:05 on the average for the treatment A and B, respectively (Table 3). In both cases there is no clear relationship with the water temperature so the occurrence of the ovulation is unpredictable. However, we have noticed that the females on the verge of ovulation jumped at the surface before ovulation; the first ova were usually released few minutes after the third jump. Lastly, presence of foam at the surface is also a good indicator of the ovulation but a large part of the ova is already released in the tank when the foam is observed.

Table 3. *Latency period (i.e. delay between the last injection and the ovulation) in the case of good ovulation for the two treatments. Average and min-max values.*

Treatment	N females	Latency period (h:mn)	Temperature (°C)
A) Injections 1 and 2 (6:20 apart): LHRHa + domperidone diluted in water.	5	3:45 (2:25-4:10)	26.5-27.5
B) Injection 1: implant with LHRHa; injection 2 (16:00 apart): LHRHa + domperidone diluted in water.	12	7:05 (6:05-10:25)	25-26

The fish fecundity

Only the females with good ovulation are taken into account to analyze the fecundity. Moreover, we have to select only the females hold individually in the small tank and then striped right after the achievement of the ovulation process. In the other females hold in a group in a large tank, a large part of the ova was indeed often released in the hapas – and then lost – before the striping. It has appeared that the ova are released soon after the achievement of the ovulation process (i.e. within only a quarter of hour). Although the difference is not significant, the mean weight of spawn tends to be higher in the females hold individually in a small tank (135 +/- 41 $g.kg^{-1}$) than in the females hold in group in a large tank (97 +/- 40 $g.kg^{-1}$). For the latest amount, we consider all the results whatever the treatment applied although it could have an effect on the weight of spawn.

For the eight females hold individually in the small tanks during the treatment, the mean weight of spawn is 134.8 $g.kg^{-1}$ (i.e. 13.5 % BW) and one gram of ova contains 436 ova, so the associated fecundity is 58.1 10^3 $ova.kg^{-1}$ (Table 4). There is no significant difference between the females issued from the two ponds in terms of weight of spawn and fecundity per kilo BW. However, females from the pond 4 shown higher weight of spawn per fish than the females from the pond 3

(+ 146 %, P < 0.01) as well as a higher fecundity per fish (+ 129 %, P < 0.01). Those differences are related to the higher body weight of the females from the pond 4 (+ 135 %, P < 0.05).

Table 4. *Fecundity of the females with good ovulation and hold individually in the small tanks during the treatment B (implant + normal injection). Average values, SD in brackets.*

Parameter	Pond		
	N° 3	N° 4	Total
N females	4	4	8
BW (kg)	0.71 (0.06)	(*) 1.67 (0.55)	1.19 (0.63)
Weight of spawn (g)			
- Per fish	91.3 (36.4)	(**) 225.0 (50.5)	158.1 (82.3)
- Per kilo BW	129.8 (52.3)	139.8 (32.2)	134.8 (40.6)
N ova per g ova	455 (43)	417 (18)	436 (36)
Fecundity (N ova)			
- Per fish (x 1000)	40.9 (14.9)	(**) 93.6 (20.3)	67.2 (32.6)
- Per kilo BW (x 1000)	58.3 (22.6)	57.9 (10.9)	58.1 (16.4)

Note: Significant differences between the two ponds: P < 0.05 (*); P < 0.01 (**).

Size of the oocytes and ova

The mean diameter of the gametes fixed in the Gilson's solution is the same for the oocytes before treatment and for the ova collected by striping (1.5 +/- 0.1 mm, Figure 7). Those data are issued from the measurement of 14 and 19 gametes samples taken before and after treatment for inducing the ovulation, respectively (30-33 oocytes per sample). It is to notice that the ova fixed in the Gilson's solution appeared much smaller than the same ova at the fresh stage (2.3 +/- 0.2 mm; P < 0.001; 14 samples, 30 ova per sample). Fresh ova are very soft so they flatten on the glass strip whereas the ova fixed in the Gilson's solution are rigid so they have an almost round and smaller shape. The diameter of the fresh ova ranges from 1.5 to 2.7 mm; this broad variation might be related to the various state of hydration of the ova. 0.1. Production of sperm

The spontaneous production of sperm is quite limited and variable for the males of Pa-phone raised in pond (264 +/- 126 µl.kg^{-1}). Depending on the dose of hormone, the mean spermiation significantly increased by 2.8 to 6 times after a single injection of LHRHa associated with domperidone diluted in water (Figure 8). The dose of 5 µg.kg^{-1} LHRHa and 5 mg.kg^{-1} domperidone with 9 h of latency period (treatment B) seems to be a suitable treatment; the volume of sperm collected was 964 +/- 361 µl.kg^{-1} (P < 0.01). Higher dose of LHRHa (30 µg.kg^{-1}) or/and domperidone (10 mg.kg^{-1}) can induce a better mean spermiation although the associated variability tends to increase. The highest mean spermiation (1580 +/- 862 µl.kg^{-1}; P < 0.05) was obtained with the treatment C (LHRHa 30 µg.kg^{-1} + domperidone 5 mg.kg^{-1}) and 8 h of latency period. For the treatment D (LHRHa 30 µg.kg^{-1} + domperidone 10 mg.kg^{-1}), the mean spermiation tends to be better while the latency period increased from 4-7 h to 21 h (NS). Injection of the implant with LHRHa (50 µg per fish) and a latency period of 20 h did not induce a significant rise of the spermiation; the mean value tends to be higher but the variability is quite high too. While considering the treatment D (LHRHa 30 µg.kg^{-1} + domperidone 10 mg.kg^{-1}) with the short latency period (4-7 h), there is no significant difference between the males from the pond 3 or 4 (Table 5).

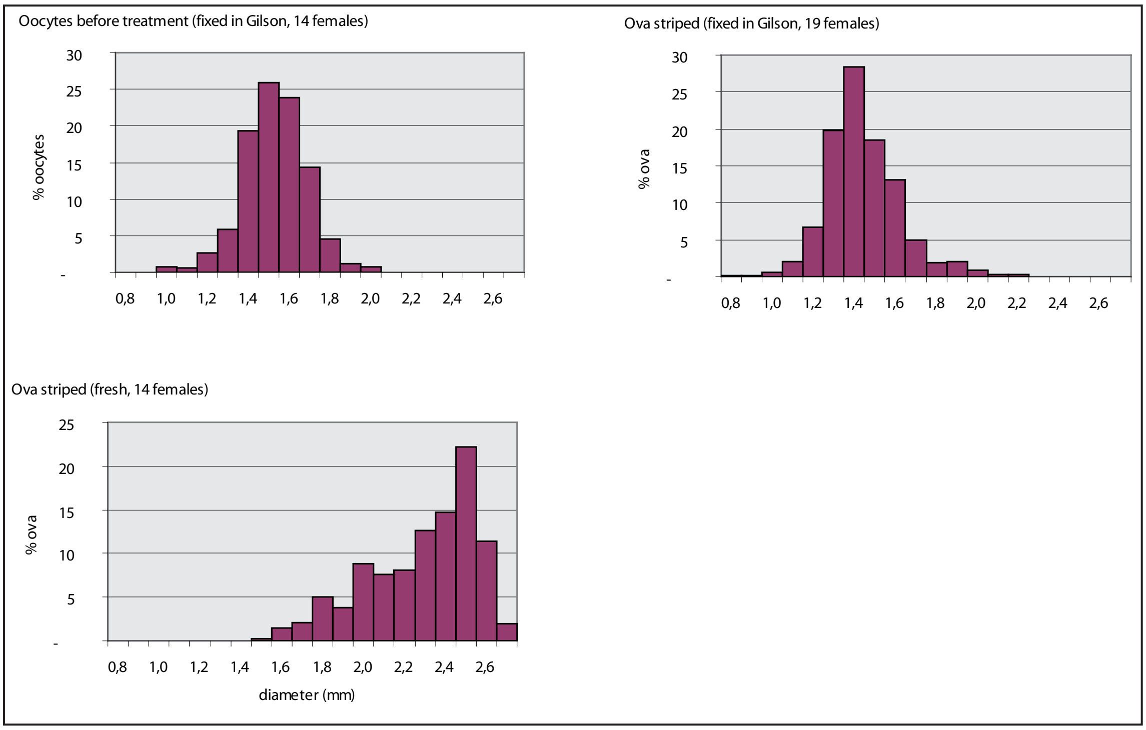
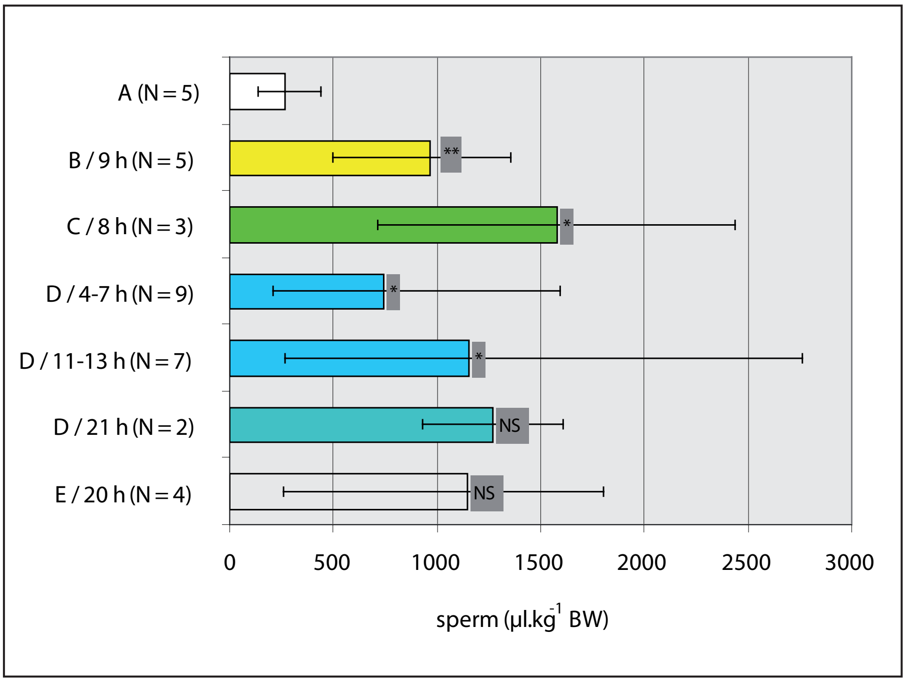


Figure 7. Mean distribution of the diameter of the oocytes and ova of C. microlepis (30-33 gametes were taken by sample, one sample per female)

Table 5 : *Volume of sperm collected from the males raised in the pond 3 or 4. Spermiation was induced by the treatment D (LHRHa 30 µg.kg^{-1} + Dom. 10 mg.kg^{-1}) with short latency period (4-7 h). Average values, min-max values into brackets.*

Parameter	Pond		
	N° 3	N° 4	Total
N males	4	5	9
BW (kg)	1.10 (0.57-1.5)	0.98 (0.58-1.94)	1.03
Sperm per fish (ml)	0.6 (0.3-1.2)	0.8 (0.2-1.4)	0.7
Sperm per kg BW (µl)	622 (208-800)	837 (286-1591)	742



(A) No treatment (i.e. spontaneous spermiation); (B) LHRHa (5 µg.kg^{-1}) + Dom. (5 mg.kg^{-1});
(C) LHRHa (30 µg.kg^{-1}) + Dom. (5 mg.kg^{-1}); (D) LHRHa (30 µg.kg^{-1}) + Dom. (10 mg.kg^{-1});
(E) Pellet with LHRHa (50 µg/fish).
Average and min-max values are mentioned. The number of fish per treatment is mentioned into brackets (N =). The difference between the treatments and the spontaneous spermiation (treatment A) is mentioned (U test, Mann-Whitney): NS (non significant); * (P < 0.05); ** P < 0.001).

Figure 8 . Volume of sperm collected by stripping per kilo of body weight (BW) in case of different treatments (A-E) applied with various latency period (i.e. delay between the injection and the collection of sperm, expressed in hours).

Storage of sperm and observation of the motility

Specific materials and methods

Sperm was collected by striping from three males and then stored in three different conditions: pure or diluted in two 'immo' solution, NaCl 9 g.L^{-1} or NaCl 12 g.L^{-1}. The sperm was diluted three times in the 'immo (1 vol. sperm plus 2 vol. 'immo'); the mixture sperm and immo is called here 'spimmo'. The three flasks containing the spimmo were stored in the fridge at 5-6°C temperature during up to 79 h. Motility of the spermatozoa was assessed several times with two activation solutions: pure water or light saline solution (NaCl 2 g.L^{-1}). Almost all the spermatozoa were activated for a brief period and then the proportion of motile spermatozoa was reduced gradually. The initial proportion of motile spermatozoa was roughly estimated and recorded as well as the duration (mn:sec) associated with the reduction by half of the motility and the end of the motility.

Storage of the pure sperm

Part of the spermatozoa in the pure sperm was spontaneously and slightly activated (i.e. vibration); this observation indicates that this storage condition was not suitable. Activity of the spermatozoa in the activation solution was excellent after one hour storage; activation lasted longer in NaCl 2 g.L^{-1} (1:05) than in pure water (00:35). After 5-6 h storage, the proportion of motile spermatozoa was reduced tremendously; only 20 % or 40 % spermatozoa were motile in NaCl 2 g.L^{-1} or pure water, respectively. Motility was nil after 20 h storage. Activity should be checked again between 1 h and 5 h in order to determine more accurately when it drops down.

Storage of the sperm diluted three times in the immobilizing solution

Whatever the salinity of the immo and the sperm dilution, spermatozoa observed in the 'spimmo' did not show any spontaneous activation; this observation indicates that this storage condition was suitable.

Motility in the activation solution was excellent with almost 100 % motile spermatozoa until 20 h storage; then the proportion of motile spermatozoa was slightly reduced to about 80 % after 22 h. With the immo NaCl 9 g.L^{-1}, motility stayed acceptable after 48-49 h storage and then was nil after 79 h. With the immo NaCl 12 g.L^{-1}, the sufficient motility was extended to 55 h and even 30-50 % motility was still observed after 79 h storage. The pattern of motility was similar whatever the salinity of the immo solution and the activation solution (Figure 9). Almost all the spermatozoa were activated within 10 seconds and then the proportion of motile spermatozoa decreased progressively. About half of the spermatozoa were still motile after 50 seconds on the average. Then the remaining motility was determined by the salinity of the activation solution ($P < 0.05$); motility lasted longer in the saline solution (NaCl 2 g.L^{-1}) than in the pure water, 120 and 90 seconds on the average, respectively.

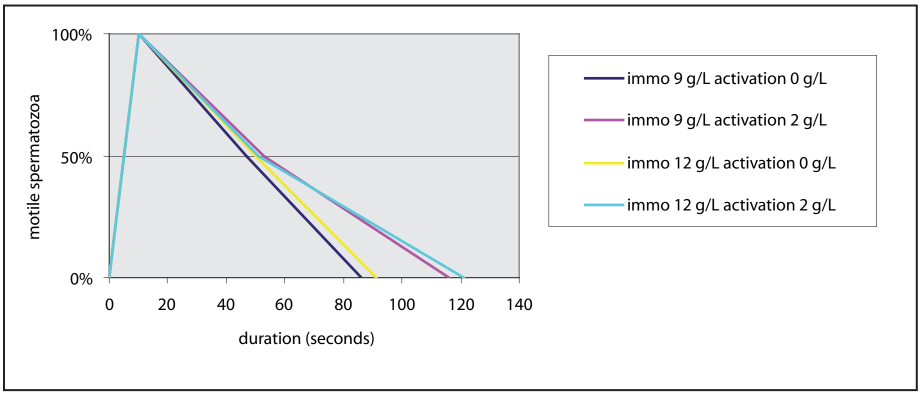


Figure 9. Motility of the spermatozoa with two different salinities for the 'immo' solution (NaCl 9 or 12 g. L-1) and the activation solution (NaCl 0 or 2 g.L-1). The delay for the maximum motility (100 %) was estimated at 10 seconds; the other delays for 50 % and 0 % motility were timed 6-7 times within 48 h storage (average values mentioned).

Fertilization and incubation of the eggs

The two last batches of eggs obtained during this season were managed in good conditions as presented in the Table 6. Females were hold individually in small tanks allowing collecting the ova right after the achievement of the ovulation, so the quality of the ova was certainly optimal (i.e. no risk of over-ripening). Moreover, large bags (150 and 200 L) made of tissue and plankton net were used as incubator. Proper incubation of the large and floating eggs of Pa-phone requires large volume of water and a soft water current; incubator like 'Mc Donald jar' (40 L) was not suitable at all. We have stocked the eggs in the large bags at the density of about one gram of dry egg per litter (i.e. about 440 eggs.L^{-1}) with satisfying results. Higher density might be applied although *a priori* three grams of dry eggs per litter might be the maximum. The quality of the sperm was good as indicated by the excellent motility of the spermatozoa. The sperm was diluted 3-4 times in the 'immo' solution (NaCl 12 g.L^{-1}) and stored in good conditions at 5-6°C temperature during about 2 or 4 h for the batch 1 and 2, respectively.

Development of the eggs

After fertilization, eggs are rinsed and put into the incubator made of tissue and plankton net. Hydration of the egg results in the detachment of the chorion (eggshell) and the swelling of the egg. Egg becomes a small ball with a low density, typically 'floating eggs' like those of the mrigal (Indian carp). The external diameter of the egg is 5-5.3 mm while the diameter of the embryo inside is 1.6 mm at the beginning of the incubation. Hatching of the eggs occurs within 14-23 h. Duration of the incubation is closely related to the temperature as indicated in the Figure 10; eggs start hatching after 14 h at about 25.8 °C (mean temperature) or after 19 h at 24.8 °C ($r = -0.991$; $P < 0.001$). Water temperature has ranged from 24.5 to 26.5 °C.

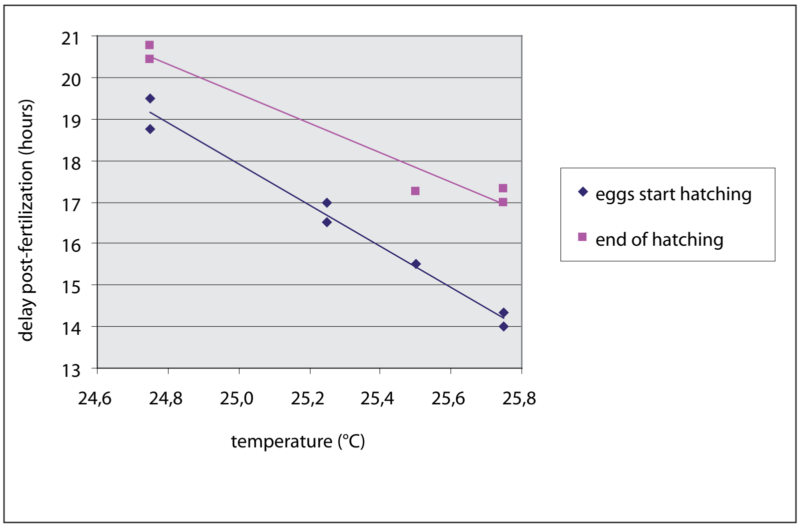


Figure 10. Correlation between the mean water temperature and duration of incubation for the eggs of Pa-phone

Table 6 . *Fertilization and hatching rates for two batches of eggs in the present optimal conditions of incubation*

				Spimmo [a]				Conditions of fertilization (volumes for 100 g ova)					x 1000		% of total eggs	
Batch of eggs	Date	Fish N°	Fish pond N°	ova (g)	Sperm dilution	Storage (h:mn)	Additional dilution [a]	Spimo (ml)	Sperm (ml)	Water (ml)	Sperm dilution in water	Incubator [c]	N ova	N larvae	Fertilization [d]	Hatching [e]
1	30/07/05	1	3	125	3.7	2:45	None	4.6	1.2	100	81	Conic	58.5	4.1	N	6.9
		2		120	3.7	2:25		4.2	1.1	100	89		47.4	15.2	N	32.0
	05/08/05	3	3	65	3.9	2:35		6.2	1.6	100	63		32.2	2.7	n	8.5
	06/08/05	4	4	255	3.9	0:35		1.7	0.4	100	231		109.5	39.4	41.1	18.7
		5		240	3.9	1:05		1.8	0.5	100	218		101.3		50.4	
Average		-	-	161	3.8	1:53	-	3.7	1.0	100	136	-	69.8	12.3	45.8	16.5
2	17/08/05	6	3	55	3.3	5:15	2.0	5.5	1.7	91	55	Cubic	25.4	13.3	67.0	52.3
		7	4	150	3.3	4:15	3.0	2.0	0.6	67	110		63.9	30.9	72.0	48.4
		8		255	3.3	3:20	3.0	1.2	0.4	59	165		99.7	38.3	42.8	38.4
Average		-	-	153	3.3	4:16	2.7	2.9	0.9	72	110	-	63	27.5	60.6	46.4

(a) : Mixture of sperm and immobilizing solution or 'immo' (saline solution NaCl 12 $g.L^{-1}$),

(b) : the spimmo is diluted in additional immo (NaCl 12 $g.L^{-1}$) just before fertilization,

(b) : incubator made of tissue and plankton net with a conic shape (volume: 150 L; surface of net 40 dm^2) or cubic shape (200 L; 70 dm^2 net),

(d) : percentage of normal embryo (head and tail visible) counted 14:20-16:30 after fertilization in eggs samples taken from the incubators (total eggs per sample: 106-159),

(e) : percentage of total number of larvae collected from the incubator.

It is to notice that most of the observations were made by the end of the spawning season of Pa-phone, during the rainy season while the water temperature was reducing progressively. Consequently, the duration of the incubation might be even shorter at higher temperature.

Eggs undergo the gastrulation about 6 h after fertilization (Figure 11). At this stage, observation with a lens allows to distinguish the fertilized eggs from the unfertilized eggs (Figure 4). The beginning of the morphogenesis (head and tail visible) about 13 h after fertilization is an other noteworthy step; abnormal embryos – if any – are distinguished from the normal embryo with a lens or even with naked eye. Moreover, unfertilized eggs have become white while the normal eggs are transparent, the two being visible to the naked eye. Thus, the early morphogenesis is the suitable step to determine the fertilization rate from egg samples. After a longer duration, the eggshell becomes weak and part of the unfertilized eggs disappear.

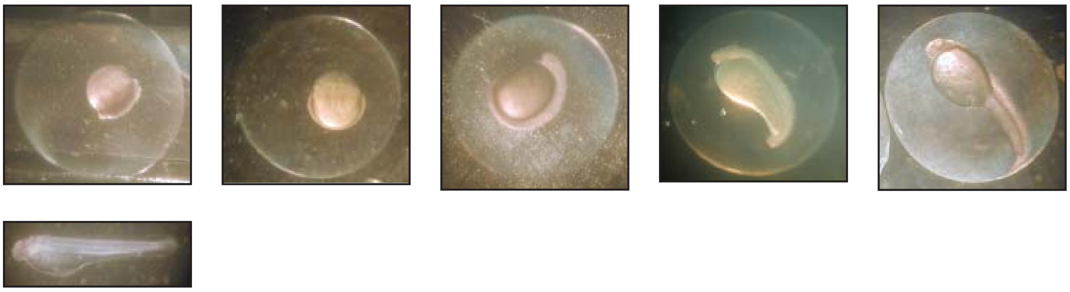


Figure 11. Key steps of the embryogenesis of Pa-phone: beginning of the cell division (a), gastrulation (b), appearance of the head and tail and somites (c), first movement inside the egg (d), on the verge of hatching (e) and newly hatched larvae (f)

Survival of the fish breeders during the treatment

Nearly one fifth of the fishes have died during the experiments on the artificial reproduction (Table 7).

Table 7. *Mortality of the fish breeders during the experiments of artificial reproduction.*

Fish	Female	Male	Total
Total handled	33	47	80
Total died	5 (15 %)	9 (19 %)	14 (18 %)

Cause of the mortality	Female	Male	Total
Jumped out of the tank	3	2	5 (36 %)
Anoxia in small container	-	3	3 (21 %)
Too long anaesthesia	-	3	3 (21 %)
Striped twice	1	1	2 (14 %)
Hard handling	1	-	1 (7 %)
Total	5	9	14 (100 %)

This proportion is relatively limited regarding to the high mortality reported from the initial trials made last year at the Km8 station (80 %?); most of the treated fishes have died at that time. The better result obtained here is associated to the suitable handling of the fish; the use of anaesthesia before any striping of sperm or ova is probably the main improvement. The second improvement is the use of the small plastic tank for the individual stocking of the female during the process of ovulation; the fish is captured only once while the ovulation is observed.

Mortality has occurred here by accident (jumping out of the tank) or because of mistakes that could be easily avoided for the next operations:

- Fish should be always put in container with aeration; they should not wait over five minutes in the small container near the pond while selecting the mature fish; fish breeders should be better kept in the net hold in the pond while waiting.
- The duration of the anaesthesia should be limited; fish can be handled as soon as it becomes quite (after about one minute in the phenoxy-ethanol), before the full – and hazardous – anaesthesia. Water in the containers for anaesthesia and recovering should be well aerated.
- Fish should be anaesthetized and striped a single time only per operation; two successive stripings indeed kill the fish.

Reproduction performed with the wild fish breeders

The fish fecundity was 165 10^3 ova per female and 46.7 10^3 ova.kg^{-1} BW on the average (Table 8).

Table 8. *Fecundity of wild females of Pa-phone captured at Don Den in July 2005. Average values, standard deviation or min-max values into brackets.*

Parameters	No induction [(a)]	Two injections [(b)]	Total
N females	7	2	9
Body weight BW (kg)	3.5 (1.4)	3.3 (2.7-3.8)	3.4 (1.3)
Weight of spawn			
- per fish (g)	454 (266)	500 (300-700)	464 (252)
- per kilo BW (g)	127 (40)	148 (111-184)	131 (40)
Number of ova [(c)]			
- per fish (x 1000)	161.3 (94.6)	177.8 (106.7-248.9)	165 (89.6)
- per kilo BW (x 1000)	45 (14.4)	52.5 (39.5-65.5)	46.7 (14.4)

[(a)] : Spontaneous ovulation of the females,

[(b)] : mixture of LHRHa associated with domperidone diluted in water for each injection,

[(c)] : equal to weight of ova x 356 ova per gram of ova (average of 333-361-372).

Fertilization seemed to be good for the eggs collected from the seven females with spontaneous ovulation although the fertilization rate was not determined. Hatching was high as well but a large proportion of larvae have died about 4 h after hatching. The cause(s) of this sudden mortality are undetermined; water temperature was 25-26°C which seems to be sufficient. No larvae were obtained from the eggs collected from the two females after induced ovulation; the fertilization was probably nil.

DISCUSSION

Reproduction performed with the wild fish breeders

The average fecundity was quite high in the females with spontaneous ovulation or after induced ovulation. On the whole, nearly 1.5 millions eggs were obtained from the nine females. This result indicates that the use of wild breeders for reproduction can provide a large amount of eggs.

However, the management of the gametes has to be improved in order to get both good hatching and good survival of the larvae at least right after hatching. First of all, the sperm has to be properly managed, from the collection to its use for fertilization, with possible storage for several hours. The hapas hold in the river is probably not the most suitable means of incubation for the eggs. It might be also not suitable for the stocking of the newly hatched larvae; strong current in the river could especially impair the survival of the weak larvae. Those techniques have been studied and improved afterwards with fish breeders stocked in ponds at the Km8 station.

Good maturation of the fish breeders raised in ponds

The present study clearly shows that the breeders of Pa-phone raised in ponds have a suitable sexual maturation; this confirms the previous observations made by Pengarun in 2004. However, this seems to be quite new since Gorda (2001) and Somboon (2002) have reported that the fish did not achieve the maturation in ponds at the Km8 station. Otherwise, Somboon has also reported that maturation was achieved by the fish breeders raised in pond in the North of Laos at Luang Prabang. Occurrence of the maturation since (at least) 2004 at the Km8 station might be related to several factors including the age of the fish and the broodstock management (suitable feeding and water exchange).

Otherwise, dissection of three females died during the treatment has confirmed the advanced stage of maturation of the breeders; the mean gonado-somatic index (GSI) was 21.6 +/- 4.9 % (details in Cacot, 2005). It is to notice that there was almost no peri-visceral fat in those fishes.

Improvement of the standard treatment

Our results clearly show that the standard treatment is not reliable, unlike the treatment including the implant followed by the normal injection. The LHRHa implant induces a positive evolution of the gametes indicated by the migration of the germinal vesicle (GV) to the periphery. This intermediate stage seems to be necessary before the injection of the dose which will trigger the ovulation. Although the implant is efficient, we should try to arrange the standard treatment involving only injections of hormone(s) diluted in water because they are more convenient than the implants. Two new sequences of standard injections could be tested in order to induce the migration of the GV before applying the resolving injection(s).

(Sequence 1) The first resolving injection should be relatively low, about 0.5-2 $\mu g.kg^{-1}$ LHRHa, followed by the second resolving injection, 20-30 $\mu g.kg^{-1}$ or even less. The low dose applied first might induce the migration of the GV. The interval between the two injections might be adjusted according to the evolution of the GV. This treatment is based on the observation of the germinal vesicle breakdown (GVBD) induced by the first injection with 5 $\mu g.kg^{-1}$ applied in the present study. This means that the latest dose is certainly too high and so the treatment was not progressive enough. This hypothesis is strengthened by the hormonal treatment applied in Bolivia (South America) on two other fish species, the *Pseudoplatystoma* sp. (catfish, Pimelodidae) and the *Piaractus* sp. (Characidae, Serrasalminae). For the latests, the total dose of LHRHa, also from the Suprefact™, is 5-6 $\mu g.Kg^{-1}$ shared between 10 % and 90 % for the first and the second injections (pers. comm. Rémy Duguet, IRD, France). The two injections are given 12 h apart and the latency period between the second injection and the ovulation is about 8 h for the *Pseudoplatystoma* and 12 h for the *Piaractus*. This treatment also indicates that the second resolving injection can be relatively low too.

(Sequence 2) The two resolving injections could be preceded by a preliminary injection given a relatively long time before (24 h ?). The latest will consist of a low dose of hCG (Human Chorionic Gonadotropin), 500 $IU.kg^{-1}$. This injection might induce the migration of the GV. Such treatment was reported for *Pangasius hypophthalmus* by Thalathiah *et al.* (1988) in Malaysia and then widely developed in the Mekong delta (Cacot, 1999). In Malaysia, after the preliminary injection (hCG 500 $IU.kg^{-1}$), various hormones and combinations of hormones are applied for the two resolving injections.

For the two treatments suggested above, the total dose of domperidone could be kept at 10 $mg.kg^{-1}$, shared between the two or the three injections consisted of LHRHa.

Improvement of the hormonal implant

The implant used here at the dose of 70 +/- 10 $\mu g.kg^{-1}$ of LHRHa had a good effect although limited to the migration of the GV to the periphery of the oocytes within 16 hours after the implantation. Completion of the ovulation process might be obtained after a longer duration and this has to be tested. It is to notice that the same kind of implant was tested before the Pa-phone to induce the ovulation in Pa-duk (African catfish, *Clarias gariepinus*) at the Km8 station (Cacot, 2005). For the Pa-duk, the full ovulation was obtained in all the females implanted with 50, 100 or 200 $\mu g.kg^{-1}$ of LHRHa within about 9 hours (five females per dose); no additional injection was required. Consequently, the response to the treatment varies from species to species.

Beside the delay, the limited effect of the implant within 16 hours could be related to the limited amount of hormone released in the fish although the dose was relatively high. Consequently, the composition of the matrix should be studied in priority. Actually, the kinetics of the hormone release is closely related to the ratio cholesterol/cellulose (Sherwood *et al.*, 1988); high proportion of cellulose (up to 25 %) is associated with a fast release (within 24 h) whereas implant with 100 % cholesterol has slow release (several weeks). Since the proportion of 15 % cellulose was tested in the present study, higher proportion could be tested (20 and 25 %) with the same dose of LHRHa (70 $\mu g.kg^{-1}$). The dose of hormone could be even reduced afterwards. The effect of the nature of the analogue of the luteinising realising hormone (GnRHa or LHRHa) could be studied in last. Other GnRHa different from the Buserelin acetate from the Suprefact ™ might have a better effect. However, those analogues are usually more expensive than the Suprefact ™ and not locally available. Lastly, it is to notice that an other – and probably more practical – method has been performed to prepare the implant, the Ethylene Vinyl Acetate copolymer (EVAc) used as matrix (reported by Mylonas and Zohar, 2001).

Beside the artificial reproduction, the use of an efficient hormonal implant will be useful to perform the natural reproduction of the Pa-phone. A first trial of natural reproduction was attempted this year with three females and five males, both induced with a standard treatment of LHRHa and domperidone, but it has failed (details in Cacot, 2005). Ovulation has occurred but there was almost no fertilization.

Management of the gametes

The mean fertilization obtained with the last batch of eggs of Pa-phone was medium (60.6 % on the average) although the ratio ova / sperm was relatively high (169 $g.ml^{-1}$). This value is similar to that reported by Gorda (2001) from the reproduction of the wild fish breeders (60-65 %). Further experiments are required to determine the optimal conditions of fertilization, including especially the ova / sperm ratio and the ratio water / ova for the fertilization (i.e. sperm dilution in the activation solution).

The mean hatching rate was not very good (46.4 %) although the fertilization rate was better. Part of the larvae might have been lost while separating the eggshell from the larvae, so the method for harvesting the larvae has to be improved. The eggshell could be better removed directly from the incubator; larvae will settle after switching off briefly the water pump while the eggshell will stay in suspension. Otherwise, as it was clearly observed in one female, part of the fertilized eggs could contain abnormal embryo which will dye before hatching. Lastly, the water flow in the incubator might have been slightly too strong, so it can have damaged part of the fertilized eggs.

Determination of the suitable management and quality of the gametes will require trials with the assessment of the fertilization and hatching rates in standard conditions. Those conditions consist in the incubation of a small batch of eggs (100-200 eggs) in suspension in a small water volume (1 L); those small and specific incubators have to be arranged first.

Quantity of gametes collected

The fish fecundity

The mean weight of spawn as well as the fecundity per kilogram of body weight (BW) is relatively similar between the females raised in the pond 3 or 4 and the females captured in the river (Table 9).

Table 9 : *Comparison of the weight of spawn and the fecundity for the Pa-phone issued from the two ponds at the Km8 station or from the Mekong River.*

Parameter	Origin of the fish		
	Pond N° 3	Pond N° 4	River
N females (*)	4	4	9
BW (kg)	(a) 0.71 (0.06)	(a) 1.67 (0.55)	(b) 3.43 (1.28)
Weight of spawn			
- per fish (g)	(a) 91.3 (36.4)	(ab) 225 (50.5)	(b) 464 (252)
- Per kg BW (g)	129.8 (52.3)	139.8 (32.2)	131.3 (40.4)
N ova per g ova	(a) 455 (43)	(a) 417 (18)	(b) 356 (20) (**)
Fecundity (N ova)			
- Per fish (x 1000)	(a) 40.9 (14.9)	(ab) 93.6 (20.3)	(b) 165 (90)
- Per kg BW (x 1000)	58.3 (22.6)	57.9 (10.9)	46.7 (14.4)

(*): Females from the pond 3 and 4 hold individually in small tanks during the hormonal treatment and having a good ovulation,
(**): calculated from three samples taken from three females only.
Significant differences between the origins are indicated by different letters (a, b) ($P < 0.05$).

However, the weight of spawn and the fecundity per fish seems to be closely related to the body weight of the fish; females from the pond 3 have the lowest mean fecundity (40.9 10^3 ova) associated with a BW 0.71 kg while the females from the river have the highest fecundity (165 10^3 ova) associated with a BW 3.43 kg ($P < 0.01$). It is to notice that the ova of the latest females are heavier than those of the females from the pond 3, with 356 and 455 ova per gram of ova, respectively. The latest difference might come from the different hydration of the ova due to the operation of striping; this might also indicates the difference in size of the gametes, probably bigger for the wild females. Females from the pond 4 shown intermediate values.

The results also clearly show that the present feeding with floating pellet provides better growth of the females and then higher fecundity per fish compared to the home-made feed. Thus, the floating pellet should be preferred for the conditioning of the fish breeders.

The production of sperm

The spermiation is moderate although significantly increased after hormonal induction (0.7-1.6 ml. kg^{-1}). This result is certainly due to the limited development of the testis as described by Cacot (2005); the mean GSI recorded from the dissection of five mature males was only 0.5 +/- 0.1 %. Small testis is probably a specific feature of the Pa-phone; this hypothesis should be verified by the comparison with the testis observed from wild and mature fishes.

CONCLUSION

The new protocol involving the use of the hormonal implant induces the ovulation of 90 % of the treated females. Moreover, the implant is relatively convenient since it is prepared locally by using the Suprefact ™ already available. Therefore, this method should be extended in order to initiate the commercial production of larvae and fingerlings of Pa-phone. Further research on the induced ovulation could focus on (1) the arrangement of the standard treatment which remains unreliable, (2) the arrangement of the implant so it can alone trigger the full ovulation and (3) the natural spawning after induction. The quantity of sperm collected from the male is increased after induction although it remains limited so it has to be collected, stored and used with care. Simple dilution of the sperm in saline solution allows postponing the use of sperm for at least 5 hours. Lastly, the conditions of fertilization should be optimized although the fertilization rate obtained here is acceptable (60 %).

In our conditions, the commercial floating pellet provides better conditioning of the fish breeders as indicated by the higher fecundity compared to the home-made feed. The reproduction cycle of the fish breeders stocked in pond should be determined by making a regular monitoring of the maturation fish (e.g. sampling on a monthly bases). The water temperature should be also recorded in the pond in order to determine its effect on the maturation. Lastly, the broodstock management could be improved by the individual tagging of the fish (i.e. use of Passive Internal Transponder, PIT-tag); by this way, we could determine the frequency of maturation and reproduction as well as the fecundity per fish. The latest procedure would contribute to identify and even to select the best fish breeders.

Although the broodstock in pond is now reliable for the reproduction and the fish seed supply, we should continue to make use of the wild fish breeders coming every year near Pakse for breeding. The latests are quite easily available, although the period is short, and they can provide a large amount of eggs. The protocol of breeding on the field with the ‘mobile hatchery’ should integrate all the improvements issued from the present work.

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Reproduction and nursing of *Cirrhinus molitorella* in a small fish farm in Luang Prabang Province, Lao PDR

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ABSTRACT

The propagation of *C. molitorella* has started in 1991 and this species is now considered domesticated. The Lao Sub-component of AIMS has supported several farmers in Luang Prabang in Northern Laos in producing *C. molitorella* through technical assistance and materials support. The present study describes the current technique for conditioning the fish breeders in ponds and for the reproduction, as practised in a small family fish farm in the Luang Prabang province. The study was carried out in 2005.

The broodstock of *C. molitorella* consisted in 35 fishes weighing 300-350. Fish were stocked in ponds (800 m^2) together with four other species of fish breeders. Fish breeders were fed with rice brand and local vegetables as main feeds and additional compound feed (30 % proteins) during the breeding season from May to August. The natural reproduction of *C. microlepis* was induced with a single injection of LHRH associated with domperidone. Spawning occurred six hours after the injection; the fecundity per female was about 31,000 eggs. Incubation of the floating eggs lasted 16-17 hours at 26-28°C; the hatching rate was 90 %. Trials of nursing were carried out successively in tanks (5-7 days) and in two kinds of hapas held in the pond for five weeks. The survival rate after nursing was about 20 %. Although this result could be improved, the net income from this activity was quite good, equivalent to 4-5 times the standard salary in rural area. Additional trials will be required in order to assess the performances of the reproduction of *C. molitorella* alone.

INTRODUCTION

The indigenous mud carp *Cirrhinus moritorella* is named 'Pa-ken' in the Lao language. Local people appreciate this fish because it is nutritive and also because old people can digest it easily. The rise of fishing pressure has lead to the reduction of the capture fisheries. Therefore, it is necessary to domesticate *C. molitorella* to meet the demand on the local market (Ounidate *et al.* 1993). Moreover, *C. moritorella* is an indigenous Mekong fish species that needs to be preserved. In terms of breeding in captivity, its reproduction is similar to *C. microlepis, Barbonymus gonionotus and Probarbus jullieni* (Somboon, 2001).

Artificial reproduction *C. molitorella* has been performed in the Luang Prabang Province (Northern Laos) since 1991 by the staff of the at Naluang Hatchery (State Farm) (Pinthip *et al.* 2001, Souksavath 2001). From 1991 to 1995, mature fish breeders were captured during the breeding period from several Mekong tributaries, including Nam Kong, Nam Karn and Nam Ou Rivers. Reproductionhas been achieved with fish breeders stocked in ponds at the Naluang station since 1996. This operation is supported by the LARReC in the frame of MRC-AIMS programme. At the present time, beside the Naluang station, *C. molitorella* is bred in two private farms including the

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Mrs La farm which is presented in this study. Fingerlings of *C. moritorella* are distributed to three other local farmers in the surroundings for grow-out.

MRS. LA'S FISH FARM

The livelihood of Mrs La and her family relies on fish farming. They live at Ban Xepeing Village, Luang Prabang District. They have collaborated with the AIMS activities since the year 2001. Their main source of income is selling fingerlings of *C. molitorella* and four other fish species, which brings in a total income of about 30,000,000 Kips per year. The detail return per species is not available. *C. moritorella* is a new species on the fingerlings market compared to other, and more common, species. Therefore, they can get better price from the fingerlings of *C. molitorella*. Technical assistance on the broodstock management and the reproduction techniques was provided to the family by the Naluang Hatchery.

The family owns only one fish pond (800 m^2) and four cement tanks for reproduction (200 L) and nursing (3 m^3) (Figure 1).

Figure 1. The single pond used for raising fish breeders and nursing the fish larvae (left) and Concrete tank used for the reproduction and nursing (right).

The labour for the maintenance of the pond and the fish reproduction is provided by the family alone. Beside *C. molitorella* (Pa-ken), the other species also bred at the Mrs La's farm include African catfish (*Clarias gariepinus*, Pa-duk), silver barb (*Barbodes gonionotus*, Pa-pak), common carp (*Cypimus carpio*, Pa-nay) and grass carp (*Ctenopharyngodon Idella*, Pa-kin-nha). All the propagation procedures of all the species are conducted on the farm, including conditioning of the fish breeders, reproduction and 45-50 days of nursing. The schedule of these activities is presented in the Table 1. It is also noteworthy, that beside the fish breeders, the nursing is also done in the same pond, either in hapas for *C. molitorella,* or in compartments in the pond for the other species. Lastly the ponds, to a limited extent, are used for grow-out of these species, plus Tilapia. The fish production is integrated with poultry or pig production.

Table 1. *Yearly schedule of activities at the fish farm.*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Selection of the fish	■											■
Conditioning		■	■	■								
Reproduction					■	■	■	■				
Nursing					■	■	■	■	■	■		

PROPAGATION AND NURSING

Broodstock management

In 2003, Mrs La purchased 40 one-year old fish breeders from the Naluang Hatchery (Luang Prabang Province). The average weight of the males and the females was 180 g and 200 g respectively. After raising the fish in the ponds for two years, the male fish (20 fishes) on average weighed 300 g and the females 350 g (15 females). These fish breeders came from the reproduction of other breeders stocked in ponds at the Naluang station for at least one generation, and possibly two or three successive generations. From 1991 to 1995, the fish breeders at the Naluang station were issued from the reproduction of wild and mature fish breeders captured in Mekong tributaries.

Fish breeders of *C. molitorella* were stocked in one pond (800 m^2) together with the four other species. The total biomass of fish breeders was about 161 kg (202 g per m^2), including 11 kg of *C. molitorella* (35 fishes x 320 g) and 150 kg of other species (214 fishes x 700 g). Therefore, *C. molitorella* was a minor species, only comprising about 14 % of the total amount of fish breeders. Feed was given twice a day and the composition and the feeding rate changed through the year (Table 2). Beside feed, fertiliser was applied with compost, dung, manure and mineral fertiliser.

Table 2: *Feeding practices for conditioning fish breeders.*

Period	Ingredients for the feed	Feeding rate (*)
Feb-Apr	Rice bran, Vegetables, Sweet potatoes, Soy been meal, cassava leaves	2-3%
May-Sep	Rice bran, Vegetables, Sweet potatoes, Tilapia feed, Catfish feed	5%
Oct-Jan	Rice bran, Vegetables, Sweet potatoes	2%

Note; Daily feeding rate expressed in percentage of the biomass.

The stock of fish breeders of *C. molitorella* at the Naluang station was different from that of Mrs La. She used about 280 fishes of between 3 to 4 years old and weighing 0.3-0.4 kg; the total biomass stocked in pond was about 100 kg. During the breeding season, fish were given commercial feed with high protein content (30-35%). Additionally, buffalo skin (2 kg) was put in the pond once or twice a month as fertiliser to provide natural feed (i.e. plankton). Other feeds such as rice bran, termite, morning glory, cassava leaf and grass were also given.

Breeding of C. molitorella

Male and female of *C. molitorella* are similar; they can be distinguished only during the breeding season. The female has a soft and swollen belly with a large and pink genital papilla. The male has rough pelvic and pectoral fins, a thin belly, and sperm is produced while stripping. The mean body weight is 300 g for males and 350 g for females.

Semi-artificial reproduction is used for the breeding. Mature fishes are selected and put for 2-3 hours in a hapas hold in the pond. Then fishes are carefully transferred to circular concrete tanks (180-200 litres per tank), with two males and one female per tank. Water in the tank is aerated with a pump. Both hapas and tank are covered with net to prevent the fish jumping out. Spawning is induced by a single injection of LHRHa from Suprefact ™ (15-18 µg/kg) associated with domperidone from Motilium ™ (10 mg/kg). Half of the dose is applied to males. The injection is applied while transferring the fish from the hapas to the tanks at 6:00 since a cool temperature is suitable for breeding fish. Spawning occurs at 12:00 and hatching between 16:00 and 17:00 pm, the following day at the temperature of 26-28°C (Table 3). The fecundity of *C. molitorella* is about 31,000 eggs per female; the fecundity per kilo of body weight is 80-100,000 eggs.

Table 3: *Water temperature and pH measured in pond at the Naluang hatchery during the breeding period (mean value +/- SD).*

	Temperature (°C)	pH
Morning (7 AM)	26+/-0.4	7.3+/-1.2
Afternoon (2 PM)	28+/-0.2	8.5+/-0.6

Eggs are put in a small hapas made of plankton net held in the small concrete tank (180-200 litres); up to 100-150,000 eggs are put in the incubator. Water is aerated with a pump to provide oxygen and mixing of the eggs. After 16-17 hour incubation, the hatching rate is about 90 %; therefore about 28,000 larvae are obtained per spawning.

Nursing C. molitorella

Hatched larvae from two females (about 56,700 larvae) were kept in a 2.5 x 2 x 0.6 m concrete tank containing 3 m^3 of water. The stocking density was about 19 larvae/L and the nursing lasted 5-7 days. Water was aerated with a pump. About one third of the water volume was changed every day. During the first two days larvae use the yolk sac, and they start to feeding on the third day. Boiled egg yolk is given, once or twice a day with some additional green plankton harvested from pond. The quantity of feed should be adjusted so there is no over-feeding and no risk of water pollution in the tank. After 5-7 days the survival rate is about 85 %; the amount of small fry harvested was 48,200 per batch.

Small fry aged 5-7 days were harvested and transferred from the tank to a first hapas held in pond. This hapas was made of plankton net with the size of 1.5 x 2 x 0.8 m containing 1.8 m^3 of water. About 5000 (about 2.8 larvae/L) of young fry were stocked in the hapas. Rice bran was given as feed together with plankton harvested from the pond. After 2 weeks 3000 fingerlings had been harvested 3000, therefore the survival rate was 60 %. The survival of small fingerlings aged 3 weeks from hatching was 51 %.

The small fingerlings aged three weeks were harvested from the first hapas and transferred to the second hapas to continuing the nursing. This hapas was made of standard 3 mm mesh net with dimensions of 3.5 x 3 x 1 m and containing 9.4 m^3 of water. About 5500 large fry were stocked in the hapas (approximately 0.7 larvae/L). Rice bran and floating pellets (25-30 %) were given as feed; fish fed also on the natural plankton from the pond. About 2000 fingerlings were harvested after 3 weeks, with a survival rate was 40 %. The survival of fingerlings aged 6 weeks from hatching was 20 %.

Mrs La conducted a test of the nursing protocol to three batches of larvae of *C. molitorella*. The results were similar for the three batches. The nursing protocol she applied to *C. molitorella* was similar to that used elsewhere for other carp species nursed in tanks and hapas.

Mrs La nursed the other species using a different protocol. After nursing 5-7 days in a tank, the young fry were released directly in the pond with compartments made of standard hapas net. The stocking density in the pond was 300-400 fry/m^2. Fry nursed in pond were fed with rice bran and commercial feed.

Budget of the production

After six weeks of nursing, the fingerlings of *C. molitorella* were sold for 100-150 kips per fish. This price is similar to that of the other species bred by Mrs La, except *Clarias gariepinus,* which sells for 200 kips per fish.

The budget presented in Table 4 was calculated for all the five fish species bred and nursed at the Mrs La's farm. It was not possible to get details for each species. The contribution from *C. molitorella* is probably minor, due to the relatively small number of fish breeders of this species (14 % of the total).

Labour is provided from within the family and no additional workers are used. The total labour spent on the farm each year is around 172 people-days, shared between 91 people. The daily maintenance takes one person two hours per day and 81 people-days are required to help with fish breeding activities (3 people during 27 days per year). The labour costs are is 115,000 kips/person.

day. This is well paid work, being 4-5 times higher than the normal salary in rural areas (25,000 kips/day).

Table 4: *The budget for Mrs La's fish farm*

1. Fixed costs

Item	Total cost (Kips)	Duration of use (years)	Cost per year (Kip)
Hatchery	10,000,000	5	2,000,000
Tools	3,000,000	2	1,500,000
Digging ponds	10,359,152	20	517,958
Maintenance of ponds	1,361,667	4	340,417
Hapa nets	1,000,000	3	333,333
Total			4,691,708

2. Operational costs

Items	Total/year (kips)
Feed	2,500,000
Electricity	1,000,000
Hormones	1,500,000
Miscellanous	500,000
Total	5,500,000

3. Total costs (Kip): 10,191,708

4. Income from selling fingerlings

Value / fingerling (Kips)	No. fingerlings	Total value (Kips)
150	200,000	30,000,000

5. Net income (4 - 3) (Kips): 19,808,292

CONCLUSIONS

Although only a single pond was available, the profit obtained by Mrs La from breeding and nursing *C. molitorella* and the four other species was quite high. The farm is now self-sufficient in fish breeders and regularly renewed with its own fishes. The farm is also relatively autonomous in terms of fish feed since most of the ingredients are produced at the farm or purchased locally; only a little quantity of commercial feed is used. Moreover, the market for *C. molitorella* is growing. Therefore, Mrs La's farm can be considered as a sustainable model to improve livelihoods in the montainous areas. At the time of the study, Mrs La was willing to extend her activities to grow-out of *C. molitorella*.

The standard conditions used for the broodstock management and the reproduction were good, as indicated by the high fish fecundity and hatching rate. However, the survival rate after nursing was low, especially during nursing in hapas. It is noteworthy that such poor result often occurs with species of carp in similar conditions in Lao PDR. Improvement of the nursing will require more trials with fry stocked in hapas or released into ponds. Otherwise, we recommend more accurate assessment of the performance of reproduction of *C. molitorella* since the fish breeders were mixed with four other species in the present study. Finally, it would be interesting to gather information related to the reproduction and the nursing of *C. molitorella,* for different generations of fish issued from controlled reproduction and raised in ponds. In this way we could assess the effects of the domestication.

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Preservation of *Cirrhinus microlepis* sperm

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ABSTRACT

Preservation of fish milt begins with collecting milt by either striping or dissecting for testis. The milt is preserved in a short – storage (4-9 °C) by either keeping fresh milt or diluted milt with variety of solutions. In the short – storage, milt which was diluted 1:5 with Modified Cortland solution can be kept for 48 hrs. Efficiency of the milt after preservations as determined by sperm motility, fertilization rate, hatching rate and survival rate were 30, 70.88±5.03, 75.59±4.50 and 77.87±7.92 %, respectively. For long-storage, or cryopreservation at -196°C, milt was diluted 1:5 with 10 % milk + 2.5 % glucose + 10 % methanol equilibration period at 4 ċ for 15 minutes and then diluted milt to freezing rate at -2.95 °C/min or cane#1 for 20 minutes before plunge into liquid nitrogen. Efficiency of the milt after preservations at 2 hrs as determined by sperm motility, fertilization rate, hatching rate and survival rate were 30, 62.66±17.59, 67.04±25.85 and 63.66±20.10 %, respectively. The efficiency of the preserved milt decreases in the longer preservation period, different species, methods and diluted solutions. If effective cryopreservation can be developed as good as in livestock cryopreservation, then the fish propragation of Thailand would be advanced in the future.

KEYWORDS : preservation, milt, *Cirrhinus microlepis*

INTRODUCTION

Techniques of sperm management have been established in several freshwater fish species such as cyprinids (Billard *et al*., 1995), siluroids (Legendre *et al*., 1996) and in salmonids (Scott and Baynes, 1980; Billard, 1992). Among these techniques, sperm storage and cryopreservation are of special interest. At 0°C conditions, spermatozoa can be stored for a few hours up to several days, depending on the species while cryopreserved gametes can be theoretically stored between 200 and 32,000 years without deleterious effect (Ashwood-Smith, 1980).

The use of cryopreserved spermatozoa can be delayed from the date of collection and adjusted to the moment of ova processing. The benefits of this technique include:

- Synchronization of gamete availability of both sexes: ovulations are only noticed when sperm production declines in cross fertilization of different strains like spring and autumn spawning herring, *Clupea harengus* L. (Blaxter, 1953).
- Use of the total volume of available semen: this is useful for sperm economy in species where semen is difficult to obtain i.e., Japanese eel, *Anguilla japonica* Temminck and Schlegel) (Ohta and Izawa, 1996), but also in species where only low volume of semen can be stripped in captivity i.e., yellowtail flounder, *Pleuronectes ferrugineus* L. (Clearwater and Crim, 1995) or turbot, *Psetta maxima* L. (Suquet et. al., 1994).
- Simplifying broodstock maintenance: off season spawning can be induced in most cultured fish species by the manipulation of photoperiod and temperature cycles

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(Bromage, 1995). However, the technique is cost intensive. When cryopreserved sperm is available all year round, the manipulation of the spawning season could be restricted to females.

- Transport of gametes: useful when male and female gametes are collected in different locations. This enables also the introduction of genes from the wild into hatchery stocks.
- Avoiding aging of sperm: the senescence of sperm during the course of the spawning season has been reported for many fish species and results in a decrease of milt quality (Rana, 1995a). Cryopreservation allows the collection of sperm when it has the highest quality.
- Experimental programs: for genetic studies, in comparing the breeding performances of successive generations in the same experiment and for experiments where the use of identical sperm samples is necessary over an extended period e.g study of short term storage of ova.
- Conserving genetic variability in domesticated populations: the use of a limited number of breeders leads to a reduction of heterozygosity. The cryopreserved semen of selected strains or genetically improved populations can be introduced in domesticated stocks e.g. the sperm of sex reversed gynogenetic hirame female *Paralichthys olivaceus* Temminck & Schlegel (Tabata and Mizuta, 1997). Gene banks of cryopreserved semen can also be used to maintain genetic diversity of fish populations that are endangered and protect against inbreeding. In protogynous hermaphrodite species such as Black grouper (*Epinephelus malabaricus* Bloch and Schneider), sperm can only be collected in 5 to 10 years old animals (Gwo, 1993). As a consequence, success in breeding is greatly enhanced by the use of frozen sperm.

If effective cryopreservation can be developed as good as in livestock cryopreservation, then the fish propragation of Thailand would be advanced in the future. The objective of this study was to compare the effective of short and long storage or cryopreservation of sperm in *C. microlepis*.

MATERIALS AND METHODS

Sperm collection

Milt was collected from mature male broodfish, reared in earthen-pond. The quality of milt was checked according to its motility. Only milt with motility more than 80% was used. The milt was transported to the laboratory (15 minutes) in a cooler at ~ 4 °C.

Short – storage (4-9 °C)

Extender of Milt

Extender solution should be compatible with seminal plasma or blood of candidate species (reduce activity of sperm before freezing) i.e., 280-300 mOsm/kg for freshwater species and 200-300 mOsm/kg for marine species. In this study, milt was diluted 1:5 with Modified Cortland's solution (MC: NaCl= 0.65 g, KCl= 0.3 g, $CaCl_2$ = 0.03 g, $NaHCO_3$ = 0.02 g at 100 ml, pH = 7.9). The extended milt was immediately drawn in to 1 ml tube and kept in refrigerator (4-9 °**C**).

Experimental design

The experiment was design with 2 treatments as followed:

- Treatment 1 fresh milt
- Treatment 2 fresh milt + Modified Cortland's
- Post fertility of Short – storage Milt

To evaluate the fertility of sperm, milt from all treatment groups were used to fertilize the eggs from a single female. Each cryo-tube was added to ~ 200 eggs. The eggs were incubation in plastic tank (size 10 l). Fertilization was estimated from the percentage of late gastrula.

Long-storage or cryopreservation (-196 °C)

Cryoprotectant

Function to protect cell destruction during freezing and thawing. There are 2 groups of cryoprotectants as follow:

1. Permeating (intracellular) cryoprotectants; these can permeate into cells for example DMSO, glycerol, MeOH, 1, 2 propanedio, and ethylene glycol

2. Nonpermeating (Extracellular) cryoprotectants; these can not permeate into cells. They are include: sugar (sucrose), polymers, starch, Polyvinylpyrrolidone (PVP), protein (egg-yolk, skim milk)

The milt was diluted 1:5 with 10 % milk + 2.5 % glucose + 10 % methanol equilibration period at 4°C. The extended milt was immediately drawn in 1 ml cryo-tube. The cryo-tubes were sealed and freezing at the rate of -2.95 °C per min. on cane #1 (about 19 cm above the liquid nitrogen surface) for 20 minutes before plunge into liquid nitrogen.

Experimental design

The experiment was designed randomly with 2 treatments as followed:

- -Treatment 1 fresh milt

- -Treatment 2 fresh milt + 10 % milk + 2.5 % glucose + 10 % methanol

Post fertility of cryopreserved Milt

To evaluate the fertility of frozen sperm, milt from all treatment groups were thawed on the same day and were used to fertilize the eggs from a single female. The cryo-tubes were thawed in water bath at ~70°**C**. The milt was added to eggs just as the thawing milt was going through the transition from solid to liquid. Each cryo-tube was added to ~ 200 eggs. The eggs were incubation in plastic tank (size 10 l). Fertilization was estimated from the percentage of late gastrula.

Statistical analysis

Differences in fertilization, hatching and survival rate relative to the time of freezing were test by use of a paired t-test. The null hypothesis was rejected for test of significance when $p<0.05$

RESULTS

Short–storage

The milt was preserved in a short–storage (4-9°C) by either keeping concentrated milt or diluted milt with Modified Cortland's. The short–storage milt was diluted 1: 5 with Modified Cortland solution can be kept for 48 hrs. Efficiency of the milt after preservations was tested by sperm motility, fertilization rate, hatching rate and survival rate were 30, 70.88±5.03, 75.59±4.50 and 77.87 7.92 %, respectively.

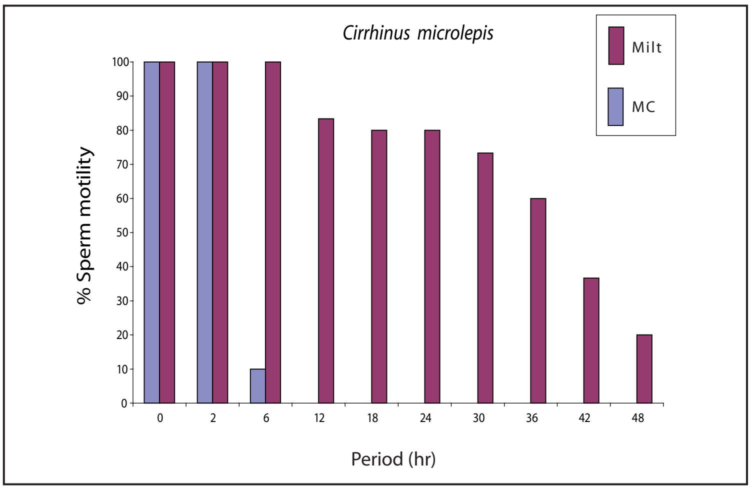
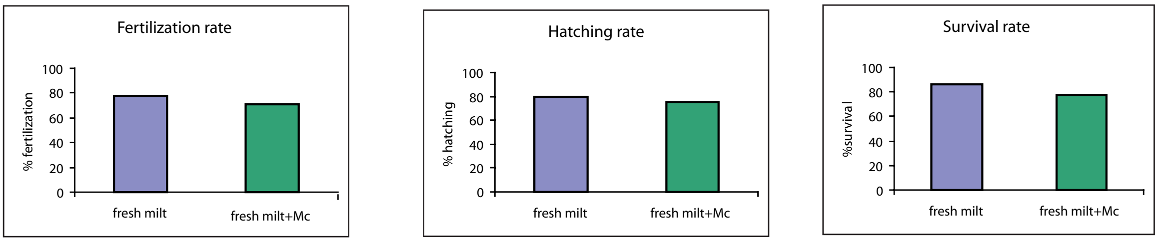


Figure 1. Differences in sperm motility rates in modified Cortland solution (MC) and milt

Percentage of fertilization, hatching and survival rate in fresh milt and diluted milt was not significantly different ($p>0.05$)



Figures 2-4. Comparisons of the effectiveness of fresh milt and fresh milt+MC of the *Cirrhinus microlepis* by monitoring the fertilization rate after kept in refrigerator (4-9 °C) for 48 hrs (left), the hatching rate (centre), and the survival rate (right)

Long-storage

The milt was preserved in a long-storage or cryopreservation at -196°C. The milt was diluted 1:5 with 10 % milk+2.5 % glucose+10 % methanol and equilibrated at 4°C for 15 minutes. Then diluted milt was freezing at a rate of -2.95°C per min or cane #1 for 20 minutes before plunge into liquid nitrogen. Efficiency of the milt after preservations at 2 hours was tested by sperm motility, fertilization rate, hatching rate and survival rate were 30, 62.66±17.59, 67.04±25.85 and 63.66±20.10 %, respectively.

Percentage of fertilization, hatching and survival rate in fresh milt and milt was diluted 1:5 with 10 % milk+2.5 % glucose+10 % methanol was not significantly different (p>0.05).

Final temperature diluted milt to freezing rate at Cane#1 Cane#2 and Cane#3 for 20 minutes

- Cane #1 (19 cm from surface): -47.1°C
- Cane #2 (14.5 cm from surface): -116.6°C
- Cane #3 (9.5 cm from surface): -190.7°C

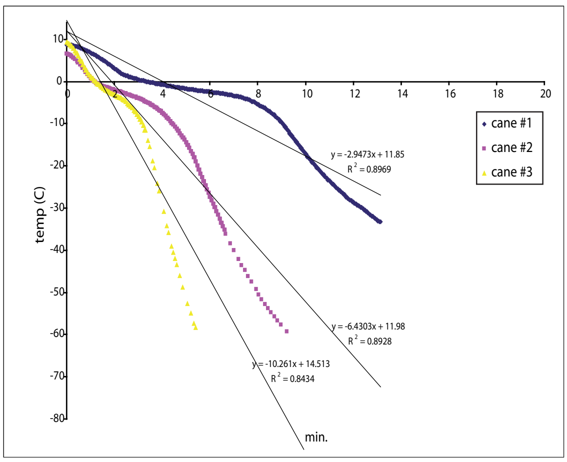
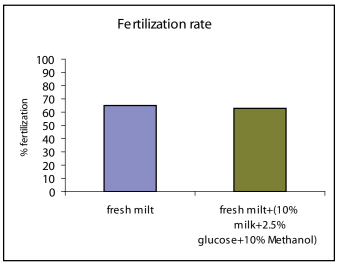
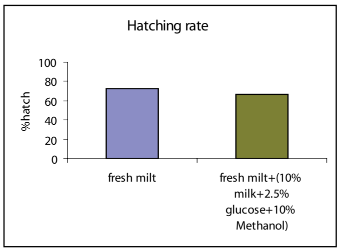
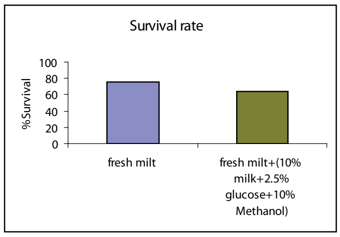


Figure 5 Diluted milt to freezing rate at cane #1, cane #2 and cane #3 before plunge into liquid nitrogen.







Figures 6-7. Comparisons of the effectiveness of fresh milt and diluted milt in 10 % milk + 2.5 % glucose + 10 % Methanol of the *Cirrhinus microlepis* by monitoring the fertilization rate after preservations at 2 hours (left), the hatching rate (centre), and the survival rate (right)

CONCLUSION AND DISCUSSION

Preservation of fish milt begins with collecting milt by either striping or dissecting for testis. The milt is preserved in a short – storage (4-9°C) by either keeping concentrated milt or diluted milt with variety of solutions.For long-storage or cryopreservation at -196°C. The cryopreservation techniques for semen of freshwater fish are applicable for production purposes in aquaculture and for establishement of sperm banks. Coupled with insemination and short term storage techniques, cryopreservation will lead to an improvement of gamete management in freshwater fish species. The efficiency of the preserved milt decreases in the longer preservation period, different species, methods and diluted solutions. If effective cryopreservation can be developed as good as in livestock cryopreservation, then the fish propragation of Thailand would be advanced in the future.

From these results, for short – storage (4-9°C) it is recommended to use milt which was diluted 1:5 with Modified Cortland solution because milt which was diluted 1:5 with Modified Cortland solution can be kept (for 48 hrs) better than fresh milt (for 6 hrs).For cryopreservation at -196°C it is't recommended to use a technique for preservation of fish milt because these results not complete (reason by will be test sperm motility, fertilization rate, hatching rate and survival rate after kept in liquid nitrogen one year).

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Culture of Red-tail Mystus, *Hemibagrus wyckioides*, in earthen ponds with different stocking densities

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ABSTRACT

Experiment on rearing of Red tail Mystus (*Hermibagrus wyckioides*) at stocking densities of 1, 2, 4 fish/m^3 and three replicates in the 400 m^2 earthen ponds were conducted at Yasothon inland fisheries research development centre during November 2003–September 2005. Fish with initial average body length and body weight of 10.7±0.8 cm and 9.1±1.9 g, respectively were fed with 32% protein pellets twice daily for 22 months. Fish were sampled monthly for body weight and body length for calculation of specific growth rate (SGR), survival rate, food conversion rate (FCR), yield and production cost. The results showed that the final average body weight were 309.7±65.4, 253.2±60.6 and 188.6±30.5g; average body length were 33.2±1.5, 31.6±2.7 and 28.9±1.1 cm; SGR were 0.53±0.03, 0.50±0.04 and 0.45±0.02 %/day; survival rate were 74.3±2.2, 80.5±8.0 and 67.8±12.4 %; FCR were 1.79±0.40, 2.20±0.46 and 3.09±0.13 at stocking densities of 1, 2, 4 fish/m^2, respectively. Statistically, all growth parameters and survival rate of Red-tail Mystus were not significantly different among the treatment ($p>0.05$). Yields were 85.1±11.8, 145.3±12.2 and 175.9±5.1 kg/pond. Production costs were 132.05, 109.59 and 130.83 baht/kg. From the result, it is suggested that rearing of Red-tail Mystus at stocking rate of 2 fish/m^2 is the most suitable stocking density when production cost is considered.

KEY WORDS: Red-tail Mystus, *Hemibagrus wyckioides*, culture, density

INTRODUCTION

Hemibagrus wyckioides is a high-value species that is popular in cage culture in the Mekong River Basin. Previous experiments conducted by AIMS show the most effective dosage to inducing spawning for natural breeding is 20 µg/kg Buserelin with 10 mg/kg domperidone at 14-15 hours. From a survey of cage culture of Mekong indigenous fish along the Mekong and Songkhram River, Nakhon Panom Province Thailand in 2001-2002, the most commonly cultured species were *Pangasius bocourti, P. Conchophilus, P. Pleurotaenia, Mystus wyckioides* and *M. Nemurus*. *Hemibagrus wyckioides* has been suggested for culture in earthen pond to increase indigenous fish species and replace the use of exotic fish species. The objective of this study is to establish a suitable stocking density in terms of growth rate, yield and production cost of Red-tail Mystus cultured in earthen ponds.

MATERIAL AND METHODS

The experiment was conducted in 400 m^2 earthen ponds of during November 2003–September 2005 at Yasothon Inland Fisheries Research and Development Center, Yasothon Province using Completely Randomized Design with three treatments and three replicates as follows:

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- Treatment I stocking at 1 fish/m^2
- Treatment II stocking at 2 fish/m^2
- Treatment III stocking at 4 fish/m^2

Fish with initial average body length and body weight of 10.7±0.8 cm and 9.1±1.9 g were fed twice daily with commercial pellets containing 32% and 30% protein for 22 months. Growth parameters in terms of body weight, body length, specific growth rate (SGR) and water quality were analysed monthly. In addition, feed conversion ratio (FCR), yield and production cost were also analysed.

RESULT

The results showed that there were no significant differences between the treatments ($p>0.05$) in terms of average final body weight (309.7±65.4, 253.2±60.6 and 188.6±30.5 g), average body length (33.2±1.5, 31.6±2.7 and 28.9±1.1 cm), SGR (0.53±0.03, 0.50±0.04 and 0.45±0.02 %/day), survival rate 74.3±2.2, 80.5±8.0 and 67.8±12.4 % and FCR (1.79±0.40, 2.20±0.46 and 3.09±0.13) at stocking densities of 1, 2, 4 fish/m^2, respectively.

Yields were 85.1±11.8, 145.3±12.2 and 175.9±5.1 kg/pond. Production costs were 110.26, 96.82 and 120.28 baht/kg. The net profits were -2,727.30, -1,392.90 and -5,422.20 baht/pond.

Table 1. *Growth rate of Hemibagrus wyckioides culture in earthen pond at 3 different stocking densities*

Items	stocking density (fish/m^2)		
	1	2	4
Initial length (cm)	10.7±0.80	10.7±0.80	10.7±0.80
Final length (cm)	33.2±1.50	31.6±2.70	28.9±1.10
Initial weight (g)	9.10±1.90	9.10±1.90	9.10±1.90
Final weight (g)	309.70±65.40	253.20±60.60	188.60±30.50
Specific growth rate (%/day)	0.53±0.03	0.50±0.04	0.45±0.02
Survival rate (%)	74.30±2.20	80.50±8.00	67.80±12.40
Food conversion ratio	1.79±0.40[a]	2.20±0.45[a]	3.09±0.13[b]
Yield (kg/pond)	85.1±11.8	145.3±12.2	175.9±5.1

Table 2. *Production cost of Hemibagrus wyckioides culture in earthen pond at 3 different stocking densities*

Items	Stocking density (fish/m^2)		
	1	2	4
Total fixed costs (baht)	3,883.09	3,883.09	3,883.09
Total variable costs (baht)	7,354.20	12,039.80	19,129.13
Total costs (baht)	11,237.29	15,922.88	23,012.22
Total revenue (baht)	8,510.00	14,350.00	17,590.00
Net profit (baht)	-2,727.30	-1,392.90	-5,422.20

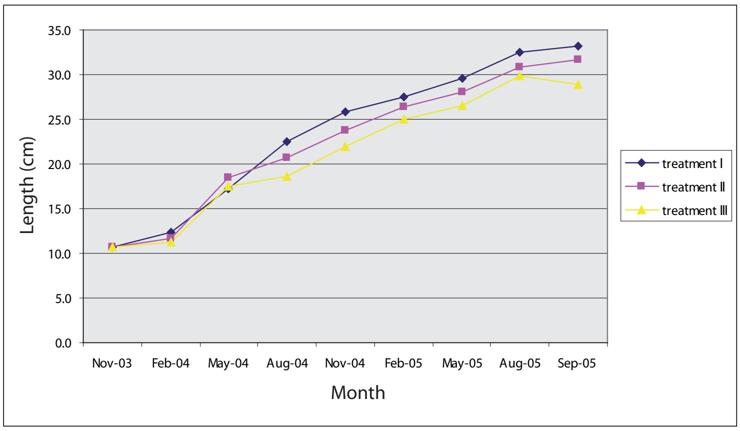

Figure 1. Body length of *Hemibagrus wyckioides* culture in earthen pond at 3 different stocking densities.

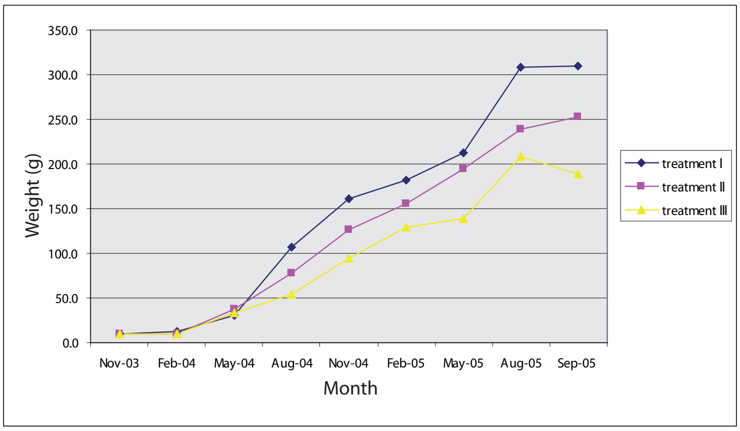

Figure 2. Body weight of *Hemibagrus wyckioides* culture in earthen pond at 3 different stocking densities

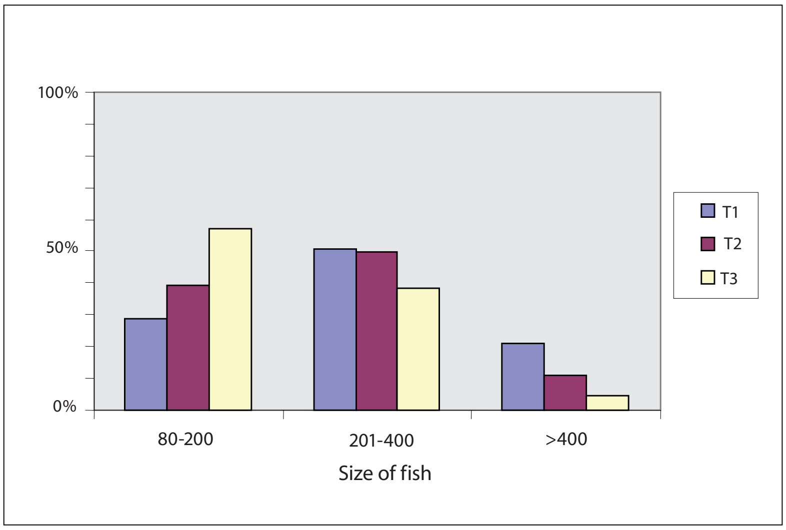

Figure 3. Size of *Hemibagrus wyckioides* culture in earthen pond at 3 different stocking densities

Table 3: *Water quality of Hemibagrus wyckioides culture in earthen pond at 3 different stocking densities*

Parameter	Stocking density (fish/m^2)		
	1	2	4
Temperature (^{o}c)	21-29	21-29	21-29
pH	6-8	6-8.5	6-8.5
Dissolved oxygen (mg/l)	4-6	4-5	4-5
Alkalinity (mg/l)	34-51	34-51	17-51
Hardness (mg/l)	20-30	20-30	20-30

CONCLUSION AND DISCUSSION

The results of this experiment suggested that the most suitable stocking density for earthen-pond culture of *Hemibagrus wyckioides* was at 2 fish/m^2 when the production cost was considered. However, stocking density of 1 fish/m^2 was the most suitable stocking density when the final body weight was considered, since more than 70% of fish grow bigger than 200 grams.

The production cost of this experiment was quite high because we used only commercial pellet. An appropriate feeding method should be studied in order to reduce the production cost.

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Preliminary results of domestication of *Pangasius krempfi*

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ABSTRACT

Pangasius krempfi is a species of high-economic value in the Mekong Delta of Viet Nam. The AIMS Viet Nam Sub-component is collecting the wild fish at various sizes for domestication and later on for artificial propagation. Preliminary results showed that 100% mortality was found when fish were stocked in ponds, whilst much high survival rates (90%) were observed among fish stocked in cages. Currently, we can be confident that cage culture is an appropriate environment for the normal grow-out and sexual maturation of *P. krempfi*.

KEYWORDS: *P. krempfi*, collection, fishing method, pond, cage.

INTRODUCTION

The Krempf's catfish *Pangasius krempfi* (Fang & Chaux, 1949) is an interesting fish for its anadromus characteristics (Roberts and Baird, 1995). The species is found throughout the Mekong basin and in the coastal waters of Southern and Eastern Viet Nam. There are two reported populations of *P. krempfi*, appearing in the Upper and Lower Mekong Basin. Both populations extend to middle Mekong (Poulsen *et al.*, 2004).

Adult fish fed mainly on fruit, leaves, filamentous algae and crustaceans. At the first stage of its life-cycle, juveniles of the lower population move to the marine environment in the Mekong estuarine zones (Poulsen *et al.*, 2004).

The spawning sites of *P. krempfi* are still unknown. The lower population spends some of its time in marine habitats at certain periods in its life cycle (Poulsen *et al.*, 2004).

P. krempfi is of economic value in the Mekong Basin (Poulsen *et al.*, 2004), probably because of its excellent taste. It is of great interest in Cambodia, Lao PDR, Thailand and Viet Nam. Since 2002, the fish has been a target species of the Aquaculture of Indigenous Fish Species (AIMS), Mekong River Commission, Fisheries Programme. The basic objectives of our work are (i) to keep the fish alive in captivity and (ii) to cultivate them to a condition and stage of maturation where they can be artificially spawned.

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METHODS

Location of collection of wild fish

We first collected wild *P. krempfi* at Tan Chau district, An Giang Province (upstream of the Mekong River in Viet Nam) in April 2003. The fish were caught using a net placed in deep water (approximately 30 metres deep).

Because of the massive mortality encountered during the capture of fish in upstream areas, the site for collection of wild *P. krempfi* moved downstream to the estuary, located at Tran De, Soc Trang Province. Unlike in An Giang Province, fishermen at Tran De used hooks to catch the fish.

The Tran De location was used to catch the fish from August 2003 to July 2005.

Transportation method from the fishing areas to Cai Be Center

After capture, the fishermen moved the fish immediately to a holding cage and provided aeration (at Tan Chau, An Giang), or moved them on-shore to tanks with freshwater and good aeration (Tran De, Soc Trang Province). After 3 to 4 days, we transferred only the healthy fish to either the National Breeding Center for Southern Freshwater Aquaculture Centre (hereafter called Cai Be Centre), or to a private cage facility located in Cao Lanh Town, Dong Thap District.

Prior to transportation, we anaesthetized and weighed the fish. We cut the first spine of the pectoral fin of small fish, or covered this spine with a piece of plastic tube if the fish was large. This spine is believed to be poisonous and, more importantly, can easily puncture the plastic holding bag, resulting in leakage's of water and air.

We then packed the fish into plastic bags encased in steel circular containers. The bags were filled with pure oxygen and tied with string. We transported the fish to Cai Be Center by van or a pick-up.

We transferred most of the fish collected in 2003 and 2004 to Cai Be Center, and some of them (115 individuals) to a private cage facility near to Cao Lanh Town, Dong Thap District.

We transferred all the fish caught in 2005 to the newly-purchased cages (8 × 4 × 3m) provided by the AIMS Project, Viet Nam sub-component, located in My Long District, Dong Thap Province, 16km from Cai Be Center.

RESULTS

Results in 2003

There were 28 fish collected at Tan Chau, Hong Ngu. Most of them died shortly after removal from the water. Few of the ones that survived died shortly afterwards at Cai Be Center.

We obtained many more fish at Tran De, Soc Trang. From August 17th to December 17th 2003, we collected 120 fish. However, on January 29th 2004 we found that only 6 fish had survived at Cai Be Center.

Results in 2004

From February 12th to March 30th, we collected 334 fish at various sizes. By the month of May, all of these fish had died.

In June, a further 127 fish had been caught. We moved 12 of them to Cai Be, and the rest to a private cage facility in Cao Lanh, Dong Thap.

At the end of August there was only a single fish remaining alive at the Cai Be Centre, but 25 fish survived in the cage facility at Cao Lanh.

Results in 2005

We restarted the capture of more fish from April 7 until June 28 2005. In total we captured 420 fish. The sizes varied from 0.05 to 3.7 kg. All the fish were stocked in the newly purchased AIMS facility cages at My Long, Dong Thap.

At the end of the year the mortality was found to be only 8.6 per cent. The weights of the remaining fish ranged from 0.4 to 5.0 kg and they appeared to grow very well.

DISCUSSION

Fish caught by net in Tan Chau, An Giang showed almost 100 per cent mortality, probably because of the fishing method used. Fish caught by net at approximately 30 m depth probably contributed to mortality during capture. Once the fish were brought to the surface, most of them were very much entangled in the net, and by the time the fishermen removed them from the net they were nearly dead. Also, the change in hydraulic pressure resulting from retrieval may have caused some mortality.

Once the capture procedure was moved to the estuary, where the fishermen caught *P. krempfi* by using hooks, the survival rate of the newly-caught fish greatly improved. The fish were subjected to less stress, since the time to remove them from the hook was shorter. Also, the water depth where the fish were caught (based on the length of the fishing line) was much less than that in Tan Chau. Thus the newly caught fish were in better condition.

Keeping fish in fresh-water in aerated tanks showed no negative effect on the fish. Mortality during this period was much reduced.

At Cai Be Center, *P. krempfi* showed that they are poorly adapted to pond conditions. They may not adapt to static water conditions very well. Under these conditions, the fish stopped eating or only consumed small amounts of food. Starvation was thought to be the main reason that caused nearly 100 per cent mortality of *P. krempfi* in ponds.

P. krempfi also showed that they are extremely sensitive to sampling and handling. Many fish died shortly after transportation to ponds and during sampling. The survival (in ponds) was very low, and was probably caused by altered environmental conditions and non-natural diets. Many fish died shortly after stocking.

Fish stocked in a private cage facility in Cao Lanh, Dong Thap showed that they can survive in a moving water environment, but they showed poor growth. The fish were stocked together with *Leptobarbus hoevenii*. The poor growth of *P. krempfi* can be explained due to its inability to compete for food with *L. hoevenii*.

Ideally a cage facility should be devoted to *P. krempfi* raised in a monoculture. During trials where this took place, the result was quite obvious. After more than half a year, mortality found in the AIMS Project cages were just only 8.6 per cent. Fish observed in this type of cage system adapted relatively fast to a pellet-type diet.

CONCLUSIONS

After three years of trial and error, we can be quite confident to say that *P. krempfi* can only be cultured in moving water, that is, a cage. We found nearly one hundred per cent mortality when we stocked fish in ponds. Many kinds of feed (home-made feeds and pelleted feeds) have been experimented with in ponds stocked with the target species, but they all failed. In contrast, fish utilise pelleted feed well in cages and have shown good growth. Thus, the culture environment is likely the single most important factor to ensure fish survival and growth rate. This is the first time in the Mekong Delta that *P. krempfi* has been kept and grown in captivity.

ACKNOWLEDGEMENTS

The authors wish to thank AIMS component for the financial support for this work. Special thanks are due to Dr. Chris Barlow, MRC FP manager and Dr. Niklas Mattson, AIMS coordinator for the approval of purchasing the AIMS Viet Nam cage facilities for *P. krempfi*. This undoubtedly led to the success of keeping the fish alive in captivity.

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Section 4. External papers

Surveys of native freshwater fishes in Surin province, Thailand

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ABSTRACT

Surveys of native freshwater fishes in Surin were conducted during October, 2000-September, 2002. Fish specimens were collected by various types of fishing gears e.g. gill net, purse seine, hook and lines, traps, and other fishing methods such as electro-fishing and Sodium cyanide were applied in some cases. The fish samplings were undertaken at the following five sampling sites; 1) Mun River at Thatoom District, 2) Chee River at Muang district, 3) Ampauen reservoir at Muang District, 4) Haui Lampork reservoir at Srikhorapoom District and 5) Haui Sa-neng reservoir and Surin Campus Reservoir at Muang District. The fish were subsequently analyzed for taxonomy and distribution. The results indicated that 108 fish species within 25 families were recorded. Cyprinidae family was found as the most dominant comprising of 49 species, followed by Siluridae (7 species), Cobitidae (7 species), Bagridae(6 species), Pangasiidae (6 species), Belontiidae (4 species), Channidae (4 species), Mastacembelidae (4 species), Notopteridae (2 species), Ambasseidae (2 species), Soleidae (2 species), Clupeidae (2 species), and the families of one species ; Blonidae, Hemiramphidae, Clupeidae, Balitoridae, Gyrinocheilidae, Anabantidae, Eleotridae, Helostomatidae, Osphronemidae, Nandidae, Sundasalangidae, Synbranchidae and Tetraodontidae.

KEY WORDS: Thailand Native Freshwater Fishes; Fishing Gears; Fishing Method,Taxonomy

INTRODUCTION

Surin province is located in the northeast of Thailand. The populations are mostly farmers, working in extensive farming systems. Natural water resources are mainly exploited as farm inputs, such as rivers, creeks, reservoirs and some from irrigation projects for crop cultivation. It is found that this quantity of water supply is not sufficient to support the whole year because most of natural water sources run dry in summer, except Mun River, Chee River (Mun tributary), streams, rivulets and the large reservoirs. However, the farmers still keep working paddy cultivation, animal rearing, wild fish capturing and aquaculture, even though water and soil quality are poor during the dry season. At the present, the quality of water is getting worse, resulting from the abundant use of many chemicals such as pesticide and insecticide in agriculture, and domestic waste water from the community has been released into water sources. This causes losses and reduction of fish species and aquatic animals. In addition, the capture of fish in the spawning season, using poisons such as rotenone, saponin, cyanide, and explosives to catch the fish were also important contributary factors.

The objectives of this study are to document the current status of native freshwater fishes in some rivers, creeks and reservoirs located in Surin province, to investigate the principle data on the biology and biodiversity of fish, to determine the ecological conditions of water supplies and to conduct taxonomical studies of fishes in the mentioned water bodies. This information can

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be used to arrange the protection and conservation plans for native fish species as well as the environmentally sustainable management water resources.

MATERIALS AND METHODS

Five sampling sites located in Surin Province including (Mun River in Thatoom district, Chee River (Mun tributary) in Muang district, Ampauen Reservoir in Muang district, Haui Lampork Reservoir in Srikoraphoom district, and Haui Sa-neng Reservoir and Surin Campus Reservoir at Muang district) were surveyed during October–September, 2002. Samples were taken at food markets and captured using fishing gears such as gillnets, purse seine, hook and line, and traps. In some cases, other fishing methods such as electro-fishing and sodium cyanide were used. These two activities were authorized by the government office specially for this study. Fish specimens were classified and identified according to Smith (1945), Taki (1974), Sontirat (1976), Mohammad (1983), Faculty of Fisheries (1985), Lumlertdacha et al. (1986), Sodsuk et al. (1988), Department of Fisheries (1992), Rainboth (1996), Vidthayanon et al. (1997), Jumpasri (1999), Baird (1999), Pantanit (2000), Sunaiyarattapron (2001) and Vidthayanon (2001).

RESULTS

The results of the sampling efforts of native fish species in Surin province were found totally 25 families, 63 genera and 108 species (Table 1). Cyprinidae was the most dominant species, comprised approximately 45.37% totally found 49 species. The most abundant species were *Barbodes gonionotus* Bleeker, *Henicorhynchus cryptopogon* Fowler and *Rasbora* spp. subsequently family Siluridae and Cobitidae which 7 species were collected in each. Six species were found in each in family Bagridae and Pangasiidae whereas in the other families, only one species were investigated (Annex 1).

DISCUSSION

The Mun River (Site 1) and Chee River (Mun tributary) (Site 2) were had the most abundant fish species, with 106 species in 25 families and 102 species in 22 families, respectively. In these two locations, the most dominant species belonged to Cyprinidae family. These results were similar to the study of Tantong and Siripan (1968), who surveyed the freshwater fish species in Mun River caught by fishers and at food markets in Ubon Ratchathani province in 1967. They found that Cyprinidae were the dominant species followed by Siluridae and Bagridae (39, 9 and 8 species, respectively), among a total of 84 species in 20 families.

In 1969 Tantong and Siripan, also found 114 fish species in 23 families in a survey from Mun River mouth at Bandan District, Ubon Ratchathani to Kantararom District, Srisaket. They found that Cyprinidae was dominant fish family (55 species), followed by Siluridae and Bagaridae (9 and 8 species respectively). The report by Team Consulting Engineers (1982), who re-surveyed the Mun River, lists 74 species from 19 families of which Cyprinidae, with 39 species, was the most dominat. In addition, Temiyajon *et al.* (1981) recorded 60 species from 19 families in the lower Mun River. Duangsawasdi and Krachangdara (1994) and Duangsawasdi and Duangsawasdi (1992) studied the distribution of fish in Mun River from Phimai District, Nakorn Ratchasrima to Khongchium District, Ubon Ratchathani from December 1990 until March, 1991. Their results recorded 70 species of freshwater fishes from 23 families. Of these the family Cyprinidae was the most dominant family followed by the family Bagridae. In addition, Duangsawasdi *et al.* (1993) found 77 fish species in 25 families from Pakmun Dam construction area, Ubon Ratchathani during two periods June 30 to July 2 1992 and March 23 to 25 1993.

It is suggested that the difference in the number of fish species found in Surin (Mun River site) water bodies surveyed from 1967 to 1993 may be caused by the different sampling methods and locations. For instance Tantong and Siripan (1968), Team Consulting Engineers (1982), Temiyajon *et al.* (1981) collected specimens from fishers and food markets only in Ubon Ratchathani Province However, Tantong and Siripan (1969) sampled both Ubon Ratchathani and Srisaket Province. Duangsawasdi and Chookajorn (1991) and Duangsawasdi and Duangsawasdi (1992) samples cover Srisaket, Surin and Nakorn Ratchasrima Province, using electro-fishing and fine net and did not collect the specimens from fishermen and food markets.

The fish species from Ampauen, Haui Lampork, Haui Sa-neng and Surin Campus reservoirs which is static water column belonged to 91 species from 21 families, 71 species from 21 families and 61 species from 19 families, respectively. The results showed that the number of fish species were less than found in running-water bodies such as rivers. This is probably because some fish, including long-nose Loaches, Loaches and Sheat-fish, live in moving water, in deep water, or on the sand. This finding was similar to Duangsawasdi and Krachangdara (1994), who recorded 81 fish species from 21 families in Ratchaprapa Dam reservoir, Suratthani province. Chittapalapong et al. (1997) found 28 species from 13 families in fisheries resources in Pranburi reservoirs. Kakkaeo et al. (2002) found 34 species from 13 families in Lamtakong Dam reservoir. Chookajorn et al. (2002) reporting on the biodiversity of fishes in Pasak Cholasit Dam and showed that 120 species from 34 families were collected before constructing the dam whereas only 102 fish species in 17 families were found after construction. This work suggests that the variation of fish species in water resources developments is determined by environmental conditions such as location, water volume and water conditions. Recently, the kinds and amount of fish have decreased due to over-fishing or reduced water quality and water volume.

CONCLUSIONS

One hundred and eight species in 25 families of the native freshwater fishes were found from all sampling sites in Surin province, as described below;

1. 25 families and 106 species in Mun River at Thatoom District
2. 22 families and 102 species in Chee River (Mun tributary) at Muang district
3. 21 families and 91 specie in Ampauen reservoir at Muang district
4. 21 families and 71 species in Haui Lampork reservoir
5. 19 families and 61 species in Haui Sa-neng and Surin Campus reservoirs at Muang district

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Table 1 *List of the names of native freshwater fishes recorded in Surin province, 2000-2002*

No	Common name	Scientific name	Sites to survey				
			1	2	3	4	5
Family Belonidae							
1	Needle fish	*Xenentodon cancilla* (Hamilton, 1822)	+	+	+	+	+
Family Hemiramphidae							
2	Half-beak	*Dermogenys pusillus* van Hasselt, 1823	+	+	+	+	+
Family Clupeidae							
3	Thai river spart	*Clupeichthys aesarnensis* Wongratana, 1983	+	+	+	+	
Family Balitoridae							
4	Loach	*Noemachilus masyae* Smith, 1933	+	+			
Family Cobitidae							
5	Long-nose loaches	*Acanthopsis choirorhynchos* (Bleeker, 1854)	+	+			
6	Long-nose loaches	*Acanthopsis* sp.	+	+			
7	Tiger loach	*Botia helodes* Sauvage, 1875	+	+			
8	Loach	*Botia lecontei* Fowler, 1937	+	+			
9	Yellow-tail botia	*Botia modesta* Bleeker, 1865	+	+			
10	Loach	*Botia morleti* Tirant, 1885	+	+			
11	-	*Lepidocephalichthys hasselti* (Val. in Cuv. & Val., 1846)	+	+	+	+	+
Family Cyprinidae							
12	Red-tail tinfoil barb	*Barbodes altus*(Gunther, 1868)	+	+	+	+	
13	Thai silver barb	*Barbodes gonionotus* (Bleeker, 1850)	+	+	+	+	+
14	Tinfoil barb	*Barbodes schwanenfeldi* (Bleeker, 1853)	+	+	+	+	
15	-	*Crossochilos oblongus* Kuhl & in van Hasselt, 1823)	+	+	+		
16	Siamese flying Fox	*Crossochilos siamensis* (Smith, 1931)	+	+	+		
17	Barb	*Cyclocheilichthys armatus* (Valenciennes, 1842)	+	+	+	+	+
18	Indian river barb	*Cyclocheilichthys apogon* (Val. in Cuv. & Val., 1842)	+	+	+	+	+
19	Sodler-river barb	*Cyclocheilichthys lagleri* Sontirat, 1985	+	+	+	+	
20	Barb	*Cyclocheilichthys repasson* (Bleeker, 1850)	+	+	+	+	
21	Barb	*Dangilla lineata* (Sauvage, 1878)	+	+	+		
22	-	*Discheronotus ashmeadi* (Fowler, 1937)	+	+	+	+	+
23	Red-tail black shark	*Epalzeorhynchos frenatus* (Fowler, 1934)	+	+			
24	Minnow barb	*Esomus metallicus* Alh, 1924	+	+	+	+	+
25	Spotted shark	*Hampala dispar* Smith, 1934	+	+	+	+	+
26	Transverse-bar barb	*Hampala macrolepidota* (Kuhl & van Hasselt, 1823)	+	+	+	+	+
27	Barb	*Henicorhynchus cryptopogon* Fowler, 1935	+	+	+	+	+

No	Common name	Scientific name	Sites to survey				
			1	2	3	4	5
28	Barb	*Henicorhynchus ormatipinnis* Roberts, 1997	+	+	+	+	+
29	Jullien's mud carb	*Henicorhynchus siamensis* (Sauvage, 1881)	+	+	+	+	+
30	Pink tail barb	*Leptobarbus hoevenii* (Bleeker,1851)	+	+	+	+	+
31	Apollo shark	*Luciosoma bleekeri* Steindachner, 1879	+	+	+	+	+
32	Greater black shark	*Morulius chrysophekadion* (Bleeker, 1850)	+	+	+	+	+
33	Barb	*Mystacoleucus atridorsalis* Fowler, 1937	+	+	+	+	+
34	Barb	*Mystacoleucus marginatus* (Val. In Cuv. & Val.,1842)	+	+	+	+	+
35	Stream barilius	*Opsarius koratensis* (Smith, 1931)	+	+	+	+	+
36	Bony-lipped barb	*Osteochilus hasselti* (Val in Cuv. & Val.,1842)	+	+	+	+	+
37	Hard-lipped barb	*Osteochilus lini* Fowler, 1935	+	+	+	+	+
38	Carp	*Osteochilus melanopleura* (Bleeker, 1852)	+	+	+	+	+
39	Bony-lipped barb	*Osteochilus waandersi* (Bleeker, 1852)	+	+	+	+	+
40	-	*Parachela maculicauda* (Smith, 1934)	+	+	+		
41	-	*Parachela oxygasteroides* (Bleeker, 1852)	+	+	+		
42	Siamese river abramine	*Parachela siamensis* (Gunther, 1868)	+	+	+		
43	Siamese river abramine	*Paralaubuca typus* Bleeker, 1863	+	+	+		
44	Seven-stripped barb	*Probarbus jullieni* Sauvage, 1880	+	+			
45	Smith's barb	*Puntioplites proctozysron* (Bleeker, 1865)	+	+	+	+	+
46	Golden little barb	*Puntius brevis* (Bleeker, 1850)	+	+	+	+	+
47	Golden little barb	*Puntius stigma*(Val., 1844)	+	+	+	+	
48	Minnow	*Raiamas guttatus* (Day, 1870)	+	+	+	+	+
49	Yellowtail rasbora	*Rasbora aurotaenia* (Tirant, 1885)	+	+	+	+	+
50	Rad tailed rasbora	*Rasbora borapetensis* Smith, 1934	+	+	+	+	+
51	Slender rasbora	*Rasbora daniconius* (Haminton, 1923)	+	+	+	+	+
52	Minnow	*Rasbora dusonensis* (Bleeker, 1851)	+	+	+	+	+
53	Silver rasbora	*Rasbora myersi* Brittan, 1954	+	+	+	+	+
54	Minnow	*Rasbora rubrodorsalis* Dunoso-Buchner	+	+	+	+	+
55	Yellowtail rasbora	*Rasbora tornieri* (Tirant, 1855)	+	+	+	+	+

No	Common name	Scientific name	Sites to survey				
			1	2	3	4	5
56	Scissor tailed rasbora	*Rasbora trilineata* Steindachner, 1870	+	+	+	+	+
57	Golden little barb	*Systomus aurotaeniatus* (Tirant, 1885)	+	+			
58	Red-cheek barb	*Systomus orphoides* (Val. in Cuv. &	+	+	+		
59	Banded barb	*Systomus partipentazona* (Fowler,1934)	+	+	+	+	+
60	White lady carp	*Thynnichthys thynnoides* (Bleeker, 1852)	+	+	+	+	
Family Gyrinocheilidae							
61	Siamese gyriocheilid	*Gyrinocheilus aymonieri* (Tirant, 1884)	+	+			
Family Notopteridae							
62	Spotted knife fish	*Chitala ornata* (Gray, 1831)	+	+	+	+	+
63	Giant feather back	*Notopterus notopterus* (Pallas, 1769)	+	+	+	+	+
Family Ambasseidae							
64	Siamese glassfish	*Parambassis siamensis* (Fowler, 1937)	+	+	+	+	+
65	Duskyfin glassy perchlet	*Parambassis wolffii* (Bleeker, 1850)	+	+			
Family Anabantidae							
66	Climbing perch	*Anabas testudineus* (Bloch, 1792)	+	+	+	+	+
Family Belontidae							
67	Snake skin gourami	*Trichogaster pectoralis* (Regan, 1910)	+	+	+	+	+
68	Blue gourami	*Trichogaster trichopterus* (Pallas, 1770)	+	+	+	+	+
69	Pygmy gourami	*Trichopsis pumila* (Arnold in Ahl, 1937)	+	+	+	+	+
70	Croaking gourami	*Trichopsis vittatus* (Cuv. in Cuv. & Val., 1831)	+	+	+	+	+
Family Channidae							
71	Red-tailed head fish	*Channa limbata* (Cuv., 1831)	+	+	+	+	+
72	Blotched snake-head fish	*Channa lucius* (Cuv. In Cuv. & Val., 1831)	+	+	+	+	+
73	Red snake head fish	*Channa micropeltes* (Cuv. in Cuv. & Val., 1831)	+	+	+	+	+
74	Stripped snake head fish	*Channa striata* (Bloch, 1797)	+	+	+	+	+
Family Eleotridae							
75	Sand goby	*Oxyeleotris marmorata* Bleeker, 1852	+	+	+	+	+
Family Helostomidae							
76	Kissing gourami	*Helostoma teminkii* (Cuv. in Cuv. & Val.,1831)	+			+	+
Family Osphronemidae							
77	Giant gourami	*Osphronemus goramy* Lacepede, 1802			+	+	+

No	Common name	Scientific name	Sites to survey				
			1	2	3	4	5
Family Nandidae							
78	Striped tiger nandid	*Pristolepis fasciatus* (Bleeker, 1851)	+	+	+	+	+
Family Soleidae							
79	Sole	*Archiroides leucorhynchos* Bleeker, 1851	+	+	+		
80	Sole	*Brachiurus siamensis* (Sauvage, 1874)	+	+	+		
Family Sundasalangidae							
81	-	*Sundasalanx praecox* Roberts, 1981	+	+			
Family Bagridae							
82	Yellow mystus	*Hemibagrus nemurus* (Val. in Cuv. & Val., 1839)	+	+	+	+	+
83	Red-tail mystus	*Hemibagrus wyckioides* (Chaux & Fang, 1949)	+	+	+		
84	bumble bee catfish	*Leiocassis siamensis* Regan, 1913	+	+	+		
85	Bocourt's river catfish	*Mystus bocourti* Bleeker, 1864	+	+			
86	Blue-stripped catfish	*Mystus mysticetus* (Bleeker, 1846)	+	+	+	+	+
87	Catfish	*Mystus singaringan* (Bleeker, 1846)	+	+	+	+	+
Family Clariidae							
88	batrachian walking catfish	*Clarias batrachus* Linnaeus, 1758	+		+	+	+
89	Gunther's walking catfish	*Clarias macrocephalus* Gunther, 1864	+		+	+	+
Family Pangasiidae							
90	-	*Helicophagus waandersii* Bleeker, 1858	+				
91	Mekong giant catfish	*Pangasianodon gigas* Sauvage, 1930			+		
92	Siriped catfish	*Pangasianodon hypophthalmus* (Sauvage, 1878)	+	+	+	+	+
93	Black ear catfish	*Pangasius larnaudii* Bocourt, 1866	+	+	+		
94	Catfish	*Pangasius polyuranodon* Bleeker, 1852	+	+	+		
95	Catfish	*Pteropangasius pleurotaenia* (Sauvage, 1878)	+	+			
Family Siluridae							
96	Twisted-jaw sheatfish	*Belodontichthys dinema* (Bleeker, 1935)	+	+	+		
97	-	*Kryptopterus cheveyi* Durand, 1940	+	+	+	+	
98	Sheat-fish	*Kryptopterus cryptopterus* (Bleeker, 1851)	+	+	+		
99	Sheat-fish	*Micronema apogon* (Bleeker, 1851)	+	+	+		
100	Whisker sheatfish	*Micronema bleekeri (Gunther, 1864)*	+	+	+		
101	Two-spot glass catfish	*Ompok bimaculatus* (Bloch, 1797)	+	+	+		
102	Great white sheatfish	*Wallago attu* (Bloch in Schneider, 1801)	+	+	+		

No	Common name	Scientific name	Sites to survey				
			1	2	3	4	5
Family Mastacembelidae							
103	Spiny eel	*Macrognathus semiocellatus* Roberts, 1986	+	+	+	+	+
104	Peacock eel	*Macrognathus siamensis* (Gunther, 1861)	+	+	+	+	+
105	Fire spiny eel	*Mastacembelus erythrotaenia* Bleeker, 1850	+	+	+	+	+
106	tire trac eel	*Mastacembelus favus* Hora ,1923	+	+	+	+	
Family Synbranchidae							
107	Swamp eel	*Monopterus albus* (Zieuw, 1793)	+	+	+	+	+
Family Tetraodontidae							
108	Puffer fish	*Monotreta fangi* (Pellegrin & Chevey, 1940)	+	+	+	+	+
		Total	**106**	**102**	**91**	**71**	

Fish passage and fishways in the Mekong Basin: getting past the barriers.

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ABSTRACT

Wild fisheries are declining in the Mekong Basin. One of the many reasons for this is that we are changing rivers so that fish can no longer have free passage for breeding, dispersion and growth. Trying to provide fish passage past the hundreds of large dams in the basin would be difficult, and in the end might not be successful. However, providing fish passage past the thousands of smaller barriers is possible and I believe, together with other fisheries management actions, would help maintain local fish fisheries. Fishways, which are structures designed to allow fish to move upstream past barriers like dams and weirs, have been used in many countries to try and protect wild fisheries. But in many cases they have failed to do the job they were built for. Only recently have fisheries biologists become closely involved in fishway projects from start to finish. Deciding what you want a fishway to achieve, and what will happen to the fish after they pass, is a key step toward judging the need and likely success of a fishway. Choosing a fishway design that has been shown to work for the species you wish to give passage to is another step. Looking at the proposed plans for a fishway, not as an engineer, but as a biologist who understands fish behaviour is another. Once built, assessing the fishways effectiveness, learning from any mistakes, and then using the fishway as a means of monitoring the river fishery over long time-periods is the final step.

KEYWORDS: Fish; Migration; Passage; Fishway; Design; Mekong; Barrier; Dam; Weir; Culvert.

INTRODUCTION

Inland fisheries throughout the world are an important source of food and income for many people, but with increasing human pressure these fisheries are undergoing change (Cowx *et al*., 2004). In the Mekong Basin, this is taking the form of declining catch of the larger longer-lived species, with the fishery in many areas becoming more dependent on smaller, faster-maturing species (van Zalinge *et al*., 2004). Initiatives such as Community Co-management of fisheries (Baird, 2001) are being promoted to improve management of these resources, especially in rural areas where fish are a major source of protein for sustenance and income, but where ownership of the resource is uncertain.

Activities not directly related to fishing, such as land clearance for agriculture and infrastructure development for water storage and hydropower production, are accelerating as Mekong Basin countries develop economically. This type of development can cause major changes in river flow and flooding cycles which can significantly disrupt recruitment and growth cycles of both large and small native species (Arthington *et al*., 2004a; Welcomme and Hall, 2004;); and approaches to mitigating some of these impacts such as environmental flow protection are being developed (Arthington *et al*., 2004b). However, rivers with large floodplains such as the Mekong are complex

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systems (Junk and Wantzen, 2004) and many processes within the system may be critical over time in maintaining fish diversity and abundance.

Fish passage and fishways

Loss of river continuum, where fish are prevented either physically or behaviourally from migrating longitudinally along rivers and laterally across floodplains has been identified as one of these key threatening processes (Northcote, 1998; Jungwirth, 1998). In many developed countries today, new barriers are not being built due to community concerns over the negative impacts of barriers on rivers and fisheries, and some barriers are being removed completely just to re-establish fish passage. However, in the Mekong Basin rapid economic development is a high priority and large numbers of new barriers are still being proposed and built.

Physically providing fish passage longitudinally along rivers, by providing pathways (fishways) that allow fish to swim upstream past barriers have been developed, especially in North America, Europe and Australia (Clay, 1995; Mallen-Cooper, 1996 and 1999; Stuart and Mallen-Cooper, 1999; Thorncraft and Harris, 2000; Stuart and Berghuis, 2002; Larinier and Marmulla, 2004; Stuart *et al*., 2004; Baumgartner, 2005). But fishways are generally not designed to provide downstream fish passage, especially when water is released through hydropower generation, gates or spillways. Providing downstream passage has focused more on fish friendly ways of releasing water using fish screens, bypasses and overshot rather than undershot gates (Clay, 1995; Odeh and Orvis 1998; and Baumgartner *et al*., 2006).

Whilst much emphasis has been placed on providing fish passage past large instream barriers throughout the world; provision of fish passage past the much more numerous smaller barriers laterally across floodplains using low-cost fishways or fish friendly culvert designs has not been addressed until relatively recently (Cowx, I.G. 1998; Newbury and Gaboury 1988; Bates and Powers, 1998; Larinier *et al*, 2002; Marsden *et al*. 2003a; Marsden *et al*. 2003b; Marsden *et al*. 2003c).

In the Mekong Basin, only a few fishways have been built, and as a mitigation tool they are not generally accepted as being either required or effective. Many reasons exist for this, most based on the belief that fishways are too expensive, don't work and any loss of natural production can be replaced with hatchery stocking. This view has been supported by the few poorly-performing fishways that have been built in the basin, which were based on fishway designs unsuitable for the height of the barrier and also for the behaviour and swimming ability of local fish species. This has resulted in high profile failures of fishways, and this is now a major impediment to the further use of fishways to mitigate barriers to fish passage in the Mekong Basin.

Critics of fishways do have many valid points including:

- fishways alone do not ensure fish passage past a barrier as many other factors, such as environmental cues required to stimulate migration, need to be maintained;
- fishways can be very expensive to build, especially on high barriers and/or if a wide range of fish species requiring passage are to be catered for;
- fishways require maintenance and finding money for this will be an ongoing problem to the owner of the fishway;
- fishways are often vulnerable to unauthorised trapping of fish;
- even if fish can get upstream past a barrier, they may not be able to complete their life cycles, especially for large dams where the reservoir may also be both an upstream and downstream barrier, and critical habitats may be altered;
- the cost of retrofitting fishways on the hundreds of large dams and thousands of smaller barriers already existing in the basin would be very high;
- the extra cost of building a fishway may make the cost of a development project too high, even though the benefits of the project to the local community would be substantial; and
- fishways do not usually provide downstream migration passage so in effect they only address half the problem.

So is there a future for fishways in the Mekong Basin?

Before advocating the use of fishways in the Mekong Basin, two things need to be resolved. The first is to put forward arguments for including effective fishways on barriers of various types, and the second is what work would be required to allow effective fishway designs to be developed. Therefore, a clear idea of what can be achieved and how the various problems can be addressed is needed. The first question can be resolved by considering the reasons for building fishways as opposed to not building them, and include:

- with the increasing awareness of the other impacts of dams and weirs on river ecology, mitigation measures such as multi-level intakes to ensure good water quality (including thermal pollution) and provision of environmental flows will be used, and whilst this will improve riverine conditions downstream, it may ultimately only result in more fish accumulating below a barrier;
- with increasing effort going into placing not only an economic but also a social and environmental value on fishery resources, the relative cost of a fishway (especially in relation to the overall cost of building the barrier) makes fishways a more cost-effective

alternative to stocking hundreds of kilometres of river using hatcheries that can usually only produce a limited number of species;

- dams and weirs also require continual maintenance and incorporating the maintenance programme for a fishway in the overall structures maintenance programme is only logical, and as the owner of the dam is the one gaining a benefit from its existence, it is also logical that they pay for the construction and maintenance of the fishways;
- community co-management systems that in effect confer ownership of the fisheries resources to local people also aim to educate people on good management practices, particularly the need to allow fish to complete their life cycles to ensure maximum production potential, so a fishway not only needs to be accepted as being important to the local community but also, by actively monitoring fish passage through them, local co-management groups can assess the effectiveness of their management actions and some sustainable harvesting of fishways may be part of this process;
- providing fish passage does have its limitations, so having a clear idea of what it is that you want to or can achieve is vital in any decision process developed by resource managers to assess if a fishway is to be required for any particular project;
- eventually all structures need major repairs or modifications which would provide the opportunity to retrofit a fishway, and in those cases where providing fish passage at a large barrier would have limited or no benefit, the retro-fitting of fishways at existing lower-barriers in other areas where it would be of benefit could be considered as a legitimate impact mitigation action;
- a major cost in retrofitting fishways is in the modification of the existing structure, particularly to allow a fishway channel to pass through the wall of the structure, so even if a fishway cannot be afforded at the time of construction, simple design considerations for future retrofitting can be of considerable future value for little or no immediate cost; and
- though fishways do not usually provide downstream passage, the process of studying migratory fish behaviour, developing fishway design criteria, assessing the effectiveness of new fishways built and the long-term monitoring of upstream migrations can provide valuable insights into how to provide for downstream migration as well as providing feedback on the success of any measures undertaken in subsequent upstream return migrations.

However, fishways do cost money (up to 5% of the total cost of a project if the fishway is built at the same time the barrier is built), so if fisheries-resource management agencies are going to consider the use of fishways as a possible mitigation tool, then they be must prepared to defend their

Case Study 1: Meeting the Dam Developer

Your boss walks into your office and tells you that you have to go to a meeting about a new water infrastructure development tomorrow. The developer of the project may be another government department wanting to build a new irrigation dam or a business group wanting to invest in hydropower; and your job will be to present your departments concerns for the areas fisheries resources. This time you are lucky, the developer has completed an Environmental Impact Assessment (EIA) and it does have a fisheries section, so you will know something about the project before the meeting starts, if you can find the time to read it before your meeting tomorrow.

The meeting will not be held in your office, it will be held at their very large and expensive offices in the middle of the city. If the developers have read the EIA, they will know that if not handled carefully, the potential impact of the project on local fisheries could be a problem for them. Therefore, as you walk into the meeting room you see not only the developer and the senior project engineer, but also representatives from their environmental consultants. As you sit down you wish that your boss had come as well, as you now feel very much outnumbered and a little intimidated by all these people dressed in expensive business suits. But you settle down quickly as the developer is making a lot of effort to be friendly and make sure you are well looked after.

Down to business, but you seem to be doing most of the listening as the developer tells you how good this project will be for the country, the local economy and the local community. But as the projects environmental consultant quickly runs over how there really will be no great impact on the local fisheries, in fact they should improve greatly as their will now be more water stored behind the dam, you shift uneasily in your chair. Taking a deep breath you start talking about the research your department has done, as well as work done by other countries fisheries groups. You point out that in fact there are a lot of migratory fish in this area, and they are very important for the local economy as well as a major source of protein for the rural villagers.

This makes the fisheries consultant sit back, but the developer has a solution though no one seems to be smiling at you anymore. Don't worry, we will stock the dam with fish for the locals; in fact we might even be able to build them a large hatchery next to the reservoir. Though you could point out that the local community has very little experience with running a large hatchery or the money to operate one, you feel the need to point out the wider problems first. If the fish cannot migrate and complete their life cycles, then areas upstream and downstream of the dam will be impacted, perhaps for hundreds of kilometres away from the dam; and though hatcheries are good for supporting aquaculture development of a few fish species, they are of no use in the maintenance of more complex and diverse native fish communities.

Now for the first time the engineer sits forward and starts talking about how there is no way that the dam gates can be opened to allow fish passage, as it would waste all the water and cost too much. And as you know, fishways do not work for fish in this country so there is really very little we can do for you. Though you don't feel very confident, you do speak up and point out that the fishways that have been built here before have been done so by engineers using designs developed in other regions in the world and not adapted for local native-fish behaviour.

Now the engineer is smiling at you as he starts to spread out the design plans for the dam and asks a series of questions without waiting for any answers. What type of fishway are you talking about? What slope does it need to be? What is the maximum water velocity and turbulence you can have in it? How wide and deep does the channel need to be? How many cumecs of water will it use? Will it need to operate all the time or only for short periods? At what river flow do fish migrate and where should we put the entrance and exit for the fishway?

As you leave the meeting with a promise by the developer to look into the possibility of building a number of small simple to operate and widely-dispersed hatcheries for the local people, you think to yourself "I really wish I could have had some answers for that dam developer's engineer". So maybe it is time to talk to the boss about starting a research program aimed at generating fishway design criteria for our local fish species; and that we need to do it in partnership with engineers so the results can be easily understood and accepted by the developers.

position. The following short story (Case Study 1.) maybe something that fisheries officers working in the Mekong Basin are facing now or will in the near future.

What design, what costs, what risks?

A key point in deciding for or against the use of fishways is to understand that there are different types of fishway designs, and that each design is different in terms of its cost and its ability to provide fish passage at different structures, especially if only limited knowledge of local fish species, behaviour and swimming ability is available. Based on increasing height of the barrier this can be generally summarised as set-out below:

- low barriers up to 2 m headloss* have a low-level of risk of not working and generally low cost:- usually between US$100 and US$10,000 (Figures 1, 2 and 3);
- medium barriers up to 6 m headloss have a medium-level of risk and medium cost:- usually between US$10,000 and US$500,000 (Figures 4 and 5);
- high barriers over 6 m headloss have a high-level of risk and high cost:- usually more than US$500,000 (Figures 6 and 7).

Figure 1. Fish-friendly designs for high water velocity barriers (example of a culvert design creating controlled water velocities and increased depth to facilitate fish passage in Queensland, Australia)

However, with increased understanding of local fish species swimming ability and behaviour, local design criteria can be applied and these general guidelines can be adjusted so the risk of a fishway design failing to provide fish passage can be reduced. However, the higher the barrier to fish

* Headloss is the difference between upstream and downstream water levels, usually but not always determined by the physical height of the barrier. However, with increased understanding of local fish species swimming ability and behaviour, local design criteria can be applied and these general guidelines can be adjusted so the risk of a fishway design failing to provide fish passage can be reduced. However, the higher the barrier to fish passage the greater the problems with fish not being able to ascend the fishway and then find their way through the reservoir upstream of the barrier. For larger barriers, knowledge of what would happen to any fish after using the fishway needs to be considered before deciding if a fishway would be effective.

passage the greater the problems with fish not being able to ascend the fishway and then find their way through the reservoir upstream of the barrier. For larger barriers, knowledge of what would happen to any fish after using the fishway needs to be considered before deciding if a fishway would be effective.

Figure 2. Fishway suitable for barriers up to 2 metres (example of a rock-ramp fishway in Phou Khao Khouay, Lao P.D.R.)

Figure 3. (left). Fishway suitable for barriers up to 2 metres (example of a bypass fishway in Queensland, Australia)

Figure 4. (right) Fishway suitable for barriers up to 6 metres (example of a vertical-slot fishway in Queensland, Australia)

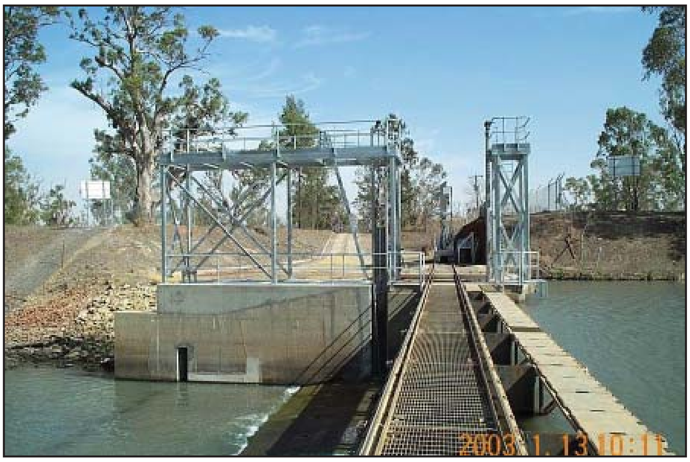

Figure 5. Fishway suitable for barriers up to 6 metres (example of a Dealder Lock in New South Wales, Australia)

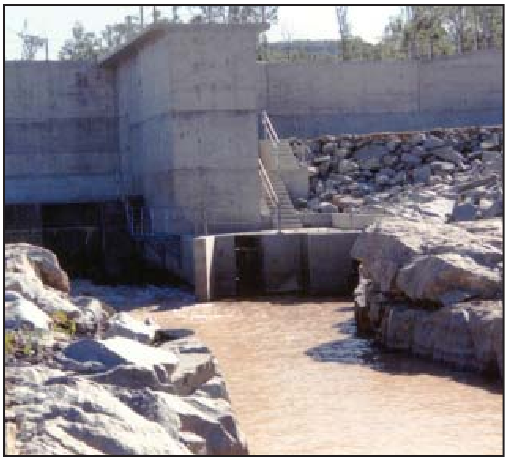

Figure 6. Fishway suitable for barriers over 6 metres (example of a lock fishway from Queensland, Australia)

Figure 7. Fishway suitable for barriers over 6 metres (example of a lift fishway under construction on left side of spillway in the photo from Queensland, Australia)

How do you develop fishway design criteria?

Like fishways themselves, the process of developing fishway design criteria is best approached as a series of relatively small steps. The key to this approach being that fishway design criteria needs to be developed based on the fish expected to use the fishway. For example, the Lower Mekong Basin it might initially be broken down into smaller eco-regions:

- Lower Mekong River mainstream reaches and estuarine interface with its large number of species, size ranges and fish abundance;
- Mekong tributaries and floodplains with its mix of white and black water species;
- Mekong tributary uplands with species adapted to high water-velocity environments.

It would be smart to start with research into small barriers first, as lessons learnt at these sites can be used later to reduce the risk of making an expensive mistake at the larger barriers. Once divided into discrete areas of research, fishway design criteria can be developed through a series of field-based experiments. During periods of fish migration, experimental sites at existing barriers can be set up to determine criteria such as:

- the species, timing, numbers and areas where fish accumulate below a barrier;
- maximum water velocity and turbulence that fish can negotiate;
- minimum depth, passage width and light conditions fish require;
- time required and the maximum height fish can ascend in the fishway.

An example of how fishway research was approached in Australia is outlined in Case Study 2.

Whilst in developed countries like Australia the public funding of research and fishway construction has been possible, in the Lower Mekong Basin a different approach may be required because of limited availability of public funding combined with the need to address other high-priority research areas. A number of options for fisheries resource managers in Mekong countries are available at the present time and these include:

- have no publicly funded fishway research programme, but place the requirement for providing effective fish passage on the developer (industry) and let them bear the risk of building ineffective fishways (present situation);
- wait until public concern over declining fish numbers and the importance of restoring fish passage results in a publicly funded research programme, the results of which can then be made available to developers;
- use relatively small amounts of public funding (targeted funding), perhaps supported by a series of international technical assistance programmes targeted at a developing local

Case Study 2: Australian Fish Passage Development

The Murray-Darling Basin (MDB) represents the largest catchment on the Australian continent and in many ways it is analogous to the Mekong River. In particular, the MDB supports large regions of agricultural production (MDBC, 2003), it has undergone substantial development (Mallen-Cooper, 1996), it supports a large population (Jacobs, 1990) and it is co-managed by four separate state governments.

Given this degree of development, it was recently estimated that over 95% of the Murray-Darling Basin was degraded in some capacity and that 40% of the river length contained biota that had declined in both range and abundance (Norris *et al*, 2001). Whilst the degradation of the Murray River has had detrimental effects on virtually all resident biota (Gippel and Blackham, 2002), impacts on the abundance and diversity of native fish have been particularly profound (Lake, 1971; Brumley, 1987; Cadwallader and Lawrence, 1990).

Fishways have been constructed in Australia since 1912 (Hooker, 1966) and at least 76 are currently operational in New South Wales (Mallen-Cooper, 2000; Thorncraft and Harris, 2000). However, early designs were based of criteria developed for strong-swimming northern hemisphere salmonids (Mallen-Cooper. 1996) and almost all were ineffective for Australian fish. Therefore, fish passage development was seldom progressed in Australia because people thought the simply didn't work.

To progress work on fish passage in Australia, the NSW government commissioned George Eicher, a prominent US ecologist, to develop a fish passage facility programme for Australia (Eicher, 1982). This report resulted in a well-directed research program that sought to determine optimal design criteria for Australian fish. The work culminated in two landmark studies, each which determined fish passage criteria for a number of commercially important species through a series of controlled laboratory tests (Mallen-Cooper, 1992, 1994).

With the development of laboratory criteria, the Australian government funded the construction of a vertical-slot fishway built to these specifications (Mallen-Cooper, 1996). The project was a resounding success and the fishway passed over 100,000 fish in its first 8 years of operation (NSW DPI, unpublished data). Since this landmark study, further research determined that many more species of fish are migratory than first thought (Stuart et al, 2004; Baumgartner 2005). Subsequently, fish passage criteria are constantly adapted and the current Australian approach is to provide passage for entire ecological communities (fish 20 mm-1500 mm in length and also macroinvertebrates).

In 2002, the Murray-Darling Basin Commission (formed and funded by the four MDB governments) committed to a $AUD25 Million program to restore fish passage to over 1,700km of the Murray-Darling Basin. The work involves the construction of 14 fishways at each major structure on the Murray River. The project incorporates a major biological assessment program to determine the effectiveness of each fishway. Since completion of the first fishway in 2003, over 150,000 fish have gained passage and the assessment team are providing important information to improve the function of future fish passage facilities (Stuart *et al*, 2004).

This Australian example is an excellent case of biologists, engineers, managers and governments working in co-operation to develop practical on-ground outcomes for fish and regional agricultural communities. It is important to note that such co-operation is necessary to develop a program that delivers favourable outcomes for all partner organisations and stakeholders.

fisheries research skills, to undertake a series of limited research projects on low-cost fishways at small barriers, and make those results available to developers overtime; and

- use targeted public funding in combination with and supporting industry initiated fishway construction projects (though still focusing initially on small and medium barriers), so that risks are shared between both groups with the trade-off being that lessons learned will be more readily taken up by the industry.

The opportunity to initiate the two last approaches listed above currently exists in Lao P.D.R. due to intensive international interest in a number of large development projects in the country. Similar opportunities may also exist in other basin countries. The authors of this paper are currently in a very early stage of exploring opportunities to initiate these approaches in Lao P.D.R., with the aim of supplying the required international assistance to help develop local fish passage research skills.

However, each of the countries in the Lower Mekong Basin will need to make their own decisions on how to approach the issue of barriers to fish passage. But by integrating their actions with the other countries within the basin, and particularly with the water infrastructure development industry in the basin, then fish passage problems can be addressed now rather than later when the cost of rehabilitating rivers in the basin and the impact on local fishing-dependant communities will be much higher.

CONCLUSIONS

As fisheries researchers and managers in the Mekong Basin, we need to keep the impacts of development upon fisheries at the forefront of discussions with resource developers and those communities affected by the loss of healthy fisheries. Fish passage along rivers and across floodplains is one of the key environmental processes that maintain healthy fisheries. By mitigating the impacts of barriers to fish passage wherever possible, development can be more effectively managed. However, fishways are not the answer to mitigating all the impacts of barriers on fish; they are just one of the tools available in a range of mitigation actions possible; which must include the option of not building the barrier or removing old barriers. Fishways do have limitations on the type of barriers they can provide fish passage past; and they require minimum levels of knowledge to employ effectively, particularly in relation to the species expected to use them. Our first step with fishways should be to develop appropriate design criteria and demonstrate their effectiveness for fish in the Mekong Basin, next we should talk to engineers about how to build fishways using these design criteria, and the last should be to use fishways as a very powerful long-term fisheries monitoring tool. Then we can sit down with resource managers, developers and the community and demonstrate that fish passage is an important issue which needs to be tackled head-on now, not dealt with as an afterthought when the fish have already disappeared.

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Identifying stock structure of two *Henicorhynchus* species in the Mekong River using mitochondrial DNA

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ABSTRACT

A primary concern in wild fisheries is the identification of stocks for management. Many freshwater fish species exist as discrete populations where a lack of gene flow among local populations results in ecological and/or genetic differentiation due to the effects of random genetic drift and for adaptation to local environments. Successful sustainable harvesting of a wild fishery requires management plans specifically designed that consider the stock structure of the target species. Ecological approaches (e.g. tagging studies) to identifying discrete stocks where they exist are, at best, inferential because they cannot confirm whether dispersing individuals contribute genes to the receiving population. The application of population genetic techniques can be an effective approach for assessing population structure because estimates of gene flow can give a measure of the movement of individuals among locations. The current ACIAR/MRC project used mitochondrial DNA (mtDNA) analysis to determine the stock structure of two commercially important cyprinid species (*Henicorhynchus siamensis* and *H. lobatus*) in the MRB. Analysis of *H. siamensis* from the lower MRB showed high levels of genetic diversity and indicated that the samples represent a single panmictic population for management purposes. Although mtDNA haplotypes were shared among sampling sites both above and below the Khone Falls, the data suggest that gene flow (dispersal) occurs predominantly downstream (i.e. over the Khone Falls) resulting in significant population structure above and below the falls. In contrast, the *H. lobatus* analysis revealed extremely low levels of genetic diversity, with no differentiation from Chau Doc in Viet Nam to Nong Khai in northern Thailand. However, the sample from Ubon Ratchathani (just upstream of the Khone Falls) represents a highly divergent *H. lobatus* population from other Mekong samples. These results suggest that *H. siamensis* and *H. lobatus* have experienced vastly different demographic histories and consequently may display very different ecologies. While previous morphological studies have suggested that these two species are closely related, genetic data reveals levels of divergence among the species more consistent with that seen among different genera of cyprinids. These data highlight the need for development of different strategies to achieve sustainable management of both species.

KEY WORDS: Mekong; Stock structure; DNA; *Henicorhynchus sp*.

INTRODUCTION

Many species exist as a collection of independently breeding units (populations) across the range of their natural habitat. This occurs where dispersal among locations is insufficient to allow random mating across the species entire range. A knowledge of spatial distribution of individuals that interbreed (population structure) is of particular importance for taxa that require management for conservation and/or commercial considerations. Successful management of a species must reflect its underlying biological processes and, as such, the level of population (or stock) is the scale at which management should be focused. Understanding population structure allows predictions to be made regarding the likelihood of natural recolonisation of a local stock following stock depletion due to environmental disturbance, either natural or anthropogenically generated (e.g. overharvesting of wild stocks).

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Species found in freshwater systems are often structured spatially, because unlike in marine systems, there are many barriers to effective dispersal among locations (Gyllensten, 1985; Ward *et al*., 1994). Firstly, river drainages are isolated from each other by terrestrial and marine environments, therefore fully aquatic species find dispersal among drainages difficult. Secondly, there are several factors, either environmental (extrinsic) or biological (intrinsic), that can limit dispersal within a drainage. Environmental factors include instream barriers (e.g. waterfalls, rapids or impoundments) and the unidirectional flow of the river. Furthermore in large systems, even physical distance among sites may present a significant barrier to dispersal across the whole system. Intrinsic biological attributes means that some species may be inherently poor dispersers, are territorial, or are extremely habitat specific, all of which may limit dispersal over a wide area.

Identifying stock structure in freshwater fishes where it is present using traditional field assessment methods is often difficult if not impossible. It is not easy to recapture tagged individuals and direct observational studies of individual movements are generally not practical. Moreover, even if direct methods can measure levels of dispersal, they may not identify 'real' stocks as they do not provide any insight into whether dispersing individuals are entering the breeding population. Application of population genetic techniques can address some of these difficulties. The basic concept is that with high levels of dispersal and subsequent interbreeding (gene flow), populations become similar genetically (genetically homogeneous). Conversely, where there is minimal gene flow, populations will tend to become genetically differentiated due to the effects of chance (random genetic drift) and at some loci natural selection favouring different genes in different local environments. Measuring the genetic variation that is partitioned among locations provides an insight into the level of connectivity (effective dispersal) and assists with the delineation of 'real' stocks.

The primary aim of the present study was to demonstrate the utility of a molecular (DNA-based) approach for defining management units for fisheries in the Mekong River Basin (MRB). The species chosen for the study were two cyprinids (*Henicorhynchus siamensis* and *H. lobatus*) that are generally considered to be some of the most abundant species in the MRB (Roberts and Baird, 1995) and form a major component of the wild fisheries in the Mekong River. As with many important species in the Mekong River, relatively little is known about their biologies and what is known has largely been inferred from anecdotal evidence. It is well documented that both species undertake mass migrations during the wet season each year, but little if any knowledge exists as to whether populations across the system are homogeneous or structured in some way. This knowledge is fundamental to developing effective stock management practices for both species in the future.

Furthermore, due to their similarities in both morphology (they are often misidentified (Roberts, 1997)) and fluctuations in relative abundances over the annual cycle, it suggests that a single management strategy will provide a sustainable fishery for both species. While the population structure for both species is expected to be complex, current taxonomic uncertainty has resulted in the grouping of *H. siamensis* and *H. lobatus* (and other *Henicorhynchus* species) together for the purposes of ecological description (MRC, 2003). It is a secondary aim therefore to identify and highlight differences in the patterns of variation among the species that are inferred from the genetic data.

Figure 1. *Henicorhynchus siamensis* and *H. lobatus*

METHODS

Sampling and DNA analysis

Samples of both *H. siamensis* and *H. lobatus* were collected from the Mekong River, from Viet Nam to northern Thailand, and from Tonle Sap Lake also in the Mekong drainage. Additional samples were collected from the Mae Klong and Chao Phraya catchments in Thailand for the purpose of placing levels of genetic divergence within the Mekong system into broader context (see Figure 2; Table 1).

Statistical Analysis

The relationship among unique mtDNA genotypes (haplotypes) was determined by constructing a haplotype network for each species using the TCS program (Clement *et al*., 2000) which gives a visual representation of the level of divergence among unique haplotypes (Figure 3a,b). The level of genetic relatedness among haplotypes is indicated by the number of lines separating nodes (unique haplotypes) in the network. Each line represents a single base pair (bp) mutation.

Stock structure was determined using a simulated annealing approach applied to the analysis of molecular variance using the SAMOVA program (Dupanloup *et al*., 2002). This method groups sampling sites together so as to simultaneously minimise the component of total genetic variation within groups (F_{SC}; among sampling sites within stock variation) while maximising the component of genetic differentiation among groups (F_{CT}; among stock variation).

Table 1: *Sampling sites and sample sizes for H. siamensis and H. lobatus used in the current study. Sites from tributaries of the Mekong are identified (TS = Tonle Sap; Mun = Mun River*

Site Name	Country and Drainage	Abbrev.	Sample Size	
			H. siamensis	*H. lobatus*
Chau Doc	Viet Nam - Mekong	CD	17	12
Phnom Penh	Cambodia - Mekong	PP	15	
Kampong Chhnang	Cambodia – Mekong (TS)	KC	11	2
Pursat	Cambodia – Mekong (TS)	PS		23
Battambang	Cambodia – Mekong (TS)	BB	21	
Siem Reap	Cambodia – Mekong (TS)	SR	5	1
Kampong Thom	Cambodia – Mekong (TS)	KT	20	
Stung Treng	Cambodia – Mekong	ST	17	7
Ubon Ratchathani	Thailand – Mekong (Mun)	UB	4	9
Mun/Mekong Conf.	Thailand – Mekong (Mun)	MR	40	
Nongkhai	Thailand – Mekong	NK	7	8
Chainard	Thailand – Chao Phraya	CH		6
Kanchanaburi	Thailand – MaeKlong	KB	10	

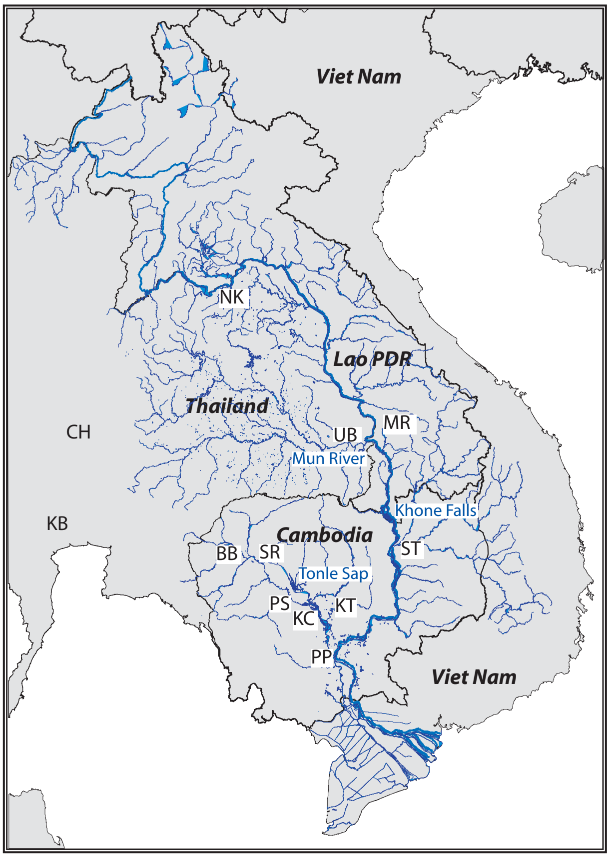

Figure 2. Map showing sampling sites for the present study.

DNA was extracted from fin tissue and a partial sequence of the ATP*ase* 6 and ATP*ase* 8 mitochondrial genes (mtDNA) was amplified using polymerase chain reaction (PCR) . The resulting mtDNA fragment was directly sequenced resulting in a 630 base pair fragment used for further analysis.

The genetic relationship between *H. siamensis* and *H. lobatus* was resolved by reconstructing the phylogeny of the two species in combination with several other Cyprinids using the neighbour joining method (Saito and Nei, 1987) in the program MEGA2 (version 2.1) (Kumar *et al*., 2001). Corrected distance was determined using the (Tamura and Nei, 1993) genetic distance model. The reliability of the phylogeny was determined with 500 bootstrap replicates.

RESULTS

H. siamensis—Genetic Variation and Stock Structure

DNA analysis of the 167 *H. siamensis* sampled for this study revealed 59 unique haplotypes with most haplotypes separated by a single or two bp differences among nearest neighbours in the haplotype network (Figure 3a). The analysis for *H. siamensis* revealed a relatively high haplotypic diversity of 0.35.

While the geographic distribution of these haplotypes is complex (i.e. several haplotypes are widespread while many others are confined to a single site), the SAMOVA analysis arranged the sampling sites into three groups (stocks) with approximately 22.5% of the genetic variation proportioned among these groups (F_{SC} = 0.010, p= 0.410; F_{CT} = 0.223, p=0.002). The three groups were: 1) all sites below the Khone Falls (CD, PP, KC, BB, SR, KT, ST); 2) sites immediately above the Khone Falls (UB, MR); and 3) Nongkhai in the MRB and Kanchanaburi in the Mae Klong River (NK, KB).

H. lobatus—Genetic Variation and Stock Structure

DNA analysis of the 68 *H. lobatus* sampled in this study revealed only 16 unique haplotypes (Figure 3b). While the sample size for *H. lobatus* was smaller than for *H. siamensis*, even so the level of genetic diversity at 0.026 was an order of magnitude lower than that seen for *H. siamensis*. Furthermore the degree of genetic divergence among haplotypes in the network was considerably greater.

The SAMOVA analysis identified three groups with approximately 99% of the genetic variation evident among groups (F_{SC} < 0.001, p= 0.596; F_{CT} = 0.985, p<0.001). The three groups identified were: 1) all sites below the Khone Falls and the major channel of the Mekong River as far north as Nongkhai (CD, KC, PS, SR, ST, NK); 2) Ubon Ratchathani in the Mun River above the Pak Mun Dam (UB); and 3) Chainard in the Chao Phraya drainage (CH).

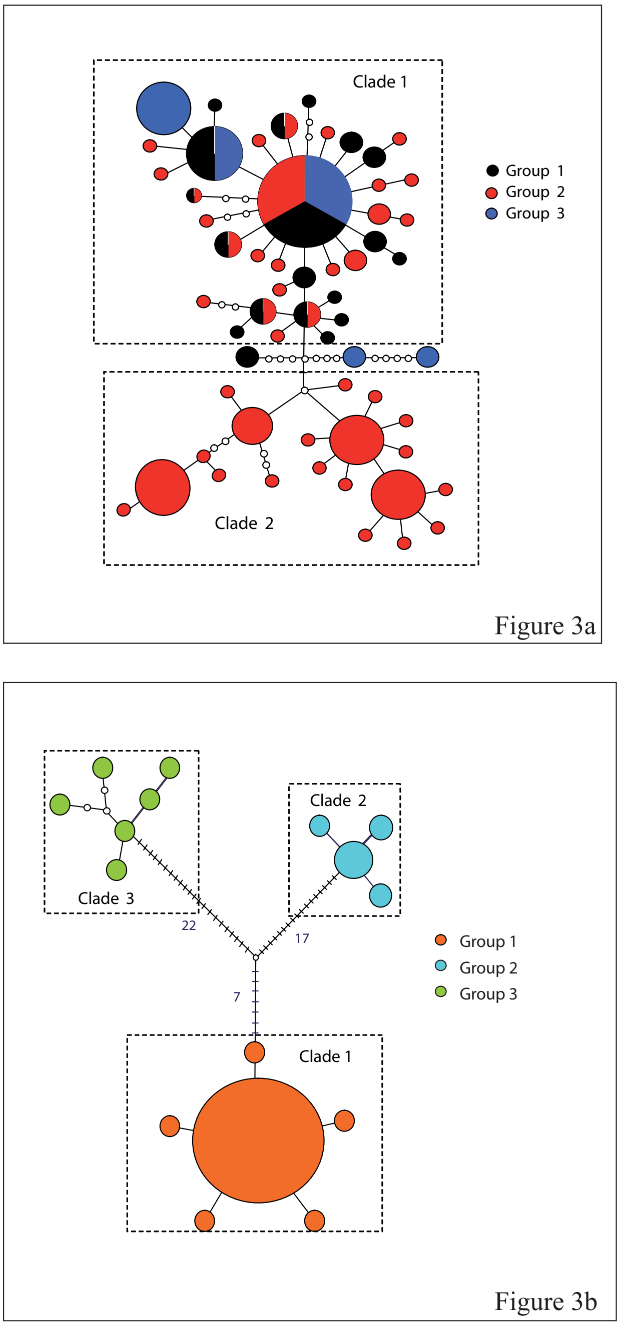

Figure 3. Parsimony networks for (a) *H. siamensis* and (b) *H. lobatus*. Circles represent unique haplotypes, the size of the circle indicates the frequency of the haplotype in the total sample and the shading of the circles represents the group (i.e. groups of sampling sites that are genetically differentiated from each other as identified in the SAMOVA analysis) from which it was detected. Small open circles represent hypothesised haplotypes that were not detected in the sample. Lines joining neighbouring haplotypes represent a single base pair mutation. The dotted lines indicate clusters of haplotypes that are closely related to each other (clades). The hash marks in 3(b) represent numbers of base pair mutations among clades (total number of mutations are given).

Phylogenetic Relationship of H. siamensis and H. lobatus

Although *H. siamensis* and *H. lobatus* present as a monophyletic clade, the phylogenetic reconstruction of cyprinid species (Figure 4) clearly shows that the two *Henicorhychus* species are not closely related and significant divergence is evident between the two species. The corrected distance of approximately 15% is the level of divergence that is more commonly detected among genera in this family based on the currently accepted systematics rather than among species within a genus.

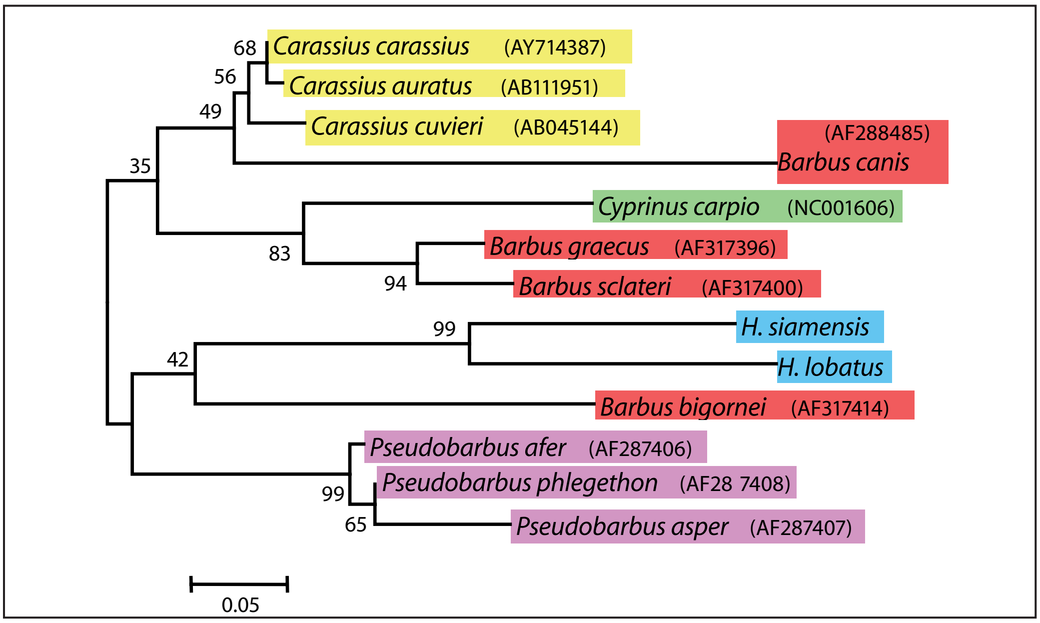

Figure 4: Neighbour joining tree depicting the relationship between *H. siamensis* and *H. lobatus* along with divergence levels among other Cyprinids. Bootstrap values represent the percentage of times a particular node was supported through 500 replicates. The scale bar represents 5% divergence. Colour coding highlights species from the same genus. (GenBank accession numbers are given for each species).

DISCUSSION

H siamensis and *H. lobatus* are two of the most abundant and widespread fishes in the Mekong River Basin and represent a significant proportion of the annual catch. As they are difficult to distinguish morphologically and appear in large numbers at roughly the same time of year in the same locations, it is not surprising that they are generally grouped together. In fact they share the same common names respectively: *trey riel* in Cambodia; *ca linh* in Viet Nam; and *pla soi* in Thailand and *pa soi* in Lao PDR. Yet the results of this study clearly indicate that the two species are significantly different in several respects.

Firstly, they are not genetically closely related, no more so than what is expected among species from different genera in this family. The fact that they shared a common ancestor millions of years ago suggests that they have been evolving independently for an extensive period of time and that they most likely have very different ecologies and perhaps different life history traits. This is highlighted by the fact that, while the analysis of the distribution of genetic variation across the sampled range revealed three groups or stocks for both species, the individual stock structures of *H. siamensis* and *H. lobatus* are markedly different.

H. siamensis—Stock Structure

The greatest amount of genetic variation was detected in the lower MRB. This is a common occurrence in freshwater systems due to unidirectional water flow. The pattern emerges because it is more difficult for new haplotypes arising downstream to disperse against the current than it is for new upstream haplotypes to move downstream with the water flow. *H. siamensis* shows a break above and below the Khone Falls, as may be expected if the falls has acted as an instream barrier to upstream dispersal. It is evident that there is some downstream dispersal (indicated by the sharing of Clade 1 above and below the falls; Figure 3a). Whether the downstream movement is part of the migration cycle or alternatively is the result of passive dispersal (i.e. moving downstream with the current) of larval or juvenile individuals from spawning events above the Khone Falls cannot be determined with the genetic marker used in the present study. There is a possibility that what appears to be a genetically diverse panmictic stock in the lower MRB is actually two sympatric but non-interbreeding stocks. A similar scenario has been recently detected for the sutchi catfish (*Pangasianodon hypophthalmus*) in the Mekong (So *et al*., 2006) using nuclear markers. The data presented here however, suggest clearly that dispersal upstream beyond the Khone Falls is limited, if not absent (Clade 2 is found solely in the lower Mekong River), or alternatively, only individuals from Clade 1 are traversing the falls.

Interestingly, the third group contained sampling sites from Nongkhai in northern Thailand and the sample from Kanchanaburi (in the Mae Klong River system). These fish are not only geographically distant but inhabit discrete drainage systems currently totally isolated from each other with no freshwater avenues of connectivity for potential dispersal. These data suggest that either at some time in the recent evolutionary past (historically) there has been some dispersal among the drainage systems, or alternatively, fish have been actively translocated among drainage basins. Further sampling and analyses are required to resolve this question.

H. lobatus—Stock Structure

Compared to *H. siamensis*, *H. lobatus* shows a much more structured population. Group 1 (i.e. the whole of the Mekong and Tonle Sap) shows widespread movement, at least across the range of the study to date. However, due to the substantially lower level of genetic variation observed for this mtDNA marker and the smaller sample size for *H. lobatus*, there is insufficient power to confidently state whether extensive gene flow occurs at this geographic scale. In contrast to *H. siamensis*, there is no evidence to suggest that the Khone Falls acts as a barrier to dispersal for *H. lobatus*. It is interesting to note, that reports based on observational data suggests that while both species move upstream (beyond the Khone Falls) during migrations at the end of the wet season (Baird *et al*., 2003), far greater numbers of *H. lobatus* (up to 10 times more than *H. siamensis*) attempt to traverse the falls. The genetic data in the present study support these observations, suggesting that the Khone Falls may not act as an instream barrier for either species, but rather the higher level of genetic differentiation seen for *H. siamensis* above and below the falls is a function of the species migratory behaviour.

The most striking aspect of the genetic pattern for *H. lobatus* is the considerable level of divergence among clades in the network (Figure 3b). The level of divergence found between Chainard in the Chao Phraya drainage (Clade 3) and other sampling sites in the Mekong River is what might be expected from freshwater fishes from isolated river catchments. That is, a relatively high level of genetic divergence among drainages with reciprocal monophyly (all individuals within a drainage are more closely related to each other than to any individual from a neighbouring drainage). However, the divergence of the samples from the Mun River and all other samples from the Mekong River is difficult to explain as there appears to be no significant barrier to dispersal between the Mun and Mekong Rivers. Although the Pak Mun Dam (completed in 1994) represents a significant barrier to upstream dispersal, the time of its construction is not concordant with the divergence levels detected in this study. However, the construction of the dam led to the flooding of significant rapids which may have acted as a natural barrier for a considerable length of time in the past.

Naturally the small sample from the Mun River prevents making conclusions regarding whether the Mekong group (Group 1, Clade 1) are present in the Mun River or not. However it appears that the Mun River fish do not disperse to the main channel of the Mekong suggesting that the full life cycle including associated migrations occurs solely within the Mun River for this stock.

IMPLICATIONS FOR MANAGEMENT

Although *H. siamensis* and *H. lobatus* are numerous and widespread throughout the Mekong and surrounding drainages, their economic importance to the region will necessitate management to allow continued sustainable harvesting. The results of the present study strongly indicate that, although both species appear similar in some respects, management strategies should be developed for each species separately.

Analysis of *H. siamensis* revealed a high level of genetic variation with three independent stocks in the Mekong River (one in northern Thailand, and one each above and below the Khone Falls, although two discrete stocks may exist below the falls). As a result , these data have provided the spatial scale at which management should be focussed for this species.

In contrast, the analysis for *H. lobatus* shows a very different picture. Firstly, the level of genetic variation present for this species is extremely low, especially considering the current abundance of this species in the MRB. These results suggest that the population as a whole has undergone a dramatic reduction in size in the recent evolutionary past. As a consequence, the reduced level of variation may compromise the 'genetic health' of the population (it is generally accepted that low variation is associated with low evolutionary potential) and thus may affect its long term viability. Effort should be directed to ensuring the level of genetic variation that currently exists for this species is not eroded further.

Secondly, the highly divergent clade detected in the Mun River suggests that this stock has been evolving independently from the Mekong stock for a considerable length of time. Thus from a management perspective, the data suggests that it would be unwise to mix these two stocks as there is a potential for outbreeding depression to occur or one of the stocks could go extinct. Outbreeding depression is essentially where the resulting hybrid offspring of genetically divergent parents have a lower fitness than both parental stocks. This may be due to the disruption of co-evolved gene complexes or by driving locally adapted phenotypes from their optimum.

The data presented here, which are the result of an ongoing study, highlight the utility of a molecular approach to stock delineation for fisheries management. Analysis at a finer spatial scale is currently being undertaken to address some of the questions raised here. Furthermore, it should be stressed that the outcomes of this study should be used in conjunction with ecological data when formulating management plans in the future.

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Section 5. Poster presentations

Effectiveness of mobile and permanent hatchery practised by community fisheries

UN Veng*, SOUN Sothea, HANG Savin, SUNG Sokunthea, OUK Vibol, and KAING Khim

Management of River and Reservoir Fisheries in the Mekong Basin, Cambodia Sub-Component, and Aquaculture of Indigenous Mekong Fish Species Sub-Component

ABSTRACT

Mobile hatchery was introduced in 2004 in order to response the needs and implement CF action plan in 2004 for CF federation in Tmorda/Teukchhar Reservoir. Based on the experiences of mobile hatchery activities, the requested permanent hatchery activities were made by other CFs in other MRRF target areas in coming year CF plan.

Concerning with several aspects related to the types of small-scale hatcheries through consultation made among CF committee members and technical person, small-scale permanent hatcheries were introduced for two CFs in Kandal Province to implement CF action 2005. Therefore, it is important to write up the effectiveness of both types of hatcheries in terms of social and economic perspectives, so that recommendations and lessons learned could be made for the better practices and support CF activities for development and management.

Based on the results of practical work by CF committee members through both types of hatchery show that mobile hatchery is suitable and useful for CFs. It could be moved and scheduled with other CFs as required. However, the maintenance cost of this mobile hatchery is more than the permanent hatchery, and it is suitable for breeding with some species only. While permanent hatchery is located in one area only, with suitable location of hatching and nursing activities, and also fish breeding, the mobile is suitable for more species than permanent hatchery.

INTRODUCTION

Alternative livelihoods was one of the important activities prioritised by Community Fishery (CF) members during CF review and CF planning for 2004, in providing job opportunities to rural poor people. Fish stocking in reservoirs, CF fish ponds and family fish pond culture were identified as the alternative livelihoods for CF members in the target areas. Therefore mobile hatcheries, as well as permanent hatcheries, are priority activities and have been proposed in the CF action plan for 2004 (Tmorda/ Teukchhar and Chroy Check Reservoir). This is in order to produce available fingerlings in the local areas for the purpose of having and increasing fish catch from the reservoirs, common/ CF ponds and family ponds for household consumption and additional income.

The main purpose of both hatchery types (permanent and mobile) is to produce fingerlings for stock enhancement in the reservoirs, and for rural aquaculture for CF members. Mobile hatcheries could be used not only at one CF or place; they can be used for other CFs to use as well in a hatching season.

Therefore, it is important to study the effectiveness of those both types of hatcheries practised by Community Fisheries.

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WHY MOBILE AND PERMANENT HATCHERIES

Mobile and permanent hatcheries were given a high priority in the action plans of Community Fisheries. Because CF committees and members thought that it is the way to increase fish stock in the reservoir and develop fish farming in CF to improve livelihoods of local people. They also think mobile and permanent hatchery are a means to provide additional income or budget for CF management and individual CF members.

The specific objectives of having mobile and permanent hatchery are as follows:

- to implement the CF action plan;
- to provide local fingerlings for fish stocking/restocking in the reservoirs, CF/common ponds, and family ponds;
- to provide/increase fish catch from the reservoirs and ponds for household consumption;
- to provide additional income or budget for CF management and individual CF members;
- to increase higher participation of CF members and actively in implementing CF management plan;
- to empower CF committee members through capacity building on livelihood coping strategy;
- to strengthen CF management in a sustainable way;
- to increase the alterative livelihood activities such small-scale aquaculture (fish pond culture) activity for CF members in the rural poor areas.

WHO BUILDS, OWNS AND USES?

Mobile and permanent hatchery are operated and used by Community Fisheries with technical support from staff of MRRF and AIMS Cambodia sub-component.

CONSTRUCTION OF HATCHERIES

The mobile hatchery was built by community fisheries committees with technical support from AIMS Cambodia sub- component and funded by MRRF.

Mobile hatchery

At each reservoir, the following equipment was used:

- 700 litre header tank (Figure 2)
- 1 induced spawning tank (made from iron pipe and plastic tent material)
- 1 hatching tank (made from iron pipe and plastic tent material)

- 1 hatching system (made from 2 litre plastic water tanks)
- Inlet and outlet system
- Aeration system
- 1 generator and
- 1 water pump

Figure 1. Spawning tank and 700 liter header tank (left) and spawning tank (right)

Permanent hatchery

The permanent hatchery was built by community fisheries committees with technical support from AIMS Cambodia sub- component and funded by MRRF. It was equipped with:

- header tank
- 1 induced spawning tank
- 1 hatching tank
- Inlet and outlet system
- Aeration system
- Water pump

Figure 2. Spawning tank and hatching tank (left) and header tank (right)

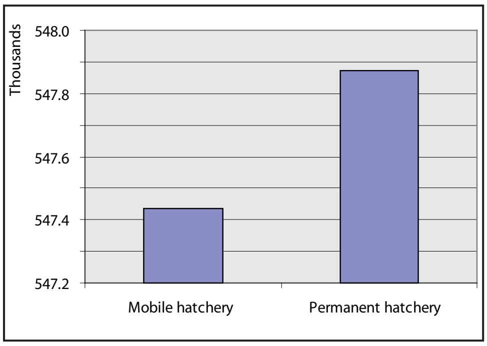
Experimental process

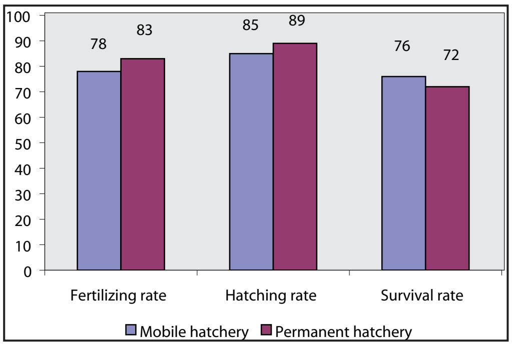
The test was made with *Barbonymus gonionotus* for both types of hatcheries. The broodstock were collected and selected from the Government Station and from the wild. Five breeding batches were obtained with each type of hatchery.

To evaluate the effectiveness of the hatcheries, the egg releasing time, hatching time, fecundity, fertilizing rate, hatching rate and survival rate were recorded and analyzed using SPSS software using ANOVA statistical analysis.

RESULTS

Figure 3 shows the mean of fecundity of a one-kilogram fish (547,400 eggs/kg) from the mobile hatcheries while for a one-kilogram fish from the permanent hatchery the fecundity was 547,800 eggs/kg from the permanent hatchery. Based on the data analysis the fecundity mean was not found to be significantly different between the permanent and mobile hatchery.





Figures 3 and 4. Result of Fecundity during the breeding of *B. gonionotus* (left) and result of F. rate, H. rate and S. rate during the breeding of *B. gonionotus* (right)

Based on data analysis, the mean of fertilization rate, hatching rate and survival rate from both types were not significantly different. The mean ranged from 78 to 83 per cent of fertilizing rate, 85 to 89 per cent of hatching rate and 72 to76 per cent of survival rate (Figure 4).

The economic efficiency was also analyzed to evaluate the effectiveness of both hatcheries. Based the analysis the operation cost of one seed produced was significantly higher in the mobile hatchery than in permanent hatchery. The higher expense in the mobile hatchery was due to high cost of maintenance. Table 1 shows the operation cost per unit seed and main expense for both types.

Table 1. *Operational costs*

Type of Hatcheries	Mobile hatchery	Permanent hatchery
Operation cost per unit fry	0.42 Riels	0.31 Riels
Main expense	Depreciation	Fuel

ADVANTAGES AND DISADVANTAGES OF MOBILE AND PERMANENT HATCHERIES

Mobile Hatchery	Permanent Hatchery
Advantages	
✓ Can be moved ✓ No specific site to place ✓ Avoid genetic problem as it uses broodstock collected from the site ✓ Good effective for scale fish	✓ Long life use ✓ Good effect for many species including catfish ✓ Easy to manage
Both Types	
✓ Increase income and food for people in community ✓ Encourage committees to strongly participate in community development	
Disadvantages	
✓ High cost of depreciation ✓ Can effect only few fish species ✓ Difficult to manage (hatchery equipments)	✓ Higher cost for operation ✓ Need specific site to install ✓ Lower survival rate when improper hatching tank preparation

CONCLUSIONS AND RECOMMENDATIONS

- Mobile and Permanent Hatchery provide the same effects in breeding of indigenous fish to enhance fish stock and develop aquaculture.
- Mobile and Permanent Hatchery play a very important role to provide income and food for community fisheries committees and local community members.
- Mobile and Permanent Hatchery provide the financial support and encourage to higher participation of CF members and to sustain the Community Fisheries in managing natural resources.
- However, mobile could be used for more than one CF and more than one stock enhancement in the reservoirs and it is useful for where no available location.

Brooder rearing of small-scale mud carp, *Cirrhinus microlepis* (Sauvage, 1878) with different commercial feeds

Decha RODRARUNG*

Aquaculture of Indigenous Mekong Fish Species, Thailand Sub-components,

ABSTRACT

Three commercial feeds, sinking fish feed (25% protein), marine shrimp feed (38% protein) and marine shrimp brooder feed (54% protein), were compared to determine the most suitable feed for rearing brooder of small scale mudcarp*, Cirrhinus microlepis*. The results on the percentages of mature fish were not significantly difference among the treatments. No male brooders spermiated when stripping and the percentages of mature female brooders were 24.8, 25.5 and 29.2 %, respectively.

KEYWORDS : *Cirrhinus microlepis*, brooder rearing

INTRODUCTION

Small-scale mud carp (*Cirrhinus microlepis*) is a high value indigenous Mekong fish species. The species is distributed throughout the Lower Mekong Basin i.e. Lao PDR, Thailand, Cambodia and Viet Nam. The Aquaculture of Indigenous Mekong Fish Species (AIMS) Component, Mekong River Commission, Fisheries Programme, has selected *C. microlepis* as one of several target species for aquaculture development research. Breeding of wild broodstock of *C. microlepis* has been done successfully in Lao PDR , but attempts to breed *C. microlepis* kept in captivity have not been very successful. One of the problems is unpredictable and variable reproductive performance. Improved broodstock nutrition and feeding may improve not only egg and sperm quality but also seed production. This study was conducted to determine the effect of three different diets on maturation in *C. microlepis* brooders.

MATERIALS AND METHODS

The experiment was carried out in one 3,200 m^2 earthen pond in the Udon Thani Inland Fisheries Research and Development Center from March - August 2005 for a period of 6 months. Nine pens sized 320 m^2 were made using polyethylene nets. 7-year-old brooders were stocked at the rate of 8 fishes per pen. Three different diets were utilized, sinking fish feed (25% protein), marine shrimp feed (38% protein) and marine shrimp brooder feed (54% protein). The fish were fed once a day at 1.5 % of body weight. The maturity condition was checked every two week from mid of May to end of August.

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RESULTS AND DISCUSSION

There was no significant difference *(P*>0.05) between diets and maturity condition. Males did not give any sperm after a soft stripping but, internally, the testis was normally developed. Females with big and soft belly were also examined the maturity status (24.8 - 29.2 % of maturation female in all treatments). The diameter of the eggs were 1.2 – 1.6 mm.

Table 1. *Comparison of three feeds*

	T1 (25% Protein)	T2 (38 % Protein)	T3 (54 % Protein)
Body Weight (Kg.)	1.4 – 2.6	1.4 – 2.7	1.4 – 2.5
Female Maturation (%)	24.8	25.5	29.2
Male Maturation (%)	0	0	0
Spawning Season	Mid of Jun. – Mid of Jul.	Mid of Jun.– Mid of Jul.	Mid of Jun. – Mid of Jul.

The three different diets tested here did not affect maturity of *C. microlepis* brooders. The pellet feed contains 25-30 % protein can be used for brooder rearing. The fish was able to produce eggs and sperms under pen condition but in the spawning season males would be mature later than female . The spawning period of farmed stocks starts from June to July , the same period of wild fish in the Mekong (Gorda 2001).

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Comparison of three feeding formulas with *Pangasius hypophthalmus* at Ban Hat Station, Khong District, Champassak Province, Lao PDR

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ABSTRACT

The experiment on the indigenous catfish (*Pangasius hypophthalmus*) consisted of testing three different feeds during grow-out. Fishes were stocked in small net cages (3.9m^3) held in the Mekong River at the Ban Hat Village, Champassak Province. The experiment lasted for three months from May 30 to August 30 2005. Two feeds were prepared locally by grinding, mixing and pressing the ingredients with a small press. The ingredients for the feed 1 were rice bran (25%), maize (25%), beer brewing waste (24%), broken rice (5%), fish meal (20%) and premix (1%). The ingredients for feed 2 were rice bran (40%), maize (15%), soybean oilcake (20%), broken rice (10%), fish meal (14%) and premix (1%). The third feed was commercial extruded pellets used for *Clarias* catfish (30% protein). The juvenile fish initially weighted 130g and measured 24cm in total length on the average. After three months, the fish fed with the commercial pellet showed better growth than the two others in terms of body weight and total length ($P < 0.05$). There was no significant difference between the two local feeds. The mean final body weight and total length were 833g and 41cm (F3), 577g and 38 cm (F2), and 506g and 36.5cm (F1). The food conversion ration (FCR) was not significantly different among the three treatments (average 1.84:1) as well as the survival rate (average 87 %). The net income per kilo of fish harvested was highest with the third feed (US$ 0.29) and second was with feed 1 (US$0.13) ($P < 0.05$); the net income with the feed 2 was in-between at US$0.19.

INTRODUCTION

Fish cage culture has become popular in the Lao PDR. There are several suitable water resources for this type of aquaculture including large reservoirs and rivers with appropriate depth and flow. However, the availability and the cost of fish feed imported from neighboring countries limit the profitability, especially for farmers living in remote areas. To reduce the production cost, local-made feed could be formulated by using local raw materials. The Nile tilapia (*Oreochromis niloticus*) is only one species being raised in cages in Lao PDR. The indigenous catfish *Pangasius hypophthalmus* (formerly named *P. sutchi*) seems to be a good candidate for the intensive form of cage culture. This fish is named '*Pa-suai*' in Lao language. *P. hypophthalmus* shows several interesting features including fast growth, high market value and seed availability. The development of the aquaculture of this species is a priority for the LARReC. The objective of this study was to assess the growth performances of *P. hypophthalmus* by testing three different feeds, including two locally made feeds and one commercial feed.

MATERIALS AND METHODS

The study was conducted at the Ban Hat Fisheries Station located along the Mekong River in the Khong District, Champassak Province, in the South of the Lao PDR. Fishes were stocked in floating

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cages on the River. Cages were made of nylon net and measuring 1.5 x 2 x 1.5m (width x length x depth) with $3.9m^3$ for the water volume. Large juveniles of *P. hypophthalmus* have been used; the initial body weight was 130g and ranged from 90g to 140g. Fishes aged about five months were issued from a hatchery and nursery ponds at the Ban Na station (Muang Khong District). Cages were stocked with 45 fish.; the stocking density was 15 fish/m^2 or 11.5 fish/m^3. It should be noted that such density is quite low regarding to the usual density in similar conditions for *P. hypophthalmus* (150 fingerlings/m^3) according to Oupasirth (2003), and for the tilapia (about 60 fingerlings/m^3) according to Koranankoun (2004). The experiment was designed with three treatments (i.e. three different feeds) including three replications for each treatment. The location of the cages was established randomly as shown in Figure 1.

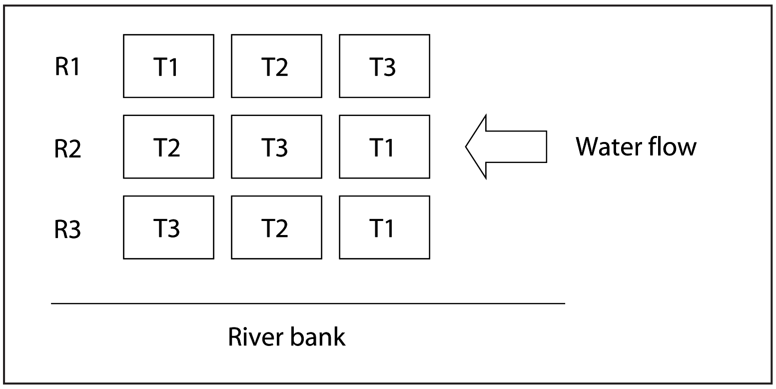

Figure 1. Location of the floating cages on the Mekong River for the three treatments in the three rows

Ten fishes per cage were sampled and measured at the stocking and then every month during three months from the 30th May to 30th August 2005. The body weight was measured to the nearest 10g and the total length of the fish was measured to the nearest millimeter. The condition factor K was determined as indicator of the fitness of the fish [$K = 10^5$ x body weight (g) / total length $(mm)^3$].The total amount of fish was determined at the end of the experiment and the survival rate calculated.

Three different feeds were tested including two local feeds prepared at the station according to Nakasen and Phanapheth (2001). Method for calculated feed formula for animal and one commercial feed imported from Thailand (Table 1). The local feeds were prepared weekly with 10 to15 kg of feed each time. Ingredients were mixed thoroughly and then passed through a small electric press (power 3.7 kwatt). Little water was added before pressing for sufficient stickiness. We have followed the method indicated by Vudphanxay (1993) and Unpasirth (2004) for the preparation of the feed. After pressing, the pellet was dried with a drying machine and also sun dried, then stored in the fridge (5-6 °C). Basic produced fish feed for farmers. The three feeds were distributed at the same feeding rate equivalent to about 3% of the biomass per day. Fish were fed twice a day at about 8:30 AM and 5:30 PM. The water quality was assessed twice a month and the data are summarized in the Table 2. The rainy season has started in June and it has affected the water temperature and also other parameters (tubidity, velocity).

Table 1:.Composition *of the three feeds used in the experiment.*

	Feed 1 (a)	Feed 2 (a)	Feed 3 (b)
Type of feed	Sinking dry pellet locally made	Sinking dry pellet locally made	Floating extruded pellets imported from Thailand
Ingredients			
Rice bran	25	40	x
Maize	25	15	x
Byproduct from brewing	24	-	-
Soybean oil cake	-	20	x
Soybean steaming	-	-	x
Broken rice	5	10	x
Fish meal	20	14	x
Coconut oil cake	-	-	x
Premix +Vitamin C	1	1	-
Vitamin and mineral	-	-	x
Antioxidants	-	-	x
Proximate composition (c)			
Moisture (% TM)	14.86	14.37	9.00
Proteins (% DM)	18.64	18.43	30.00
Carbohydrates (% DM) (d)	46.09	43.57	35.5
Lipids (% DM)	4.81	7.65	11.00
Ash (% DM)	7.24	7.99	6.50
Fiber (% DM)	8.36	7.99	8.00
Price (USD/kg)	0.32	0.34	0.55

(a): Proportion of the raw materials,(b): the proportion of the ingredients composition is unknown, (c): composition issued from the analysis of one sample per feed (100 g); amounts are given in percents of total matter (TM) or dry matter (DM),(d): calculated value.

Table 2. *Evolution of the water quality two measurements per month.*

Parameter	June (*)	July (*)	August (*)	Minimum	Maximum
Temperature (°C)	28.2	26.4	25.4	24.5	30
DO (mg/liter)	6.1	6.6	6	4.8	7.3
pH	7.1	7.2	7.3	6.7	7.9

Data were analysed with One-way analysis of variance (ANOVA) and Duncan's test with the SPSS statistical software.

RESULTS

After three months the fish fed with the feed 3 (commercial feed) showed higher body weight than that of the fish fed with the two local feeds by 1.6 times (feed 1) and 1.4 times (feed 2) ($P < 0.05$); the two local feeds were not significantly different from each other (Table 3).

Table 3. *Growth performances after (average ± SD). Significant differences between the feeds for each duration are indicated by different letters (a, b, c; P < 0.05).*

	Feed 1	Feed 2	Feed 3
Initial conditions			
Density (fish/m^3)	11.5	11.5	11.5
Biomass (kg/m3)	0.97 ± 0.01 ^{a}	0.99 ± 0.04^a	0.99 ± 0.02 ^{a}
Body weight (g/fish)	129 ± 28 ^{a}	132 ± 30^a	130 ± 35 ^{a}
Length (cm/fish)	24 ± 1.9 ^{a}	23.25 ± 1.9^b	24 ± 1.8 ^{a}
K	1 ± 0.08 ^{a}	1.1 ± 0.08^a	1 ± 0.05 ^{a}
Final conditions			
Biomass (kg/m^3)	3.4 ± 0.2^b	3.6 ± 0.03^b	5.4 ± 0.2^a
Net production / m^3 / month	0.8 ± 0.14^b	0.9 ± 0.03^b	1.5 ± 0.12^a
Body weight (g/fish)	506 ± 39^b	577 ± 51 ^{b}	833 ± 59 ^{a}
Length (cm fish)	36 ± 1.5^b	38 ± 1.7^b	41 ± 1.6^a
K	1.06 ± 0.13^a	1.09 ± 0.1^a	1.2 ± 0.1^a
Daily weight gain (g)	4.2 ± 0.5^b	5 ± 0.3^b	7.8 ± 0.4^a
Daily length gain (mm)	1.4 ± 0.2 ^{c}	1.6 ± 0.6 ^{b}	1.9 ± 0.1 ^{a}
Specific growth rate total (%)	1.52 ± 0.10 ^{b}	1.64 ± 0.04 ^{b}	2.06 ± 0.03 ^{a}
FCR	1.87 ± 0.1^a	1.91 ± 0.14^a	1.74 ± 0.1^a
Survival rate (%)	91 ± 4 ^{a}	84 ± 3 ^{a}	87 ± 4 ^{a}

The same result was obtained with the total length although the difference was more limited. There was no significant difference for the condition factor K although it tended to be higher for the fish fed with the commercial feed.

The feed conversion ration (FCR) was not significantly different among the treatments although it tended to be slightly lower with the commercial feed.

The survival rate was also not different among the treatments. The growth between the three treatments varied already from the first month as presented in the Figure 2. The growth rate in body weight tended to increase from the first to the second month for the three feeds and then it was much lower during the third month (Figure 3).

The commercial feed is more profitable than the two local feeds by 3.7 times (feed 1) and 2.1 times (feed 2) while considering the net income per cage ($P < 0.05$; Table 4).

The net income per kilo of fish showed the same pattern although the feed 2 (local feed) was not significantly different from the two others. It should be noticed that the net income with the commercial feed is equivalent to about one fourth or one fifth of the income while considering the cage or the kilo of harvested fish, respectively.

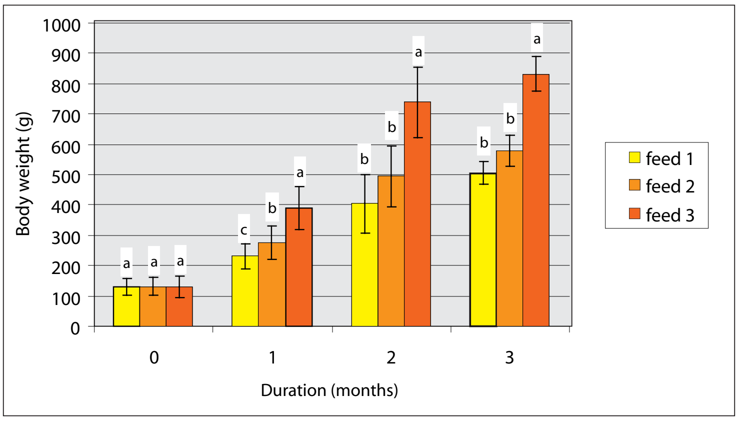

Figure 2 . Evolution of the fish body weight along the experiment (average ± SD). Significant differences between the feeds for each month are indicated by different letters (a, b, c; P < 0.05)

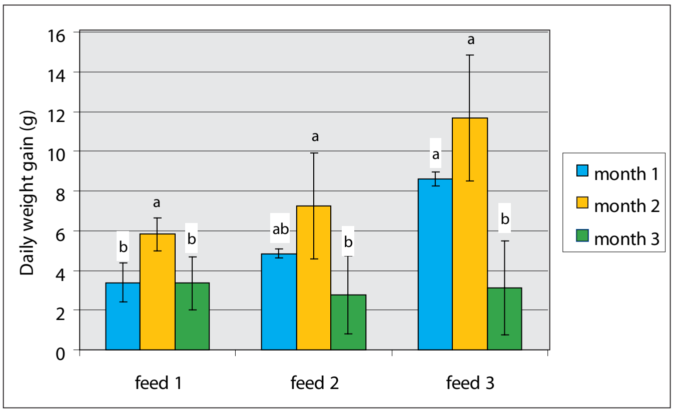

Figure 3. Evolution of the daily weight gain of the fish along the experiment (average ± SD). Significant differences between the months for each feed are indicated by different letters (a, b, c; P< 0.05).

DISCUSSION

Fish fed with commercial feed grew faster than those fed with local feed. The main reason might be the higher protein content in the commercial feed. Otherwise, the commercial pellets are extruded, so are probably more digestible. The FCR is not significantly different between the feed although it tended to be slightly lower with the commercial feed; this might be due to the fluctuation of the survival in the different replications. The extruded pellet floats so its consumption is indeed usually optimal compared to the local and sinking pellet. For the latest, the feed should be consumed right after distribution otherwise it is lost in the River. Lastly, the commercial feed led to a much higher profit although its price per kilo is higher than that of the ingredients for the local feeds. Preparation of the latter requires specific equipment and labor, which caused higher fixed and operational costs. It is to notice that the fixation of proteins by the fish could be better with the local feed but the protein content in the harvested fish was not determined.

Table 4. *Cost and profit per feed (amounts in US$; average values). Significant differences between the feeds are indicated by different letters (a, b, c; P < 0.05).*

	Feed 1	Feed 2	Feed 3
	Per cage		
Cages			
Equipment for the feed (*)	3.01	3.01	0.00
Scale	0.13	0.13	0.13
Total fixed cost	7.18	7.18	4.16
Ingredients or feed	9.05	11.06	25.98
Fingerlings	3.33	3.33	3.33
Electricity	0.14	0.14	0.14
Labor	8.45	8.45	5.91
Total Operational cost	c 20.97	b 22.99	a 35.23
Total cost	c 28.15	b 30.17	a 39.39
Income (**)	b 31.60	b 36.07	a 52.04
Net income	b 3.45	b 5.91	a 12.65
Net income (% income)	10.9%	16.4%	24.3%
	Per kg of fish harvested		
Fixed cost	a 0.31	b 0.28	c 0.11
Operational cost	a 0.94	a 0.94	a 0.99
Total cost	a 1.27	ab 1.22	b 1.10
Income	1.39	1.39	1.39
Net income	b 0.13	ab 0.17	a 0.29
Net income (% income)	9.3%	12.0%	20.7%

(*): Includes mixing, pressing and drying machines and containers,

(**): The quantity of fish harvested per cage was: c 22.8 +/- 2 kg (feed 1), b 26 +/- 1.4 kg (feed 2) and c 37.5 +/- 1.8 kg (feed 3). The net income is calculated by multiplying the quantity harvested by the price of selling per kilo of fish (1.39 USD whatever the feed used).

Note: 1 US$ = 10,800 Kip.

In Thailand, Oupasirth (2003) mentioned that cultivation of *P. hypophthalmus* is made in cages with the stocking density of 150 fish/m^3. Local feed is used and given with the feeding rate of 3 per cent of the biomass per day. After one year, the average body weight is 1.5kg. Therefore, the daily weight gain is about 4.1g that is similar to that obtained here with the feed 1 (local feed). The tilapia is also raised in similar conditions as reported by Koranankoun (2004). The stocking density in cage is 60 fish/m^3 and the grow-out lasts 63 days. The commercial feed is used with the feeding rate of 4 per cent of the biomass per day. Harvested fish weight was 300g on average, therefore the daily weight gain is about 4.8g which is similar to that obtained with feed 2 (local feed). Based on the two last references, the growth of *P. hypophthalmus* fed with commercial pellet in the present experiment was quite high (7.8 g per day).

The growth rate increased during the second month probably because the fish adapted to the new condition since they initially came from pond. The growth rate decreased during the third month probably because of the fast change in water quality due to the rainy season. The turbidity usually increases as well as the water velocity while the temperature decreases as observed here (- 2.8°C between June and August). Such changes have caused a reduction in the feed consumption. Otherwise several fishes produced sperm by the end of the experiment which indicates that the sexual maturation in the male occurs at the age of about eight months. Such maturation might have also impaired the growth.

CONCLUSIONS

Our experiment showed that the use of local feed is profitable although the profit was much lower than that with the commercial feed tested here. The fish growth was good on the whole even if it was affected by the change in the water quality during the last month whatever the feed used. The fluctuations in the survival rate between the replications do not allow any conclusions to be made regarding FCR values between the different feeds. Better profit with the local feed would likely be obtained with higher stocking density since it was quite low in the present experiment. Moreover, higher protein content in the local feed would probably lead to better result. The same experiment could be repeated by testing the two kinds of feed (commercial and local) with similar contents for both proteins and lipids: 25 per cent and 5-7 per cent could be tested, respectively. Stocking density ranging from 20 to 60 fingerlings/m^3 could be reasonably tested. Lastly, the local feed could be tested in pond where the consumption of the sinking pellet can be delayed (i.e. consumption on the bottom).

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Fish larvae during the dry season in the Tonle Sap River

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ABSTRACT

Drift of fish fry and larvae from the Great Lake only occurs at certain times of the year in the Tonle Sap River near to Phnom Penh. This study aims to examine fish larval drift during the dry season and their numbers in the Tonle Sap River. Larval and juveniles fish were collected three times per week, four times per day (06:00, 12:00, 18:00 and 24:00 hours) from January to April 2004 using a *Bongo* net. The results indicated that some species may have recently spawned in the Tonle Sap River, or the Great Lake, prior to sampling. Three species were found to be most abundant. These were *Brachygobius mekongensis* (21%) *Sundasalanx praecox* (18%) and *Clupeoides borneensis* (26%). Together these three species accounted for 65% of the total number of species occurring in samples. We examined 35 larval fish species, occurring in 18 families in the Tonle Sap River. Only a small number of the *Pangasius* genus were found, and then only during the middle of April.

KEYWORDS: Tonle Sap River, larvae, sampling, species occurrence, Cambodia

INTRODUCTION

The Tonle Sap River connects Cambodia's Great Lake and the Mekong River. It joins the Mekong in Phnom Penh, where the Mekong splits into two branches; the Mekong mainstream and the Bassac River. A remarkable hydrological phenomenon takes place during the annual flooding of the Mekong River. Forced by enormous quantities of water transported down the Mekong, the Tonle Sap River changes direction and flows upstream to the Great Lake for about 4 months, until the floods subside and the river resumes its normal course. The spawning grounds and distribution of fish in the dry season (January to April) in the Tonle Sap River is poorly documented. Mainly, it is only the smaller species of fish that spawn in the Tonle Sap during the dry season months. Previous studies have shown that greater numbers of fish spawn in the Tonle Sap River and the Great Lake during the rainy season months (Chevey 1930, Chea et al., 2002, Tung Bao and Tuan 1998, Tung 2002). The results indicated that floods are important ecological events in the life cycle of fish. Knowledge about fish eggs and larvae of freshwater fish is of great importance to the establishment of management regimes and fisheries protection rules and regulations. The main objectives of this study were to examine larvae that apparently spawn in the dry season, and to determine their relative abundance in the Tonle Sap River.

MATERIALS AND METHODS

Sampling locations

Samples were collected in the Tonle Sap River at Phnom Penh (Figure 1)

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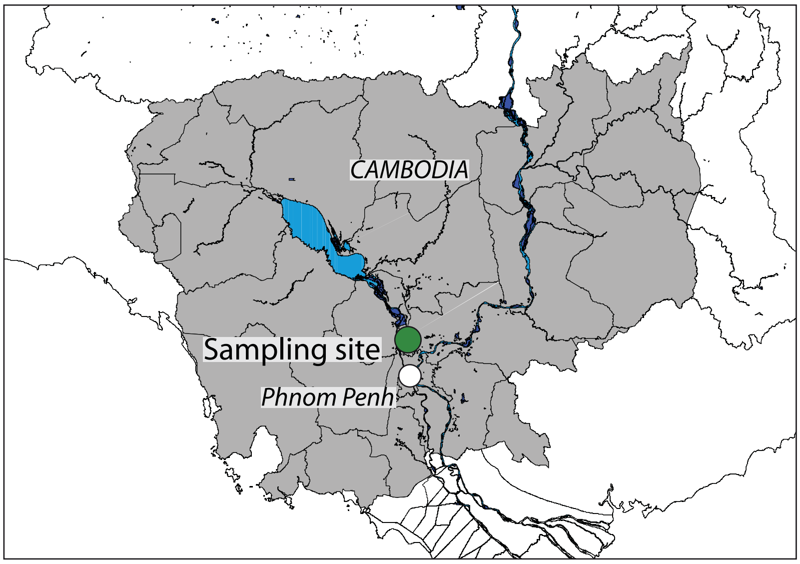

Figure 1. Sampling location

Sampling time

Samples were collected three times per week and at four times per day on sampling days (06:00, 12:00, 18:00 and 24:00 hours) by a *Bongo* net. The dimensions of the *Bongo* net were 1 metre in diameter at the mouth; 5 metres in length and 1 mm mesh size. The net was placed 2 meters below the water surface (Figure 2). Fish larvae and juveniles were preserved immediately after capture in 8 per cent formalin solution.

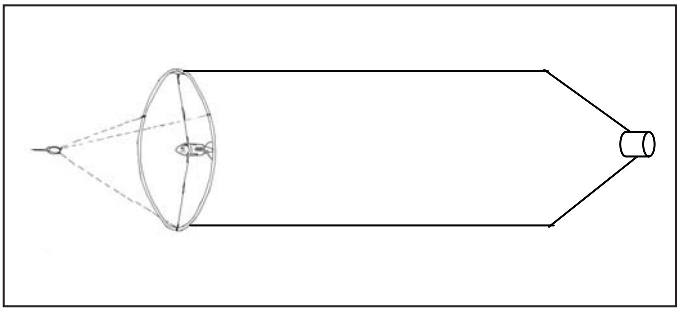

Figure 2. The Bongo net used for collecting fish larvae

Fish larvae identification

Fish larvae and juvenile fish species were identified using Rainboth (1996), Termvidchakorn (2003) and Chevey (1930).

Counting and sub-sampling

All fish larvae from each sample were counted and preserved. Sometimes a sample consisted of several thousand tiny larvae mixed with lots of organic material. In such cases, we resorted to sub-sampling. Sub-sampling carried out using the following procedure:

Weigh the total sample. Take three sub-samples from different parts of the sample. Weigh each sub-sample individually. Identify all species in the sub-sample and count them. Estimate the number of larvae in the full sample according to the following formula:

$$Ntotal = \frac{N1}{W1} + \frac{N2}{W2} + \frac{N3}{W3} * \frac{Wtotal}{3}$$

N_{total} = Number of larvae fish in the sample

N_1= Number of larvae fish in the sub-sample one

N_2 = Number of larvae fish in the sub-sample two

N_3 = Number of larvae fish in the sub-sample three

W_{total} = Weight of larvae fish sample

W_1 = Weight of sub-sample one, W_2: Weight of sub-sample two, W_3: Weight of sub-sample three

Flux velocity calculated by the expression:

V = ((n*f)/999999/t; V1 = [((n*f)/999999)*ϕ2 *π]/4

Where: V= flux velocity (m/s); V1= volume, n = number turns of flow meter; f = calibration factor of flow meter (26.873); t = time of exposure

RESULTS

Over the period of study, we counted 6,485 fish larvae represented in 35 families caught during sampling in the Tonle Sap River. Three families were found to be most important. These were Clupeidae (26.18%), Gobiidae (30.38%) and Sundasalangidae (17.83%). *Clupeoides borneensis* was the most abundant species (Table1). Larvae of the *Tetraodon* genus were found in January. Larvae of *C. borneensis* were found from January to February and larvae of *B. mekongensis* were found in February. In addition, larvae of *Sundasalanx praecox* were found from February to March and larvae of the Pangasidae family were encountered during the middle of April (Table 2 and Figure 3).

Table 1. *Numbers and frequencies fish of larvae/fry collected in the Tonle Sap River from January to April 2004*

Species name	Number	% of total number	Frequency	(%)Frequency
Homaloptera zollingeri	20	0.31	10	2.05
Parambassis sp	314	4.84	30	6.16
Parambassis wolffii	175	2.70	7	1.44
Parambassis ranga	96	1.48	13	2.67
Channa micropeltes	33	0.51	5	1.03
Clupeichthys aesarnensis	9	0.14	6	1.23
Clupeoides borneensis	1678	25.88	96	19.71
Corica laciniata	11	0.17	5	1.03
Botia lecontei	2	0.03	1	0.21
Amblypharyngodon chulabhornae	23	0.35	1	0.21
Cyclocheilichthys furcatus	2	0.03	2	0.41
Henicorhynchus spp	334	5.15	34	6.98
Hypsibarbus lagleri	2	0.03	1	0.21
Parachela oxygastroides	2	0.03	2	0.41
Puntioplites proctozysron	6	0.09	1	0.21
Rasbora paucisqualis	14	0.22	9	1.85
Rasbora sp2	4	0.06	1	0.21
Rasbora spilocerca	7	0.11	4	0.82
Sikukia stejnegeri	2	0.03	2	0.41
Puntius partipentazona	1	0.02	1	0.21
Oxyeleotris marmorata	300	4.63	31	6.37
Lycothrissa crocodilus	1	0.02	1	0.21
Acentrogobius viridipunctatus	3	0.05	1	0.21
Brachygobius kabiliensis	1356	20.91	71	14.58
Glossogobius sparsipapillus	611	9.42	41	8.42
Xenentodon cancila	3	0.05	3	0.62
Mastacembelus armatus	9	0.14	1	0.21
Pristolepis sp.	26	0.40	8	1.64
Pangasianodon hypophthalmus	59	0.91	1	0.21
Pangasius conchophilus	7	0.11	1	0.21
Pangasius larnaudiei	7	0.11	1	0.21
Pangasius siamensis	47	0.72	1	0.21
Sundasalanx praecox	1156	17.83	76	15.61
Ichthyocampus carce	14	0.22	8	1.64
Tetraodon sp.	151	2.33	11	2.26
Total	6485		487	

DISCUSSION

We found that larvae of *S. praecox, B. mekongensis, C. borneensis, G. sparsipapillus* and *Tetraodon* spp., in the Tonle Sap River from January to March 2004. This suggests that they may spawn during the dry season months. However, they may of course spawn at other times of the year also. We have identified the juvenile life-cycle stages of 35 species of fish, represented in 18 families of fish in the dry season months of January to April 2004. We also observed *Puntius partipentazona* larvae in the Tonle Sap River, and some larval stages of the Pangasiidae family in the middle of April 2004 in the Tonle Sap River.

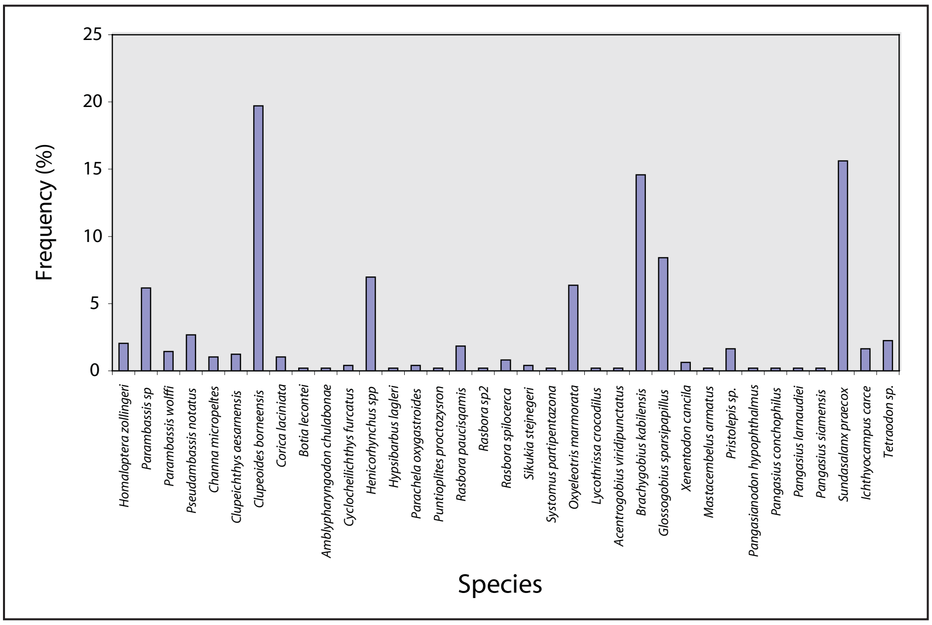

Figure 3. Species and frequencies of fish larvae collected from the Tonle Sap River from Jan. to Apr. 2004.

Table 2. *Overview of fish larvae collected by family from the Tonle Sap River from Jan. to Apr. 2004.*

Family	Total No. of individuals	Total No. of individuals (%)	Frequency (%)
Gobiidae	3	0.05	0.21
Hemiramphidae	3	0.05	0.62
Chandidae	175	2.70	1.44
Clupeidae	1698	26.18	21.97
Engraulidae	1	0.02	0.21
Cobitidae	2	0.03	0.21
Cyprinidae	397	6.12	11.91
Syngnathidae	14	0.22	1.64
Sundasalangidae	1156	17.83	15.61
Balitoridae	20	0.31	2.05
Chandidae	410	6.32	8.83
Channidae	33	0.51	1.03
Eleotridae	300	4.63	6.37
Gobiidae	1967	30.33	23.00
Nandidae	26	0.40	1.64
Pangasiidae	120	1.85	0.82
Mastacembelidae	9	0.14	0.21
Tetraodontidae	151	2.33	2.26
Total	6485		

ACKNOWLEDGEMENTS

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Drift of fish fry and larvae in five large tributaries of the Tonle Sap-Great Lake system in Cambodia

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ABSTRACT

Drift of fish fry and larvae has been studied for several years in the Mekong, Tonle Sap and Bassac Rivers near Phnom Penh (Tharith and Touch 2001), (Tharith, Sophat and Thach 2002), (Tharith, Thach and Hortle 2003), (Tharith, Thach and Hortle 2004), (Tharih, and Thach 2006). These studies have shown that important spawning areas are in the Mekong and major tributaries upstream of Kratie. The larvae and fry resulting from spawning in these areas colonize the Tonle Sap - Great Lake floodplain system. There are no comparative data for the many tributaries of the Tonle Sap-Great Lake system from other studies. This pilot study was carried out to investigate the abundance of larvae/fry in these tributaries during the period of rising waters, which is when fish fry and larvae are abundant in the Mekong. Larvae and juvenile stages of fish were collected from June to December 2005 (during the wet season and early dry season) in five large tributaries. We sampled at sites 20 to50km upstream of the seasonally flooded areas. We used a small seine net, 1.5m long, 1.2m deep with 1mm mesh size and we sampled for about 4 hours when we visited each site. Sites were visited once in June and in July, and twice in August, September and December. In the five tributaries under investigation, we identified 131 species, and there were on average 55 to 70 species in the samples from each tributary. The abundance and number of species appeared to be related to the size of the tributary and the quality of the habitat. Some tributaries still have riparian forests that are intact and good water quality in their upper reaches, or have good floodplain habitat. The numbers of most species in samples increased over the period of the study, probably because of spawning in the tributaries. The fish fauna of each tributary was quite distinctive with only two tributaries, Staung and Chinit, having similar fish fauna. The fry of the main commercial species (e.g. *Henicorhynchus* spp. and Pangasid catfishes) which are very abundant in the drift from the Mekong are rare or absent in the tributaries. If spawning of these fish in - and migration from - the Mekong are affected by development, the Tonle Sap tributaries are not likely to provide a replacement source of fry for these key species.

KEYWORDS: fish fry, fish larvae, Tonle Sap, Mekong, Staung, Sangker, Pursat, Sen, Chinit, Great Lake

INTRODUCTION

Migration is one of the most important events in the life cycle of many fish species and other animals. Migratory behavior of many fish species is intimately linked to current flows in the area where any particular fish population is found. The overall direction of fish movement with respect to the current may change many times during the life cycle of any particular species. The Sangker and Pursat Rivers flow into the southwest side of the Great Lake. The Staung River flows into the northeast side of the Great Lake. The Sen River enters the Great Lake near the Tonle Sap. The Chinit River enters the Tonle Sap River downstream of the Great Lake from the northeast.

OBJECTIVES

- To identify of larval and fry fish in five tributaries.

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- To examine species abundance in each tributary.
- The relative of specie numbers in each site.

METHODS

Sampling was carried out around the Great Lake in five large tributary rivers. These were the Sangker, the Pursat, the Staung, the Sen and the Chinit River. We sampled 20-50km upstream of the seasonally flooded areas.

Fish larvae were collected from June to October 2005. Sampling took place for about 4 hours when each site was visited. Samples were collected by a small seine net, 1.5m long, 1.2m deep and with 1mm mesh size. Samples were preserved immediately in 8 per cent formalin solution.

Fish larvae identification

Fish larvae and juveniles were identified from various sources of literature; Rainboth (1996), Termvidchakorn (2003) and Chevey (1930).

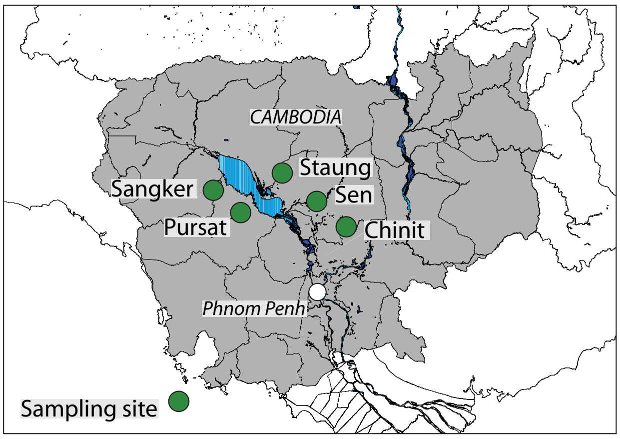

Figure 1. Sampling sites were 20 to 50 km upstream from the Great Lake

Figures 2 and 3. Sampling activities (left) and larvae/fry fish caught by small seine net (right)

RESULTS

Over the period of study, we have identified the following regarding larvae/fry:

1. Seventy-three species, in 18 families in the Pursat tributary
2. Fifty-four species, in 11 families in the Staung tributary
3. Seventy-one species, in 17 families in the Chinit tributary
4. Seventy-three species, in 20 families in the Sangker tributary
5. Eighty-five species, in 20 families in the Sen tributary

Eighteen species were found to be present in all five tributaries, and amounted to greater than 0.76 per cent of the total numbers of species recorded in all five tributaries (Table 1). The numbers of these species differs by site. The Chinit and Sen River have an above-average numbers of species, and two sites in the Staung and the Pursat tributaries have a below-average numbers of species. The most abundant families were Clupeidae, Sundasalangidae and Cyprinidae. Early life-cycle stages of *Henicorhynchus siamensis* were found in the Sen River. The species *Chela laubuca* was only found at a juvenile stage in the Staung River in August.

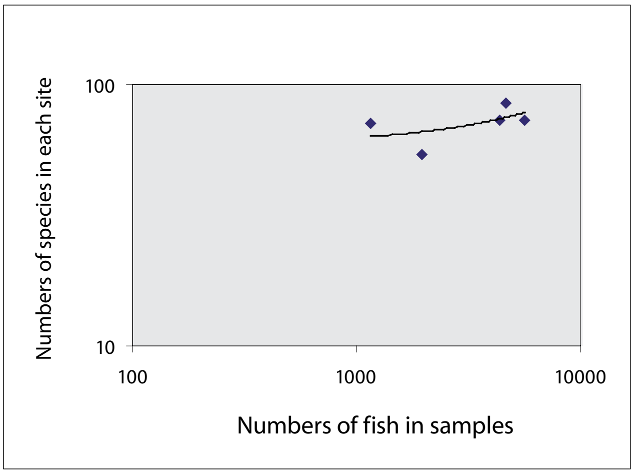

Figure. 4. Numbers of species in each tributary related to the numbers fish in samples

For the sites at the Sen and Chinit tributaries, the line indicates that these tributaries have an above-average number of species (Figure 4).

For the sites at the Pursat, Sangker and Staung tributaries, the line indicates that these tributaries have a below-average number of species (Figure 4).

Table 1. *Species abundance in each tributary*

Species name	Quantities	Chinit	Pursat	Sangker	Sen	Staung
Acantopsis sp.1	420	136	33	46	68	137
Acantopsis sp.2	217	111	32	15	53	6
Amblypharyngodon chulabhornae	169		18	15	9	127
Clupeoides borneensis	5090	42	605	3707	600	136
Esomus longimanus	221	19	75	14	6	107
Esomus metallicus	201	26	80	60	5	30
Hypsibarbus malcolmi	539	2			537	
Labiobarbus kuhli	151	12		29		110
Mystacoleucus marginatus	1674	11	327	33	1303	
Mystacoleucus sp.	444		112	332		
Opsarius koratensis	614	56	40	463	13	42
Parachela oxygastroides	1019	43	7	41	173	755
Parambassis siamensis	686	56	131	5	344	150
Rasbora aurotaenia	582	207	13	128	234	
Rasbora dusonensis	259	13	1	224	7	14
Rhinogobius mekongianus	213				213	
Sundasalanx n sp.	2371		2348	18	5	
Xenentodon cancila	132	22	6	72	12	20

Table 2. *Numbers of species by family at each site*

Family	Chinit	Pursat	Sangker	Sen	Staung	Total Nunbers of species
Akysidae	*	1		1	1	3
Anabantidae	*	*	1	*	*	1
Bagridae	2	*	3	5	3	13
Balitoridae	2	2	4	1	3	12
Belonidae	1	2	2	2	2	9
Belontiidae	1	3	2	*	*	6
Chandidae	1	2	1	2	1	7
Channidae	*	*	1	*	*	1
Clupeidae	3	3	2	2	3	13
Cobitidae	9	10	10	10	7	46
Cyprinidae	40	37	33	41	27	178
Eleotridae	*	1	*	1	*	2
Gobiidae	*	*	1	2	*	3
Gyrinocheilidae	1	*	1	1	*	3
Hemiramphidae	1	1	2	1	1	6
Mastacembelidae	3	4	3	4		14
Moxotidae	*	1	1	1	*	3
Nandidae	1	1	*	*	1	3
Notopteridae	*	*	1	*	*	1
Pangasiidae	2	1	2	2	*	7
Phallostethidae	*	1	*	*	*	1
Polynemidae	*	*	*	1	*	1
Schilbeidae	1	*	*	*	*	1
Siluridae	1	1	1	4	5	12
Sisoridae	*	1	*	*	*	1
Soleidae	1	*	1	2	*	4
Sundasalangidae	*	1	1	1	*	4
Tetraodontidae	1	*	*	*	*	1

Note: * species not present at sampling site.

DISCUSSION

We think that some juvenile fish species, during their migrations from the Mekong, have been affected by various water-related development projects. We consider that during the period of rising water, many species of fish migrate from the Great Lake into the Sen River for spawning. For example, juvenile Henicorhynchus spp. were found in the Sen River during our study. However, the intensity and duration of fish migrations at specific locations can be very different. Sometimes, the sampling produced only a single specimen, whereas in other cases sampling over a period of a few days produced hundreds or even thousands of specimens, and at different stages of development. For Henicorhynchus spp., the migrations appear to be to particularly complex as observed in the Sangke tributary and at other sites. For one particular species (Chela laubuca) migrations only seemed to occur during juvenile stages in the Stung tributary.

ACKNOWLEDGEMENTS

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Monitoring river fishers along the Mekong River in Lao PDR

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ABSTRACT

Thousands of people fish along the Mekong River in Lao PDR, but there is little quantitative data on their catches. This study documents catches of eighteen typical fishers from six river sites over one year (2004) at six locations along the Mekong from Huay Xai in the north to Tha Kaek, south of Vientiane. They recorded their catches daily in logbooks. The fishers all used drifting gill-nets and often used two or three nets of different sizes in layers, so they could catch fish of various sizes. They all fished the Mekong mainstream and the lower reaches of tributaries near their villages.

The fishers caught about 1.2 million fish weighing about 25 tonnes and 156 species were recorded. Eight exotic species were recorded but none was very common. Individual catches were 0.2 to11.6 tonnes per year, the most common fish in catches were Pa soi (*Henicorhynchus siamensis* and *H. lobatus*), making up 28 per cent of all weight caught and around 90 per cent of individual fish. Other common species (>5 per cent of the catch by weight) were *Labeo chrysophekadion, Bagarius yarrelli, Cosmochilus harmandi* and *Pangasius conchophilus.* Despite the apparently heavy fishing pressure along the Mekong, these 18 fishers caught significant numbers of large fish, for about one-third of the species the largest fish they caught was more than 1kg in weight. The largest fish species included *Bagarius yarrelli* up to 134cm length and 34kg in weight, *Wallago attu* up to 135cm and 35kg, and *Pangasius* spp. up to 142cm and 61kg. Seasonal variations in catch of many species appear related to migrations with peak catches during the early flood or the flood recession.

Monitoring typical river fishers over long periods, while requiring long–term commitment from fishery staff and the fishers themselves, can provide useful information on the status of the fishery. The data in the paper will be further analysed to assist in optimizing sampling frequency and number of fishers at any location.

KEYWORDS: Mekong, river fishers, Lao PDR

INTRODUCTION

Many people's livelihoods near the bank of the Mekong River rely on fishing. The main occupation is often rice farming and other agricultural crops. However, fishing constitutes an important activity for many, and for some is the main occupation.

Fishers at six locations in Lao PDR, from Bokeo to Khammouan Province participated in a data collection programme under the Assessment Component of the MRC Fisheries Programme (AMFC). Local fishers along the Mekong mainstream volunteered to collect certain data on their catch every day for one whole year

Although the full data set from this project has yet to be analysed, it has already provided interesting information and illustrates that fisheries in the upper and southern reaches of the Mekong River in Lao PDR are extremely important to the livelihoods of local communities.

Some places in Lao PDR are famous for the seasonal capture of the now nearly extinct giant Mekong catfish, *Pangasianodon gigas.* However, the most important group of fish from a

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livelihoods perspective is the Pa Soi, or *Henicorhynchus* spp. This genus is probably the most important in the fisheries of the Mekong basin, but is mainly recognized as such in the lower reaches in Southern Lao PDR, Sjorslev (2000), and in Cambodia Lieng, Yim and van Zalinge (1995).

This study documents the catches of eighteen typical fishers from six river sites over one year (2004) at five locations along the Mekong River. The main objective is to provide information on fish species caught, and changes in gear use over the year, across a range of different locations.

MATERIALS AND METHODS

The six villages (Table 1) have a total of about 256 fishers. Fishers for the study were selected with assistance from Provincial and District officers.

Table 1. *The participating fishers age, experience, village location and gear size.*

No	Fisher names	Ages	Experience (years)	Village/ Province	Mesh sizes used
1	Mr.Houmpheng	44	30	Ban Done/ Bokeo	2-8 cm
2	Mr.BounGnong	32	21		
3	Mr.Xiengpheng	57	34		
4	Mr.Thongchanh	45	29	Ban Pha O/ Luangphrabang	2-8 cm
5	Mr.Bounkhong	58	35		
6	Mr.La	33	19		
7	Mr.Khamsing	40	20	Ban Tha Muang/ Vientiane	2-12 cm
8	Mr.Sounthone	45	25		
9	Mr.Somsamay	27	5		
10	Mr.Khounsavat	41	27	Ban Sinh Xay/ Borikhamxay	2-25 cm
11	Mr.Sit	46	23		
12	Mr.Vang	66	55		
13	Mr.Sisamone	48	30	Ban Nam Ngieb/ Borikhamxay	2-12 cm
14	Mr.Bounthavy	24	9		
15	Mr.Baeng	29	15		
16	Mr.Khieo	28	14	Ban Muang Sum/ Khammuane	2-25 cm
17	Mr.Xay	45	32		
18	Mr.Anousone	30	17		

The details of the 18 participating fishers and their villages are given in Table 1. The village headmen and all fishers were interviewed in order to get general information on the fish and the fishery. The selected fishers were trained in how to record data at a workshop held in November 2003. The data entry forms were tested and revised so that fishers were able to enter data correctly. The fishers recorded all their catches daily in logbooks, which were collected by LARReC staff every three months.

Some of the participating fishers are full time fishers, while others have additional occupations like rice farming; one fisher is also a teacher. However, they all regularly go fishing using drifting gillnets. The fishermen use gillnets with stretched mesh size of 2-25 cm. The lengths of the nets are 100-250m and the depth 1-2.5m. The nets are set to drift for 30-40 minutes, which brings them about 1.5km along the river. The fishing season extended throughout the year. The mesh sizes used varied depending on the fish species and sizes present. The fishers use two or three nets of different sizes in layers, so that they can catch fish of various sizes. They all fished the Mekong mainstream and/or the lower reaches of tributaries near their villages. When major fish migrations occurred fishing took place both day and night. During spawning migrations, which occur with rising river levels, the fish tend to be bigger, and the fishers some locations used large mesh sizes, i.e. 17-25cm.

RESULTS

The fishers caught 156 species across the six locations. The combined total catch of all fishers was about 1.2 million fish weighing some 25 tonnes. The individual fish catches were 0.2-11.6 tonnes per year. The peak catches occurred in July (Figure 1).

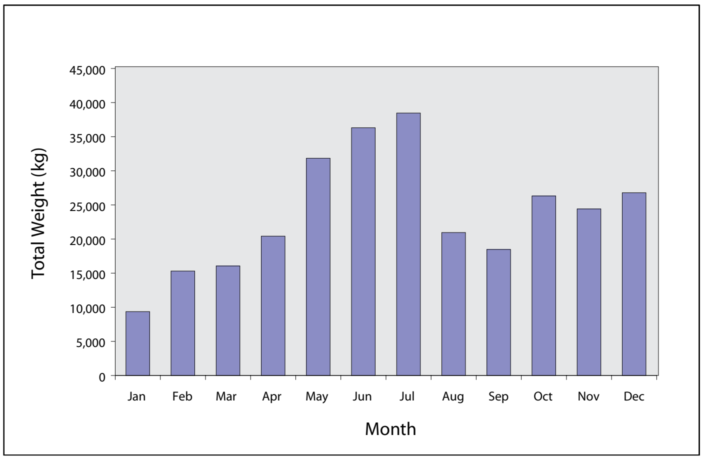

Figure 1. Total weight of fish caught.

For about a third of the species the largest fish caught weighed more than 1 kg. The catch was dominated by 'Pa soi' (*Henicorhynchus siamensis* and *Henicorhynchus lobatus*) making up 28 per cent of total weight caught and around 90 per cent of numbers of fish. Other common species (each contributing >5 per cent of the catch by weight) were *Labeo chrysophekadion, Bagarius yarrelli, Pangasius djambal* and *Pangasius conchophilus* (Figure 2). The largest fish species included *Bagarius yarrelli* (up to 134cm length and 34kg in weight), *Wallago attu* (up to 135cm and 35kg), and *Pangasius* spp. (up to 142cm and 61 kg). The seasonal variation in catch of many species is related to migrations with peak catches during the early flood recession. The Catch Per Unit Effort (CPUE) was estimated to 3.8kg/fisher/day, 1.35kg/net/day and 0.15kg/m^2/day.

Eight exotic species (*Cirrhinus cirrhosus, Labeo rohita, Catla catla, Hypophthalmichthys molitrix, Aristichthys nobilis, Ctenopharyngodon idella, Cyprinus carpio* and *Oreochromis* sp.) were recorded, but none was very common.

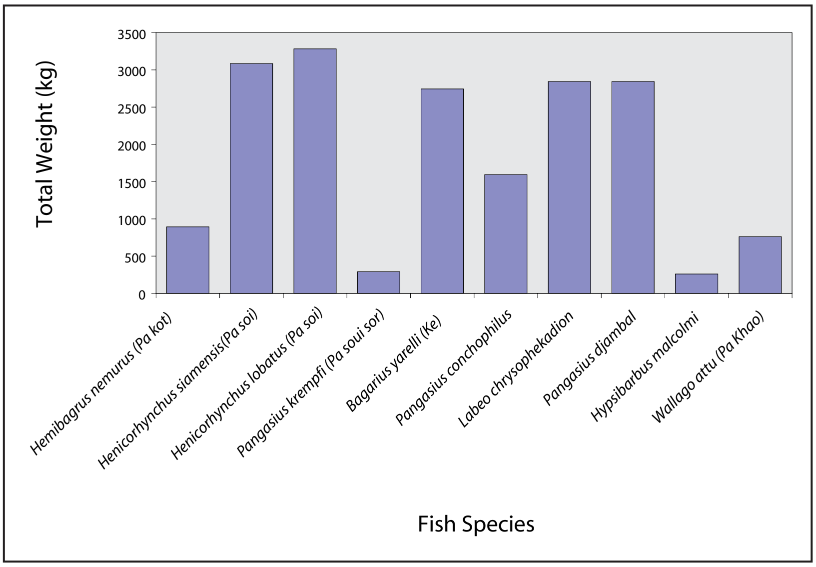

Figure 2. Total weight of the ten most important fish species.

DISCUSSION

Some larger scale fisheries, e.g. the *Dai* fishery in Cambodia are well defined and the landings take place over a limited time period at a few places that are relatively easily monitored by fisheries agency staff. However, small scale fisheries like drifting gillnets are 'diffuse', so that the landings are dispersed along the river. The combined catch of a very large number of small-scale gears are believed to be part of a major component of the annual yields, and it is important to monitor and assess these fisheries. The use of fisheries agency staff to monitor small scale fisheries is expensive, and is therefore usually limited to 'snapshots' (sub-sampling), which may or may not identify important properties of the fishery. The use of fishers to monitor their own catches, as with this study, has potential advantages. Fishers are present at the river continuously over time and can observe and record events that would often be missed in sample based surveys. Also, the cost per sample will be much lower than for surveys carried out by fisheries agency staff.

There are also potential disadvantages with fishers recording data. Fishers often have only basic education, and it may be difficult to instil the need for accuracy and precision in the recording of data. There is also a risk that fishers get bored with the additional work of data recording, and therefore invent ways of 'simplifying' the task so that the data becomes biased. However, experience has shown that by careful selection and training fishers, they are quite capable of recording useful data that can be used to assess the fishery.

CONCLUSIONS

- *Henicorhynchus* spp. (Pa soi) was the dominant fish species caught and also the most important food of the local people.
- The total catch was 25 tonnes and about 50 per cent were catfish.
- The CPUE was 3.8kg/fisher/day, 1.35kg/net/day and 0.15kg/m^2/day.
- Data collecting by local fishers is low cost and saves time.

ACKNOWLEDGEMENTS

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Adaptive community fisheries management in Cambodia what indicators?

CHHUON Kimchhea, BUOY Roitana, KAING Khim, and DARREN Conquest

Management of River and Reservoir Fisheries in the Mekong Basin, Cambodia Sub-Component

ABSTRACT

There are more than 400 Community Fisheries now established in Cambodia. Among those around 10% are supported by the Mekong River Commissions (MRC), Management of River and Reservoir Fisheries (MRRF) sub component; located in Kampong Cham, Kampong Chhnang, Kandal and Stung Treng province as well as Phnom Penh. Some MRRF Community Fisheries (CF) have been established since 2001.

In the process of protecting and conserving fisheries natural resources, for sustainable use and management, many lessons have been learnt and experience gained by CF committee members. Local authorities and CF facilitators on Community Fisheries management and development activities have also benefited greatly in new skill acquisition, experience and knowledge..

Among those lessons learned, the application indicators for CF adaptive management are the important elements. This paper outlines the application indicators adapted by Community Fisheries groups for management practices and how they have been applied in the target areas.

KEY WORDS: Community fisheries management, Cambodia, Kampong Cham, Kampong Chhnang, Kandal, Stung Treng, Phnom Penh

BACKGROUND

Over the last 40 years, Cambodia has seen many different types of Fisheries management from the original fishing lot system installed by the French, to no fishing lot management under the Pol Pot regime, to Solidarity groups, fishing lot auctions and sub-leasing to the current trend towards Community Fisheries.

This move towards wide scale Community Fisheries came about due to the Fisheries Management Policy Reform in October 2000 when the Royal government of Cambodia released more than 56% of fishing lots for community use. However, as far back as 1994 the AIT were establishing community fishing ponds in places such as Svay Reing and in 1995 the Food and Agricultural Organisation (FAO) started community management projects in flooded forests. In 1998 CAA and CEPA established deep pool co-management in Kratie and Stung Treng.

MRRF/MRC started working in this area in 1999 when they developed a co-managed reservoir project in Kandal and K. Cham provinces. This has now expanded to cover projects with released fishing lots in rivers and lakes in K. Chhnang, Phnom Penh and public fishing grounds in Stung Treng. This expansion now means that MRRF/MRC is currently supporting around 10% of the more than 400 community fisheries in Cambodia.

In the case of Adaptive Fisheries Management for the Application of Indicator, the demonstration site will be introduced. The reservoir co-management project has been implemented since 1999 with the MRRF/MRC providing support, funding and technology in 2 fresh-water provinces; Kandal and Kg Cham province. The initial project activities were focused only on reservoirs. After fisheries reform in 2000, the target areas extended to the release of fishing lots in Kampong Chhnang and Phnom Penh, and the management of deep pool by CF in Stung Treng province.

The objective of this paper is to understand the lessons learnt from this MRRF/MRC project regarding co-management of fishery resources. Not just those lessons learnt by MRC/MRRF staff or Department of Fishery (DoF) counterparts, but also the lessons learnt by CF Committees, local authorities, and CF facilitators.

The key lesson of which, is the use of application indicators in CF adaptive management. This paper will show which indicators were used in this CF management project of the fisheries resources, and how they were applicable.

TARGET AREAS:

- From 1999-present: The management of reservoirs in lower Mekong Basin (3 reservoirs) in Kandal and Kampong Cham provinces.
- From 2001- present: The target area was extended to the release fishing lot No 18 in Kandal province.
- From 2003-present: The target areas were extended to release fishing lots No 13-15 in Kampong Chhnang and fishing lot No 1 in Phnom Penh and deep pool in Stung Treng province.

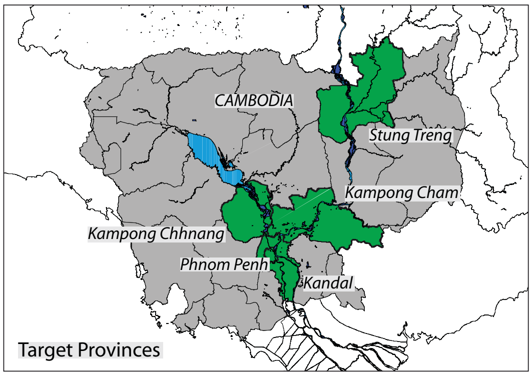

Figure 1. Location of target sites

TARGET STAKEHOLDERS

The key stakeholders identified in the MRRF are:

- Village water-body 'CF committee'
- Villagers/ fishers
- Local authorities (Chief of village/ commune)

- District fisheries officers / provincial fisheries officers/ central fisheries officers (DoF)
- Researchers/ experts (local NGO: CCD, CEPA, CAA; international NGO)

INSTITUTIONAL STRUCTURE IN MANAGEMENT ROLES AND RESPONSIBILITIES

Memberships and CF committees:

Khmer citizens of either sex who intend to become members of the community fisheries must comply with the following conditions:

- Have residency in one of the villages of the community fisheries;
- Hold Khmer citizenship;
- Be at least 18 years of age.
- One individual may only be a single community fisheries member in the community where he or she lives.

A Community Fisheries Committee leads each Community Fisheries. The CF committees were selected through confidential, free, and fair elections at village meetings, by an absolute majority of the members of the community fisheries who voted. The candidate who received the most votes became the Chief of the Community Fisheries Committee. The candidate who received the second most votes took on the position of Vice-Chief of the Community Fisheries Committee. The fisheries officers, local authorities or the commune/sangkat council were invited to observe or facilitate elections.

Management Roles and Responsibilities

Roles and responsibilities of community fisheries:

- Participate in managing and conserving fisheries resources in compliance with the by-laws and community fishing area management plan, which are in conformity with laws and other legal instruments related to fisheries;
- Respect instructions of the Department of Fisheries and Ministry of Agriculture, Forestry and Fisheries;
- Participate in establishing conservation areas within the community fishing area, protection and reforestation of inundated forest and mangrove forest, and restoration of shallow streams and lakes to improve ecosystems and fisheries environments;
- Guarantee all members of the community fisheries have equal rights in the sustainable use of fisheries resources as stipulated in the by-laws;

- Implement the by-laws of the community fisheries and formulate the community fishing area management plan;
- Enter into community fishing area agreements with the Department of Fisheries in order to manage the fisheries resources sustainable;
- Keep all documents related to the community fisheries.

THE PROCESS OF CO-MANAGEMENT IN THE MRRF PROJECT

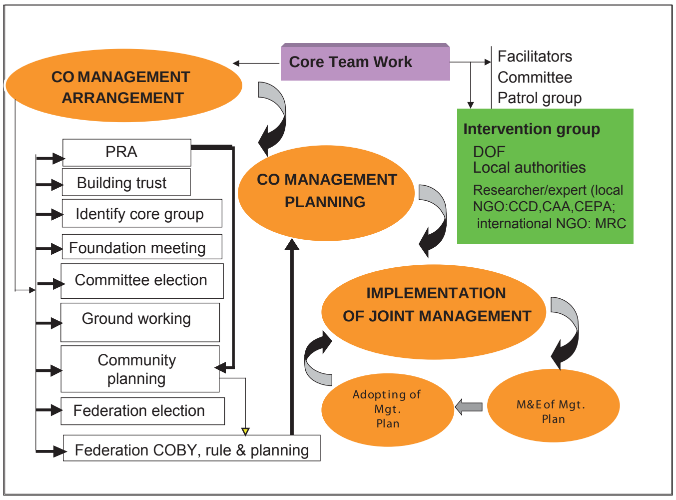

Figure 2. Co-management process

The above diagram shows the process of co-management used. On the left are the individual steps and tasks for establishing the CF, the right hand side shows the various stakeholders and groups involved in the co-management process and the diagonal represents the overall management process of establishing a co-managed community fishery.

INDICATORS USED FOR FISHERIES MANAGEMENT

Indicators uesd for fisheries management are split into different areas:

CF Activities Monitors

Regular events: Information/data on CF situation and activities are reported through regular monthly meetings by users, CF committee members and village chiefs, and written up in the CF note book at MRRF sites (not including CF in fishing lots 13-15, Kampong Chhnang province) through regular bi-monthly meetings. The monthly report is sent to Province Fisheries Office and CFDO/DoF through MRRF counterparts.

Irregular events: Matters/issues/events (such as illegal fishing activities) which happen un-regularly are recorded as minutes of these events by CF committee members/patrol group. The minutes should be accepted by local government, or village or commune chief, if they are available at the time of the event. The events must be immediately reported to local authorities and Provincial Fisheries Office or relative government agencies, with help provided by MRRF counterparts and CF facilitators.

The indicators used:

- Activities carried out from the CF Management Plan
- The situation of management
- Number of conflicts and illegal fishers
- The situation of patrol activities
- Number of interventions in stopping illegal fishing activities
- The situation of CF livelihood activities, e.g. cow/rice bank; women handicraft activities; small-scale business of selling fishing gears, mobile hatcharies etc. (expenditure and income recorded)

Why monitor?

To strengthen and follow up CF management and take action in subsequent CF monthly planning meetings, or immediate action, where necessary, by committee members, local authorities and provincial fisheries officers.

MONITORING OF MANAGEMENT IMPACTS (CATCH ASSESSMENT)

Catch assessment is conducted once a year, in the middle of the year, through focus group discussions with key informants (who do fishing regularly in reservoirs) by using questionnaires in all reservoir sites.

The indicators used:

- High and low season per gears
- Main gears used and mesh size
- Mean catch per gear and species by high and low season
- Number of fishers in high and low season by fishing gear
- Number of fishing days by fishing gear per week, per season and per fisher
- Species composition in the reservoir

- Number of motorized boats and non motorized boats by high and low season and by number of day

Why monitor?

- Results of fisheries co-management/CF management in the area;
- Data on fish catch, species and gear used in high and low seasons are used for monitoring activities and comparisons in the following year, to see how the situation of fish catch has changed in the area. This is important information for the users and CF members to see the results of their efforts and encourage them to participate in fisheries co-management.

CF MANAGEMENT PLAN REVIEW/EVALUATION

The CF management plan review is conducted once a year, at the end of the year, through focus group discussions with CF committee members, village chiefs, as well as some patrol members and CF members at each MRRF site. Strengths, weakness, opportunities and threats (SWOT) analysis is also used to see the strengths, weakness, opportunities, and threat of implementing CF management plans, and finding solutions for setting up management plans the following year.

The indicators used:

- Number and types of activities done and not done, and the reasons/causes
- Percentage achievement of each activity done
- Percentage of satisfaction and no satisfaction by each activity, and the reasons/causes
- Strengths, weakness, opportunities, and threats of CF management plan implementation and recommendations

MONITORING AND DATA NEEDS

Monitoring and data needs that have been addressed by CF committee members, CF members and local authorities while setting up the CF management plan review, are as follows:

- Monitoring of fish catch at river sites
- The effectiveness of CF management with regards to sustainability
- The effectiveness of CF regarding compliance with regulations
- Methods of patrolling and how to arrest and stop illegal fishing in an effective and sufficient manner
- Information and knowledge on community fisheries development to be self-reliant and financed
- Number of fish traders and fish prices in the area
- The appropriate gear used

- Ecological information in CF areas

Why monitor?

Results of CF management plan implementation are required to be reported to the provincial fisheries office and CFDO/DoF. Monitoring and data is also important to establish the CF management plan for the following year.

BENEFITS FROM ADAPTIVE MANAGEMENT, POSSIBILITIES AND CONSTRAINTS TO SCALE-UP TO NATIONAL LEVEL

Benefits

Awareness creation

- Stakeholders and local authorities more clearly understood the importance of participation in natural fisheries resources management in line with DoF/PFO officers, and the importance of management and conservation of natural resources.
- Stakeholders built up their confidence to speak out on the problems they were facing, how they thought these problems could be solved, and ask for assistance from DoF and PFO officers.
- High level of participation by women.
- Increased human capacity at grassroots level.

Fisheries management:

- A majority of CF members do not use illegal fishing gears and become active participants in patrolling activities.
- Limited access in place.
- Significant reduction of conflict.
- More fish in the reservoir and management target areas.
- High level of community participation.
- Significant decrease in illegal fishing.
- Increase in fish numbers and household income in some target areas with fingerling release program.
- Decentralisation of power and fishing rights to the local level.

Planning and Development for the CF

- While CF members have the capacity to plan and develop fishing communities, assistance is sought from DoF and PFO officers or NGOs working in the area.

- Plans manage natural resources and provide alternative job options for fishers.

Responsibility and Constraints to scale-up to a National Level

The main constraints on replicating to scale up to a national level are, funding for a nationwide project from a single source, and having enough trained and skilled fisheries officers to run it. Currently, the wide variety of projects undertaken by DoF are funded by a range of donor organisations, each with their own set of indicators and evaluation criteria.

CONCLUSIONS AND RECOMMENDATIONS

To conclude, there are some clear benefits to using adaptive management in fisheries co-management, the benefits to the fishers themselves are the most easy to see . Furthermore, with the continuing increase in participation by communities, the benefits from fisheries can be seen in other areas of work, part of this is due to member networking.

The application of indicators is a useful method, not only to monitor a project, but also to help in the management and planning process for the community fishery itself. Helping the community fisheries committee become more self reliant and sustainable in its workings and processes.

However, there are some serious constraints to scaling this up to a national level. It is recommended that all NGO's, donor organisations and government departments, adopt a national, common set of indicators in order to achieve successful CF management.

Constraints imposed by the limitations of staff qualifications and skills can be overcome through adequate funding. This would provide the ability to hire more qualified staff members and fund additional training for existing staff. Funding is the main constraint in scaling up to a national project; additional funding needs to be secured.

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Established process and activities of fisheries co-management model in Lak Lake, Daklak Province, Viet Nam

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Management of River and Reservoir Fisheries in the Lower MeKong Basin (MRRF) - Buon Ma Thuot- Daklak

ABSTRACT

Lak is the largest natural lake in Dak Lak Province, with an area of 658ha. The swamps and low-lying fields around the lake, provide nutrition for fish species. Based on the data from the Mekong River and Reservoir Fisheries (MRRF) component, the average fish yield from Lak Lake was around 100 tons annually, and the fisheries created livelihoods and income for over 300 fishers living around the lake.

From 1980 to 2001, several agencies and organisations managed the fisheries of Lak Lake however, all management schemes seemed to be ineffective, and the fisheries were open access. To solve this, the MRRF worked with local authorities and line agencies to establish a co-management model to improve the fisheries situation and to maintain the yield from Lak Lake.

The process of establishing fisheries co-management in Lak Lake had four stages; Discussion with the local authorities and line agencies; Strengthening awareness of local community; Finding the leaderships and the memberships; and Establishing the Fishers Union. The Lak Fishers Union was established in June 2001. Initial results led to an improved fisheries situation, environmental awareness enhancement for fishers, and protection of the environment and fisheries resources. The use of destructive fishing methods has been reduced by 80-90%. The MRRF and local authorities helped the Lak Fishers Union to establish credit and savings groups in the sub-unions and to carry out the plan of fenced-net fish culture in one area of Lak Lake.

This paper presents the establishing process and initial results from the fisheries co-management model implemented by the Fishers Union in Lak Lake

INTRODUCTION

Lak Lake (12°25’23” N; 108°10’34” E; 658 ha) is the largest standing natural water body of Daklak Province, with a water surface area of 658ha. Lak is shallow, with maximum depth of about 3m and a drawdown about 1m. Long time fishers report that the lake is becoming increasingly shallow, and deforestation and landslides have added to the natural situation. These phenomena represent the greatest threat to the lake and its fisheries (Thai *et al*., 2001).

Four communes surround Lak Lake: Lien Son, Dak Lieng, Bong Krang, and Yang Tao. These four communes consist of 44 villages with a total population of approximately 20,000 (Nguyen *et al*., 1999). Lak Lake fishery has been exploited through a high fishing effort and use of diverse fishing gears. The annual fish yield was about 100 tons from 1997 to 2001 (Truong and Tran, 2003), with an estimated value of around 500,000 million Viet Namese Dong (VND). The fisheries sector has created livelihoods and income for over 300 fishers living around the lake.

Phase II (2000-2005) of the MRRF Project focused on the objective of ‘Sustainable co-management model for optimal fish production in reservoir selected, implemented and disseminated’, and has worked to establish fisheries co-management examples in some water bodies in Dak Lak Province. The MRRF co-ordinated with local authorities, line agencies in Lak District, as well as fishers communities around the lake in order to establish fisheries co-management in Lak Lake. The Lak Fishers Union has been established since June 2001, this paper presents the process of establishing fisheries co-management in Lak, some initial results of this model, and recommendations in order to enhance the fisheries co-management system in Lak Lake.

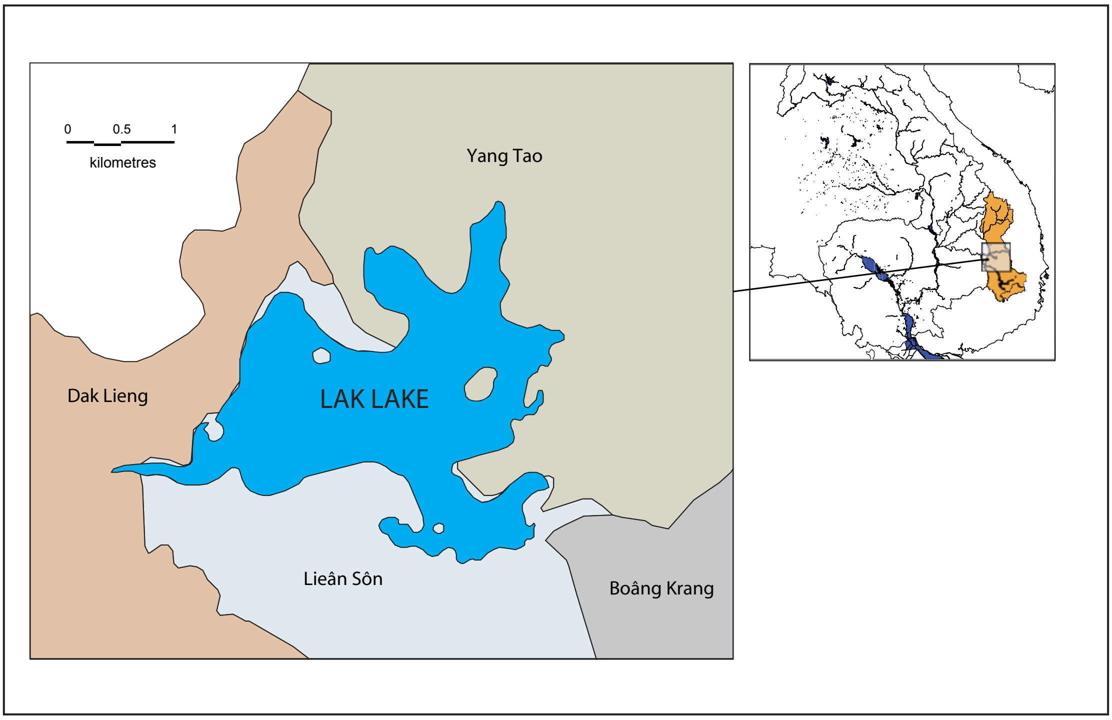

Figure 1. Map of Lak Lake and the neighbourhood communes

HISTORICAL MANAGEMENT SYSTEM BEFORE ESTABLISHING FISHERIES CO- MANAGEMENT MODEL

The Agriculture, Rural and Development Office managed the Lak Lake fisheries from 1975 to 1991. The Lien Son commune managed the fisheries from 1991 to 1994, at which point the District Police took over the responsibility for fisheries management until 1997, when taxes were doubled. From 1997 – 1999, fisheries management of Lak Lake was handed over to the Board for the Protection of History, Culture and Environment of Lak Lake. The Board had to pay the People's Committee eight million VND per year for managing the fisheries and tried to collect 35,000 VND per month from each registered Kinh fisher, regardless of type and quantity of gears used. The tax on indigenous fishers was only 15,000 VND per month.

The management mandate of the agency covered regulation of resource utilisation, protection, tax collection, and dissemination of rules on fisheries. The rules however, were not formally written but were disseminated by word of mouth. Out of the Board's fifteen full-time staff, five staff members were assigned the task of collecting taxes and patrolling. In early 1999, the Board closed the Lak fishery to fishers from outside the District, with limited success. Finally, the Board could not get the taxes they needed, and fisheries management was returned to the District. Later in 1999, the District once again handed over responsibility for taxation of fishers, this time to Lien Son Township but this agency was not successful in this task. Although the fishery in Lak Lake was managed by many organisations, it has actually been open access for a long time.

ESTABLISHING A CO-MANAGEMENT SYSTEM IN LAK LAKE

Co-management can respond to a wide range of circumstances, including stock depletion, threats to biological sustainability, or aboriginal rights to manage fisheries. It can be used to give legitimacy to a management regime or to create equitable regulations (Ahmed 1997). The co-management concept that has been implemented in Daklak is 'the sharing of rights and responsibility between Government and resource users'.

Before setting up a new management system, the biological aspects of the water bodies and the socio-economic information related to the local community were investigated. The co- management scheme in the Lak Lake was initially set up in 2000 and the process of establishing a co- management scheme is described below.

Discussion with the local authorities and line agencies

The purpose of this phase is to explain the objective of the project, and getting the agreement and the necessary support of local authorities, to allow the promotion of the management systems. In Lak Lake this phase was carried out over a 16 month period from January 1999 to April 2000 with a series of meetings organised between local authorities, line agencies and representatives of the fishers. The objectives of these meetings were to present the results of the projects studies, including the current situation of the socio-economic and biological aspects of Lak Lake, and suggest an appropriate management model, which involved the local community to a higher degree. The plan of the project was also presented in these meetings. Finally, a steering committee of 7 members was set up in December 1999 to approve and advise on project activities, assure compliance with the laws, and promote good communication between the community and local government. This committee consisted of; a member of the district People's Committee; the township People's committee; the police; the Agricultural Extension Office; the Board for the Protection of History, Culture, and Environment of Lak Lake; and two representatives from the fishing community. A meeting was held every three months to discuss the plan for establishing the management scheme.

Strengthening awareness of local community

As a next step, training courses on environmental awareness and fisheries management were held for the fishing community. The participants in the training course were selected based on a 'training needs' survey. This survey determined the level of interest in training with randomly selected fishers. Over 60% of those interested in the training course were selected, with consideration given to geographical region and literacy of fishers. The maximum number of participants at each training course was 20, each course was carried out over two days.

Seven training courses were held around Lak Lake. The contents of the training course included awareness of the environment, concept of resource management, and the need for participation of the local community in management. The training used lectures, diagrams, group discussions, and presentations, and plenary discussions. In the last section of each course, local officials were invited to join the plenary discussion. This helped them understand the constraints of the fisheries and the expectations of the fishing community. It was also necessary for common understanding and support of the fishing community. Through the training courses, participants became aware of the need to maintain their fisheries resource and that, in order to achieve this, they must first organise themselves.

Participants in the training workshops, not only developed a greater awareness of their resource, but also improved many skills necessary to community activities such as, addressing and presenting ideas for group discussion. It also helped the project to identify a core group based on receptiveness and leadership potential displayed during the training courses (Tran 2001). Twenty participants were selected in Lak Lake to establish the core group.

Finding the leaderships and the memberships

The participants in all training courses saw the need for new management systems, which involved the community more in terms of making decisions and regulations for the fisheries. Many management models were discussed by project staff, consultants (experts, local authorities, line agencies etc.), and fishing community. Based on the country situation and Viet Namese law; local authorities, the project, and the fishers recognised that the union model was suitable for fisheries management in Lak Lake.

A series of discussions were then held with the core groups with a view to organise Fishers Unions that could work jointly with local authorities to manage the fisheries in these water bodies (Tran *et al*. 2001). The core group was divided into small groups of 2-5 members, based on geographical areas and each one had one leader and vice team-leader. Every one or two months, the core group held a plenary meeting to plan activities and review previous results. The core group communicated the awareness they had developed from the courses to others fishers, who could not join the training courses. In order to insure that the fishers joined the Fishers Union voluntarily, the core group conducted a survey to determine who was interested in joining the union. The potential members of the Fishers Union were determined after the survey and divided into small groups based on core groups.

Establishing the Fishers Union

In Lak Lake, a meeting with the steering committee, local authorities, line agencies and representatives of fishers was held in January 2001 in order to discuss the plan to establish the Fishers Union. In the same month, the project held a training course for the core group to discuss the method of drafting the Fishers Union regulations. Following this, the core group organised successive meetings for anyone concerned with fisheries and guided them in drafting the Fishers Union regulations. Draft regulations consisting of 22 clauses were drawn up with high agreement of fishers and submitted to the district People's Committee and the Steering Committee in April 2001. Their comments were incorporated into … regulation on … 2001? (Tran *et al*., 2001).

In March 2001, the core group attended a training course on organisational mechanics and leadership for enhancing their capacity. A Fishers Union was established with an interim Executive Committee of seven members in June 2001, and the district People's Committee approved the Union Regulations in August of the same year. In April 2002, the Province approved a permanent Union and all members of the union elected the Executive Committee. The Union was divided into two geographic sub-unions, each with a team leader, who is a member of the Executive Committee. Currently, 216 fishers have joined the Fishers Union, including 114 Kinh and 102 indigenous people.

Figure 2. The fisheries co-management structure in Lak Lake (From 2002 to now)

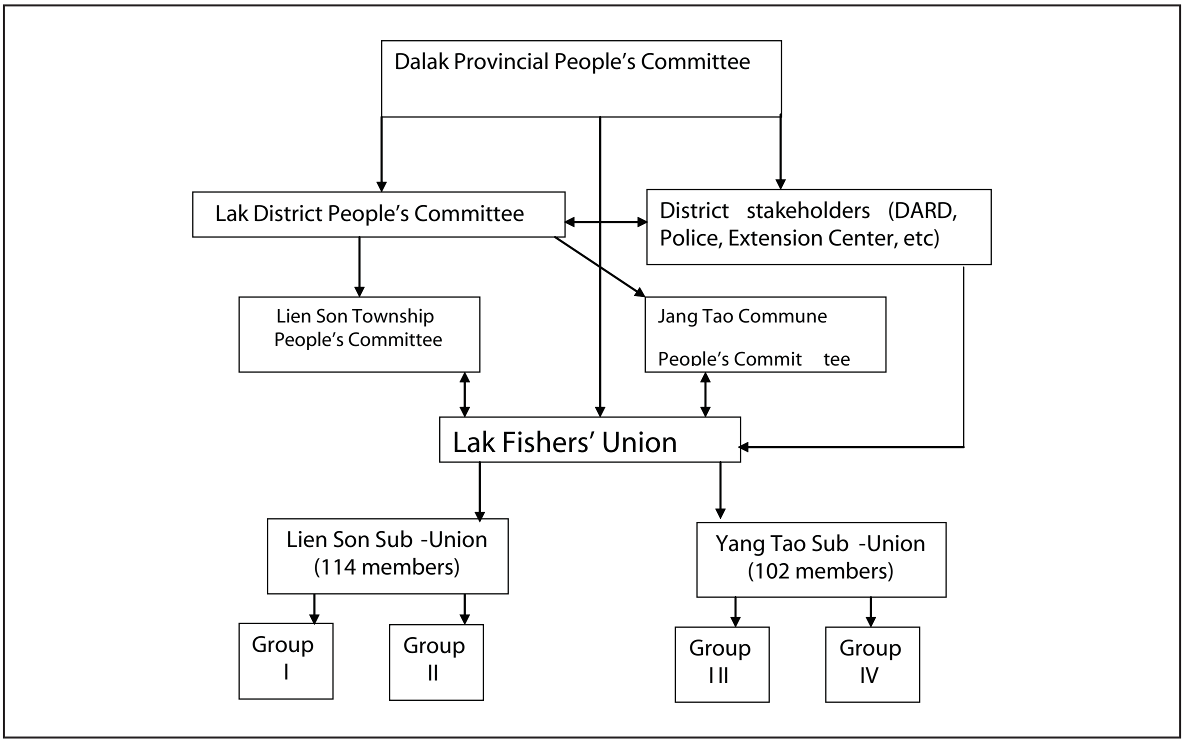

Table 1. *Number of fishers and fishing fee level of the Lak Fisher' Union*

Target \ Place		Lien Son Township	Jang Tao Commune
Number of members		112 (Kinh members)	104 (Ethnic members)
Fishing fee	Members of Union	25,000 VND / boat/month4 0,000 VND / 2 boats/month 50,000 VND / 3 boats/month	5,000 VND/household/month
	Non-members of Union	50,000 VND / boat/month 80,000 VND / 2 boats/month 100,000 VND / 3 boats/month	15,000 VND/household/month

In general, people who joined the Fishers Union in Lak Lake wanted to participate in environmental management and hoped that they could improve their living standards through the activities of the Union.

ACTIVITIES OF FISHERIES CO-MANAGEMENT MODEL

Fishers Unions in Lak Lake faced many initial obstacles, the two most serious of which were, electro-fishing and a lack of funds for development.

In order to reduce electro fishing in the water bodies, a guard team was established with the main members belonging to the Fishers Union. The guard team, cooperating with the police, patrolled and confiscated electro-fishing gears, however, no official punishment was applied. Nevertheless, the patrols have effectively reduced electro-fishing activities in Lak Lake. After the guard team confiscated six boats and quantities of dynamite, the use of electro-gear was seen to decline.

Insufficient financing was a common priority problem facing all fishers groups and the project was not in a position to help. Experience with Lak Lake indicated that the opportunity costs of voluntary community service might not be affordable for many fishers. The activities of all fishers groups required financing from the fishing community, but this was often not enough to lead to effective results. As a result, the Australian Embassy provided a total grant of VND 52.7 million (about US 3,500) in support of fishers group activities at the six water bodies, in October 2001. This has been used for a variety of purposes by different water bodies. In Lak Lake the money has been used for the purchase of a motorised boat for patrolling activities and for payments to patrol members (Nguyen *et al*., 2002).

All activities of the union need money: guard team patrols, meetings, and stationery are examples. Initially, the project supported money for stationery but in the long term the Fishers Unions should pay by themselves. Some fishers contribute a lot of effort and time, and this affects the fishers income, which is normally low. For example, all members of the guard team are fishers and they fish almost every night. If they patrol, they cannot catch fish and earn money. Members of the Union Executive Committees have a similar problem. They spend a lot of time on Union activities. In the short term, the fishers can afford the sacrifice, but in the long term they cannot, because their living standard depends on the fishing activities. Consequently, nobody wants to commit to long-term Union activities. Hence, in the near future the fishers, who contribute a lot of effort to the Fishers Union should be supported with some money as regular income. Additionally, in the fishers Union, most members need money to invest in fishing gears. They cannot get a loan from the banks because the procedure is too complicated. How to find money to support union activities is a major outstanding question.

When the fishers joined the Fishers Union in Lak Lake, initial membership fee was set at VND 60,000, of which VND 50,000 is returned if anyone leaves the Union. The remaining VND 10,000 went to the welfare fund. There are additional monthly dues of VND 2,000, which cover routine union expenses, however, this fund is still not adequate for union activities. Previously, VND 10,000 for one night of patrolling, was allocated from the monthly dues paid by Union members. This fund soon became exhausted, and in March 2002 a halt was called on patrolling activities.

In order to improve the economic status of union members and increase benefits of the Unions, credit and savings became a main activity. Many credit and savings groups were successfully established for farmers groups by the Support to Water Resources Management Project (SWRM) in Daklak. Training courses on credit and saving management held in cooperation with SWRM for the Union Executive Committee and other interested members in Lak Lake in July and August 2002. After that, credit and saving groups were established in Lak Lake and this activity has so far operated well, especially in all the minority ethnic groups.

Table 2. *Number of members and amount of money of credit and savings groups*

	Credit and savings groups		
	Group I	Group II	Group III
Number of members (fishers)	13	10	11
Amount of monthly loan (VND million)	2.0 - 3.5	2.0 - 3.2	1.0 - 2.8
Amount of money of each group (VND million)	14.2	11.9	10.0

Regular meetings are an important component, ensuring that activities implemented by the Fishers Union are in line with their initial plans. Both sub groups and the Executive Committee hold monthly meeting in order to review activities being carried out, consider current and potential problems, and make both short and long term plans. Subgroup meetings are generally held prior to Union Executive meets. In some cases, the monthly meeting of a subgroup is combined with discussions on credit and savings.

Almost all fishers are poor, and any increase in living standard is desirable. Hence, many people use destructive gears such as seines and electro-fishing gears as these gears can increase their income quickly. Many fishers realised that they should manage fisheries sustainably and should follow the fisheries regulation, but cannot always afford to do what they should. Diversified livelihoods of fishers can reduce dependence on income solely from the fisheries. So, another type of training for fishers, organised by the project and the Fishers Unions, in cooperation with the Agricultural Extension office, was related to livelihoods: fishing technology, fish culture, and various agriculture and livestock technologies (Nguyen *et al*. 2002)

Collecting taxes from fishers is not a new concept in Lak Lake, and as such, has not been a difficult activity to implement. However, previous management systems were unsuccessful in collecting taxes as fishers did not benefit from these management practices due to destructive gears (seines, electro-fishing) being operated intensively in the lake and a lack of enforcement on regulations. The Fishers Union has been able to stop the use of destructive gears, as a result, fishers are paying the tax voluntarily. Currently, according to the fisheries regulation, the fishers need to pay a tax of 25000d/month /household and minority people pay 15000d /month/ household to the Fishers Union. Old and young fishermen (under 18 years) do not pay tax. The Fishers Union has to pay 7 million per year to the local government as a tax of natural resource exploitation. 10% and 15% of the remainder of the fisheries tax are paid to the tax collectors and all members of the Union Executive Committee, respectively.

Currently, in order to improve the economic status of Union members and increase the benefit from the fisheries, the Union initiated aquaculture in a fenced-net area in Lak Lake, with an area of around 30 hectares used. The Union stocked 500kg of fingerlings with five species in pen culture: Grass carp, Big head carp, Silver barb, Ro hu and Common carp from July 2005. Four months after stocking, the average weight of grass carp, silver barb, and common carp were 310g, 130g, and 110g, respectively. The average length of grass carp, silver barb, and common carp were 35.8cm, 21.8cm, and 23.1cm, respectively.

CONCLUSIONS AND RECOMMENDATIONS

- Lak Lake has a long history and tradition in indigenous fishery. From 1997 – 2001, the Lak fishery was managed by many organisations, but has actually been open access for a long time, and use of destructive fishing gears such as electro fishing and seine nets was a prevalent problem.
- Lak Lake Fisheries Union was established in June 2001. Initially improving the fisheries situation, enhancing awareness through training courses, meetings, credit and savings activity.
- In order to increase the benefit to Fishers Union members, the Union cultured fish in a fenced–net area from July 2005.
- All activities of the Union need money: guard team patrols, meeting, fenced-nets cultural area, stationery etc. The fishing fee was often not enough for these activities. So, the

Lak district People's Committee, Viet Nam Fisheries Association, the bank, and other organisations need to help the Fishers Union to solve this financial problem.

- Participation of users in managing the resource on which they depend should be encouraged more actively by higher levels of government. This may be accomplished in different ways such as; campaigns to promote awareness of the need for fisheries co-management, related training courses, advice and liaison.

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Local ecological knowledge and customary resource tenure for a *Macrobrachium* fishery on the Nam Khan

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ABSTRACT

A unique freshwater prawn fishery targeting a species of *Macrobrachium* is found on the Nam Khan, a tributary of the Mekong River in northern Lao PDR. Fishermen place bamboo basket traps near the banks of the Nam Khan to catch the prawn during seasonal migrations into clear water streams that are percolating through the surrounding limestone mountains. A system of customary tenure arrangements exists to clarify property rights amongst the fishermen for access to the habitat where the prawns are migrating. These tenure arrangements, inherited by each successive generation, effectively reduce excessive competition for access rights to the prawn habitat. While this prawn species has yet to be systematically classified the ecological knowledge of local fishermen offers important information of the prawn's life cycle. Further research is required to determine the range and taxonomic classification of the species.

KEYWORDS: *Macrobrachium*, freshwater prawn, customary resource tenure, Nam Khan

INTRODUCTION

The Nam Khan River is a tributary of the Mekong River in Northern Lao PDR (Figure 1). The city of Luang Prabang is located near the confluence of the Nam Khan with the Mekong. Being the former royal capital of Lao PDR and a World Heritage city, Luang Prabang has been an important city for trade, culture and tourism for generations. As such the commerce and culture of Luang Prabang has been shaped by the wealth of natural resources from the surrounding area.

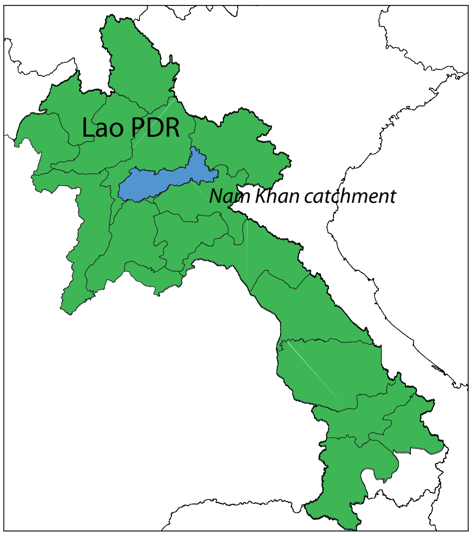

Figure 1. Location map

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This report is a summary of information based on local fishermen's knowledge of a unique freshwater prawn fishery from select sites of the Nam Khan. The purpose of this study was to enhance our understanding of the freshwater biodiversity of the Nam Khan, highlighting the important role of biodiversity in the culture and economy of Lao PDR.

In Luang Prabang province there are important prawn fisheries targeting species of freshwater prawn in rivers like the Nam Ou, Nam Xouang, Nam Khan and the Mekong mainstream. It is unclear how many species of prawn are involved in these localized fisheries, but fishermen understand there could be as many as 5 different species (Souksavat *et al*. 2000).

The freshwater fauna of the Nam Khan is notable for a locally important freshwater prawn fishery found at the village of KengGung. Judging from the large chelae these prawn are from the *Palaemonidae* family of the genus *Macrobrachium*, a highly specious genus of prawn found throughout the tropics. It is estimated there are around 200 species of *Macrobrachium* prawn distributed throughout the tropics, most of which require brackish water at some stage of the life cycle (New 2002). In the land-locked country of Lao PDR it is presumed that the Nam Khan prawn are spending their entire life cycle in the freshwater environment of the Nam Khan and possibly the Mekong.

METHODOLOGY

Participatory assessments of prawn harvesting and habitat were carried out in KengGung Village during the prawn fishing season of 2005. The survey team consisted of staff from the Department of Livestock and Fisheries, the Livestock and Fisheries Section of Luang Prabang Province, the Xieng Ngeun District Agriculture and Forestry Office, and WWF Laos.

The participatory assessment of fishing livelihoods in KengGung allowed the survey team to directly observe the fishing gear, habitat and species of importance to the livelihoods of local fishermen. Semi-structured interviews with both individuals and groups of prawn fishermen offered information on the type of gear used to harvest prawn, the seasonality of the prawn fishery, important habitat for harvesting prawn, management systems and customary resource tenure. This qualitative information is based upon local fishermen's knowledge of the resource. No attempt was made at this time to collect quantitative data on prawn yield during the harvesting season.

RESULTS

Local Knowledge of Prawn Ecology

On the Nam Khan the fishermen from KengGung village have been harvesting prawn for generations. While little scientific information is available for the Nam Khan prawn fishery, the fishermen themselves have a good understanding of the seasonal migrations and habitat for harvesting prawn.

The prawns, called *gung boh* in Lao language, spend most of the year in the turbid water of the Nam Khan. In this riverine environment fishermen have great difficulty catching the prawn in any significant quantity. Women and children occasionally catch individual specimens in the mainstream river using scoop nets called *sving*.

Once the rainy season begins, clear water streams called *boh* begin to percolate through the karst mountains surrounding KengGung village and into the Nam Khan. The fishermen place bamboo basket traps at the confluence of the *boh* streams and the Nam Khan. At the onset of the rains the prawn begin migrating from the Nam Khan into the *boh* streams and are captured in the bamboo traps. Fishermen check the traps every morning and evening to remove the prawn. While some traps are placed at the rivers edge, other *boh* streams join the Nam Khan at a depth of 1-2 meters under water and the fishermen must dive down to remove the trap and collect the prawn.

The fishing season for these freshwater prawn is from June-November when heavy rain causes the *boh* streams to flow. Fishermen at KengGung village believe the prawns are migrating into the *boh* for reproductive purposes. Typically they are catching more female prawn than male, identified by the size and colour of the chelae, and they often notice that they are catching gravid females during these months. These prawn fishermen estimate they can harvest up to 4 kg in a single day during peak migration periods. Prawns are sold fresh in the village for 35,000 Kip (~3.5 USD) and in the District town for at least 50,000 Kip (~5 USD).

Customary resource tenure

There are about 10 households that are actively involved in the freshwater prawn fishery at KengGung Village. Each household has roughly 4-5 areas where they set their prawn traps. In a village of 49 households this means that only select families are involved in this locally important fishery. To eliminate competition over the *boh* stream habitat a system of customary tenure arrangements has long been established within the families of KengGung Village.

Customary resource tenure refers to an individual or community's right to ownership and access to land or natural resources over which they have ancestral claims. It may involve complex social systems that include traditional use and cultural beliefs (WRI *et al.* 2005). In KengGung village the access rights to the *boh* stream habitat where the prawn are harvested have been owned by individual households for generations. Ownership rights are passed on within the family from generation to generation. Due to the limited habitat available for placing the *gung* traps, this system of tenure arrangements allows select households the access to the *boh* streams for harvesting prawn. This effectively reduces resource competition for setting *gung* traps and places the responsibility for managing the habitat in the hands of the person with access rights.

CONCLUSION

The Nam Khan prawn is a unique species in that it lives its entire life cycle in a freshwater environment. Local knowledge of prawn habitat and seasonal migrations can offer useful information towards understanding the life cycle of this species. Further research of the life cycle should be conducted to determine the distribution and taxonomy of the Nam Khan prawn. This would help clarify the range of *Macrobrachium* species in the Mekong Basin. It would also provide useful information on the management and potential culture of the species. The existing customary tenure arrangements in KengGung village appear to be effective at clarifying property rights and reducing excessive competition for harvesting prawn

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