ITTO PROJECT PD16/99 REV. 2(F) • PHASE III

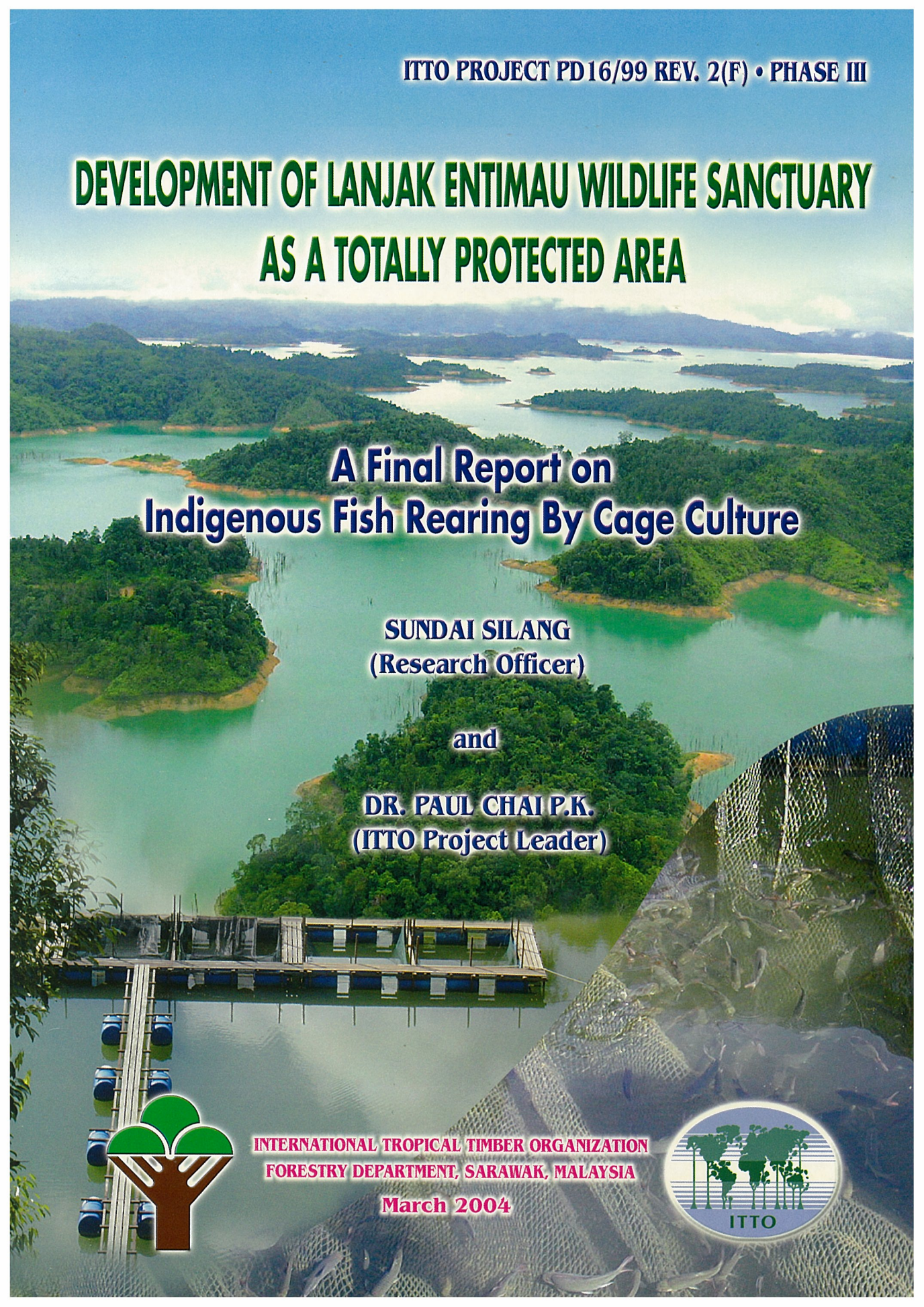
DEVELOPMENT OF LANJAK ENTIMAU WILDLIFE SANCTUARY AS A TOTALLY PROTECTED AREA

A Final Report on Indigenous Fish Rearing By Cage Culture

SUNDAI SILANG
(Research Officer)

and

DR. PAUL CHAI P.K.
(ITTO Project Leader)



INTERNATIONAL TROPICAL TIMBER ORGANIZATION
FORESTRY DEPARTMENT, SARAWAK, MALAYSIA
March 2004

EXECUTIVE SUMMARY

The rearing of indigenous fish species is still new in Sarawak. The local communities have been relying on fishes caught from the wild for their livelihoods. However, over exploitation by humans have caused the fish populations in the wild to decline. This pilot study was conducted to study the feasibility of cage culturing of high-value indigenous species as a community activity and possibly on a commercial scale by the local communities and other interested stakeholders. Much assistance and technical inputs were provided by the Department of Agriculture (DOA) Sarawak. The high-value species reared were Semah (*Tor duoronensis*), Tengadak (*Puntius schwanenfeldii*) and Mata merah (*Osteochilus melanopleura*). One fast-growing exotic species *Oreochromis* sp. (Red tilapia) was added later for fast cash.

From the study, it was found that Semah and Tengadak have the potential to be mass-produced by cage culture and can be recommended to the local communities and interested stakeholders even though the growth rates may be slow. Although the maturing period may be as long as 5 years, rearing of these species can be highly profitable if it is done on a commercial scale. It is estimated that, based on the current market prices, profits collected from the sale of 1,000 tails (1,000 kg) of Semah and Tengadak would be RM 20,600.00 (US$ 5,400.00) and RM 88,000.00 (US$ 23,200.00) respectively. Results from Mata merah is still pending as this species was introduced at a later date.

The species have a good survival rate, are easy to manage, and the investment costs are low. No disease problem was encountered since the study started in June 2002, except for certain deformities in Tengadak fries due to artificial breeding. Obtaining sufficient stocks of Semah from the wild can be a challenging task. Other problems encountered are discussed. Apart from monitoring the existing cage culture, further studies should be conducted on the feeding regimes and natural diets that include several fruits, with a view to enhancing growth. Uncontrolled fishing in Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park must be stopped.

ACKNOWLEDGEMENTS

We are grateful to Dr. Manoel Sobral Filho (Executive Director of ITTO), Datu Cheong Ek Choon (Director of Forest, Sarawak Forest Department), and Dr. Penguang Manggil (ITTO Projects Coordinator) for the opportunity to carry out this study.

Our sincere thanks go to Mr. Christopher Kri who helped in the early preparation of the project; to Mr. Stephen Sungan (Fisheries Officer) and Mr Nigel Salam (Fisheries Assistant) from Department of Agriculture for their valuable technical inputs, support and assistance throughout the study. We also would like to thanks all the staff at Ng. Delok Park HQ, especially Mr. Salang ak Bangkong, Mr. Gadang ak Gajah, Mr. Sirai ak Dayung, Mr. Angai ak Ngelingkong, Mr Nyanggau ak Ukur and Ms. Roseny Chang, for looking after the cage culture.

Finally, we would like to extend our gratitude to the ITTO staff, Mr. Johnny Poh, Miss Chiang Moi Sien, Miss Jong Pei Yung for their assistance in the office; and to the drivers Mr. Francis Dihom, Mr. Liboy ak Nyaku and Mr. Azman Hipni for transporting the study team safely to the field and back on many occasions.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	iv
LIST OF FIGURES	iv
GLOSSARY	v
1.0 INTRODUCTION	1
2.0 OBJECTIVES	1
3.0 METHODOLOGY	2
3.1 Site Selection	2
3.2 Cage Construction	2
3.3 Collection of Fish Stocks	3
3.4 Release of Fries in Cages	5
3.5 Feeding	5
3.6 Growth Data	6
4.0 RESULTS	7
4.1 Growth Rates	7
(i) Semah (*Tor duoronensis*)	7
(ii) Tengadak (*Puntius schwanenfeldii*)	8
(iii) Red tilapia (*Oreochromis sp.*) and Mata merah (*Osteochilus melanopleura*)	9
4.2 Mortality Rates	9
4.3 Income Projections	10
5.0 PROBLEMS ENCOUNTERED	11
5.1 Quality of the Fries	11
5.2 Availability of Fries	11
5.3 Fry Collection	11
5.4 Adaptability to New Environment	12
5.5 Slow Growth Rates	12
5.6 Feeding Regime	12
5.7 Competition	12
5.8 Cage Maintenance	13
6.0 DISCUSSIONS AND CONCLUSIONS	14
7.0 RECOMMENDATIONS	15
REFERENCES	
APPENDICES	

LIST OF TABLES

		Page
Table 1.	Materials used to construct one cage (3 x 3 x 3m)	3
Table 2	Fish stocking densities	5
Table 3	Standard feeding regimes for all species	6
Table 4.	Amount of feed given to Semah (November 2002 to September 2003)	8
Table 5	Amount of feed given to Tengadak (June 2002 to September 2003)	9

LIST OF FIGURES

		Page
Figure 1	Growth rates of Semah from November 2002 to September 2003	7
Figure 2	Growth rates of Tengadak from June 2002 to September 2003	8

GLOSSARY

Local Terms/Abbreviations	Meaning
BANP	Batang Ai National Park
Batang	Main river
cm	centimetre
DO	Dissolved Oxygen
DOA	Department of Agriculture
FCR	Food Conversion Ratio
HDPE	High-density Polyethylene
ITTO	International Tropical Timber Organization
kg	kilogram
Ladong	basket made of rattan
LEWS	Lanjak Entimau Wildlife Sanctuary
Logan	Lake
m	metre
mg/l	milligram/litre
mm	millimetre
NG, Nanga, Ng.	river mouth or confluence
PE	Polyethylene
SFD	Sarawak Forestry Department
Ulu	interior, hinterland

1.0 INTRODUCTION

Fishes are a staple food and a valuable source of income for the many indigenous peoples of Sarawak, ranging from the coastal fishermen to the rural inhabitants in the interior. The rearing of indigenous fish species is still new in Sarawak, and the local communities living adjacent to Lanjak Entimau Wildlife Sanctuary (LEWS) and Batang Ai National Park (BANP) are among the first to benefit from this venture. The people here have been relying on fishes caught from the rivers and the lake for their livelihoods. Habitat degradation and uncontrolled exploitation by humans have caused the fish populations in the wild to decline. As noted by Sungan (2000), major popular species such as Semah (*Tor duoronensis*), Empurau (*Tor tambra*) and Tengadak (*Puntius schwanenfeldii*), once abundant in many river systems, have significantly decreased in populations by between 50 to 100 % in LEWS.

The Department of Agriculture (DOA) first introduced fish rearing in cages in the Batang Ai Lake in the 1990s, involving the villagers that live around the dam. The lake was created for the generation of hydro-electricity. Similar projects were initiated in other places, in the ox-bow lakes such as Logan Terikan and Logan Teraja around Marudi in the Ulu Baram. According to Sungan (pers. comm.), the introduced (exotic) species Red tilapia (*Oreochromis* sp.) was used as it was fast growing and popular in demand. Trial cultures of indigenous species such as Tengadak, Baung (Mystus sp.) and Patin (*Pangasius* sutchi) have only been introduced recently. High- value species like Semah has so far only been tried in ponds.

This cage culture of high-value fish has been introduced for the first time in Sarawak under the current ITTO project in LEWS. The high-value fish species selected were Semah and Tengadak, and later the Mata-merah (*Osteochilus melanopleura*). These occur naturally in LEWS, but their populations have been affected by over-fishing in many areas. They are among the total 96 species that are so far known from LEWS. Many also occur in the adjacent BANP where 62 species have been recorded (Ivy, 2004).

2.0 OBJECTIVES

The pilot study was conducted with much assistance from the Department of Agriculture (DOA) Sarawak. It is a community-related activity under the ITTO Project PD 16/99 Rev. 2 (f): Development of Lanjak Entimau Wildlife Sanctuary as a Totally Protected Area, Phase III. The objectives are as follows:

i. To study the feasibility of cage culturing high-value indigenous fish species in the Batang Ai Lake;

ii. To study the potential of culturing indigenous fish species on a commercial scale by the local communities and other interested stakeholders;
iii. To improve the economic status of the local stakeholders and reduce their dependence on the natural stocks in the rivers;
iv. To use the information and experience obtained from the study as a guide for cage culturing of high-value indigenous fish in the lake and other suitable areas in the buffer zones.

3.0 METHODOLOGY

3.1 Site Selection

Two sites were originally proposed for cage culture: Batang Ai River and Delok River. Both sites are very near to the Nanga Delok Park Headquarters. The Delok River was selected because the area is free from floating debris (rotten logs) that are brought into the lake when there is a flash food. This area is also more accessible compared to the Batang Ai site. The water is always clear except during rainy season when murky water may be discharged into the lake. The depth of the water is around 25 to 30 m even during the lowest the water level, and is believed to be suitable for cage culture. The water quality is also conducive for fish culture. The dissolved oxygen (DO) is between 10.0 and 15.0 mg/l, the water temperature is in the range of 29°C to 30°C, and the ammonia content is low (0.1– 0.2 mg/l). The ammonia content is an important parameter that needs frequent monitoring because a high concentration of over 2.0 mg/l can affect the growth of the fish, and may even be fatal to the fish. According to Mr. Nigel Salam (pers. comm.) the fish will not take any feed when ammonia content is high (>1.0 mg/l). In critical condition (ammonia content >1.5 mg/l) the fish will come to the water surface for breathing and if the condition worsens (2.0 mg/l and above), mortality will occur.

3.2 Cage Construction

The cages used were adopted from those used by DOA in the culturing of Red tilapia in the lake. Cages can vary in size depending on the quantities of fishes to be reared. For the present study, the size used was 3 x 3 x 3 m as it was easier to maintain. Cage design follows that used by DOA (Appendix 1). The materials used are shown in Table 1 below.

Available mesh size of nylon nets ranges from 0.6 cm to 3.8 cm. There is a disadvantage of using nets of smaller mesh size of between 0.6 mm and 1.3 cm. Previous studies by DOA have shown that smaller mess size nets could reduce the flow of water inside the cage and also become easily clogged.

Table 1. Materials used to construct one cage (3 x 3 x 3 m)

Uses	Specification	Size	Qty.	Price/unit RM	Total cost RM
Floater	High-density Polyethylene (HDPE) Drum	105cm(L)x 60cm(D)	8	39.00	312.00
Culturing cage	3.8 cm x 18 ply Polyethylene (PE) Net - ready made cage	3m(L)x3m(W) x3m(H)	1	910.00	910.00
Main frame	Heavy hardwood (Belian timber)	3m(L)x10cm(W) x5cm(T)	8	39.00	312.00
Main frame	Heavy hardwood (Belian timber)	3m(L)x5cm(W) x5cm(T)	12	23.00	276.00
Platform	Heavy hardwood (Belian timber)	3m(L)x10cm(W) x2.5cm(T)	16	23.00	368.00
Total Cost (RM)					**2,178.00 (US$ 570.00)**

Two carpenters from other ranger stations were engaged to help in the construction. The construction began in early April 2002 and was completed at the end of May 2002. Altogether six cages were constructed for this pilot study. As shown in Table 1, Belian (*Eusideroxylon zwageri*) timber was used for the construction of the cage because it is very strong and durable even when completely submerged for many years. If budget is limited, other timbers can also be used, such as Selangan batu (*Shorea* spp.), Tekam (*Shorea* spp.), Resak (*Vatica* spp.), Giam (*Hopea nutans*), or other suitable hardwoods. These are much less durable than Belian.

The HDPE drum was selected because it is environmentally friendly, light and easy to maintain, although the price is slightly more expensive than a metal drum. HDPE drums are also readily available in the local market even in remote towns such as Lubok Antu. The use of metal drums as a floater should be discouraged because they are less durable and cause pollution problem as they rust. Bamboos can be a good alternative if budget is a constraint. They are easily available in the area. This material has been widely used by the fishermen in West Kalimantan, Indonesia.

3.3 Collection of Fish Stocks

Three indigenous species were stocked, *Tor duoronensis* (Semah), *Puntius schwanenfeldii* (Tengadak) and *Osteochilus melanopleura* (Mata merah). The selection of the species was based on their market values and also the availability of stocking materials locally. The fast growing and exotic *Oreochromis* sp. (Red tilapia) was later included upon request by the staff involved to obtain quick cash income that can be used as capital. This species

has been successfully cage cultured at Batang Ai by the local communities on a commercial scale.

Tengadak and Mata-merah fries were supplied by the Fisheries Research and Production Centre of DOA based at Tarat. These two species have been successfully mass-produced through artificial breeding. Semah fries were sourced from the wild because artificial breeding experiment was underway. It has just been learned that DOA has achieved success in the breeding programme.

Semah fries are available in several tributaries inside and outside Batang Ai National Park. A numbers of collections were made during the drier season between September and October with the help of labourers from the Park. Most of the collections were from the rivers outside the Park boundary. Catching the fries did not require special equipment but careful handling was necessary in order to avoid injuries and minimise stress. Bad handling has been known to result in high mortality.

Two smaller cast nets with a mesh size of 0.6 cm and a length of 3 m and 4 m respectively were used. It has been shown that this mesh size would reduce the chances of the fries getting entangled in the net. Net length of 3 to 4 m is suitable for use in the small streams where the water is usually less than 1m deep. The size of the fries collected ranged from 10 to 15 cm in length. A collecting team of 5 to 7 members with at least two cast nets per trip would enable more fries to be collected within a short period of time.

Short travelling time in transporting the stocks to the study site would help to reduce stress and ensure higher survival. One way to reduce stress was to temporarily keep the stocks inside a net placed inside the water as soon as they were caught. For transporting, the fries were kept inside small polythene bags and supplied with oxygen from a portable air pump operated by dry-cell batteries. To prevent damage, the bags were carried in locally made rattan baskets called *ladong*. To ensure better survival, only small quantities of fries (30-40 fries) were put in each polythene bag, the numbering depending on the size of the fries. This was to reduce stress and minimise injuries *en route*.

Upon reaching the landing point at the main river, the fries were transferred to a larger plastic bag with approximately 50 fries per bag, and bag filled with oxygen from the oxygen tank. At the site, the stocks were immediately released

into a nursery cage. No food was given because they were still under stress condition. Feeding was done only one or two days later.

3.4 Release of Fries in Cages

Altogether 6 cages were constructed, 2 for Tengadak, 2 for Semah and 1 each for Mata-merah, and Red-tilapia. The fries were first released into the nursery cages with small mesh size for the first 3 to 4 months, or more depending on the size, to ensure that they did not escape. Tengadak was stocked in the cage in June 2002. Although from different stocks, the fries were uniform in size, ranging from 5 to 7 cm in length. As such, no selection for size was necessary. Collection of Semah took a longer time. This species was stocked between September and October 2002, which coincided with the drier period. Mata-merah and Red-tilapia were both stocked in February 2003 after receiving the fries from the Fisheries Centre at Tarat. The stocking densities for all four species are shown in Table 2. The stocks were transferred to the larger culturing cages when they attained a minimum size of 12 cm. The targeted marketable size was 1 kg or more.

Table 2. Fish stocking densities

Species	Date stocked	Stocking density
Tor duoronensis (Semah)	September & October 2002	250 tails per cage
Puntius schwanenfeldii (Tengadak)	June 2002	300 tails per cage
Osteochilus melanopleura (Mata-merah)	February 2003	200 tails per cage
Oreochromis sp. (Red tilapia)	February 2003	200 tails per cage

3.5 Feeding

Feeding was usually carried out daily early in the morning at daybreak and late evening when the water temperature in the lake was cooler. The amount of feeds depended on the size and body weight and on the species. Generally, feeding was normally heavier during the first two to three months at the rate of 5 % of the body weight. This was gradually reduced at each intervals of two or three months throughout the culture period until the final rate of 2 % of the body weight was attained (Table 3).

Table 3. Standard feeding regimes for all species

Age	Feeding Rate (%)
1 – 3 months old	5 % of body weight
4 – 6 months old	4 % of body weight
7 – 9 months old	3 % of body weight
10 – 12 months old	2 % of body weight
13 months onward	Maintain at 2 % of body weight

As this study was the first of its kind in Sarawak, no information on the feeding of indigenous species was available. The feeding regime was adopted based on the commercial cage culture of Red-tilapia in the lake. Whether or not this adopted regime is adequate or effective needs to be further studied and monitored.

Two types of pellet feeds, starter and grower, were recommended by the Fisheries Officers Mr. Stephen Sungan and Mr. Nigel Salam from DOA. The starter feed was mainly for fingerling size fries, while the grower feed was given to the bigger ones. The feed is produced locally, and contains protein, fibre and moisture. For the first three months, Tengadak, Red tilapia and Mata merah were fed with starter feed. After that, feeding was continued with the grower feed until maturity. Both the feeds were the floating type. Semah was directly fed with the sinker type grower feed because of their bigger size when caught. The sinker feed was given because the fries had not adapted to the new environment and were still scared to feed on the water surface. Tengadak and Mata merah, on the other hand, are used to feeding on the water surface.

3.6 Growth Data

Growth data was collected at two monthly intervals. The data collected included body weight, total body length and forked tail length. Each time a sample of 30 individuals equivalent to 10 % of the total population in each cage were measured. The water qualities were also monitored using Horiba Water Checker and Ammonia Test Kid. The parameters measured were dissolved oxygen, water temperature and ammonia content.

4.0 RESULTS

4.1 Growth Rates

(i) Semah (*Tor duoronensis*)

The growth of Semah is shown in Figure 1. There was a steady increase in weight starting from the first measurement in November 2002. The growth rate was around 0.36 grams a day or 11 grams a month during the period between November 2002 and September 2003. The average weight attained in September 2003 was 187 grams per tail.

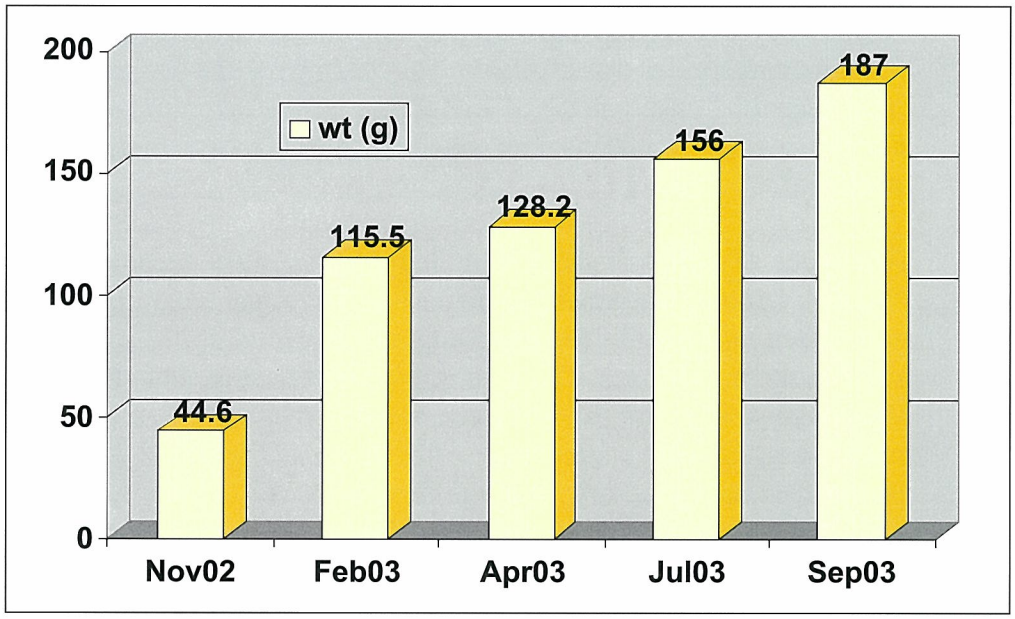


Figure 1. Growth rates of Semah from November 2002 to September 2003

Based on this figure, it was projected that it would take at least 5 years for the species to reach the marketable size of 1 kg. The rapid growth recorded during the first two months was not maintained during subsequent months. However, this is a normal trend for fish because after reaching certain size or age the feeding intensity will become slow and this will affect their growth rate (Salam, pers. comm.).

The feeding regime used for this period was 4 % of the total body weight (Table 4). This feeding regime was maintained until September 2003 because it was felt that if the feeding was reduced then the amount of feed given might not be sufficient to achieve optimal growth. The total amount of feed after 11 months was 1,281.2 grams for each tail. The required amount for 500 tails in the cages was 640 kilograms.

Table 4. Amount of feed given to Semah (November 2002 to September 2003)

Period	Total No. of Days	Feed g/day/tail *	Total amount of feed (g)
Nov 02 to Feb 03	86	2.2 (5 %)	189.2
Feb 03 to Apr 03	61	4.6 (4 %)	280.6
Apr 03 to Jul 03	74	5.1 (4 %)	377.4
Jul 03 to Sep 03	70	6.2 (4 %)	434.0
Total amount of feed in g/tail			**1,281.2**

* Figure in parentheses are percentage of total body weight

(ii) Tengadak (*Puntius schwanenfeldii*)

The total numbers of fries supplied for this project were 600 tails. The average weight of Tengadak at the beginning was 4.9 grams per tail (Figure 2). After two months the average weight increased by nearly 6 times to 36.5 grams, with a monthly mean of 18 g during the 15 months starting from June 2002 to September 2003. Growth appeared to have stagnated from April 2003 to July 2003 as compared to other months. This coincided with the drier period. According to Sungan (pers. comm.), the feeding intensity would be low when there was greater fluctuation between low and high daily water temperature and the fish would not come to the water surface to feed. This could be the reason behind the slow growth rate during that particular period. From the last sampling, the average weight of Tengadak after 15 months in cage was 266 grams per tail, and the biggest fish measured was 500 grams.

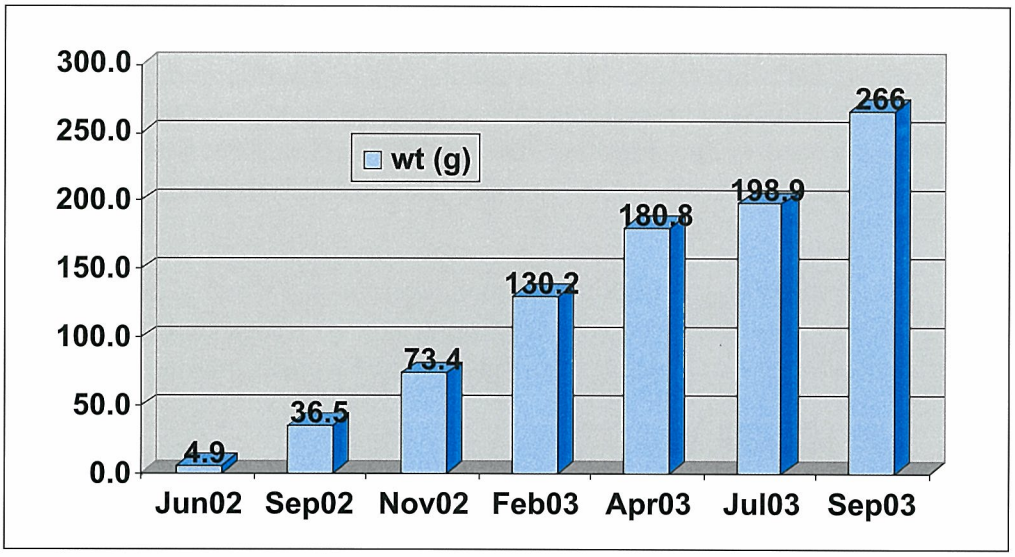


Figure 2. Growth rates of Tengadak from June 2002 to September 2003

The feeding regime differed from that applied for Semah. At the advice of Mr. Nigel the amount was reduced to 3 % of body weight after April 2003, and to 2 % after July 2003, after 12 months. This was to prevent over-feeding as it was estimated the amount of 6 grams was sufficient to achieve the desired growth. This was maintained subsequently. A total of 1.5 kg of feed was given to each individual during the 15-month period (Table 5). The total amount of feed consumed by 600 tails was 900 kilograms. Based on the current growth rate it was estimated that the species would take at least 5 years to reach maturity.

Table 5. Amount of feed given to Tengadak (June 2002 to September 2003)

Period	Total No. of Days	feed g/day/tail *	Total amount of feed (g)
Jun 02 – Sep 02	99	0.3 (5 %)	29.7
Sep 02 to Nov 02	60	1.8 (5 %)	108.6
Nov 02 to Feb 03	86	2.9 (4 %)	249.4
Feb 03 to Apr 03	61	5.2 (4 %)	317.2
Apr 03 to Jul 03	74	5.4 (3 %)	399.6
Jul 03 to Sep 03	70	6.0 (2 %)	420.0
Total amount of feed in g/tail			**1,524.5**

* Figure in parentheses are percentage of total body weight

(iii) Red tilapia (*Oreochromis* sp.) and Mata-merah (*Osteochilus melanopleura*)

The growth of Red tilapia was excellent. It took about 6 months for the fish to grow from fingerling size (average 10g) to the minimum marketable size of 500g. This was most likely due to its good Food Conversion Ratio (FCR) of nearly one to one, meaning that for every gram of feed consumed the weight will increase by 1 gram. Besides that, the fries supplied were also good in quality.

Mata-merah was introduced more recently in February 2002, and showed a steady progress in growth. Its weight had increased to 135 grams during the initial period of 7 months. Its performance would continue to be monitored.

4.2 Mortality Rates

Mortality of Tengadak was well below 5%, while no mortality among Mata-merah and Red tilapia was observed. For Semah, a higher mortality rate of 10 % was observed during the initial period of a few weeks. This species could be

more sensitive to stress and had problem in adapting to the new environment. No disease among any of the species had been detected.

4.3 Income Projections

Based on the current growth rates obtained so far, it would take at least 5 years for Semah and Tengadak to reach the marketable size of about one kg. This is the minimum body weight that is needed in order to fetch a good price in the market. The current market price is around RM 35.00 (US$ 9.00) per kg for Semah, and RM 100.00 (US$ 26.00) per kg for Tengadak.

The estimated costs of producing 1 kg of Semah and Tengadak are RM 14.40 (US$ 4.00) and RM 12.00 (US$ 3.00) respectively (Appendix 2). At year-5 the total net income from the sale would be RM 9,311.00 (US$ 2,450.00) for Semah (452 tails), and RM 50,160.00 (US$ 13,200.00) for Tengadak (570 tails). This does take into consideration inflations in the next few years that would affect the cost of production and the prices. With the growth rates being similar, it is obviously more profitable to rear Tengadak than Semah. However, Semah is also a popular species that is in high demand. Although the maturity period may be as long as 5 years, the project would be highly profitable if it is done on a commercial scale. The projected income for 1,000 tails of fish is given in Appendix 3. The estimated income after year-5 for Semah would be RM 20,600.00 (US$ 5,400.00) and RM 88,000.00 (US$ 23,200.00) for Tengadak.

In this report, a profit comparison was made between Red tilapia, Semah and Tengadak in five years. The cost of producing 1 kilogram of Red tilapia is RM 5.00 (DOA) and the current market price of the fish at the lake is RM 6.00 per kilogram. Therefore, profit earned from the sale of Red tilapia is RM 1.00 per kg. In order to achieve the same amount of profit derived from the sale of Semah and Tengadak, a person would need to raise an equivalent of 20,000 tails of Red tilapia to 1,000 tails of Semah, and 80,000 tails to 1,000 tails of Tengadak. Based on the comparison, it expected to be better to either rear Semah or Tengadak (preferably Tengadak) because looking after small numbers of fishes is much easier than high numbers for one culture period. One advantage for rearing for Red tilapia is that it can generate fast cash in six months, and two harvests can be made in a year. The estimates of market prices quoted in all cases are locally based. The prices of Red tilapia, Semah and Tengadak can easily double once they are brought to the major towns.

No estimate was made for Mata-merah because growth data were insufficient. Compared to Semah or Tengadak, the price is much lower at about RM 9.00 or US$ 2.00 for 1 kg. For the Red tilapia, 200 tails from the project attained an average size of 700 g after 6 months and were sold at the end of July 2003 for a total of RM 709.00 (US$ 186.50) at RM 6.00 per kg. The cash was to be used as a start-up capital by the local participants.

5.0 PROBLEMS ENCOUNTERED

5.1 Quality of the Fries

The quality of fries is an important factor in determining the success of cage culture. One problem encountered was deformities among the Tengadak fries supplied by DOA's Fisheries Unit, due to improper development of gills, tails and heads. However, this is not a serious problem because it only involves a small number of fishes (<3%). According to the fisheries officers (pers. comm.), gill deformity not only affects growth but also the intake of oxygen, especially during the collection of sample data when the fish has to be briefly taken out of the water. Deformity is common under artificial breeding conditions because some of the eggs used may not be fully mature.

As the fries supplied were still in fingerling size, identification and selection of good quality fries was difficult, thus affecting the overall growth results. Since selection is possible only when the fries have reached a length of 10 cm or so, the solution to overcome this problem is to start the culture with larger fries. For Semah, the fry quality was more uniform because selection process was easier with bigger fries (12 cm to 20 cm in length) collected from the wild. As a result, its growth was more uniform than that of Tengadak. No disease has been detected.

5.2 Availability of Fries

Tengadak, Mata-merah and Red tilapia can be easily obtained as they have been successfully bred under artificial conditions. Semah is more difficult to sustain due to decreasing populations in the wild, both in LEWS and BANP. Over fishing in several river systems have been observed during the recent fish resource surveys, particularly in BANP (Sungan, 2000; Ivy, 2004). This problem needs to be urgently addressed.

5.3 Fry Collection

Collecting Semah fries from the wild stock is a challenging task. The species normally lives in the rivers with fast moving water and are difficult to catch. They also easily escape from the nets because of their fast movement. Collection should preferably be planned during the drier months when the water level is low.

5.4 Adaptability to New Environment

Semah seemed to have difficulties in adapting to the new environment during the initial culture period when mortality was relatively high. This could be due to stress and injuries during collection, and to changing water temperature in the lake. During the collection in the dry period, the water temperature of the rivers was between 25°C to 27°C, whereas that in the lake was in the range of 29°C to 31°C. The water in the lake is also slow moving. Movements inside the cages are restricted. To counter the difference in temperature, the cages may be placed deeper in the water where the temperature would be lower. The species appeared to need about a month to adapt to the new condition, as indicated by a marked decrease in mortality initially.

5.5 Slow Growth Rates

Compared to the exotic Red tilapia, the very slow growth of Semah and Tengadak may be discouraging to local participants who expect quick returns from their investments. However, as the initial results have indicated great potential for culturing on a commercial scale, it is worthwhile for serious entrepreneurs to consider venturing in long-term investments as start up capital is small, especially for those living adjacent to the Batang Ai Lake. Management is relatively easy and maintenance is low. After all, fruit trees would take just as long to mature and bear fruits and the returns are much less attractive.

5.6 Feeding Regime

The feeding regime used in this study has been adopted from the Red-tilapia project. Although it has not been possible to ascertain possible reasons for the slow weight increment of the indigenous species, it is suspected that this may be due to their naturally slow growth rates rather than the amount, types and frequencies of feeding. This would require further studies.

5.7 Competition

One major problem with cage culture is caused by competition from fishes that already exist in the lake, such as wild Tengadak and Kalui (*Osphronemus goramy*). The wild Tengadak was introduced to the lake around 15 years ago. These are the two most common species in the lake. Besides Kalui, the wild Tengadak has to be taken out because of their poor quality and they are also from a different breed as compared to the cultured stocks. The populations of

the fishes outside of the cages have been observed to increase since the study started. They laid their eggs inside the cages. When the eggs hatched most of the fries would remain and feed inside the cages. As they increased in size after a few months, they could no longer escape and would compete for food and space inside the cages.

Being a different species, it was quite easy to pick out Kalui from the rest, but this was not possible for Tengadak, except for the differences in size during the initial hatching period. However, because of the large number of fries involved, getting rid of the intruders would require great efforts. The operation to get rid of the smaller visitors is tedious but necessary in order to avoid contamination to the cultured stocks, although it would also cause unnecessary stress and injuries to the cultured stocks.

5.8 Cage Maintenance

Maintenance is very important to ensure that the cages are clean and the fish is in good health. So far maintenance of the cage is not difficult. This is probably because the water is clean. One problem is here to the floating debris from upstream that get entangled to the nets. In addition, small water plants tend to grow on the nets and the cage frame (above the water level) and may cause possible damage. Cleaning of the nets should only be done when they get clogged, taking care to avoid stress on the fish. To reduce clogging problem, longer anchor ropes must be used so the nets can be extended fully with enough weights tied at the bottoms.

6.0 DISCUSSIONS AND CONCLUSIONS

The study so far has indicated that the high-value Semah and Tengadak have the potential to be cultured on a commercial scale using cages in the Batang Ai Lake. They have a good survival rate, easy to manage, and investment costs are low. The major cost is in the purchase of materials for the cages. For communities living in other areas, valley ponds or concrete tanks can be used instead. Interested entrepreneurs can apply to the Department of Agriculture for subsidies, or participate in the ITTO project when this is extended in due course. It is important, however, that they must strive to be independent after receiving the initial assistance to start the project.

Of the two species, Tengadak is more promising because of its better value, its relatively lower cost of production, and fries are readily available. Semah is still relatively abundant in the wild, and the populations can be increased and maintained through proper management to prevent over fishing. Under the current phase of the project, three spawning areas have been identified as special protection zones to ensure that the wild populations are not depleted. Fries of Mata-merah are also easily available from breeding experiments.

It is still not certain whether the feeding regime adopted from the Red-tilapia and the type of artificial feed used is suitable for the indigenous species. This would require further experiments to find out. Further studies are also needed to determine the effects of wild fruits that make up their natural diet. Engkabang (*Shorea macrophylla*) has irregular fruit production, but other common riverbanks species such as wild *Ficus, Eugenia* and *Bellucia pentamera*, fruit more regularly. Fruiting of *B. pentamera* is in fact all year round. These species can be easily cultivated. The tubers and leaves of tapioca (*Manihot* sp.) can also be tried out. Natural diets may reduce the maturing period to below five years.

No disease problem was encountered after more than 15 months of culture, except for certain deformities that are due to artificial breeding. The water quality in the lake is generally good for culture and large areas are still available for use. Further studies can also include other local species such as Sayan (Leptobarbus hosii) and Mengalan (*Puntius bulu*).

7.0 RECOMMENDATIONS

The following recommendations are made:

1. The use of cheaper, lighter and less durable timber such as *Shorea* spp. in place of Belian, can significantly reduce the initial cost. Lighter timber also means fewer drums will be needed for the floating platforms. Bamboo is another cheap alternative and is easily available. It can be used for constructing the frames of the cages and the platforms;

2. Selection of healthy fries should be carried out in the early stages. Before stocking, the fingerlings should be raised to a length of 10 cm or more, so that any deformities can be detected. Having good quality fries will ensure uniform growth and survival;

3. Further studies should be carried out to determine the optimal feeding regime using the standard feed, while other available feeds should also be investigated. Optimal feeding regime is essential when involving a big scale project. The studies should also include the use of natural plant diets as an alternative or as a supplement, and whether these natural foods will ensure better productivity.

4. To increase the income margins, culturing on a big scale of at least 1,000 individuals is desirable. This would not substantially increase management efforts, although the cost of cage construction and maintenance will be higher. Additionally, it will help to compensate for the slow growth and long gestation period. Red tilapia can be raised simultaneously to obtain fast cash for the long-term and more profitable investments.

5. As human management is very much a part of conservation, the challenge of the Executing Agency is to intensify participatory approaches between the State and local stakeholders. It must continue to provide the necessary guidance, technical training, and assistance to the local stakeholders in the sustainable utilizations of the natural resources, especially after the completion of the ITTO project. The activity should be extended to other communities in the buffer zones. Assistance can initially be in the form of supplying some of the materials for the cages, valley ponds or tanks. The last Project Steering Committee held on 18 November 2003 had recommended a revolving fund to be made available as a loan to interested and serious participants as start up capital. This should be favourably considered. ITTO will continue in its efforts to help develop and complete the community-related activities during the final phase of the Lanjak Entimau project.

6. Strategies for integrated management of the fish resources in LEWS and BANP need to be formulated, and illegal fishing must be contained. Another challenge is to make the local stakeholders more aware of the ecological, social and economic consequences if the natural stocks are depleted. Strengthening management presence on the ground will definitely enhance the collaborative efforts to totally protect the TPAs and their valuable natural resources.

REFERENCES

Abdullah, Ivy S. (2004). Fish resources assessment study of Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park. ITTO Project PD16/99 Rev.2(F). Phase III. Development of Lanjak Entimau Wildlife Santuray As A Totally Protected Area. 70p.

Leh, Charles. M.U. (2000). Fishes. In E. Soepadmo and Paul.P.K. Chai (eds.) Development of Lanjak-Entimau As A Totally Protected Area, Phase I and Phase II: Scientific Report, pp.124-139. ITTO/Sarawak Forest Department.

Sungan, S. (2000). Indigenous fish management study. In E. Soepadmo and Paul.P.K. Chai (eds.) Development of Lanjak-Entimau As A Totally Protected Area, Phase I and Phase II: Scientific Report, pp.247-264. ITTO/Sarawak Forest Department

Appendix 1

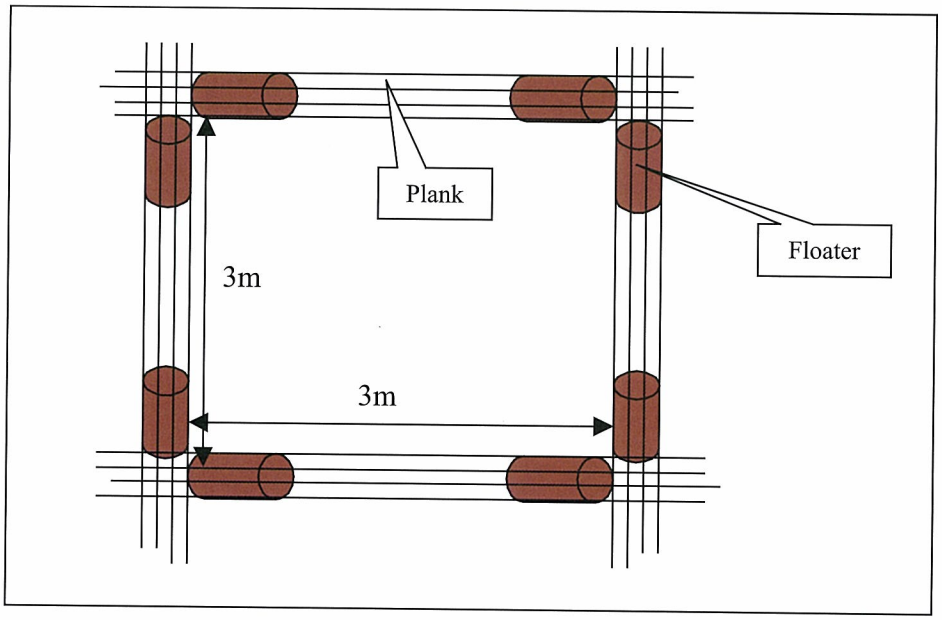


Figure 1. Cage design (top view)

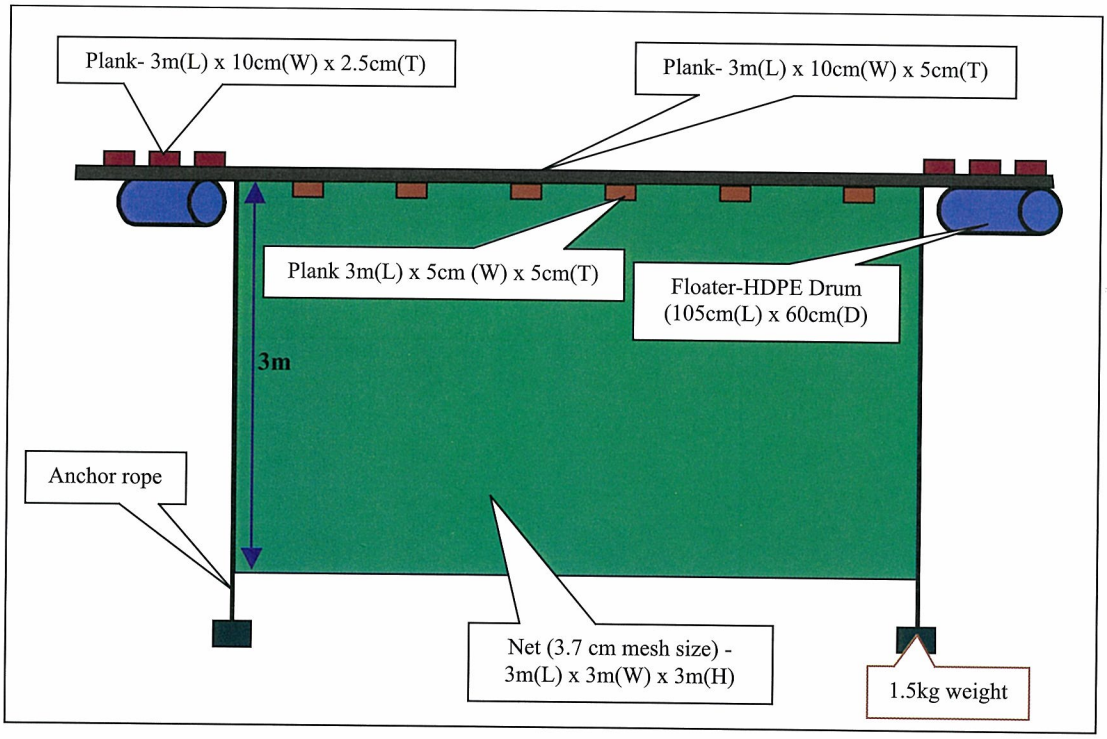


Figure 2. Cage design (side view)

Appendix 2

Estimated Cost for Producing per kilogram of Semah and Tengadak after year-5

A. SEMAH

i. Mean weight after 11 months = 180 g

ii. To raise Semah up to 180 g = 1,200 g of feed is needed (minimum)

iii. Total amount of feed per kilogram of fish = $\frac{1,200}{180}$

= 7.2 kg

iv. Cost of feed material = RM 2.00 per kg (current price)

v. Cost per kilogram of Semah = 7.2 kg x RM 2.00

= **RM14.40** (US$ 4.00)

B. TENGADAK

i. Mean weight after 15 months = 250 g

ii. To raise up Tengadak up to 250 g = 1,500 g of feed is needed (minimum)

iii. Total amount of feed per kilogram of fish = $\frac{1,500}{250}$

= 6.0 kg of feed per 1 kg fish

iv. Cost of feed = RM 2.00 per kg (current price)

v. Cost per kilogram of Tengadak = 6.0 kg x RM 2.00

= **RM 12.00** (US$3.00)

Appendix 3

Income Projection For Rearing 1,000 tails of Semah and Tengadak

A. SEMAH

i. Cost

Total cost	= RM 14.40 per kg of fish
	= 1,000 kg x RM 14.40
	= RM 14,400.00 (US$ 3,800.00)

ii. Projected Income

Price	= RM 35.00 per kg
	= 1,000 kg x RM 35.00
Total Sale	= RM 35,000.00
Total Income	= RM 35,000 – RM 14,400.00
Net Income	= **RM 20,600.00** (US$ 5,400.00)
Income per year	= RM 4,100.00 (US$ 1,900.00)

B. TENGADAK

i. Cost

Total Cost	= 1,000 kg x RM 12.00
	= **RM 12,000.00** (US$ 3,800.00)

ii. Projected Income

Price	= RM 100.00 per 1.0 kg
	= 1,000 kg x RM 100.00
Total Sale	= RM 100,000.00
Total Income	= RM 100,000.00 – RM 12,000.00
Net Income	= **RM 88,000.00** (US$ 23,200.00)
Income per year	= RM 17,600.00 (US$ 4,600.00)

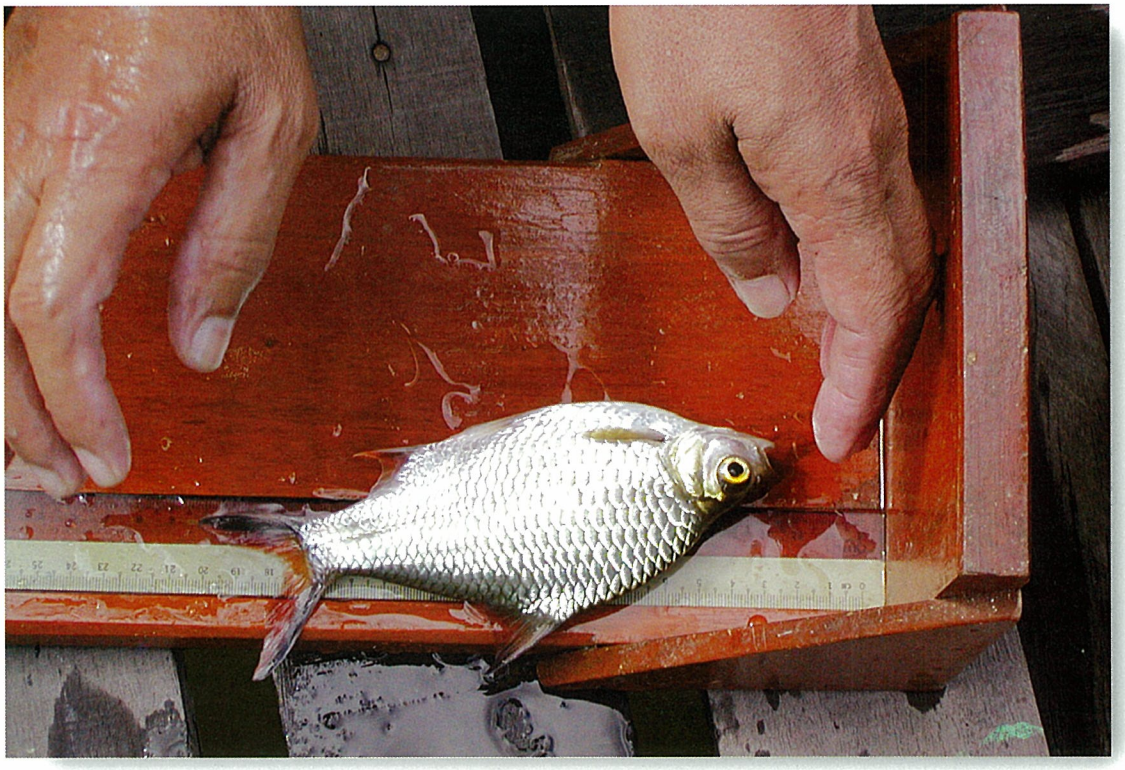
The Batang Ai Dam at Lubok Antu provides vast opportunity for fish culture

Cage layout with a floating bridge to connect the cage to riverbank

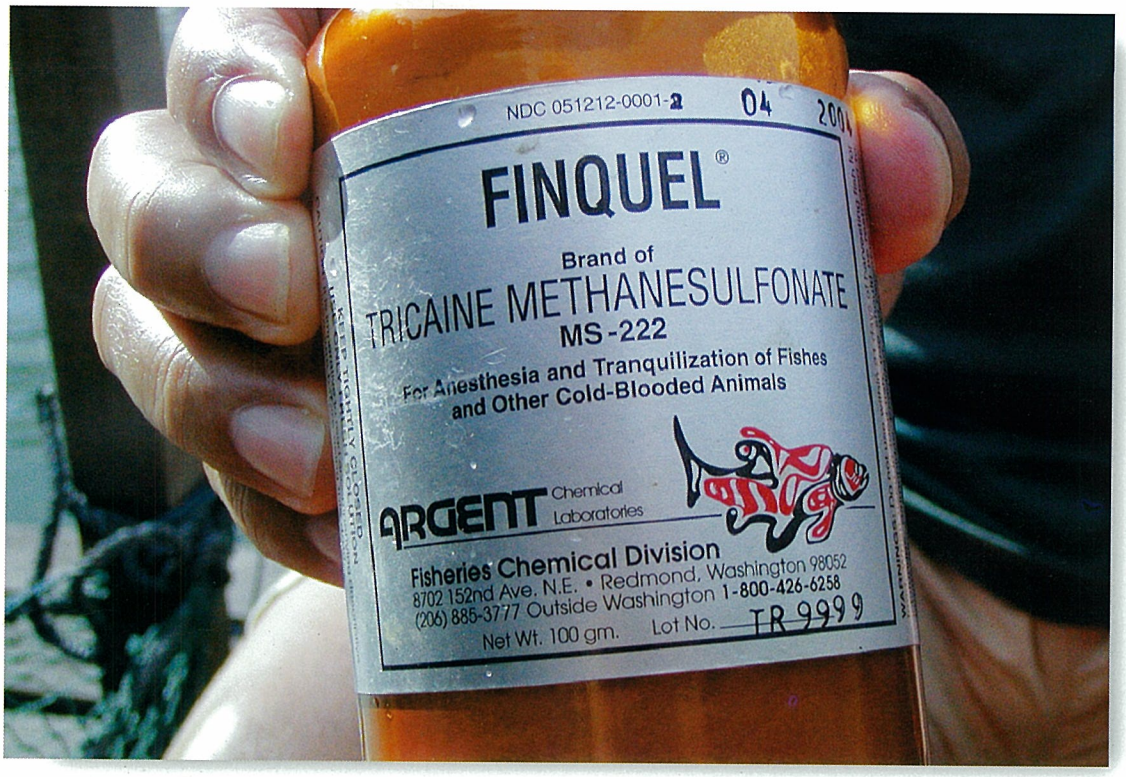
Fishes inside the cage

Sometimes big Semah (*Tor duoronensis*) was caught during the collection of fries

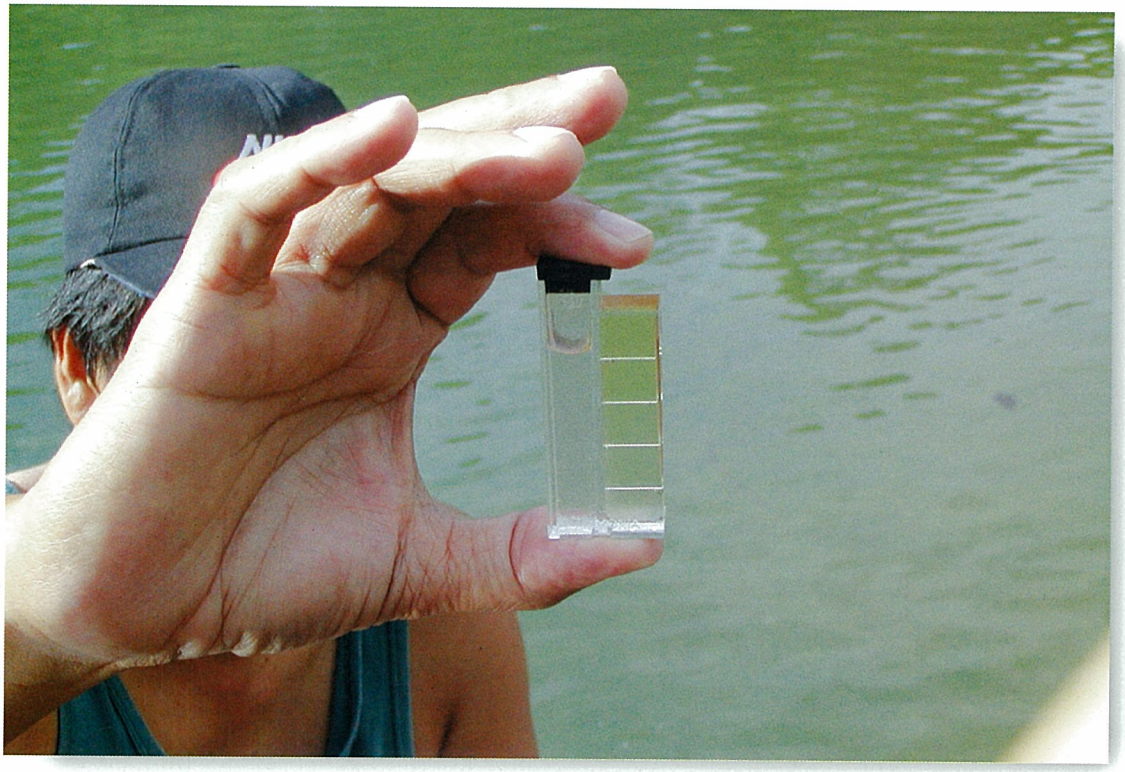
Weighing the fish using spring balance to determine their growth increment



Length measurement during data collection



Anesthesia used to immobilize the fish during data collection

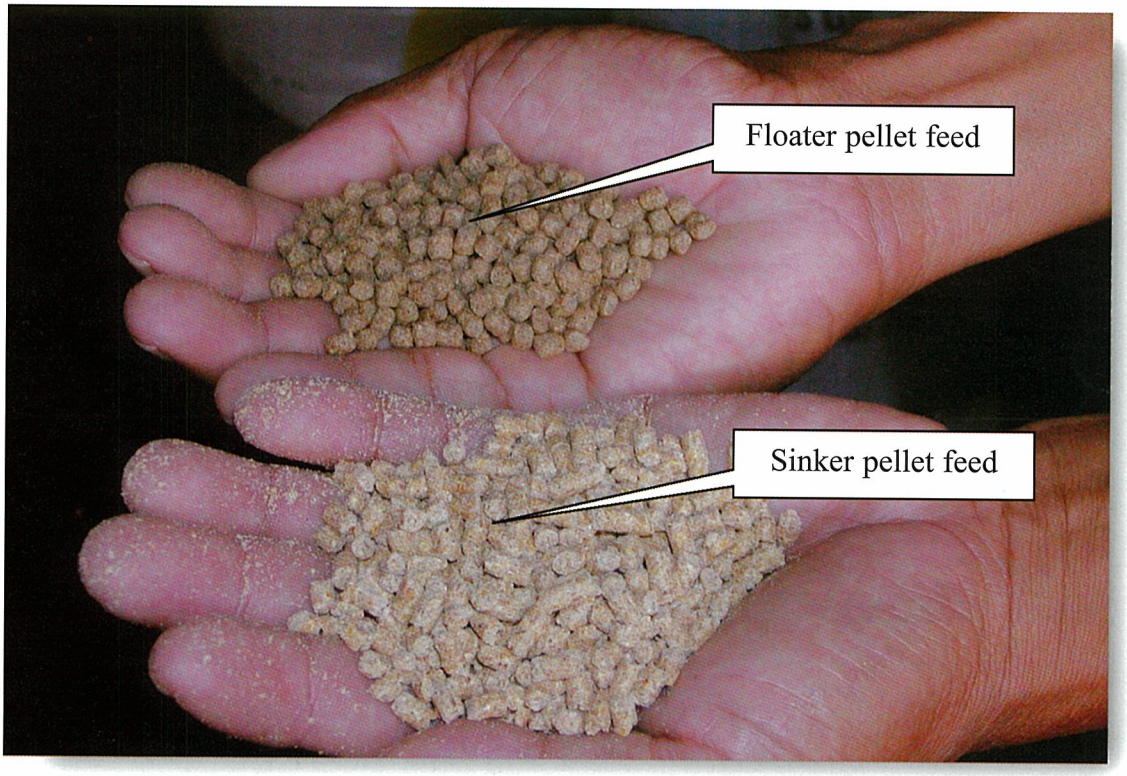


The test showed that the ammonia content in Sg. Delok is very low

Net cleaning using high water pressure pump

His Excellency Dr. Peter A. Schweizer, Ambassador, Swiss Embassy and his group during their visit to the project site

VIP visit to the project site



Two types of pellet feeds used for fish feeding

The use of bamboo in cage construction by the local people in Kalimantan, Indonesia


LeeMingPress
KUCHING