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

DEVELOPMENT OF LANJAK ENTIMAU WILDLIFE SANCTUARY AS A TOTALLY PROTECTED AREA

FISH RESOURCES ASSESSMENT STUDY OF LANJAK ENTIMAU WILDLIFE SANCTUARY AND BATANG AI NATIONAL PARK

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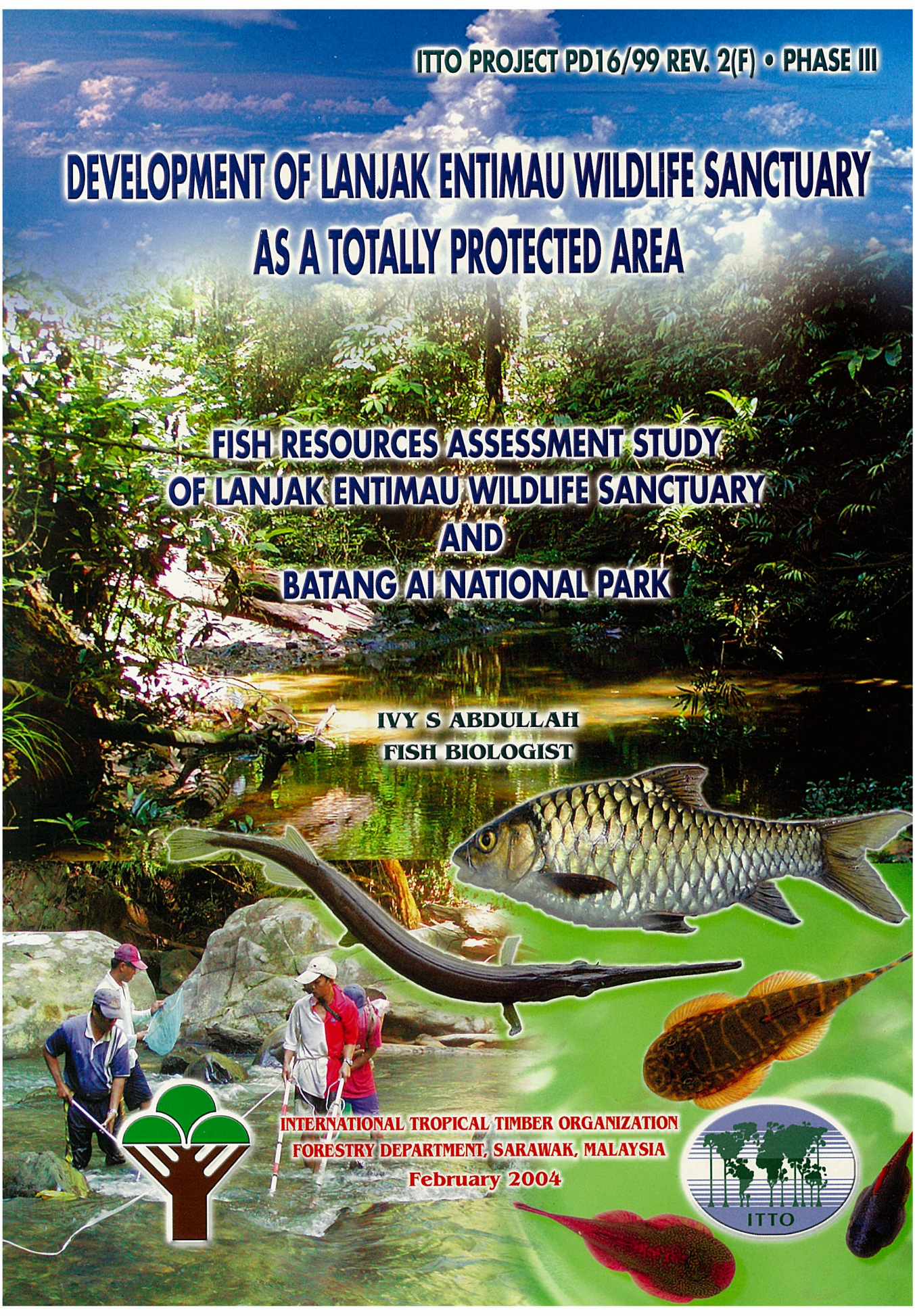

INTERNATIONAL TROPICAL TIMBER ORGANIZATION
FORESTRY DEPARTMENT, SARAWAK, MALAYSIA
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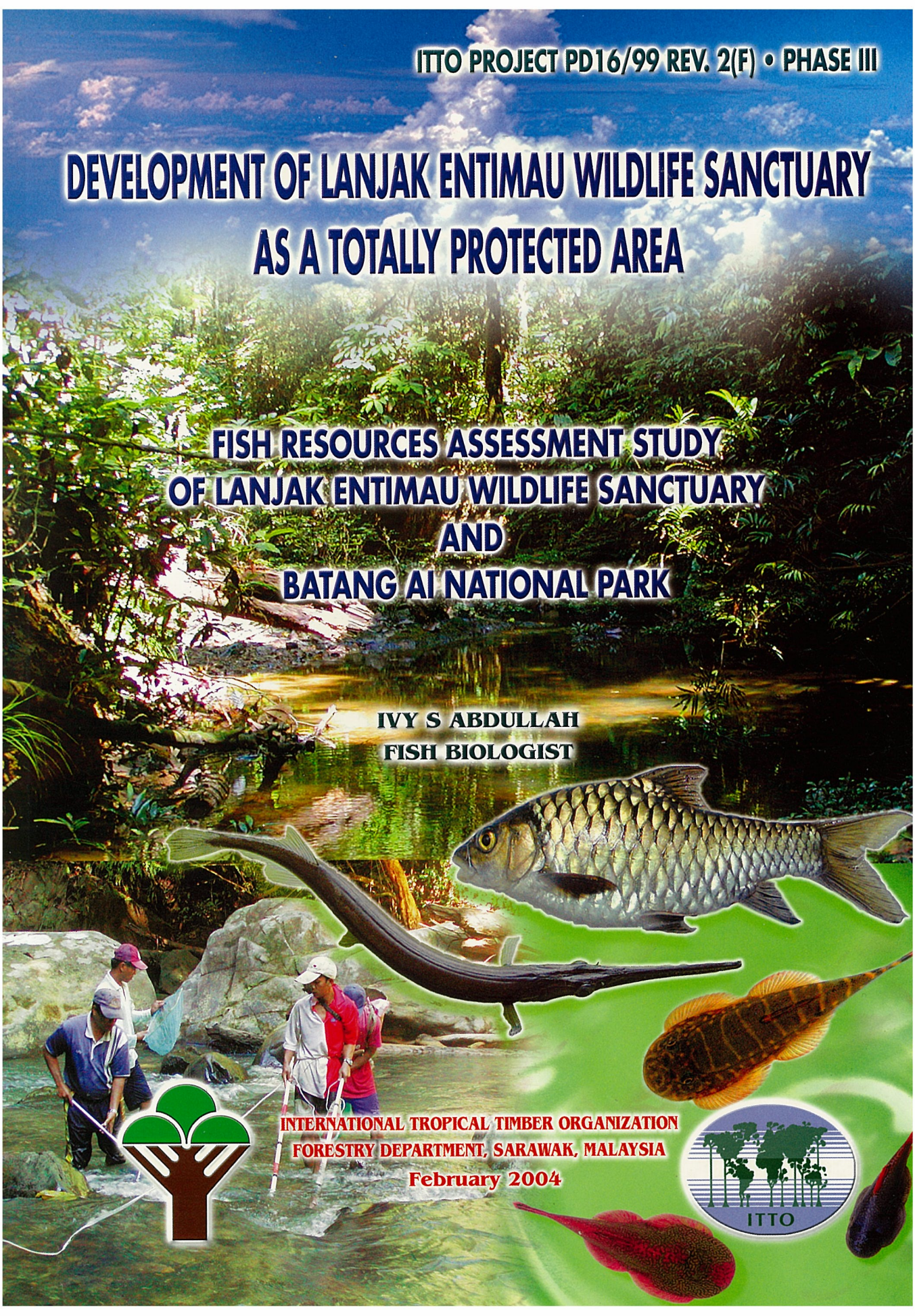

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EXECUTIVE SUMMARY

Sampling work in two sites in Lanjak Entimau Wildlife Sanctuary (LEWS) and two sites Batang Ai National Park (BANP) revealed 56 species of fishes from 10 families. This brings the total fish list for LEWS and BANP to 96 species and 63 species respectively. Six new records for LEWS were documented from Sg. Mujok while another 3 new records were from Sg. Katibas. In BANP, the inventory revealed a total of 18 new records. The current fish list for BANP of 63 species covers the areas between the headwater regions and the inundated waters at the Batang Ai Hydroelectric Dam.

Two species are new to science, from the genera *Gastromyzon* and *Glaniopsis*. The geographical distribution of fish fauna in LEWS and BANP is even, as similar habitats can be found in both TPAs with the exception of Sg. Mujok. The topography and properties of water in Sg. Mujok differ from those of Sg. Katibas and Batang Ai.

Forest streams in Sg. Katibas especially Sg. Takai and Sg. Jenuah have among the highest fish diversity index measured i.e. 1.2 and 1.1 respectively. These streams have been identified as Fish Spawning Ground for LEWS and measures to protect them have been recommended. This includes placing signboards in three languages indicating the status of the streams and the prohibition to fish there. Dialogue sessions with the local longhouse communities on the significance of the spawning ground have been carried out. Other proposed conservation efforts include control of mesh size of nets and closed fishing seasons.

Induced spawning programs for Semah (*Tor tambra)* and Empurau (*Tor tambroides)* must be pursued to provide future fish fries for rearing by the local people. This will help to ensure the availability and sustainability of the wild stocks. The newly completed headquarters at the Bloh Rangers Station in Katibas is the most suitable venue to build a hatchery for this purpose due to its proximity to the natural spawning ground.

The potential of several indigenous fish species for culture has been recognized due to their high market demand. These include Semah (*Tor tambra*), Empurau (*Tor tambroides*), Tengadak (*Barbodes schwanenfeldii*) and Palau (*Osteocheilus*

kahajanensis. Other indigenous species that do not occur here but can also be cultured are the Mata merah (*Osteocheilus melanopleura*) and Kachong (*Puntius bramoides*) from the Baram areas. Apart from reducing dependence on the wild stocks, the culturing of these species will also bring economic benefits to the local communities.

The threats faced by the fish fauna of LEWS include siltation due to logging and shifting agriculture outside the buffer zone. In BANP the immediate threat is over fishing, release of exotics into the lake and loss of habitat from the increased level of inundated waters of the lake. As an immediate measure, a monitoring system to document the number of fishermen as well as the amount of fish taken out of the area has to be initiated. This will provide information for the management authorities to develop strategic plans to reduce dependence on natural stocks or provide alternative plans for the local communities on fish and fisheries.

LEWS and BANP must be managed to ensure the preservation and conservation of a full range of aquatic habitats for the future. There should be more rigorous enforcement of existing laws and regulations to prevent encroachment and uncontrolled fishing. Long-term measures should include programs for research on the breeding patterns and fecundity as well as implementing public awareness program and environmental education with the local communities especially the younger generations.

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3.1 Lanjak Entimau Wildlife Sanctuary

Lanjak Entimau W.S. comprises a major part of the hilly terrain between Batang Rajang in the north and Batang Lupar in the south. The terrain of the Sanctuary is rugged throughout with its most strongly dissected terrain located in the south. Elevations range from 60 m a.s.l. in the flood plains of the Rajang tributaries to a maximum of 1,285 m a.s.l. at the summit of Bukit Lanjak in the south-west.

Vegetation consists of unlogged primary tropical rain forest. Rainfall data obtained from the surrounding meteorological stations indicate a mean annual rainfall of 3,500 mm. The wettest months from October through January receive about 300 - 350 mm while the driest months receive about 200 mm of rainfall. Temperatures are moderate, rarely exceeding 27°C or falling below 21°C at the Tintieng Geronggang (300 m a.s.l.). The relative humidity ranges from 32% to 100%.

Lanjak Entimau was first gazetted as a protected forest in 1940 and later established as Wildlife Sanctuary in 1983 to protect the animals living there namely, the orangutan, *Pongo pygmaeus* and the hornbills. The Sanctuary is represented by 8 different forest types namely, riparian forest, alluvial forest, lowland mixed dipterocarp forest, hill dipeterocarp forest, summit ridge forest, sub-montane mossy forest, montane mossy forest and old secondary forests (Chai, 2000).

These forests are home to as many as 2,807 species of vascular plants comprising 1,826 tree species and 911 non-tree species. LEWS also contains no less than 218 species of medicinal plants, 158 species of jungle fruits and 108 species of wild vegetables (Chai, 2000). Over 500 species of fungi and 42 species of lichens are also known (Chin, 1998), and 68 species of mosses are also recorded (Chai, *et al.* 1999). No less than ten species of plants including a large leaf *Ixora* are potentially new to science; seven species are new records; 11 and 50 species are respectively endemic to Sarawak and Borneo. *Helicia mahmudii* P. Chai, *Symplocos leochaii* P. Chai and a rattan *Korthalsia rostratioides* Mogea are three new species recently described.

The Sanctuary comprises two watersheds. The northern part of the Sanctuary is drained by the Rajang tributaries such as Sungai Katibas, Sungai Ngemah and Sungai Kanowit, and in the south by the tributaries of Batang Lupar namely Batang Ai, Sungai Engkari and Batang Skrang. The two main drainages of Batang Lupar and Batang Rejang have their origins traced to the Kapuas River, West Kalimantan.

Figure 1: Location of Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park in Sarawak

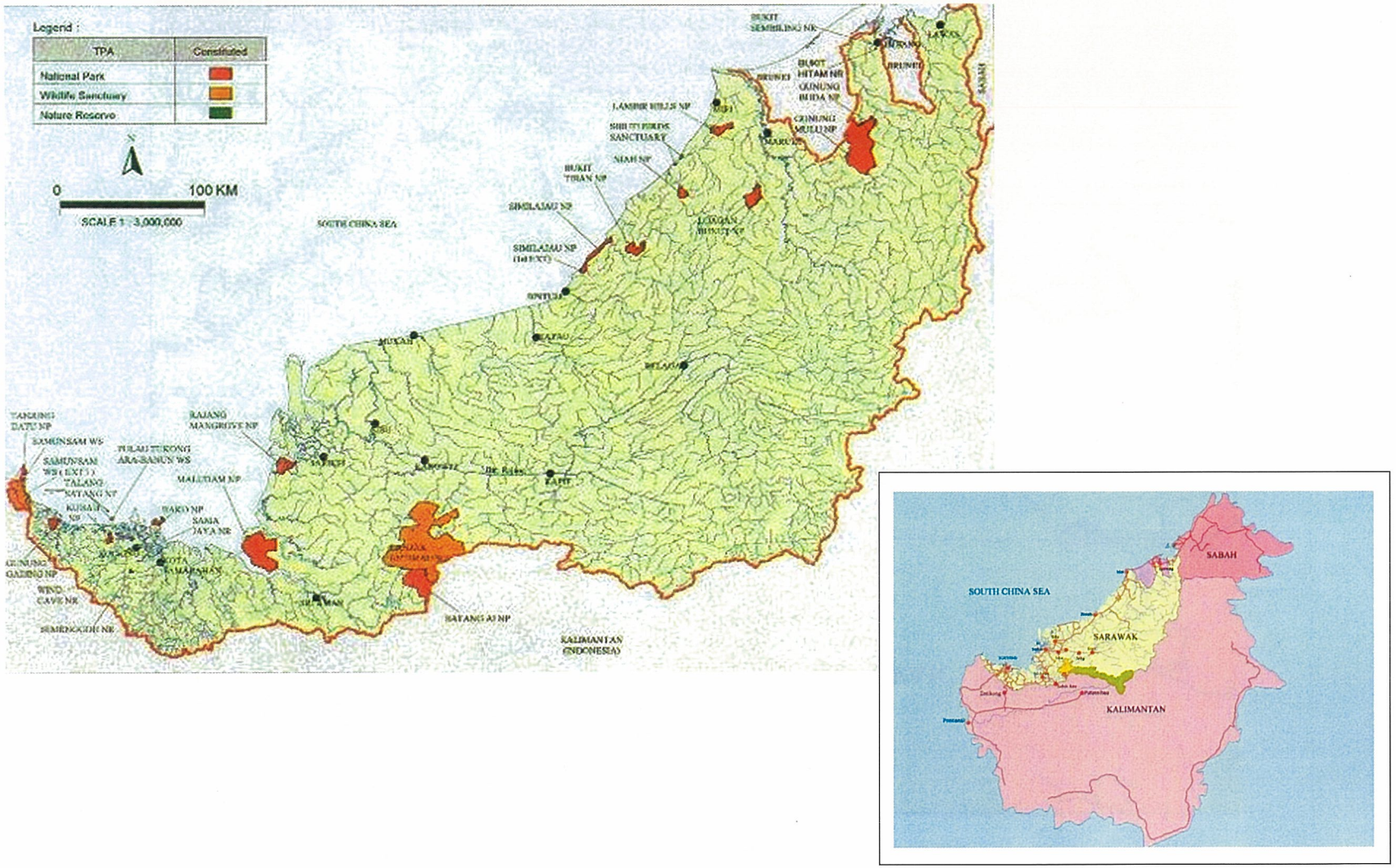
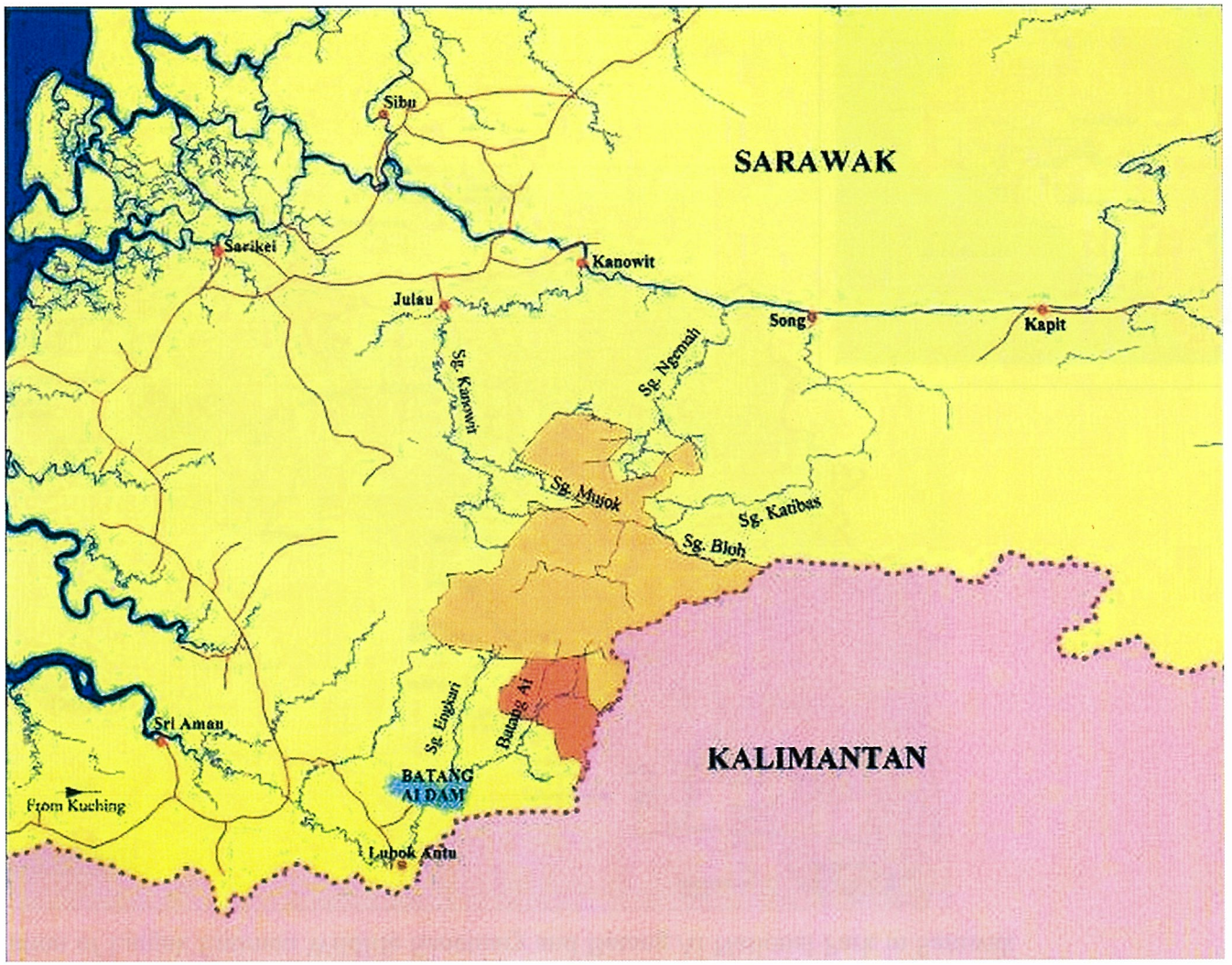


Figure 2: Access Point to Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park



Sungai Mujok

Sg. Mujok, which flows westward from the central part of LEWS into Sg. Kanowit has a flat topography with very few rapids or torrents. The width of the main Sg. Mujok is significantly smaller than Sg. Katibas and Sg. Bloh. Turbidity is relatively low as sediment load is minimal. This is because of the tributaries of Sg. Mujok originate from the middle of the Sanctuary. Sungai Mujok has a tea color appearance due to the decomposition of leaf litter and tannin being produced by trees in water logged areas.

Sungai Katibas and Sungai Bloh

Sungai Katibas and Sungai Bloh are located on the eastern side of LEWS, flowing into the Batang Rajang. The topography of headwaters of Sg. Katibas and Sg. Bloh is very hilly with many rapids and rock walls as riverbanks. The water of Sg. Katibas is clear and while at Sg. Bloh, the water is slightly turbid. This is due to the activities of logging or timber extraction as well as shifting cultivation still being carried out in the buffer area.

3.2 Batang Ai National Park

Batang Ai N.P. encompasses the tributaries and headwaters of Batang Ai which flows into the reservoir of Batang Ai Hydro-electric dam operated by Sarawak Electricity Supply Corporation. The terrain is steep with elevations ranging from 100 m to 975 m a.s.l. at the summit of Bukit Ensanga. When the area was first proposed as National park in 1984, there was no longhouse or recent cultivation (NPWO 1984) as the people moved out of the area during the Indonesian "confrontation" with Malaysia in 1963. People began to move back into the area in 1987 as a result of the flooding of the lower valley for the hydro-electricity project. There are three longhouses within the Park boundary.

BANP is mostly forest covered although a large proportion is secondary forest and rubber plantation. The primary forest is unlogged and consists of mixed dipterocarp forest, kerangas forest and secondary forests. Although montane forest has not been noted it could occur in Bukit Ensanga, which rises to 975 m a.s.l. These forests are home to a varied fauna, notably the orangutan and white fronted langur. Rainfall data from the three meteorological stations indicates a mean annual rainfall of 3,500 mm. Temperature rarely exceeds 28°C.

Batang Ai National Park was established in 1991 with the aim of conserving its wildlife inhabitants, eco-tourism and recreation. The wildlife targeted were orang utan (*Pongo pygmaeus*), bornean gibbons (*Hylobates muelleri*), langurs (*Presbytis frontata and Presbytis rubicunda*), and hornbills (*Buceros rhinoceros, Buceros vigil, Aceros undulates* and *Aceros corrugatus*).

The riparian ecosystem and its vegetation plays an important role in the ecology and biology of aquatic fauna (Leh, 2000 and Sungan, 2000). Trees of the ensurai (*Dipterocarpus oblongifolius*, family Dipterocarpaceae), engkabang (*Shorea macrophylla*, family Dipterocarpaceae) and jambu air (*Eugenia* sp., family: Myrtaceae) not only provide shade but also fruits to the aquatic fauna. There is evidence that the nutrients in these fruits provide the vital link to the maturity and fecundity of Semah and Empurau, (Sungan, pers. comm.).

BANP and its tributaries form part of the water catchments of an artificial lake created by the Batang Ai Hydro-electric dam outside the park. The Batang Ai hydroelectric lake was created to generate electricity. The lake has an area of 84 km? and spreads into the valleys of Batang Ai and Sungai Engkari (Hazebroek and Abg Kassim, 2001). The origin of Batang Ai and Lubang Baya has been traced to the Kapuas drainage over in West Kalimantan. Similarities exist among the drainages on the fish species but endemism and differences occur too.

The headwaters of BANP are relatively clean as it borders with LEWS in the north. No logging activity has been observed and the sediment load as well as the turbidity of the water are significantly very low. However, natural causes of sediment load to the streams brought about by heavy down pour do occur but only when it rains heavily in the headwaters.

4.0 METHODS

4.1 Selection of Study Sites

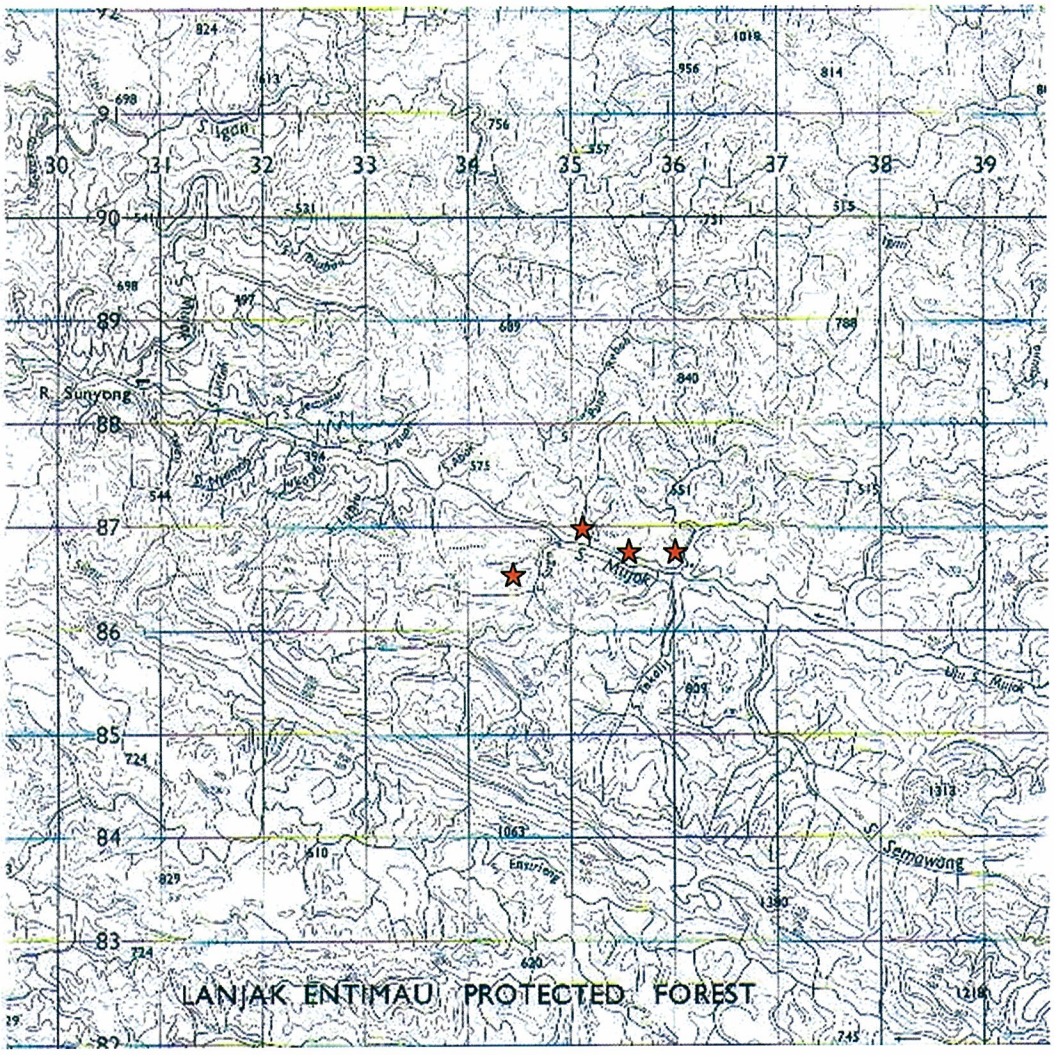
In LEWS, the sampling work was carried out in Ulu Sg. Mujok, Ulu Sg. Katibas and Sg. Bloh. In Ulu Sg. Mujok (Figure 3), the surveys covered Sg. Spuna Ili, Sg. Sepulau Besai, Sg. Selabei and Sg. Suga. All these streams have never been sampled nor surveyed before. Therefore, the study collected voucher specimens of fishes representing the fish fauna of Ulu Sg. Mujok and its tributaries.

In Ulu Sg. Katibas (Figure 4 & 5), Sg. Takai, was surveyed while in Sg. Bloh, the tributaries of Sg. Jenuah and Sg. Liang, were sampled. Sg. Takai and Sg. Jenuah were chosen as no voucher specimens of the fish fauna have been collected before and it was previously recommended for protection. The current work was intended to verify and strengthen the recommendations by seeking additional information on the diversity of the streams as well as their ecological features. Another stream, Sg. Liang located in the buffer zone was chosen as a sampling site for direct comparison with Sg. Jenuah on fish diversity as well as fish population.

In BANP, the surveys covered the tributaries of Sg. Lubang Baya and Batang Ai proper. These streams were chosen primarily because no surveys were carried out in these streams before. The sampling work was carried out in the most northern part of the national park and in some areas moving into the wildlife sanctuary i.e. the southern part of LEWS.

The fieldwork in Sg. Lubang Baya was carried out in Sg. Telangon, Sg. Ensanga, Sg. Engkabau, Sg. Rian, Sg. Supa, Sg. Jitung, Sg. Lalap, Sg. Giling and Sg. Lubang Baya (Figure 6). In Batang Ai, streams that were surveyed were Sg. Gaung, Sg. Menamung, Sg. Anak Gaung, Sg. Pantu and Sg. Panah (Figure 6). These tributaries are located in the northern most areas of the BANP, adjacent to the boundaries of LEWS.

Figure 3: Location of Streams Sampled in Ulu Mujok, Lanjak Entimau Wildlife Sanctuary



Legend

★ Sampling Sites

Figure 4: Location of Sungai Takai in Ulu Sg. Katibas, Lanjak Entimau Wildlife Sanctuary

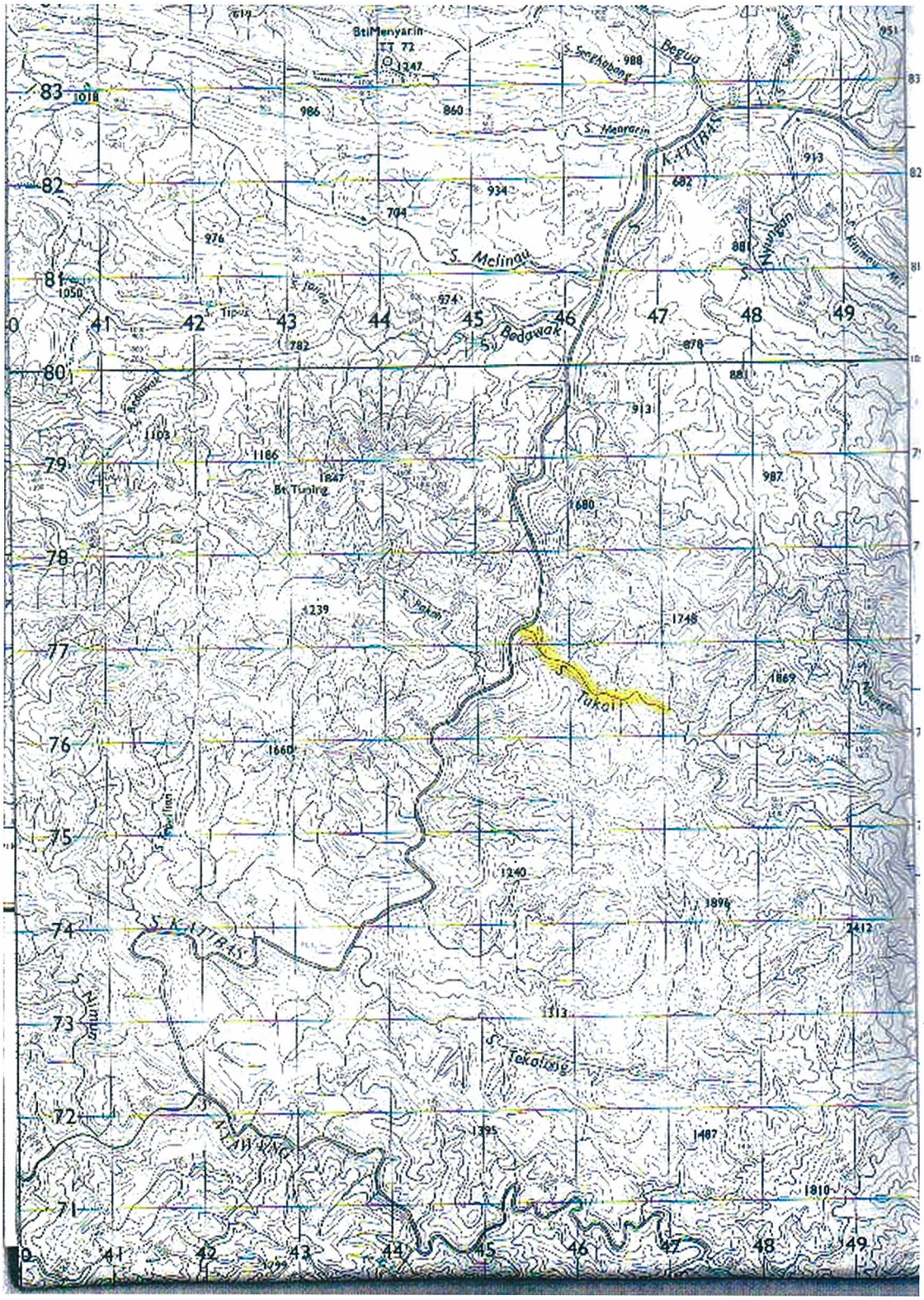


Figure 5: Location of Sungai Jenuah and Sungai Liang in Ulu Sungai Bloh, Lanjak Entimau Wildlife Sanctuary

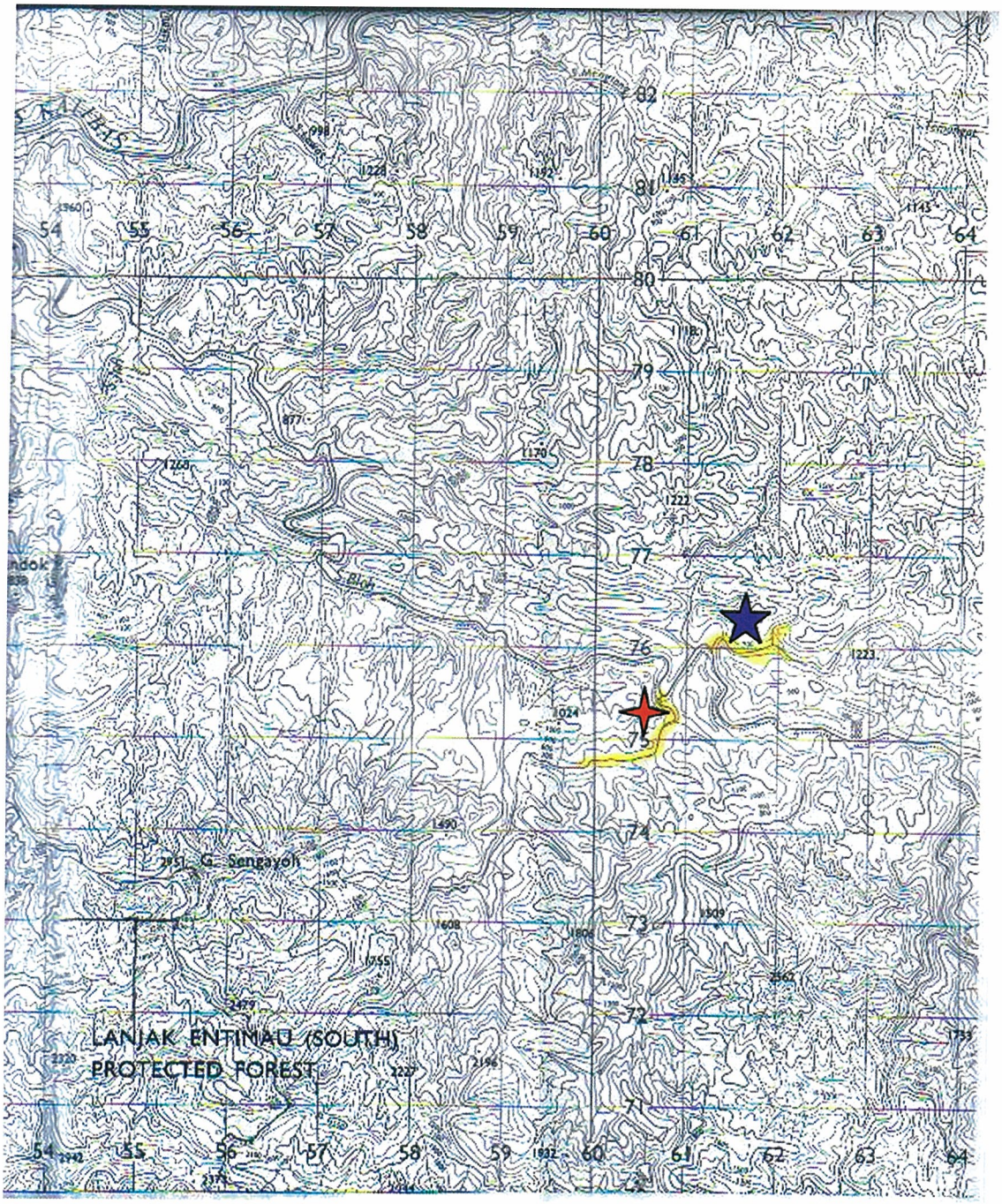
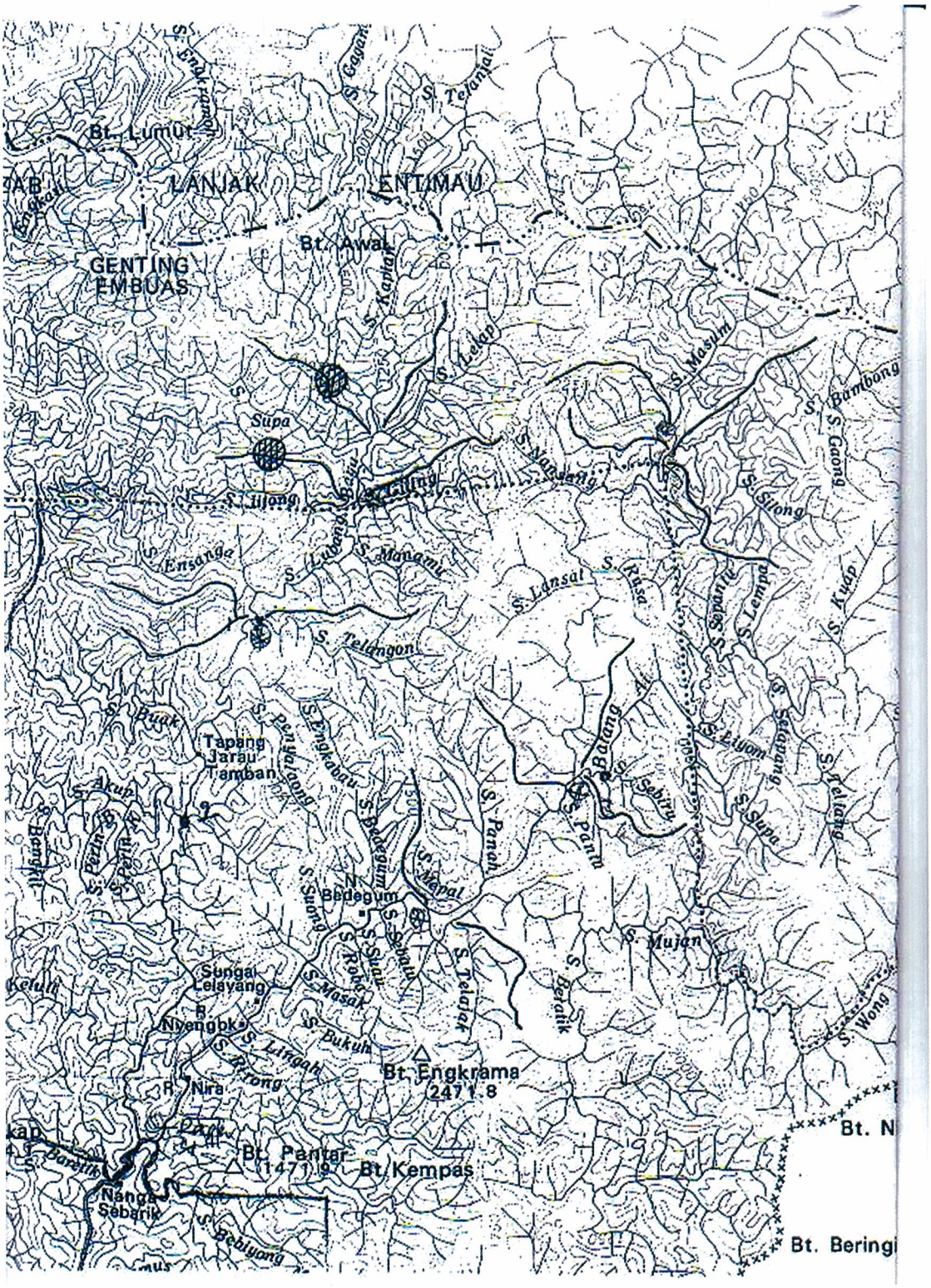


Figure 6: Location of Streams Sampled in Batang Ai National Park



4.2 Fish Collection

Fish sampling in LEWS and BANP were carried out in tributaries by a transect method (300m) whereby a starting point was marked off with a flagging tape. Then at every 50 m mark, a flagging tape was used to mark the interval distance. Description of tributaries and water quality parameters were taken at the starting point. Any unusual physical characteristics of the tributaries were noted along the way. A total of 20 transects were surveyed with lengths of 250m.

The fish surveys in BANP were carried out using an electro-shocker powered by a Yamaha Generator (EV650) with a current of 650V. At LEWS, a HONDA Green generator (1 KVA) was used. The electro-fishing method was effective in areas of ripples and torrents of various widths but cast nets were utilized in areas of deep pools (depths greater than 1m). Sampling was carried out for a fixed distance of 300m. The fishes upon introduction to the electricity current generated by the generator through its conductor pole, will experience a temporary palpitation of the coronary system and float to the surface. Fish specimen were then scooped up with nets and fixed in 10% formalin immediately. The stomach regions were also injected with 10% formalin.

Fish collection was supplemented with the use of cast nets of 3.5m diameter with mesh sizes of 1.5cm (1") and 5 cm (2 ?"). When using the cast netting method, the sampling time and number of times that the cast nest was thrown were recorded. Fishes caught using this method were identified, measured and stages of maturity noted. Suitable representative specimens of the catch were taken for the collection and fixed in 10% formalin with their stomach region injected with 10% formalin. Upon returning to the laboratory, they were washed clean of the formalin and transferred to 70% ethanol.

4.3 Fish Identification

Fish identification exercise was mainly carried out in the laboratory at the Sarawak Museum. Upon return to the laboratory at the Sarawak Museum, the specimens were washed clean of formalin. They were left soaking in running tap water for a few hours or soaking in tap water overnight. The fishes were then sorted, measured and identified. The fish identification exercise was carried out using keys and descriptions by Inger and Chin (1962), Kottelat *et al.*, (1993), Kottelat and Lim (1995), Roberts (1980) and Weber and Beaufort (1922).

4.4. Analysis of Fish Diversity

The Species Diversity (H), Evenness and Richness were calculated for the stations. Species diversity was calculated for each stream using the Shannon-Weaver (1963) H' Index.

$H' = {}^{S}\sum pi \log Pi$

Where $Pi = ni / N$

Ni = the number of individuals of species I

N = total number of individuals in the collection of S Species

The variable of H' is a measure of species diversity which is dimensionless, independent of sample size, and express the relative importance of each species. Diversity is a good descriptive statistic used to measure population heterogeneity based on the pooled samples examined.

Species Evenness

$(J) = H / (H_{max})$ (Pielou, 1966)

Where H = species richness index

H_{max} = ln S

S = number of species in the collection

The value of J ranges from 0 – 1. A value of 1 indicates a perfectly even distribution of individuals among species, thus no dominance of a particular species. A value approaching 0 indicates a concentration of individuals in one of the species or dominance by one species.

The species richness of a station is described by Margalef's D (1968)

$D = (S-1)(\log N)$

Where S = the number of species

N = the number of individuals

This index explores the abundance of species found in a particular stream or station looking at number of individuals in a particular species.

4.5 Water Quality Parameters of Streams

The water quality parameters of the streams were collected. The physical parameters included physical description i.e. stream substrate, canopy cover of stream, width of stream, water depth and local weather. The chemical parameters that were sampled included water dissolved oxygen content, water temperature, conductivity, turbidity and pH. All chemical parameters of the tributaries were taken using a Horiba Water Quality Checker U-10.

Water quality data collection was taken in the morning, prior to the fish collection in every stream.

5.0 FINDINGS

5.1 Physical Characteristics of the River Systems

The streams in the study areas vary in width from 2m to 20m and depth from 2cm to more than 5m. The banks and bottoms of the river system of Sungai Katibas are predominately deposits of sand and clay particles, whereas those in the Batang Ai areas consist of rocks and pebbles often with steep with vertical walls or cliffs. In general, the gradients vary from 30 - 70°. The streams are fringed by a relatively undisturbed vegetation of trees and shrubs typical of the inland habitats, such as Engkabang jantung (*Shorea macrophylla),* Ensurai (*Dipterocarpus oblongifolius)*, Kasai (*Pometia pinñata*), Segera (*Aglaia odoratissima*), and Ubah (*Eugenia* spp.). The vegetation canopy normally occupies 40 – 80 % of the streams. The trees provide shade and an important food source for the aquatic fauna.

The aquatic habitats in LEWS and BANP comprise the main rivers of Sg. Katibas and Batang Ai and their network of tributaries and intermittent streams. The upper stretches of Sg. Katibas above Ng Bloh are fast flowing. The water is normally clear except after heavy rainfall in the interior. The tributary of Sg. Bloh, on the other hand, is more heavily loaded with sediments after each heavy rain due to logging operation in the interior, in the buffer area outside of the Santcuary.

The microhabitats formed by the tributaries and sub-tributaries are torrents, riffles, side pools, deep pools and waterfalls. Torrents are characterized by high velocity of water occurring over and around the stones and boulders that are too heavy to be washed away. Very few plants grow here. Fishes that live here have adapted to the swift flowing water by having their pelvic fins modified into suction-like pads. Riffles are scaled down versions of torrents found in smaller streams where the water velocity is generally slower. These differences in the habitats are factors that determine species distribution and their adaptations.

5.2 Chemical Characteristics of the River Systems

The dissolved oxygen content in most of the streams exceeded 8.0mg/l except for Sungai Mujok and its tributaries and Sg. Liang in Ulu Sg. Bloh. The lower values in the Sungai Mujok and its tributaries are believed to

be due to the flat topography while Sg. Liang, it is due to logging activities in its interior. The flat topography of Sg. Mujok and its tributaries results in slow flowing water and higher water temperature and therefore a lower dissolved oxygen content. The lower dissolved oxygen content for Sg. Liang is probably due to higher sediment load that normally includes organic debris.

The temperature of the streams was quite uniform at around 24°C for most of the streams except for Sg. Mujok and Sg. Liang (Table1). In general, as temperature of water increases, the level of dissolved oxygen decreases. Sedimentation is another cause for low dissolved oxygen content (Cranbrook and Furtado, 1988). Although the present study did not record changes in water temperature at different times of the day, studies carried out by Johnson, (1967) indicated that significant temperature changes can have an impact on the life cycle of the fishes.

Although all the streams surveyed yielded a null turbidity reading, it was observed that the water of Sg. Liang in Ulu Sg. Bloh was visibly cloudy while that of Sg. Mujok was tea colored due to presence of tannic acid released by decomposition of plant debris. It is well known knowledge that the bigger rivers will invariably be loaded with heavy sediments of sand, silt and clay and organic matter after a heavy rain in the interior. It may take a few days for the rivers to be clear again.

The water pH ranged from 6.6 to about 7.6 whereas the conductivity values were very low at between 0.02 and 0.06 μm/l. Conductivity is an index of the flow of electrical current in the water which is in turn determined by the occurrence of mineral salts. The low conductivity indicates the low presence of nutrients in the water. The main source of nutrient in these streams and tributaries comes from the accumulation of leaf litter and not from the soils in the watershed. Lelek (1987) observed that accumulation of leaf litter occurs during torrential rain while mineralization of organic matter occurs during low water level.

Table 1: Water Quality of Streams in LEWS and BANP

Stream	pH	Conductivity µmhos/cm	Dissolved Oxygen mg/L	Temperature °C	Turbidity NTU
Batang Ai					
Sg. Menamong	6.8	0.02	8.6	24	0
Sg. Anak Gaung	7.1	0.02	8.5	24	0
Sg. Gaung	7.1	0.03	8.7	24	0
Sg. Pantu	7.2	0.03	8.4	24	0
Sg. Panah	7.2	0.02	8.6	24	0
Sg. Lubang Baya					
Sg. Giling	7.2	0.03	8.5	23	0
Sg. Lalap	7.1	0.03	8.7	23	0
Sg. Supa	7.2	0.02	8.8	23	0
Sg. Rian	6.7	0.02	8.3	25	0
Sg. Jitung	7.4	0.02	8.7	23	0
Sg. Engsanga Tekal	7.4	0.02	8.4	24	0
Sg. Engkabau	7.4	0.02	8	24	0
Sg. Telangon	7.6	0.03	8.8	24	0
Sg. Mujok					
Sg. Spuna Ili	6.8	0.05	7.3	24.8	0
Sg. Sepulau Besai	7.2	0.05	7.23	25.1	0
Sg. Selabei	7.33	0.06	6.5	25	0
Sg. Suga	7.2	0.04	7.1	25	0
Sg. Katibas					
Sg. Takai	6.6	0.02	8.1	24	0
Sg. Jenuah	7.2	0.03	7.9	24	0
Sg. Liang	7.2	0.03	7	24	0

5.3 Species Inventory and Diversity

5.3.1 Lanjak Entimau Wildlife Sanctuary

Species Inventory

1) Katibas drainage system

This drainage system includes the upper stretches of the Katibas river and their network of tributaries above the park headquarters at Nanga Bloh, in areas not previously sampled This included Sungai Liang, a tributary on the true right bank of Sungai Bloh and is outside the Sanctuary (see Figure 5). A total of 533 specimens of fishes were collected comprising 37 species from 7 families (Table 2a). Out of this, 13 are new records for Sg. Katibas while 3 are new records for LEWS. A possible new species belongs to the genus *Gastromyzon.* This new species is characterized by having reddish dorsal, pectoral, pelvic, anal and caudal fins.

2) Mujok drainage system

In the Mujok drainage system, a total of 800 specimens were collected comprising 29 species from 10 families (Table 2a). These are all new records for the area, as it was not previously surveyed and includes 6 new records for the LEWS. Noteworthy species are the pipefish, *Xenentodon canciloides* and the halfbeaks, *Hemirhamphodon kuekenthalli*, both surface feeders; and a Ballitorid, *Homaloptera orthogonionata,* a bottom dweller. The Ballitorid has the potential for the aquarium trade on account of its reddish and dark brown body patterns comparable to *Botia macanthra* of West Kalimantan (See plate 31).

3) The present inventory revealed a low occurrence of the highly prized Semah (*Tor tambra*) and Empurau (*Tor tambroides*) in most of the streams except Sg. Juh. By contrast there was dominance of Adong (*Hampala bimaculata)* in terms of numbers and size in these waters. Individuals of Adong caught were generally more and above 30cm in total length with several specimens longer, whereas only 1 specimen of Semah was above 20 cm. All three species are predators. The dominance of Adong indicated a keen competition for food and space resulting in the low occurrence and smaller body size of Semah and Empurau. A reverse situation was observed in Batang Ai drainage (see Section 5. 3.2 para 6).

From the above studies, 9 new records were added to the list of fishes known from LEWS. The Mujok drainage provided 6 of the 9 new records.

Species Diversity

In the Katibas river system, Sg. Takai has the highest fish species diversity index of 1.28 with 25 species. Sg. Jenuah follows this with a species index of 1.19 and 22 species. Sg. Liang outside the Sanctuary's boundary on the opposite bank of Sg. Bloh and a short distance above Sg. Jenuah has a diversity index of 1.10 with 23 species. The lower diversity index of Sg. Liang is due to lower population densities of certain species occurring there.

In the Ulu Mujok river system, the tributary of Sg. Spuna Ili has the highest diversity index of 1.00 with a total of 18 species, compared to an index of 0.93 comprising 17 species at Sg. Sepulau Besai, while 14 species occur in both tributaries. This indicates uniformity in species diversity between the two tributaries.

Table 2: Fish Species List from Lanjak Entimau Wildlife Sanctuary

NO.	Species	Family	Mujok	Katibas
1	*Hemibagrus nemurus*	Bagridae	+	O
2	*Hemibagrus planiceps*	Bagridae	+	+
3	*Leiocassis micropogon*	Bagridae	O	+
4	*Leiocassis poecilopterus*	Bagridae	+	O
5	*Gastromyzon contractus*	Ballitoridae	O	+
6	*Gastromyzon fasciatus*	Ballitoridae	+	+
7	*Gastromyzon ridens*	Ballitoridae	O	+
8	*Gastromyzon* sp.	Ballitoridae	O	+
9	*Glaniopsis denudata*	Ballitoridae	O	+
10	*Glaniopsis gossei*	Ballitoridae	O	+
11	*Glaniopsis multiradiata*	Ballitoridae	O	+
12	*Homaloptera nebulosa*	Ballitoridae	+	+
13	*Homaloptera orthogonionata*	Ballitoridae	+	O
14	*Homaloptera stephensonii*	Ballitoridae	+	+
15	*Homaloptera wassinki*	Ballitoridae	O	+
16	*Nemacheilus sarawacensis*	Ballitoridae	+	O
17	*Neogastromyzon niewenhuisi*	Ballitoridae	O	+
18	*Parhomaloptera microstoma*	Ballitoridae	O	+
19	*Xenentodon canciloides*	Belonidae	+	O
20	*Channa lucius*	Channidae	+	+
21	*Clarias teijsmanni*	Claridae	+	O
22	*Cyclocheilichthys apogon*	Cyprinidae	+	O
23	*Cyclocheilichthys heteronema*	Cyprinidae	O	+
24	*Hampala bimaculata*	Cyprinidae	+	+
25	*Hampala macrolepidota*	Cyprinidae	O	+
26	*Lobochilus cf. bo*	Cyprinidae	+	+
27	*Lobocheilus hispidus*	Cyprinidae	O	+
28	*Osteocheilus hasselti*	Cyprinidae	+	O
29	*Osteocheilus kahajanensis*	Cyprinidae	O	+
30	*Osteocheilus microcephalus*	Cyprinidae	O	+
31	*Oxygaster anomalura*	Cyprinidae	O	+
32	*Paracrossocheilus acerus*	Cyprinidae	O	+
33	*Paracrossocheilus vittatus*	Cyprinidae	+	+
34	*Puntius banksi*	Cyprinidae	+	O
35	*Puntius binotatus*	Cyprinidae	+	O
36	*Puntius collingwoodii*	Cyprinidae	+	+
37	*Puntius kuchingensis*	Cyprinidae	+	+
38	*Puntius schwanenfeldii*	Cyprinidae	O	+
39	*Rasbora lateristriata*	Cyprinidae	O	+
40	*Rasbora volzi volzi*	Cyprinidae	+	+
41	*Rasbora sarawakensis*	Cyprinidae	+	O
42	*Tor tambra*	Cyprinidae	+	+
43	*Tor tambroides*	Cyprinidae	+	+
44	*Hemirhamphodon kuekenthalli*	Hemirhamphidae	+	O
45	*Macrognathus aculeatus*	Mastacembelidae	+	+
46	*Mastacembelus unicolor*	Mastacembelidae	+	+
47	*Glyptothorax platypogon*	Sisoridae	+	+
48	*Glyptothorax platypogonoides*	Sisoridae	O	+
49	*Chonerhinus nefastus*	Tetraodontidae	+	O

+ = present; O = absent

The stream evenness indices for Sg. Takai, Sg. Liang and Sg. Jenuah ranged between 0.3529 and 0.3986 (Table 5). Leh (2000) considered the low evenness of between 0.3 and 0.37 to be due to dominance by certain species in the overall distribution of fish population in a stream. Based on this criterion, Sg. Takai and Sg. Jenuah with evenness indices above 3.7 would seem to indicate a significant level of evenness in species distribution.

Table 3: Fish Species Diversity Index, Evenness and Richness of LEWS

Stream	H	Hmax	J	D
Ulu Mujok				
Suga	0.9039	2.7726	0.3260	6.8223
Selabei	0.8562	2.9444	0.2908	7.7443
Sepulau Besai	0.9371	2.8332	0.3307	6.7480
Spuna Ili	1.0086	4.8520	0.2079	8.0675
Ulu Katibas				
Takai	1.2829	3.2189	0.3986	11.1352
Liang	1.1064	3.1355	0.3529	10.5811
Jenuah	1.1953	3.1355	0.3812	9.8863

H – Species Diversity Index; J – Species Evenness; D – Species Richness

While logging activities may continue in the upstream stretches of Sg. Liang, recovery by the fishes especially the bottom feeders is still feasible if the disturbance was kept to a short-term cycle. Any logging activities carried out for long periods of time, e.g. more than 6 months, should be avoided in the buffer areas, so as to allow the fishes to re-colonize the streams.

5.3.2 Batang Ai National Park

Species Inventory

In the Batang Ai drainage, 26 species of fishes were documented from 9 families (Table 2b). A total of 407 specimens were collected. The dominant group was from the family of Cyprinidae (a major food fish group), followed by Ballitoridae i.e. the suckerfishes.

In the Lubang Baya drainage, 31 species were recorded from 8 families. A total of 953 specimens were collected from this drainage. The main groups caught were from the family of Cyprinidae followed by the Ballitoridae.

In comparison to earlier work on fishes in BANP (Meredith 1993 and Cramphorn 1982), a total of 7 species were found to occur in all three lists (Table 4). As the sites of each collector differs, the compilation of the

3 study represents the total fish inventory for BANP covering headwaters of Lubang Baya and Batang Ai to areas adjacent to the reservoir areas. Thus, a total of 62 species of fishes are known to occur in BANP to-date. Differences in the methods, i.e. use of cast nets and gill nets can also be summarized from the fish lists as the two previous studies only collected fishes from the mid water level to surface areas of the water body. The present work sampled fishes from the bottom of the stream right up to the surface. The present survey added 18 new records to the whole list of fishes known from BANP.

Table 4: Fish Species List from Batang Ai National Park

NO.	Species	Family	Lubang Baya	Batang Ai
1	*Akysis baramensis*	Akysidae	+	O
2	*Hemibagrus nemurus*	Bagridae	+	O
3	*Leiocassis micropogon*	Bagridae	+	O
4	*Leiocassis poecilopterus*	Bagridae	+	O
5	*Gastromyzon borneensis*	Ballitoridae	O	+
6	*Gastromyzon fasciatus*	Ballitoridae	+	+
7	*Gastromyzon punctulatus*	Ballitoridae	+	O
8	*Gastromyzon ridens*	Ballitoridae	+	+
9	*Glaniopsis denudata*	Ballitoridae	O	+
10	*Glaniopsis gossei*	Ballitoridae	+	O
11	*Glaniopsis multiradiata*	Ballitoridae	+	+
12	*Glaniopsis sp.*	Ballitoridae	+	O
13	*Homaloptera nebulosa*	Ballitoridae	+	+
14	*Homaloptera stephensonii*	Ballitoridae	+	O
15	*Hypergastromyzon eubranchus*	Ballitoridae	+	+
16	*Parhomaloptera microstoma*	Ballitoridae	+	+
17	*Channa lucius*	Channidae	O	+
18	*Clarias teijsmanni*	Claridae	+	+
19	*Cyclocheilichthys armatus*	Cyprinidae	O	+
20	*Cyclocheilichthys heteronema*	Cyprinidae	+	O
21	*Hampala bimaculata*	Cyprinidae	+	+
22	*Lobochilus cf. bo*	Cyprinidae	O	+
23	*Lobocheilus hispidus*	Cyprinidae	+	O
24	*Osteocheilus hasselti*	Cyprinidae	O	+
25	*Osteocheilus microcephalus*	Cyprinidae	+	O
26	*Osteocheilus waandersii*	Cyprinidae	O	+
27	*Oxygaster anomalura*	Cyprinidae	+	+
28	*Paracrossocheilus acerus*	Cyprinidae	+	+
29	*Paracrossocheilus vittatus*	Cyprinidae	+	+
30	*Puntius banksi*	Cyprinidae	+	O
31	*Puntius collingwoodii*	Cyprinidae	+	+
32	*Puntius kuchingensis*	Cyprinidae	+	+
33	*Rasbora volzi volzi*	Cyprinidae	+	+
34	*Tor tambra*	Cyprinidae	+	+
35	*Tor tambroides*	Cyprinidae	+	+
36	*Macrognathus aculeatus*	Mastacembelidae	+	+
37	*Mastacembelus unicolor*	Mastacembelidae	+	+
38	*Glyptothorax platypogon*	Sisoridae	+	+

+ = present; O = absent

Table 5: Comparative List of Fishes from BANP by different researchers

NO.	Species	Cramphorn	Meredith	Abdullah	Similarities	New Records from present survey
1	*Akysis baramensis*			+		1
2	*Hemibagrus nemurus*		+	+		
3	*Hemibagrus baramensis*	+				
4	*Hemibagrus* cf. *planiceps*	+				
5	*Leiocassis borneensis*		+			
6	*Leiocassis micropogon*	+		+		
7	*Leiocassis poecilopterus*	+		+		
8	*Gastromyzon borneensis*			+		2
9	*Gastromyzon fasciatus*	+		+		
10	*Gastromyzon punctulatus*			+		3
11	*Gastromyzon ridens*	+		+		
12	*Glaniopsis denudata*			+		4
13	*Glaniopsis gossei*			+		5
14	*Glaniopsis multiradiata*			+		6
15	*Glaniopsis* sp.			+		7
16	*Homaloptera nebulosa*			+		8
17	*Homaloptera stephensonii*			+		9
18	*Hypergastromyzon eubranchus*	+		+		
19	*Parhomaloptera microstoma*	+		+		
20	*Neogastromyzon niewenhuisi*	+				
21	*Pangio mariarum*	+				
22	*Channa lucius*	+	+	+	1	
23	*Channa striata*	+				
24	*Clarias batrachus*		+			
25	*Clarias teijsmanni*	+		+		
26	*Colius microlepis*	+				
27	*Barboides balleroides*	+				
28	*Cyclocheilichthys apogon*	+	+			
29	*Cyclocheilichthys armatus*			+		10
30	*Cyclocheilichthys heteronema*			+		11
31	*Cyclocheilichthys reprasson*	+				
32	*Epalzeorhynchos* sp.	+				
33	*Hampala bimaculata*	+		+		
34	*Hampala macrolepidota*	+	+			
35	*Lobochilus* cf. *bo*	+	+	+	2	
36	*Lobocheilus hispidus*			+		12
37	*Osteocheilus hasselti*		+	+		
38	*Osteocheilus microcephalus*			+		13
39	*Osteocheilus vittatus*		+			
40	*Osteocheilus waandersii*			+		14
41	*Oxygaster anomalura*	+	+	+	3	
42	*Paracrossocheilus acerus*	+		+		
43	*Paracrossocheilus vittatus*	+		+		
44	*Puntius banksi*	+	+	+	4	
45	*Puntius collingwoodii*	+	+	+	5	
46	*Puntius kuchingensis*	+		+		
47	*Puntius schwanenfeldii*		+	+		
48	*Puntius orphoides*	+				
49	*Rasnora semilineata*	+				

NO.	Species	Cramphorn	Meredith	Abdullah	Similarities	New Records from present survey
50	*Rasbora* cf. *sumatrana*	+				
51	*Rasbora* sp.		+			
52	*Rasbora tornieri*	+				
53	*Rasbora volzi volzi*			+		15
54	*Tor douronensis*	+				
55	*Tor tambra*			+		16
56	*Tor tambroides*	+	+	+	6	
57	*Macrognathus aculeatus*			+		17
58	*Mastacembelus unicolor*		+	+		
59	*Glyptothorax platypogon*			+		18
60	*Glyptothorax major*	+				
61	*Pseudogobiopsis oligactis*	+				
62	*Osphronemus gouramy*	+	+	+	7	

Two species recorded by Cramphorn (1982) i.e. *Coius microlepis* and *Epalzeorhynchus* sp. had not been collected in this study. Several possible suggestions to this would be the possibility of a miss-identification of the fishes by author or extinction from the area. As the fishes collected were not kept at the Sarawak Museum, no confirmation could be given on their identification. Meredith in 1993 also did not collect any of the two species caught by Cramphorn from BANP. The Senior Curator from Sarawak Museum concurred on the possibility of a miss-identification as he strongly stated that the species were not known to exist from this area (Leh, *pers. comm.*).

A new species of *Glaniopsis* has been tentatively listed from BANP. The specimens were collected mainly from the headwaters of Sg. Lubang Baya. The species was not collected prior to this study probably because of the remoteness of its locality as well as the method of collection. The traveling time is about 2 days from the Nanga Delok Station on high water level. This fish lives in fast flowing waters and needs fine mesh size nets to catch it.

Another significant observation from this study was competition for food and space between Semah (*Tor tambra)* and Adong (*Hampala bimaculata)*. In Sg. Lubang Baya, Adong was found to be dominant while in Batang Ai, Semah was dominant. Hence, the size of one species collected were smaller where the other species was dominant. Both species are carnivorous or predators in their feeding behavior. Competition for food exists for both species in the both river systems. One possible reason for the establishment of dominance of either one species in a particular stream would be the presence of rapids or waterfalls. It has been noted that rivers with significantly raised rapids or waterfalls have bigger specimens of Semah while rivers without significantly raised

rapids or waterfalls will have Adong. Sg. Lubang Baya is generally a fast flowing river with many torrents and deep pool areas but do not have any significantly raised rapids in it. Batang Ai, however, has several rapids and waterfalls, that are significantly raised.

Species Diversity

For the tributaries of Sg. Lubang Baya, Sg. Engkabau has the highest fish species diversity followed by Sg. Telangon, i.e. 0.96 and 0.94 respectively. Sg. Lubang Baya has a comparable high fish species diversity index of 0.96 as the two tributaries mainly because of its diverse habitats in the river itself. Sg. Engkabau has 18 species listed, the same for Sg. Lubang Baya.

For the tributaries of Batang Ai, Sg. Menamong has the highest species diversity index of 0.84 with 13 species listed. Sg. Pantu, has the lowest with 0.50 species diversity index and only 4 species. A possible reason for the variation would be the difference in stream size and bottom substrate as Sg. Pantu is about half the width of Sg. Menamong and having a slower rate of water flow.

Stream evenness indices with ranges between 0.3 to 0.37 indicate low or dominance by a certain species in the whole distribution of fishes in the stream. Sg. Anak Gaung from Batang Ai has the most significantly high level of evenness of 0.37. The remainder of the streams falls in the range that is stipulated indicating a dominance by a certain group of fishes.

Table 6: Fish Species Diversity Index, Evenness and Richness of BANP

Stream	H	Hmax	J	D
Lubang Baya				
Giling	0.5193	2.5649	0.2024	6.2195
Lalap	0.7843	2.4849	0.3156	6.0676
Supa	0.4852	1.6094	0.3015	2.8981
Rian	0.3672	1.7918	0.2049	3.2927
Jitung	0.5469	2.3026	0.2375	5.5097
Engsanga	0.8908	2.6391	0.3375	5.1379
Engkabau	0.9589	2.8904	0.3318	8.5186
Telangon	0.9422	2.6391	0.3570	6.6856
Lubang Baya	0.9612	2.8904	0.3325	7.8122
Ulu Batang Ai				
Menamong	0.8429	2.5649	0.3286	6.0537
Gaung	0.7377	2.4849	0.2969	5.5242
Anak Gaung	0.7292	1.9459	0.3747	3.9512
Pantu	0.5051	1.3863	0.3644	2.3460
Panah	0.7278	2.7726	0.2625	6.8660

H – Species Diversity Index; S – Species Evenness; D – Species Richness

5.4 Fish Ecology and Distribution

The geographical distribution of the fish fauna is rather uniform since most of the habitats are common throughout LEWS and BANP. For example, some species are found only in torrents and riffles (*Gastromyzon borneensis, Glaniopsis denudata, Neogastromyzon niewenhuisi, Parhomaloptera microstoma, Paracrossocheilus acerus*), while others occur in deep pool areas (*Osteocheilus waandersii, Oxygaster anomalura*), and others in both habitats (*Tor tambra, Barbodes schwanenfeldii, Hampala bimaculata*).

Generally the fishes depend on uncontaminated waters for successful breeding with oxygen rich waters of rapidly flowing rocky streams. Very few species can survive in streams with high dissolved solids (siltation) and are mostly species that have adapted their ecological guild of surface feeders, e.g. halfbeaks, pipefish and the rasboras.

The bottom substrate of streams in the upstream areas is generally pebble to rocky bottom. These are very important areas for feeding as well as spawning for most of the fishes, and any changes to the water quality as well as the sediment load will affect their survival. Notably associated with this type of stream bottom are the Ballitorids (bottom sucker fishes) and the cyprinids with inferior mouths[1] (*Lobocheilus bo, paracrossocheilus acerus, Paracrossocheilus vitatus* and *Osteocheilus waandersii*).

Several factors are believed to be related to the distribution patterns of the fish fauna. The most common and visible are:

1) River Size and Volume of Water

The distribution pattern of the fish fauna in a river in LEWS is influenced by the changes in water speed, changes in the volume of water, turbidity, substrate and type of food available. Generally as the river size increases, the number and diversity of species increases (Bishop, 1973), and the proportion of the fish biomass depending on aquatic and terrestrial plants increases, while the proportion that depends on the aquatic and terrestrial invertebrates decreases. The number of feeding guilds and number of species in each of the guilds increases as the river size increases. Watson and Balon (1984) discovered that the breadth of each species as well as the mean life span and adult size of individual species decreases nearer to the river mouth. The number of bottom dwelling species increases nearer to the river mouth.

[1] The location of the mouth is on the ventral side of the body and it feeds on algae scraped off rocks or invertebrates living among the bottom substrate.

2) Feeding Guild

The distribution of feeding guilds differs even over a small stretch of river. The factors that may influence this are the presence of plant material, shading canopy, distribution of riffles and pools. For a given stream with a community of fishes, its members will occupy different levels in the water body. Most forested streams have one or two species of surface feeders, three to five mid-water species, two to four living just above the bottom and three to ten living on or in the bottom (Inger and Chin, 1962). Differences in the proportion at each level between streams are attributed to the bottom substrate and the current.

The streams in LEWS show a high number of species that live just above the bottom as well as on the bottom or in the bottom as compared to the studies by Inger and Chin (1962). This shows the importance of the bottom substrate in the determination of species survival and how any changes to the bottom substrate of streams can significantly reduce the number of species in the streams as well as their populations.

Table 7: The number of species found in respective feeding guilds in forested streams in LEWS

Type of Feeding Guilds	Sg. Takai	Sg. Jenuah	Sg. Liang
Surface Feeders	2	2	2
Mid water	5	6	4
Just above bottom	8	7	8
On the bottom	11	8	8

5.5 Fish Spawning Ground

5.4.1 Lanjak Entimau Wildlife Sanctuary

Fish spawning ground is generally associated with clean and well-oxygenated waters, availability of suitable substrate for egg laying as well as cover for protection from predators.

The three tributaries of Ulu Sg. Katibas and Sg. Bloh, i.e. Sg. Takai, Sg. Jenuah and Sg. Joh, have been proposed as Fish Spawning Ground in the Katibas drainage system. The tributaries were found to have high species diversity as compared with the remainder of the streams surveyed (Sg. Takai and Sg. Jenuah were sampled in this study while Sg. Joh was sampled during the IBBE 1997). Another supporting factor is the existence of various sizes of the major food fishes in the streams especially Semah. The findings from the sampling of the streams showed a wide range of the lengths of the fish and the numbers of individuals inhabiting them. This shows the utilization of the streams as spawning and grow-out streams for the major food fishes in LEWS.

Figure 7: Total Lengths of Semah, *Tor tambra* caught in Sg. Jenuah

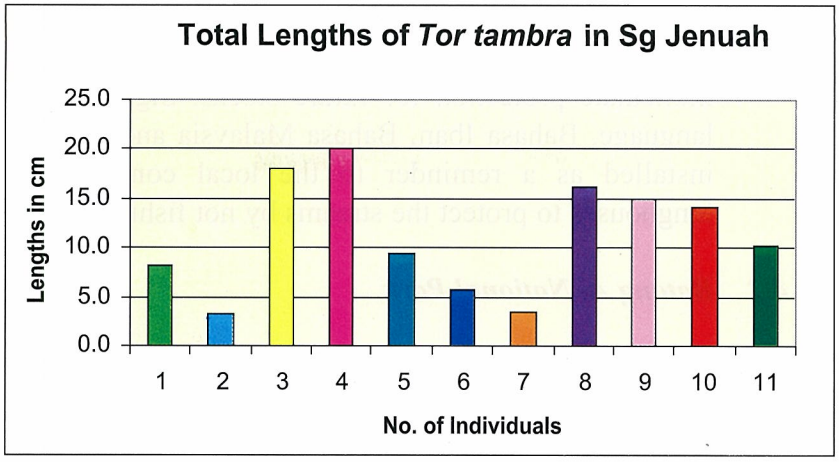


Figure 8: Total Lengths of Semah, *Tor tambra* in Sg. Liang

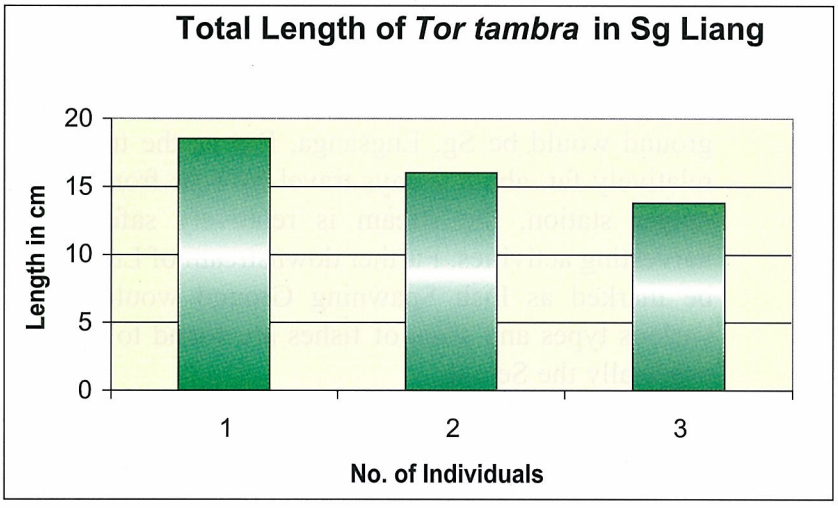
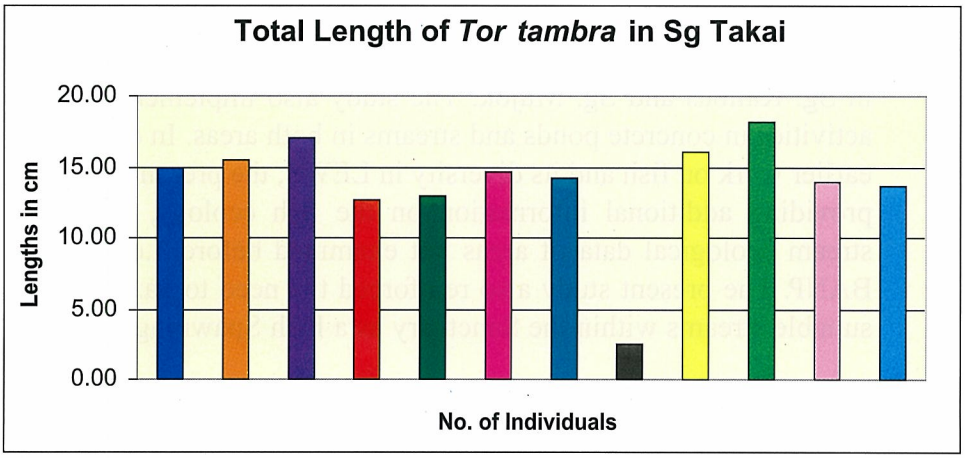


Figure 9: Total Lengths of Semah, *Tor tambra* in Sg. Takai



The species lists for Sg. Takai and Sg. Jenuah were above the 20s with a dominance of the Cyprinid group. As these fishes form the main group caught for food consumption, these streams warrant immediate protection for future stocks. Signages in three main language, Bahasa Iban, Bahasa Malaysia and English have been installed as a reminder to the local communities from the longhouses to protect the streams by not fishing there.

5.4.2 Batang Ai National Park

In BANP, the headwaters of the park, the Batang Ai drainage, especially the streams located above the Mepal waterfalls are relatively safe from any major fish harvesting activity. The Mepal waterfall acts as the main deterrence as visitors basically have to carry their boats up the rapid, as it is too dangerous and not possible to boat up the fall. The height of the waterfall is about 5ft from the water level with many hidden sharp rocks.

For Sg. Lubang Baya, a possible stream for protection as spawning ground would be Sg. Engsanga. But as the traveling distance is relatively far, about 2 days travel by boat from the Lubang Baya ranger station, the stream is relatively safe from any major harvesting activities. Further downstream of Lubang Baya that can be marked as Fish Spawning Ground would be Sg. Akup as various types and sizes of fishes are found to be abundant there, especially the Semah.

5.6 General discussion

The first study by Leh (1998) and later through the IBBE, (1997) provided a listing of fishes found in LEWS and stream ecological data especially from the Katibas and Bloh drainage. This was the baseline information needed to build upon what needs to be studied in LEWS. Later, an applied fisheries study i.e. aquaculture and the interaction between human and fish fauna was carried out by Sungan in 2000. The work focused on the areas in Sg. Katibas and Sg. Mujok. The study also implemented fish rearing activities in concrete ponds and streams in both areas. In comparison with earlier work on fish and its diversity in LEWS, the present study looked at providing additional information on the fish ecology, fish listing and stream ecological data of areas not examined before, i.e. in LEWS and BANP. The present study also reinforced the need to gazette and protect suitable streams within the Sanctuary as a Fish Spawning Ground.

The present work provided a better understanding of fish distribution pattern in LEWS and BANP especially in habitats of rapids, riffles and

slow moving streams. Sg. Mujok with its totally different topography, i.e. rather flat with tea color water provided new information to the stream and fish database for LEWS. It was also discovered in this work that competition for food and space occurred between two genera of cyprinid: Semah, *(Tor tambra)* and Adong *(Hampala bimaculata)* which are important food source for the local communities.

The dominance expressed by a particular species will affect the size of the other species and generally, the topography of a stream will determine the dominance of either species. The current survey together with previous studies in LEWS brings the total fish species list at 96 while BANP has 63 species. Nine new records were added to LEWS while 18 were added to BANP. Two new species from the genera of *Gastromyzon* and *Glaniopsis* have been recorded from LEWS and BANP.

The Fish Spawning Ground identified through this study and currently protected with the cooperation of the local communities is another means of protection for the fish and the environment it lives in.

Together LEWS and BANP can be regarded as a very important sanctuary for the conservation of inland fisheries for the state of Sarawak. The two areas make up Sarawak's largest protected area and protect the numerous streams, rivers, forests and its inhabitants. The benefit of it can be seen through the continuation of fish supply, clean water to the communities living adjacent to the protected areas. The protection of LEWS and BANP prevents environmental disasters e.g. landslides and flash floods, from affecting the towns downriver.

The current fish study contributes to the knowledge of the trans-boundary conservation area (TBCA) established between Malaysia and Indonesia for Lanjak Entimau Wildlife Sanctuary and Betung Kerihun National Park, with the inclusion of Batang Ai National Park in 2002. The total protection of the TBCA is significant on a regional level providing clean water and clean air, preventing environmental disasters, conservation of the genetic pool of its inhabitants, continuous supply of fish and other game species for local consumption of the local communities living within and surrounding the TBCA.

5.7 Potential Indigenous Fishes for Aquaculture

5.7.1 Species of Fish

The pilot projects on fish rearing in concrete ponds and valley ponds have been implemented by ITTO in LEWS. The

participating longhouses were Rumah Gerasi in Ulu Mujok and Rumah Api and Rumah Enggong in Ulu Katibas. In Ulu Mujok, a valley pond was constructed while in Ulu Katibas, a concrete pond and valley pond was constructed in Rumah Api and Rumah Enggong respectively. The species reared were mainly Semah, Empurau and Tengadak. The stocking rate recommended was 9 tails/m^3. The indigenous fish rearing pilot project with the local longhouse communities have yet to be harvested since it was initiated.

Prior to the current study, the ITTO Project implemented another experimental cage culture of food fishes at the Nanga Delok Ranger Station in BANP. Several food species both indigenous and exotic, were reared in cages of 27m^3 dimensions. The fishes were reared on an experimental basis to study the conversion rate of feed to body weight ratio. Artificial feed was used and only lately, cassava leaves and wild jambu fruits were used to supplement the feeding.

The species reared in the cages included Tengadak (*Barbodes schwanenfeldii*), Semah (*Tor tambra)* Tilapia (*Oreochromis* sp.) and Mata merah (*Osteocheilus melanopleura)*. Semah was obtained from the wild while the rest were supplied by the Inland Fisheries Division of the Department of Agriculture Sarawak. Table 7 illustrates the preliminary results for the experimental cage culture.

Table 8: Experimental Fish Culture in Ng. Delok Station, BANP

Species	Local Name	Date Reared	Stocking Rate, /m^3	Conversion Ratio (gm food: 1 Body Weight)
Barbodes schwanenfeldii	Tengadak	June 2002	11	4:1
Tor tambra; *Tor tambroides*	Semah	Sept 2002	9	17:1
Oreochromis sp.	Tilapia merah	Feb 2003	7	2.4: 1
Osteocheilus melanopleura	Mata Merah	Feb 2003	7	4:1

(Preliminary data provided by RO Sundai Silang)

The indigenous fish culture by the local longhouse communities shows promising results but according to the local experts, routine monitoring and feeding program and consultation would need to be provided to the participating longhouses on how to care for the fishes as well maintenance of the ponds. Results of the

preliminary experimental cage culture of indigenous species show that it is possible to rear these fishes in cages in inundated areas. However, the conversion rate is relatively high for Semah as it will need 17 gm of feed to transform into 1 gm of fish flesh. But as the study is still experimental, no conclusion can be made until a longer period of culture. There exists the question on the fecundity of the eggs of these fishes reared in cages and the ability of these species to spawn naturally in the wild, when released.

From the pilot projects that have been implemented and the current culinary indigenous freshwater fish selectivity by the urban populations, the species that have shown great potential and feasibility to be cultured are the Semah (*Tor tambra)*, Empurau (*Tor tambroides)* and Tengadak (*Barboides schwanenfeldii).*

A joint venture between the Sarawak Forestry Department and the Inland Fisheries Division to look into the spawning of Semah and Empurau, is materializing with the newly completed facility at Ng Bloh Headquarters. The priority areas are conservation of natural fish breeding areas and at the same time documenting its ecology as well as induced spawning of these species. This will eventually reduce dependence on the wild stocks. Rearing of these two species can be carried out on a commercial basis once the production of the fish fries from hatcheries is successful.

5.7.2 Market Value

There has been no change in the market price of the indigenous freshwater fishes since the 1998 survey by Sungan. The local communities living along and beyond the peripheral of LEWS and BANP, e.g. the Katibas River, Rajang River, Mujok, and Batang Ai still prize the Semah and Empurau highly. The prices of life or frozen Semah and Empurau in Sibu are RM40 (US $ 10.00) and RM300 (US $ 79.00) per kg respectively.

5.8 Threats to the Fish Fauna

5.8.1 Lanjak Entimau Wildlife Sanctuary

The threats faced by fishes and other species of freshwater habitat are manifold and all encompassing. There are several synergistic and cumulative effects, and tolerance to one factor may be reduced due to stress originating from another factor. Generally, aquatic environment faces threats from chemical pollution, increased sediment load, flow alteration and water diversion, introduced species, habitat loss, over-fishing and pet trade (Beverton, 1992; Kottelat and Whitten, 1996).

At present, the most serious threat faced by the aquatic environment in LEWS would be from the cyclical increased sediment load from upstream logging activities in the buffer zone. Long exposure to sedimentation is not good and should be avoided. In relation to this would be habitat loss due to the logging activities as localized species would be depleted and riparian fringing vegetation is destroyed or altered when silt or earth smothers bed of larger particles.

The fishing activity by the local longhouse communities living adjacent to LEWS is still at a manageable level. The monitoring system that is currently in place at the Ranger Station is the locals inform the park warden of the total catch of each fishing trip in the Sanctuary. Usually the catch would be about 10 kg of salted fish per boat comprising mainly Semah and Empurau as well as Kulong, Bantak and Tengadak. Presently, it is still under control but as the possibility of scarcity of food becomes more evident and as more leisure time is at hand, the activity can be foreseen to increase significantly in the near future.

5.8.2 Batang Ai National Park

In BANP, the possible threats faced by the aquatic environment and its inhabitants would be habitat loss due to the spread of increased level of inundated waters upstream, accidental release of exotic species into natural waters, e.g. Tilapia and over-fishing. Experiences from Indonesia, the Philippines and Sri Lanka have shown that Tilapia, *Oreochromis* sp. out-compete native species, causing the extinction of several local species and mollusks (Kottelat and Whittan, 1996).

Over-fishing in BANP is feared as an immediate threat as the number of fishermen going upriver has increased significantly with weekly visits of between 3 – 5 boats. The fishermen have now ventured further upstream, nearer to the Lubang Baya Station, while others have ventured into the Park to fish. The majority of the fishermen are not from the eight longhouses that still have the special privilege to fish and hunt wild boar in the park. There is no control mechanism to monitor the number of fishermen entering BANP and the amount of fish that is taken out. At present, the Park Warden and the representatives of the eight longhouses working at the park lack the initiative or authority to stop the fishermen from entering the area. A monitoring system is needed to log the number of fishermen entering the area as well as to monitor the amount of fish taken out.

5.9 Fish Conservation and Management

LEWS and BANP combined form the largest TPAs in the state. By virtue of their protected area status, the fish fauna are abundant. It becomes very tempting for the local communities to fish there. They are becoming a serious threat to the sustainability of fish fauna in the TPA, due partly to lack of awareness and education on conservation and species protection. Increasing evidence of over fishing has been observed in BANP. In order to protect the fish fauna the following measures are recommended.

a) Enforcement

There is a lack of officers to manage the TPAs on the ground. It is also evident that enforcement officers are based in the headquarters in Kuching are not effective in implementing and carrying out activities in the field. At the Ng. Delok Ranger Station, it has been reported that hunting and fishing activities by local people peaks during the weekends and similar reports have been received from Ng Bloh Ranger Station. There is an apparent need for an increase in regular patrolling and checking of visitors especially during weekends. In the case of Batang Ai, enforcement team should be posted at Ng. Lubang Baya whereas in Ulu Katibas it should be at Ng Bloh headquarters. Such efforts should be carried out continuously over a period of time in order to be effective.

b) Signboards

There is a shortage of boundary markers or signboards to inform the public of the boundaries of the TPAs. Regular cleaning of the boundaries is also needed to inform visitors of the area status.

Several rivers, namely Sg. Takai in Ulu Katibas, Sg. Jenuah and Sg. Joh in Ulu Sg. Bloh have been identified as Fish Spawning Ground. Signboards with notification to prohibit fishing activities in these streams have been proposed and designed and will be placed at the streams concerned. Together with local dialogue sessions, it is hoped that the boards will act as a deterrent to any fishing activity in the streams.

In BANP, Sg. Akup, a tributary of Sg. Lubang, is being proposed as a fish spawning ground, while Sg. Bebiyong Mit of Batang Ai is also proposed. Sg. Bebiyong Mit is currently the nearest and also the collection ground for the fish fries for the cage culture project at the Ng Delok Station.

c) Mesh Size Control

Although some of the local communities living in the buffer zone have been granted the special privileges to fish in the TPA for their own consumption, this does not mean that they should fish indiscriminately. One way to control excessive fishing is to limit the mesh size so that only bigger fish are taken.

The common cast nets currently being used by communities in LEWS and BANP has a mesh size of 1.5 cm (1 in.). This should be increased to be greater than 1 in. This is also true for gillnets being utilized. The workers at the Ng Delok Ranger Station have reported at least one incident of tuba poison fishing (Root of *Derris* sp.) in the Batang Ai area. This is to be strictly disallowed.

Another mechanism to protect the indigenous fish population would be the strict enforcement of the mesh size permitted for cast nets and gillnets in the Park and Sanctuary. This effort will allow the smaller size of fishes to escape and mature. It is a normal practice when big fishes are scarce, the fishermen would turn their attention to species of smaller sizes. At present, all the species from both protected areas are eaten, big or small.

d) Closed Fishing Season

Closed fishing season or total prohibition of fishing during certain months of the year are proposed. The closing of the fishing season should coincide with the natural breeding cycles of the popular indigenous species namely Semah, Empurau, Tengadak and Bantak. For this to be implemented, a longer study period (minimum 1 year) on the natural ecology and breeding cycles of the species should be carried out first.

Presently what is known of the breeding seasonality of Semah, Empurau and Tengadak is that spawning occurs with the onset of the dry season or low water level. This information gathered from the local fishermen needs scientific verification and supported with studies before a closing season can be introduced, implemented and accepted.

e) Reducing Pressure on the Natural Fish Stocks

i. Induced spawning program of fishes

Induced spawning program of fishes in captivity to produce fish fries is another form of conservation effort that can be carried out. The production will reduce dependence on the wild species,

as a regular supply of fish fries can be produced for rearing purposes. This, currently is being pursued by the Sarawak Forestry Department together with the Inland Fisheries Division of the Department of Agriculture. This can be set up at the recently completed Ng Bloh Headquarters at Sg. Katibas.

The induced spawning program should place emphasis on Semah and Empurau as the first group of fishes to work on. The success of this program will have tremendous effect on the indigenous fish rearing activity in Sarawak as well as the protection of the wild stocks.

ii **Fish culture in valley ponds and concrete ponds in longhouses**

The ITTO project in Phase II introduced the practice of fish culturing in valley ponds and concrete ponds to the local communities living in the buffer areas of the two TPAs. The response and acceptability by the local communities have been encouraging. Fish culture will reduce dependence on the wild stocks as well as provide continuous source of protein and additional income to the local communities should they sell the fish cultured. This activity should be expanded to the other areas.

f) **Awareness Program**

An awareness program on the conservation and protection of the fish fauna and the river systems in the two TPAs should be implemented with the local communities living in the buffer areas. This awareness program should touch on the importance of the TPAs, the role of the people and the forests as well as the sustainability of the fish fauna in the TPAs for future generation. The awareness program can be conducted through talks, discussion dialogue, distribution of printed media, slide shows, video shows with the communities as well as with the school children.

6.0 CONCLUSIONS

LEWS is rich in fish fauna with new records and new species yet to be discovered. The current study revealed a total of 56 species from 10 families from LEWS and BANP. At least 2 species are new to science. The present work has revealed a total of 6 new records for LEWS in the areas of Sg. Mujok. Three other new records were from Sg. Katibas bringing the total fish list for LEWS to 96 species. For BANP, the total number of species to date is 63 of which 18 species are new records.

For both LEWS and BANP, the occurrence of bottom dwelling species outnumbers the mid-water level species. This is due to the topography of the area, i.e. upstream areas and the availability of the range of bottom habitat and relative good water quality of the water. Species of bottom dwellers are good indicators of water quality and are a potential for aquarium trade.

Competition for food and space between Semah (*Tor tambra)* and Adong (*Hampala bimaculata)* were observed in several streams in LEWS and also in BANP. When one encounters one particular species of a significant size, the other species will be smaller in size. Streams in Ulu Mujok and Lubang Baya have Adong dominating while at Batang Ai, Sg. Katibas and Sg. Bloh, Semah dominates. Another possible reason for the dominance of specific species would be the presence of raised waterfalls. Adong dominates in areas of relatively flat to gradual incline of streams and rivers, with either slow or fast flowing water while Semah in torrents and areas of raised waterfalls and rapids.

The famous food fishes i.e. Semah and Empurau, are currently plentiful from the waters of Ulu Sg. Katibas and Sg. Bloh but conservation efforts must be in place to ensure their survival and sustainability. Reducing fishing pressure as well as protecting their spawning ground are emphasized. Dialogues sessions with the local longhouse communities on the importance of the fish resources and joint cooperation to protect the tributaries are essential to achieve success.

In Ulu Sg. Mujok, Ulu Batang Ai and Ulu Lubang Baya, the sizes of the food fishes caught were relatively smaller than those found in Ulu Katibas. This could be attributed to the size of the river and the type of its stream bottom as well as the fishing pressure form local longhouse communities and outsiders. It is known that fishes that experience unpredictable environmental perturbations or disturbances will produce large number of offsprings to compensate for the high mortalities (Watson and Balon, 1983). This would bring about more competition for food thus reducing the size of the fishes.

The threats faced by the fish fauna in LEWS are mainly the siltation from the logging and shifting agriculture activities. The threats observed for BANP include over fishing, release of exotic species and habitat loss from increased level of inundated waters of the artificial lake of the Batang Ai hydroelectric dam.

Conservation efforts for indigenous fish fauna should include habitat protection, protection of spawning ground, placing of signboards along boundaries in designated streams, the strict enforcement of the mesh size of cast-nets and gillnets, closed fishing season and induced spawning of major food fishes in hatcheries to produce fish fries for rearing activities.

The culture of indigenous fish by the local longhouse communities should be encouraged and extended to other longhouses. Government agencies such as Agriculture Department and Forestry Department should continue to participate to provide support.

7.0 RECOMMENDATIONS

1. Systematic fish fauna collection should be an on-going activity in LEWS and BANP as many other areas are still unexplored. Studies on stream characteristics and their chemical components as well as the physical parameters should also be implemented concurrently with the fish resource survey.

2. There is a need to make available data on fish fauna of LEWS and BANP generated by taxonomists, field managers and biologists. This will ensure that the information generated, skills learned and technical know how can be shared, upgraded and improved.

3. Active work on the taxonomic description of new species should be pursued especially those from LEWS and BANP. Currently there has been a lack in the publication of fish species from Sarawak and Borneo.

4. A fish resources monitoring program should be initiated in areas where heavy fishing pressures are observed. The monitoring program can document the number of fishermen entering the TPAs, the amount of catch, the species caught as well as the natural breeding seasons of the economically valuable species.

5. An indigenous fish-spawning program should be set up. It is crucial that this breeding program be implemented as soon as possible as the demand for indigenous fishes in both rural and urban areas have risen significantly. With the new facilities at Ng. Bloh Ranger Station, it will be possible for the program to be implemented and for researchers to base their work in LEWS. The availability of good water and pristine forest in the area will enable the program to have a high probability of success.

6. Over-fishing within the Sanctuary and National Park should be strongly discouraged. Any method of fishing should be disallowed within the TPA. The privileges granted to the local communities living adjacent to the Sanctuary and National Park to fish is recognized but proper monitoring and control should be carried out. The Forestry Department must ensure that the privileges should not be abused.

7. The on-going Nature Interpretation Programs conducted by the Forest Department should include educational as well as awareness modules on indigenous fishes in the area. This can be implemented through constant local dialogues, hands on training, talks, visits, as well as through printed media. This program will be invaluable, and any actions and program implemented by the Forestry Department or any agency would need the support of the local communities. The level of awareness on the fishes especially their need for undisturbed spawning grounds and proper fishing period will be enhanced with this program.

8. Training opportunities e.g. field experimentation, field surveys and monitoring program, data collection, systematic and taxonomy and conservation biology, nature interpretation and environmental education should be expanded to rangers from various levels and officers within the Forest Department. This will enhance and improve their commitment and dedication towards the conservation of indigenous fishes of Sarawak.

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APPENDIX 1:
Plates of Fishes found in LEWS and BANP

Plate 1: Adong, *Hampala macrolepidota*

Plate 2: Bangah, *Puntius banksi*

Plate 3: Bangah, *Puntius binotatus*

Plate 4: Bantak Burung, *Osteocheilus waandersii*

Plate 5: Bantak, *Osteocheilus hasseltii*

Plate 6: Bantak, *Osteocheilus microcephalus*

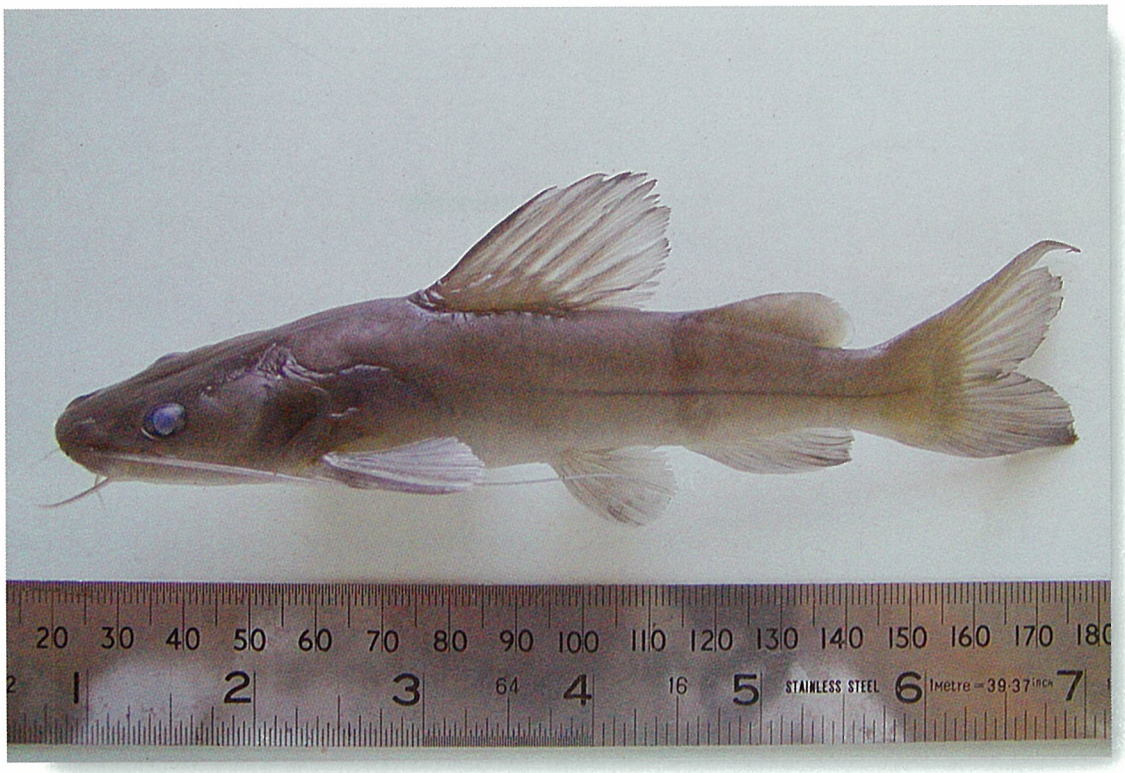


Plate 7: Baung, *Hemibagrus nemurus*

Plate 8: Baung, *Hemibagrus planiceps*

Plate 9: Boeng, *Cyclocheilichthys apogon*

Plate 10: Buntal, *Chonerhinus nefastus*

Plate 11: Empurau, *Tor tambroides*

Plate 12: Semah, *Tor tambra*

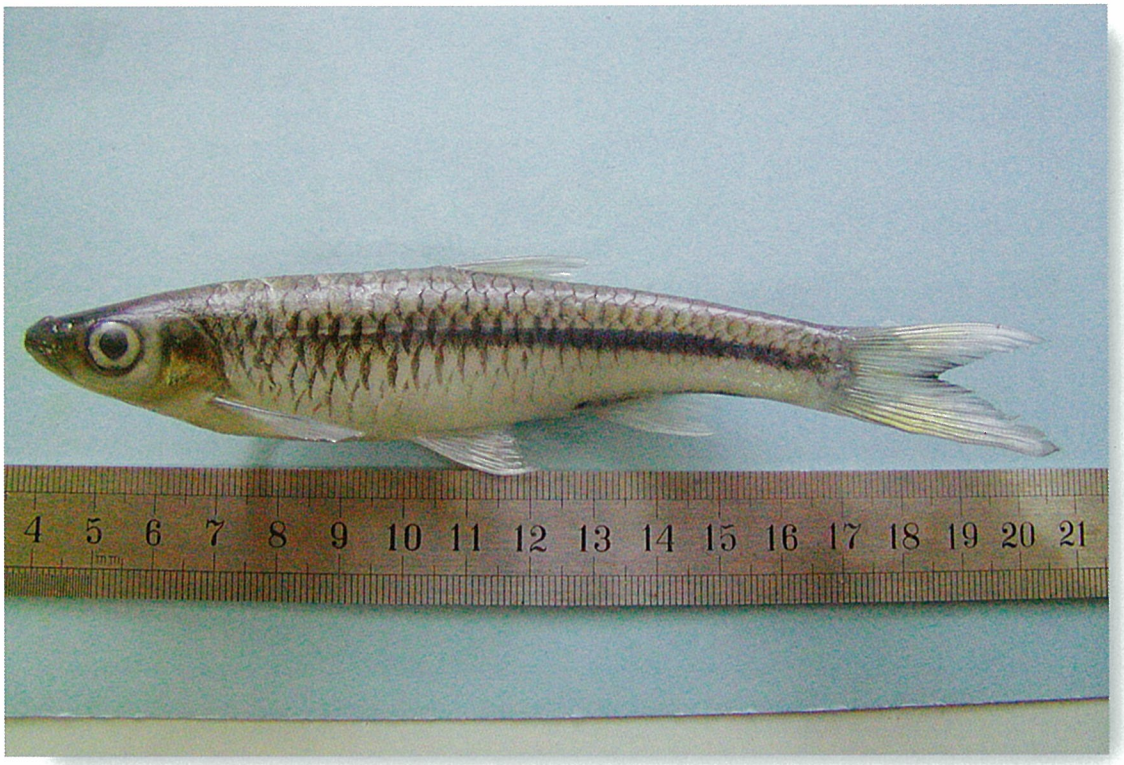


Plate 13: Enseluai, *Rasbora lateristriata*

Plate 14: Enseluai, *Rasbora sarawakensis*

Plate 15: Enseluai, *Rasbora volzi*

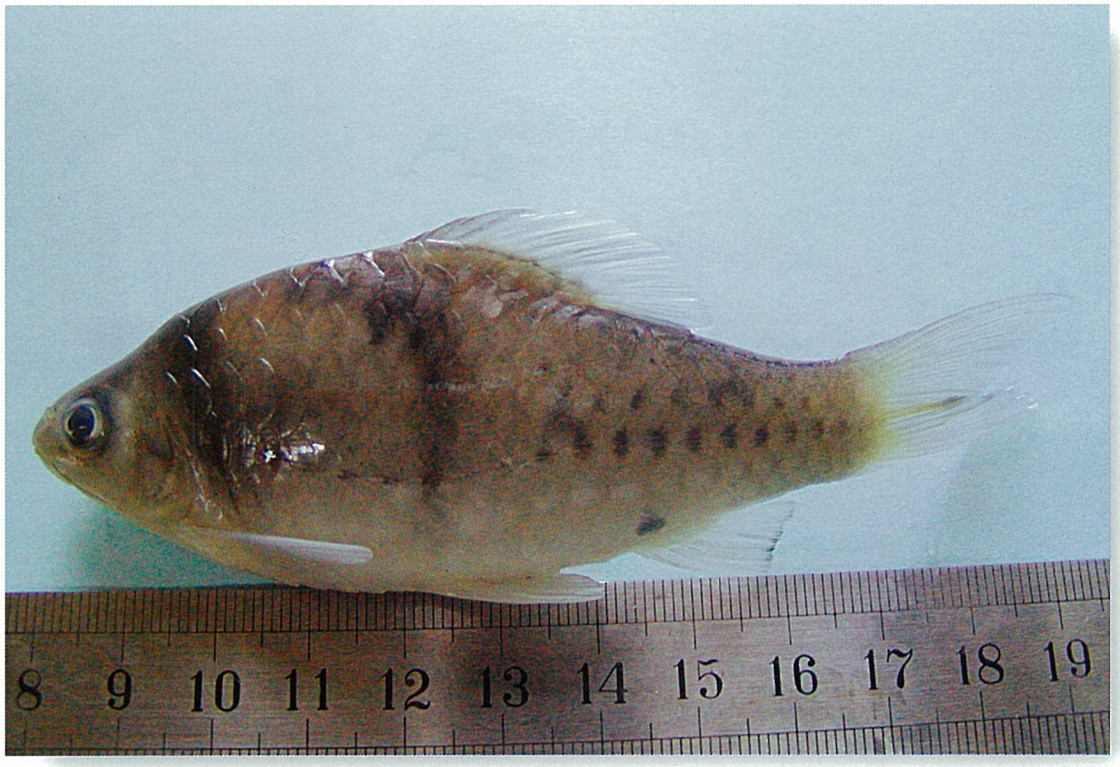


Plate 16: Entabalang, *Puntius kuchingensis*

Plate 17: Entabuluh, *Oxygaster anomalura*

Plate 18 : Gerigit, *Glyptothorax platypogon*

Plate 19: Juak, *Hampala bimaculata*

Plate 20: Keli,*Clarias teijsmanni*

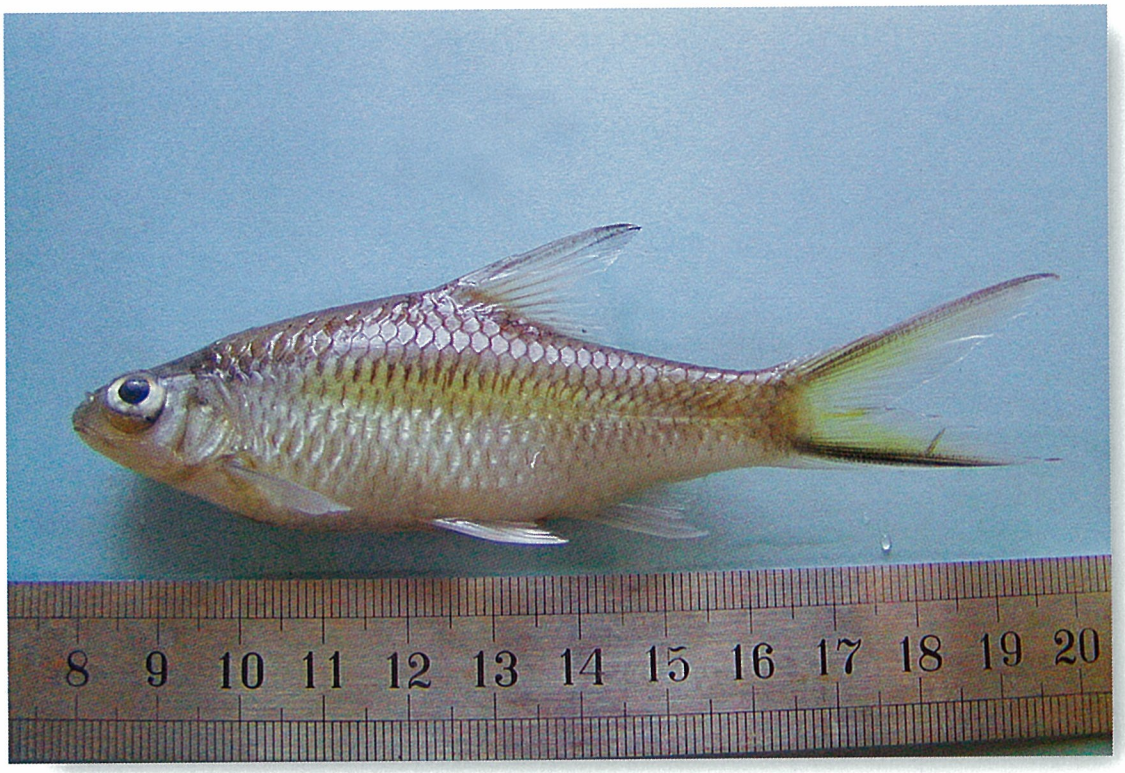


Plate 21: Kepiat, *Puntius collingwoodii*

Plate 22: Kulong Manang, *Paracrossocheilus acerus* (above) and *Paracrossocheilus vittatus* (below, with distinctive horn structure on snout)

Plate 23: Kulong, *Lobocheilus bo*

Plate 24: Kulong, *Lobocheilus hispidus*

Plate 25: Lelekat, *Gastromyzon contractus*

Plate 26: Lelekat, *Gastromyzon fasciatus*

Plate 27: Lelekat, *Gastromyzon fasciatus* (live specimen)

Plate 28: Lelekat, *Gastromyzon* sp. nov. (dorsal view)

Plate 29: Lelekat, *Gastromyzon* sp. nov. (ventral view)

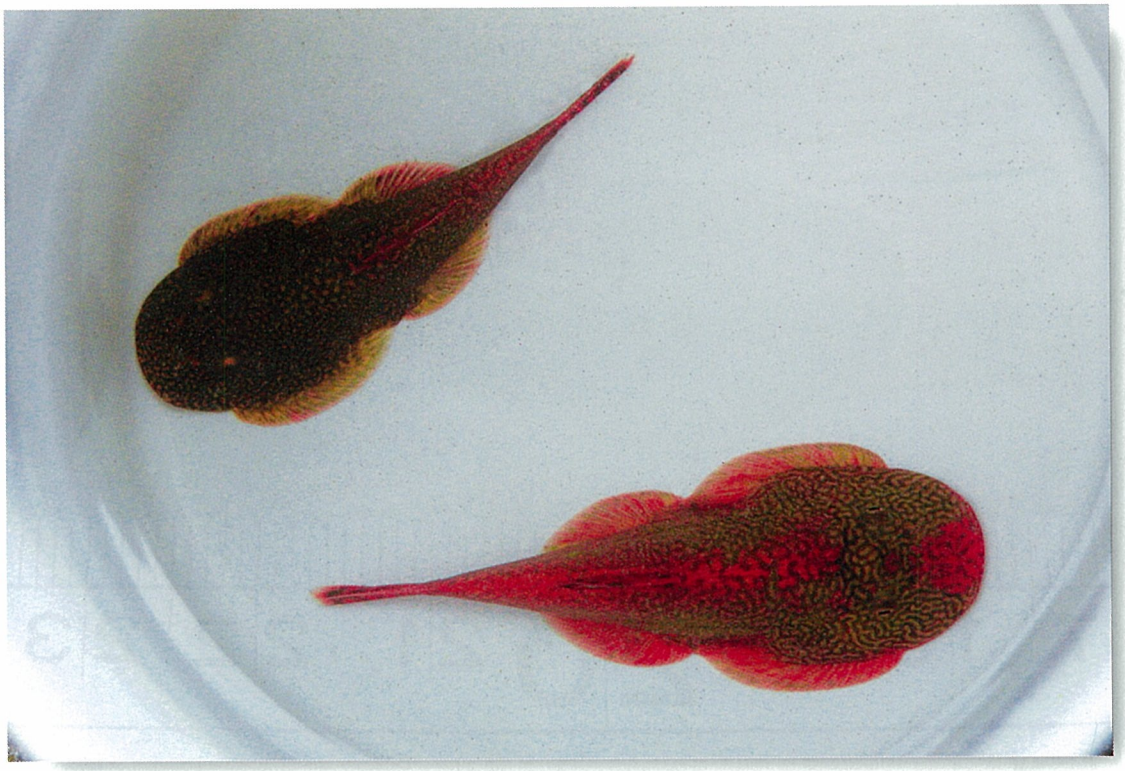


Plate 30: Lelekat, *Gastromyzon* sp. nov. (live specimen)

Plate 31: Lelekat, *Homaloptera nebulosa*

Plate 32: Lelekat, *Homaloptera orthogonionata*

Plate 33: Lelekat, *Homaloptera stephensonii*

Plate 34: Lelekat, *Homaloptera wassinkii*

Plate 35: Lelekat, *Homaloptera sarawacensis*

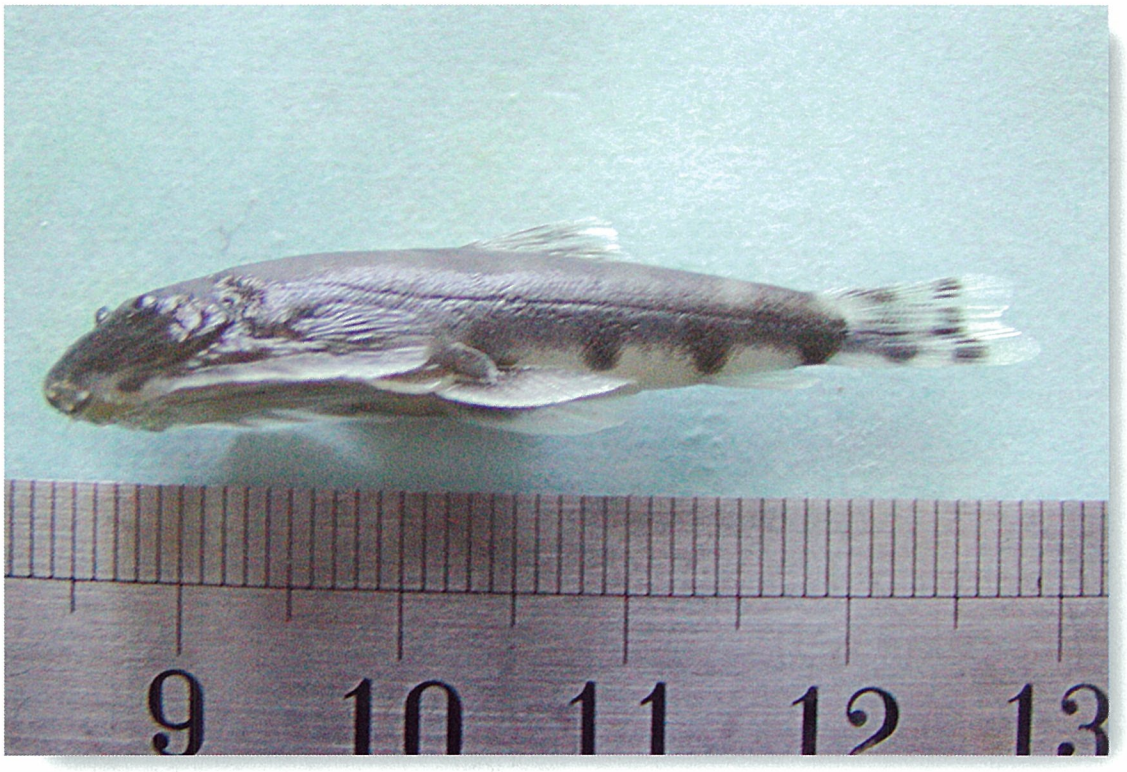


Plate 36: Lelekat, *Neogastromyzon niewenhuisi*

Plate 37: Mulau, *Leiocassis micropogon*

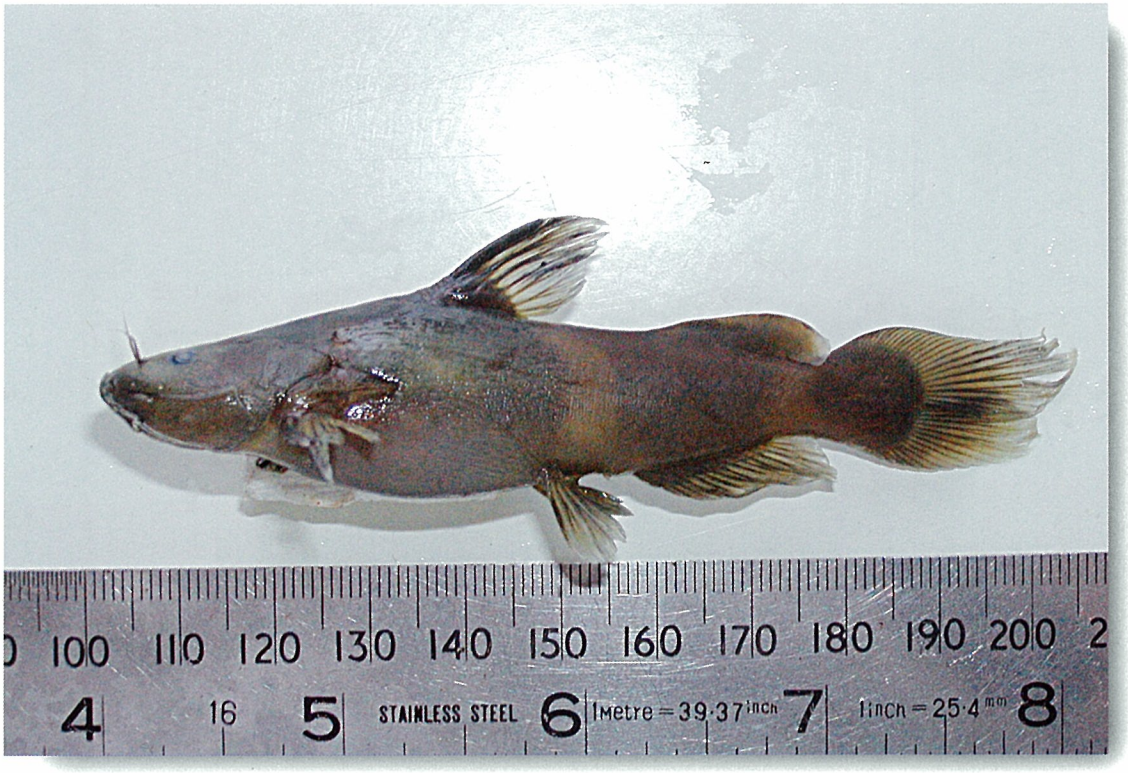


Plate 38: Mulau, *Leiocassis poecilopterus*

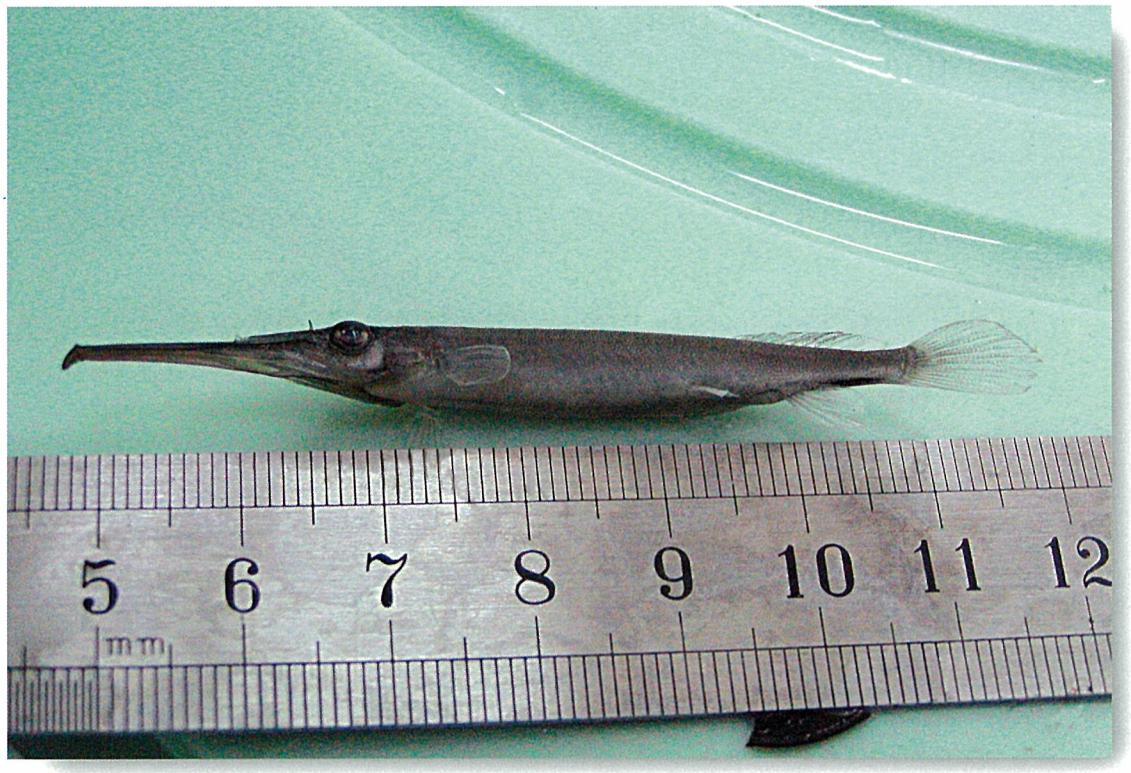


Plate 39: Nyulong, *Hemirhamphodon kuekenthalli*

Plate 40: Palau, *Osteocheilus kahajanensis*

Plate 41: Pipefish, *Xenentodon canciloides*

Plate 42: Pipefish, *Xenentodon canciloides* (Head View)

Plate 43: Pipefish, *Xenentodon canciloides* (Tail view)

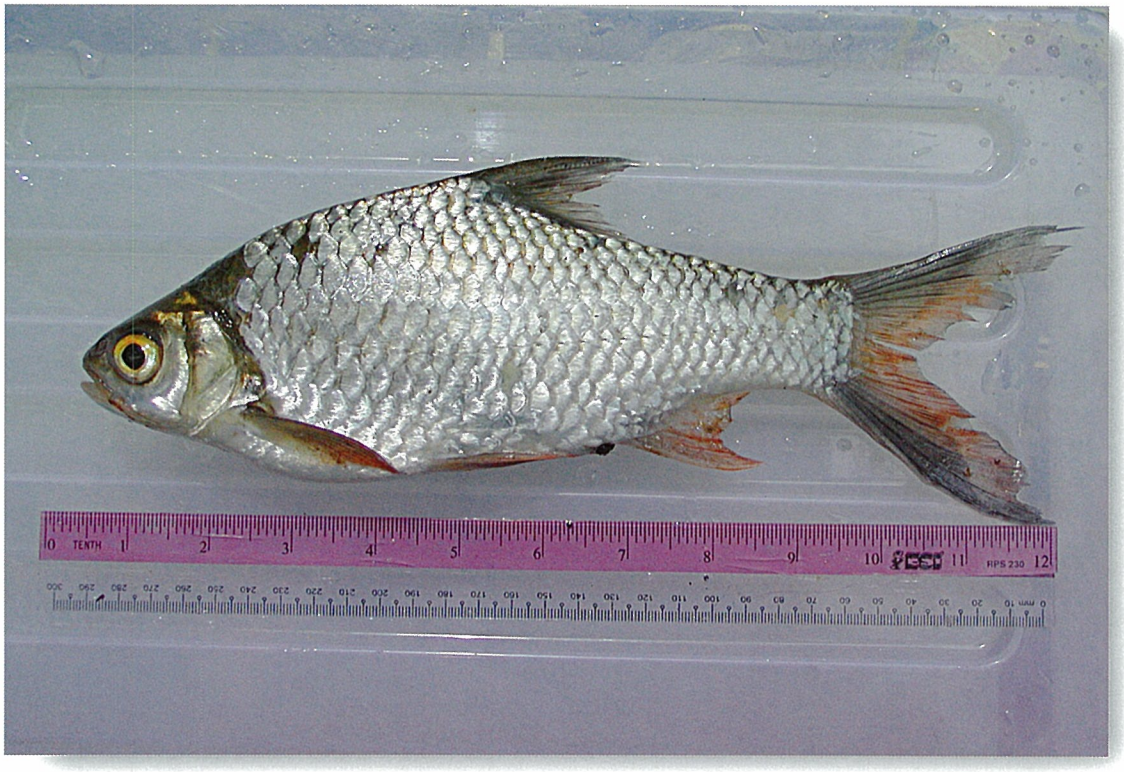


Plate 44: Tengadak, *Barbodes schwanenfeldii*

Plate 45: Tilan, *Macrognathus aculeatus*

Plate 46: Tilan, *Mastacembelus unicolor*

Plate 47: Tubercles of the genus *Lobocheilus*

Plate 48: Udon, *Channa lucius* (Adult)

Plate 49: Udon, *Channa lucius* (Juvenile)

Plate 50: Electrofishing in slow flowing streams

Plate 51: Electrofishing in moderate flowing streams

Plate 52: Electrofishing in torrents

Plate 53: Manual catching of *Gastromyzon* in Ulu Katibas

Plate 54: Rearing of fishes in cages at Ng Delok, Batang Ai National Park

Plate 55: Sungai Katibas

Plate 56: Sungai Pantu, tributary of Batang Ai

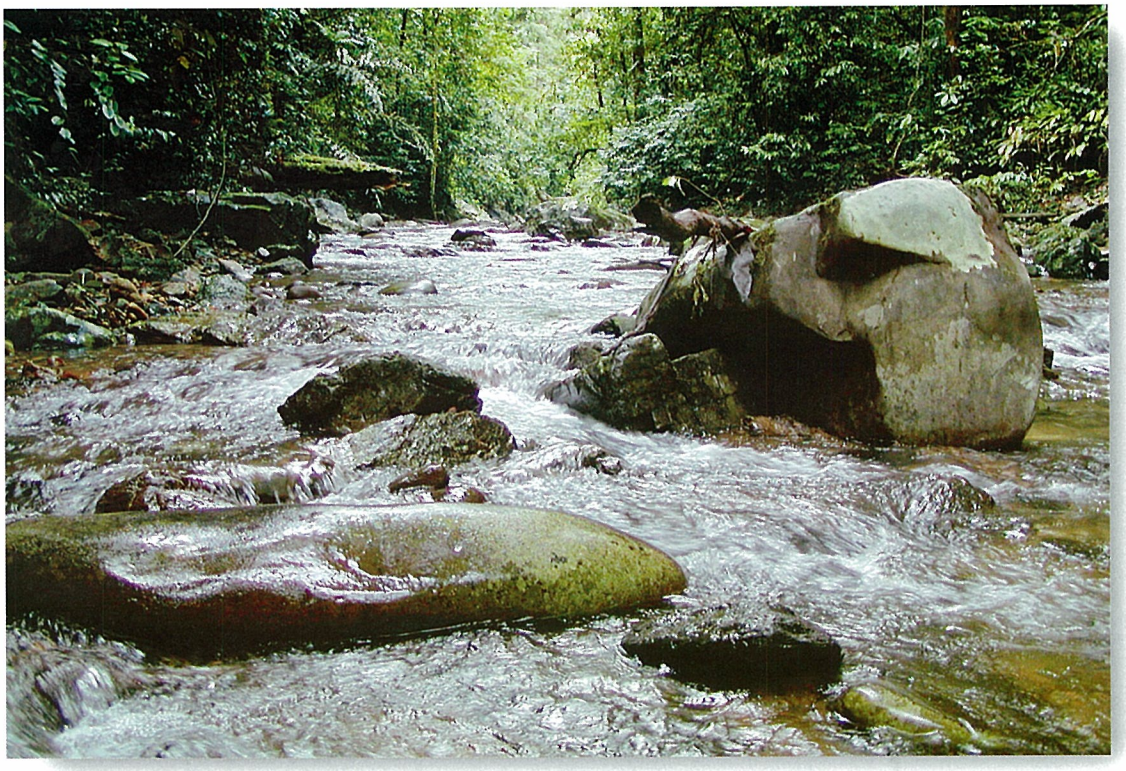
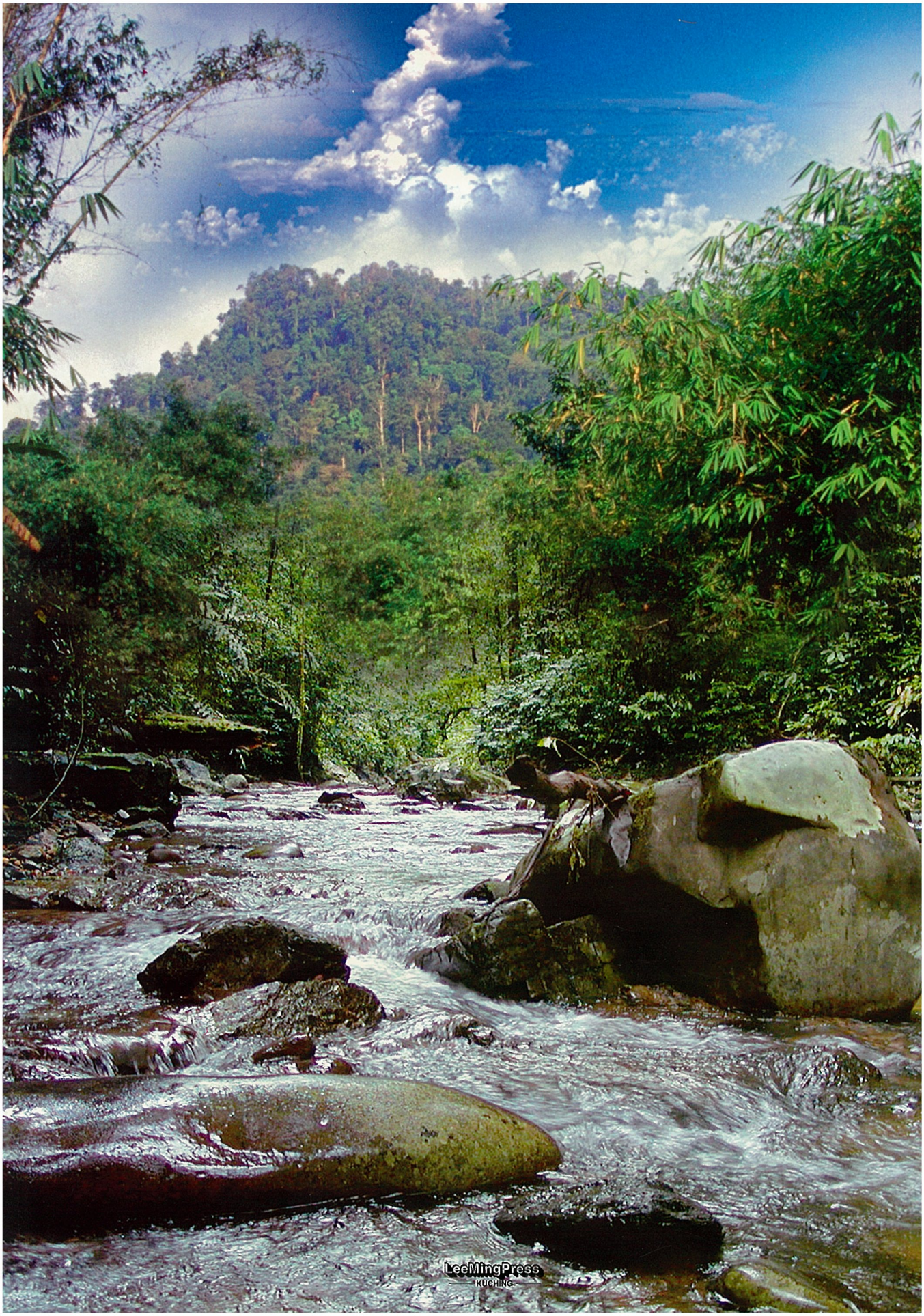


Plate 57: Sungai Takai, tributary of Sungai Katibas

Plate 58: Sungai Spuna Ili, tributary of Sungai Mujok

Plate 59: Sg Bloh

Plate 60: Sungai Engsanga, tributrary of Sg Lubang Baya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