A First Look at the Fish Species of the Middle Malinau

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A preamble regarding CIFOR's work in Malinau

The Malinau area of East Kalimantan (Borneo) was until recently little known biologically. It was suspected that the rugged and forested landscape, next to the Kayan Mentarang National Park, would have a high value in terms of its plants and animals. A major emphasis for CIFOR's research has been to document this biological wealth. This research has had three major components:

1. Finding out what occurs and where;
2. Assessing to whom it matters and in what way; and
3. Identifying what steps are needed to maintain this biota in the future.

Together, these three strands of information help define priorities that reflect local considerations and can inform a wide range of processes, from the development of reduced impact logging guidelines to international forestry and conservation policy. The account of fish reported here provides information relevant to each of these strands by combining an extensive field study with an evaluation of local views and practices, as well as some review of what is know about the vulnerability and sensitivity of each species. Using available reference material and knowledge helps provide a body of information that is available to guide management (for a fuller discussion of this philosophy see Sheil and van Heist 2000). It is however, the second aspect - what matters and how priorities are established - that has been so overlooked in earlier environmental science. Therefore, we will briefly introduce this topic.

There is an increasing appreciation of environmental values, including biodiversity, and their role in maintaining human well-being and economic development. Under Article 7 of the Convention on Biological Diversity, for example, signatory countries must assess and monitor their biodiversity. Despite these developments, there is little general guidance - or practical consensus - on how to proceed. The academic approach to surveys has generally been to match very specific methods to very specific questions. However, the most obvious and urgent practical questions have been too broad and multifaceted for such clear resolution. One such question, which we consider here, is 'how can we find out what we should know to make better decisions about tropical forest landscapes?' Following CIFOR's goals, we emphasize biodiversity, forest dependent people and the environment.

Much of the global concern about tropical rainforests derives from fears of major impending extinctions. Considerable efforts have focused on identifying the most important sites for protection or sensitive management. Biodiversity surveys have become a major preoccupation of conservation agencies and are increasingly included in impact assessments. However, the information generated by these efforts remains less influential than many would wish. In many tropical forest countries, the opportunity costs of large-scale conservation are considerable and local people frequently have other priorities. The notion that 'every species must be maintained at all costs' is thus a view irrelevant to many key decision makers.

Local decisions can only balance 'biodiversity' goals with other demands if the values and preferences of local stakeholders, especially forest dependent communities, are addressed.

Local decision makers are not the only agents of landscape changes we need to consider: outsider-led interventions can also lead to major changes for local people and the environment. Indeed, from a rural perspective, a town-based official may be viewed as much of an 'outsider' as an overseas funding agency or a foreigner-led research project. For many stakeholders, especially commercial enterprises, such as timber concessionaires and mining companies, their preferences and motivations are relatively clear and easily communicated and understood. But, when rural communities with strong indigenous cultures are considered, their needs and perceptions remain hidden to most outsiders unless a specific effort is made to uncover them.

Is there a solution to this problem? Ideally, detailed knowledge would be gained through intimate personal knowledge, but few decision makers are willing to live for long periods in the communities they will influence. What is needed is a practical method or, indeed, a suite of methods, that can reduce the understanding gap and provide a comprehensible summary of what actually matters locally. Such a approach could also determine what is important, to whom, how much, and why, as well as a means to make these local values and preferences more understandable and relevant to the decision making process.

CIFOR research is thus committed to developing an emerging paradigm in biodiversity research that fits these key objectives. Its goal is to record and assess the biophysical environment while building clear links to the needs and priorities of key stakeholders. For CIFOR, the key stakeholders are often the poor and forest dependent people that are often neglected in national development strategies. Such knowledge helps identify the priorities and needs of local stakeholders, and identifies priorities for both effective interventions and further research.

Douglas Sheil - CIFOR, Bogor, Indonesia

Introduction

Logging, agriculture, and activities like road construction have led to increased sedimentation, siltation, and decreasing water quality in numerous rivers around the world (Alabaster & Lloyd 1981; Rivier & Seguier 1985; Scarbovick 1993; Moring *et al*. 1995). This is obviously of some concern when considering the status of fish populations, since increased suspended sediment can adhere to gill tissue and lead to respiration difficulties, with subsequent gill abrasion leading to pathogenic penetration. Suspended sediments also decrease phytoplankton, attached algae, and rooted aquatic vegetation. In addition, settled sediment may impair reproduction by inhibiting egg respiration and increasing incubation periods. Finally, according to Moring *et al*. (1995), logging activity not only increases sediment load but also increases water temperature, which in turn decreases dissolved oxygen content.

Indonesia is one of the richest centres of biodiversity in the world, and Kalimantan is categorised as having one of the highest levels of biodiversity in the seven bio-geographic regions of the Indonesian Archipelago (Ministry of National Development Planning 1992). Nevertheless, knowledge of freshwater fish diversity in the Kalimantan is still largely incomplete (Kottelat 1994).

The purpose of this study was to prepare an initial checklist of the fish in the area bordered by the Seturan and Rian rivers. This list was to be annotated with special reference to the habitats each species is found in, and an assessment of which species have importance in local communities – and for what reasons.

The Malinau Research Forest

Location

The focal area of this research is located in the Indonesian province of East Kalimantan on the island of Borneo. The lowland rainforests on the island of Borneo are globally important for their high species richness and endemism (MacKinnon *et al*. 1996). The Malinau region is part of the last relatively intact contiguous large scale forest cover in Borneo.

When CIFOR was established in 1993, the Indonesian Government committed itself to providing a forest area where CIFOR could conduct long-term research. An area in East Kalimantan was finally selected and named Malinau Research Forest (previously Bulungan Research Forest). The area is about 3 degrees north of the equator in a block 2º45' to 3º21' North and 115º48' to 116º34' East, adjacent to the Kayan Mentarang National Park and lies in the heart of the largest more or less continuous area of rainforests remaining in tropical Asia (more than 5 million ha encompassing parts of Central and East Kalimantan, Sarawak and Sabah) (see Figure 1)[1].

The Malinau watershed in Northeast Kalimantan is essential for local communities both as a source of food and as a means of transport. The Malinau river eventually joins the Mentarang river and becomes the Sesayap river, which empties into the Celebes Sea, a volcanic rift that falls on the Wallace line. The two main rivers sampled in this study (Seturan and Rian rivers) belong to the Malinau watershed.

[1] Sungai is the Indonesian term for river and is abbreviated to "S" (e.g. S. Temalang = Sungai Temalang).

Much of the Malinau area is covered by timber concessions. The principle study area is located within a 48,000 ha forest concession managed by INHUTANI II, a state-owned timber company. The climate is equatorial. Annual rainfall is c. 4,000 mm. The topography is deeply eroded with a dense network of steep ridges and drainage gullies. Soils are derived principally from alluvial deposits and sedimentary rocks. Altitudes in the main study area where surveys have been conducted range from 100 to 700 m above sea level.

Fish are important to local people

A parallel study performed by CIFOR that asked and rated the importance of all animal and plant species with seven different communities on the upper Malinau (see Sheil 2002; Sheil *et al*. 2003a, b, c) noted that fish (when considered as a category) came at number 12 on a list of most important animal "species" for all uses (Sheil *et al*. unpublished data) – however, these assessments included communities with easy access to other sources of wild meat, and the data strongly suggests that fish become more important as access to forest areas become more limited. Fish actually ranked at four (after gaharu and two timber species) as the most important species for selling. Remarkably they were not mentioned amongst the top ten most important species for food by any informants. They ranked at 11. In any case, staying for any length of time with these communities makes it clear that much fishing is done and much of the catch is eaten. It was the inability of this larger study to access information on fish – its field based

Figure 1. Sampling stations of fish study in Malinau Research Forest and adjacent areas

sampling and overly broad question focusing on vegetation in general and forests in particular – that encouraged CIFOR to consider a more specific study of fish.

Area surveyed and weather conditions during survey

The first survey, in 1999, sampled 46 stations, 12 of which were located in plots affected by logging. Sites covered the Seturan and Rian rivers and 14 of their tributaries (including Korok, Biyo, Lirung, Ulet, Lit, Belakau, Kenowan, Melalat, Temalang and Bengahau). To add variability to the overall samples, the second survey in 2000 encompassed several new stations in addition to stations sampled during the first survey. This included a relatively undisturbed stream with a coal layer bank (Todok river), streams with past logging activities (Uping and Nguhai rivers), recently disturbed streams (unnamed stream passing through plot 45, upper part of Bengahau river) and a spring (often referred as a salt spring (*mata air asin*)) habitat (Kenowan river). The listing and description of sampled stations are given in Appendix 1[2].

The 1999 survey was undertaken from 15-27 November and 6-12 December during the rainy season, which was marked by particularly heavy rainfall (>300 mm/month). In the morning of 20 November 1999 the water level of Seturan river rose up about 1.5 m and flooded the Seturan village. The second survey was carried out from 30 October to 27 November 2000. During the beginning of the second survey rainfall was less frequent and water levels were generally lower than for the 1999 survey. One tributary of Menalat river had no water at all and a large pond in the RKT[3] 1996/1997 area was very shallow. However, by 23 November heavy rains started causing a 1.5 m rise of the Seturan river. These climatic differences were important because variations in water level between samplings might account for some of the differences noted between the 1999 and 2000 surveys.

[2] Because field naming of the various sampled stations was not consistent between 1999 and 2000 - creating some confusion during the preliminary analyses - we gave a 'unified' identification code for each sample.

[3] RKT = Rencana Kerja Tahun (Work Plan Year)

Material and Methods

Community-based survey

A total of 22 people from three villages (Seturan, Langap and Loreh) were interviewed in order to ascertain indigenous knowledge of freshwater fish. These interviews were conducted using participatory methods, which involved showing photographs of 45 fish species and asking interviewees to rank fish species according to which were the most abundant in their catches, most abundant in their diet and which were the most preferred food species. The interviewees were also asked to list the local medicinal uses of each fish. These scoring approaches drew on parallel surveys simultaneously being applied for terrestrial resources in CIFOR's more vegetation oriented surveys (see Sheil 2002; Sheil *et al*. 2003a, b, c). An additional survey examined the role of amphibians and reptiles (Iskandar 2004).

Field-based survey

Sampling stations were 50 meter-long segments of river or stream[4] where fish were gathered. In both stream and river sites, electric fishing (10 A, 12 V) was used for one hour per station for each survey. The results were recorded as "Catch Per Unit of Effort" (CPU) (Kallemeyn & Novotny 1977). In river sites the use of electric fishing was supplemented with a cast net (2.6 m long and 2.5 cm mesh) which was cast ten times per station per survey. Some specimens of catfishes were also obtained from ponds using hooks and lines. In addition, catches of Punan fishermen were used as samples.

The physical and chemical parameters of the rivers (dissolved oxygen, pH, water temperature and conductivity) were measured at six different points for each sample site using a Kagaku Kit - UC Series Type. Depth, width, substrate, bank height, canopy coverage, water velocity and clarity were also recorded. Silt depth was measured in several logged sites (plots 27, 29, 32 and RKT 1996/1997 in 1999; and plots 27, 29, the mouth of Temalang river and the upper part of Bengahau river in 2000).

Collected fishes and shrimps were fixed in the field using 5-10% formaldehyde; for fishes larger than 10 cm, this solution was injected. On arrival at the laboratory of the Research Center for Biology (LIPI) in Bogor, the specimens were washed and transferred into 70% alcohol. The specimens were then measured using criteria described by Hubbs and Lagler (1974).

Species identification was based on the key identification series outlined by Weber and de Beaufort (1913, 1916, 1922), de Beaufort and Briggs (1962), Inger and Chin (1962), Chin (1990) and Kottelat *et al*. (1993). Comparisons of the current collection with specimen types available in Museum Zoologicum Bogoriense (MZB) were also conducted. Information on the geographic distribution or range of a species was gathered from Kottelat *et al*. (1993), Kottelat and Whitten (1996), Haryono (1992), and Tan and Wowor (2000). Collections were later added into the permanent collection of MZB.

[4] 'River' is used to denote the mainstream of the Seturan and Rian rivers, while 'stream' is used for their various tributaries.

Results and Discussion

Water quality

The water velocity in the sampling localities varied from slow to fast. The average dissolved oxygen content ranged from 6.30 to 8.34 mg/L, average pH ranged from 6.81 to 7.09 and average water temperature ranged from 25.26 to 27.30º C (see Table 1a & b).

Over the course of the two-year survey, there were seven (unaveraged) records of sites with low oxygen levels, ranging from 1.97 to 3.58 mg/L. Such low dissolved oxygen content might be a limiting factor for fish life. According to Sylvester (1958) and NTAC (1968) in Wardoyo (1978), a dissolved oxygen content of 4 mg/L is the threshold for good fisheries activity and fish survival. The number of fish collected at these sites did not confirm this theory, with the exception of still water sites like the ponds (plot 45 and RKT 1996/1997) and the spring (*mata air asin*) with 0, 1 and 1 species respectively.

In most of the logged plots, water quality parameters such as dissolved oxygen and water temperature (Table 2a & b) did not appear to be the limiting factors for fish survival, except for pond of RKT 1996/1997 in 1999 survey, the dissolved oxygen content (3.15 mg/L) was lower than the threshold value for good fishery activity and fish survival.

For logged-over stations, the turbidity ranged from 2.50-37 NTU (Nephelometric Turbidity Unit); while TSS (Total Suspended Solid), which ranged from 9-70 mg/L (Table 2a & b), depended largely on the amount of time since the plot had been logged or the presence of active logging activities upstream. The highest TSS, 70 mg/L, occurred in Seturan river about 50 m downstream of RKT 2000/2001, a site which was being logged during our 2000 survey. However these TSS levels still fall below 80 mg/L. According to Alabaster and Lloyd (1981) anything over 80 – 400 mg/L of TSS may not support good fisheries. Siltation was evident in logged plots and ranged in depth from 20.29 to 43.37 cm (Table 2a) [5].

Interestingly, plots[6] logged a few years ago did not show any residual evidence of turbidity above recommended levels for good fisheries. This indicates that water quality may partially recover (in terms of clarity and low siltation) following logging (Table 2a), but could equally reflect the lower water levels during the survey period.

In conclusion, overall water quality parameters are generally within the acceptable range for fish survival even in logged-over areas.

Uses by and views of local people

Food

Fish are an important element of local diets, along with bearded pig (*Sus barbatus)*, Sambar deer (*Cervus unicolor)*, domesticated pig (*Sus scrofa)*

[5] Plot 29, with a siltation depth of 40.17 cm might receive silt particles from the discharged silt of plot 27, located upstream.

[6] Plots 27, 29, and 32.

Table 1. Summary of water quality parameters of the four main studied rivers and tributaries

a) 1999 survey

Water Quality Parameters	Temalang	Seturan (upstream)	Seturan (downstream)	Rian
Number of station	4	11	4	14
pH	6.97 ± 0.12	7.00 ± 0.08	6.95 ± 0.08	7.08 ± 0.13
Temperature (°C)	26.31 ± 0.82	26.01 ± 0.84	25.26 ± 0.32	25.89 ± 0.96
Dissolved oxygen (mg/L)	8.34 ± 0.79	7.30 ± 1.04	NA	8.21 ± 1.54
Conductivity (2mS/cm)	0.118 ± 0.017	0.051 ± 0.018	0.064 ± 0.007	0.061 ± 0.030
Velocity (m/sec)	0.49 ± 0.17[1] 0.30 ± 0.02[2]	0.68 ± 0.26[1] 0.32 ± 0.07[2]	0.27 ± 0.07[1]	0.86 ± 0.14[1] 0.60 ± 0.23[2]
Water colour	Clear	Clear	Clear	Clear to turbid
Bank vegetation	Primary forest	Primary forest	Current *ladang* (agriculture)	Young *jekau* (fallow), old *jekau*, current *ladang* (agriculture) & primary forest

b) 2000 survey

Water Quality Parameters	Temalang	Seturan (upstream)	Seturan (downstream)	Rian
Number of station	5	11	4	21
pH	7.04 ± 0.22	7.09 ± 0.15	6.81 ± 0.09	6.86 ± 0.21
Temperature (°C)	25.68 ± 1.04	25.92 ± 1.19	27.30 ± 0.82	26.41 ± 1.18
Dissolved oxygen (mg/L)	6.33 ± 2.17	7.33 ± 0.73	6.82 ± 1.46	6.30 ± 1.91
Conductivity (2mS/cm)	0.106 ± 0.010	0.058 ± 0.020	0.070 ± 0.007	0.075 ± 0.030
Velocity (m/sec)	0.57 ± 0.04[1]	0.46 ± 0.38[1] 0.53 ± 0.08[2]	0.56 ± 0.20[1]	0.51 ± 0.20[1] 0.42 ± 0.14[2]
Water colour	Clear	Clear	Clear	Clear-turbid
Bank vegetation	Primary forest	Primary forest	Primary forest	Varied: from *jekau* to primary forest

[1] Measured in the main stream
[2] Measured in the tributaries

and chicken. Twenty-two villagers (Punan, Merap and Kenyah) were interviewed to ascertain the most commonly caught fish, the most commonly eaten fish and the most preferred fish (Table 3a, b & c). They recognised a total of 45 different fish species.

In the three surveyed communities: the most commonly caught fish are *Hemibagrus* cf. *nemurus, Osphronemus septemfasciatus, Barbodes* cf. *balleroides, Barbodes* sp. and *Rasbora caudimaculata;* the predominant fish in the diet are *Pangasius* sp., *Barbodes* sp., *Tor tambroides*, *Barbodes* cf. *balleroides* and *Ompok bimaculatus*; and the most preferred fish are *Pangasius* sp., *Tor* spp., *Neogastromyzon nieuwenhuisii*, *Leptobarbus melanotaenia* and *Osphronemus septemfasciatus*. Not surprisingly, these species, with the exception of *Neogastromyzon*, have large individuals with relatively few bones[7].

Differences in fishing equipment depend on the species sought and the gender of the person fishing. In general men who look for larger fishes during the beginning of the rainy season will use gill nets, cast nets and spears (*tumbak*). Women will primarily fish for smaller species[8] during the dry season using dip nets and sometimes traps. It was also rumored that some people catch fish using potash, an activity much more destructive and prohibited by law; therefore, never openly acknowledged.

People almost always fish only for their own domestic consumption. However, some fishes fetch good market prices and are; therefore, also fished for sale. *Tor tambroides* has a good market price,

[7] There are, of course, exceptions: *Hampala macrolepidota* is often large (up to 47 cm total length), but is regarded as tasteless, and thus less widely consumed.

[8] *Garra borneensis*, *Gastromyzon* spp. and *Neogastromyzon nieuwenhuisii*.

Table 2. Summary of water quality parameters of streams/rivers passing through the Reduced Impact Logging (RIL) and Conventional Logging (CL) areas

a) 1999 survey

Water Quality Parameters	Plot 27	Plot 29	Plot 32	Pond RKT 1996/1997	Seturan river (RKT 2000/2001)
Number of stations	4	2	3	2	1
pH	6.73 ± 0.12	6.99 ± 0.07	7.08 ± 0.11	6.78 ± 0.09	6.90 ± 0.01
Temperature (°C)	25.53 ± 0.32	24.98 ± 0.25	25.69 ± 0.53	26.95 ± 0.28	25.62± 0.07
Dissolved oxygen (mg/L)	7.66 ± 0.59	7.48 ± 0.58	7.97 ± 0.61	3.15 ± 0.64	8.03 ± 0.49
Conductivity (2mS/cm)	0.011 ± 0.000	0.012 ± 0.000	0.040 ± 0.000	0.029 ± 0.000	0.062 ± 0.000
Velocity (m/sec)	0.34 ± 0.07	0.31 ± 0.02	0.39 ± 0.05	NA	1.14 ± 0.05
Water colour	Muddy	Muddy	Muddy-clear	Muddy	Clear
Turbidity (NTU)	21	NA	30	37	24
TSS (mg/L)	20	NA	40	28	70
Siltation (cm)	35.60	40.17	20.29	43.37	0.00

b) 2000 survey

Water Quality Parameters	Plot 27	Plot 29	Plot 32	Pond RKT 1996/1997	Seturan river (RKT 2000/2001)
Number of stations	3	2	3	2	1
pH	6.98 ± 0.09	6.91 ± 0.10	6.76 ± 0.26	6.98 ± 0.10	7.13 ± 0.01
Temperature (°C)	25.05 ± 0.55	24.73 ± 0.10	25.62 ± 0.54	33.67 ± 0.34	25.22 ± 0.14
Dissolved oxygen (mg/L)	7.06 ± 0.76	7.61 ± 0.32	7.66 ± 0.63	4.33 ± 0.72	6.95 ± 0.30
Conductivity (2mS/cm)	0.015 ± 0.010	0.010 ± 0.000	0.080 ± 0.030	0.050 ± 0.000	0.076 ± 0.000
Velocity (m/sec)	0.37 ± 0.09	0.53 ± 0.08	0.49 ± 0.00	NA	0.74 ± 0.05
Water colour	Clear[1]	Clear[1]	Clear[1]	Muddy	Clear-Turbid
Turbidity (NTU)	NA	NA	2.5	NA	16.0
TSS (mg/L)	NA	NA	9.0	NA	53.0
Siltation[2]	Not significant	Not significant	Not significant	Present	Not significant

[1] Water was clear though rain occurred the night before sampling
[2] In some areas (plot 27 and plot 32) rocky substrate was covered by green algae but thin siltation (5-15 cm deep) remains at the bank of the stream

averaging Rp7,000/kg, with a relatively wide market in the surrounding area. During the dry season, the migratory and hence seasonally scarce *Pangasius* species are widely fished with individuals selling for Rp15,000/kg. Such a high value, of course, increases demand for these species beyond subsistence levels.

The most consumed or preferred fish species are also disconcertingly low in abundance and in frequency of occurrence (Table 4). Though there is little information on the fecundity, growth rates or habitat preferences of most of these species other than *Tor* spp., the combined high demand and apparent low abundance suggests that these fishes could be potentially vulnerable or threatened. The community members have already noted that *Pangasius* sp. and *Tor* spp., two the most widely preferred fish species, are becoming rare in the Seturan watershed.

Comprehensive data on the abundance and variation of these high value species through routine monitoring would be valuable to ensure that population numbers are kept in check. Also, since information on the population dynamics, life cycle, and ecology of these species is not well known, research on this matter would be of invaluable assistance for future monitoring efforts.

Other uses

Some fish are believed to have medicinal values. For example, eating *Clarias anfractus* is believed to help a woman physically recover from childbirth, while powder made from the spiny pectoral fin of *Hemibagrus* cf. *nemurus* is used to relieve toothache. Fat from the second dorsal fin of *Hemibagrus* can be applied to ease any wound caused by its spiny pectoral fin. In addition, the macerated flesh of *Puntius* sp. is believed to ease the sting of a caterpillar when applied to the inflamed skin.

Table 3. Catch, diet and preferred species

- Three questions were asked in our survey: 1) which is the most common fish caught, 2) which is the most commonly eaten, and 3) which is the most preferred.
- For each question, respondents were asked to distribute 100 seeds among the various fish species randomly listed, according to their importance.
- The average scores are the mean number of the total seeds for each fish divided by number of respondents.

a) Seturan community[1]

Rank	Catch (Fishes Species)	Average Score	Diet (Fishes Species)	Average Score	Preferred food (Fishes Species)	Average Score
1.	*Hemibagrus cf. nemurus*	10.14	*Pangasius* sp.	13.00	*Tor tambroides*	19.33
2.	*Osphronemus septemfasciatus*	10.00	*Barbodes* cf. *balleroides*	11.66	*Leptobarbus melanotaenia*	14.71
3.	*Barbodes* cf. *balleroides*	9.80	*Tor tambroides*	11.50	*Osphronemus septemfasciatus*	11.71
4.	*Barbodes* sp.	9.60	*Ompok* cf. *bimaculatus*	11.00	*Pangasius* sp.	10.66
5.	*Rasbora caudimaculata*	9.00	*Leptobarbus melanotaenia*	10.70	*Hemibagrus* cf. *nemurus*	10.60
6.	*Leptobarbus melanotaenia*	8.28	*Barbodes* sp.	10.00	*Lobocheilus* cf. *bo*	10.33
7.	*Tor tambroides*	8.00	*Hemibagrus* cf. *nemurus*	10.00	*Barbodes* sp.	9.40
8.	*Clarias anfractus*	7.60	*Osphronemus septemfasciatus*	9.30	*Barbodes* cf. *balleroides*	8.60
9.	*Gastromyzon* cf. *lepidogaster*	7.33	*Cyclocheilichthys armatus*	9.16	*Osteochilus waandersii*	8.00
10.	*Mastacembelus* cf. *maculatus*	7.25	*Parachela ingerkongi*	8.60	*Ompok bimaculatus*	7.33
			Gastromyzon sp.	8.00	*Mastacembelus maculatus*	7.33
			Homaloptera stephensoni	8.00		

[1] In Seturan three men and five women, ranging from 20 to 55 years old, were interviewed. At the time of the interview all eight were still active in farming and fishing. The interview was held on 23 November 2000.

b) Langap community[2]

Rank	Catch (Fishes Species)	Average Score	Diet (Fishes Species)	Average Score	Preferred Food (Fishes Species)	Average Score
1.	*Barbodes* cf. *balleroides*	8.37	*Barbodes* sp.	12.10	*Pangasius* sp.	32.50
2.	*Barbodes* sp.	7.50	*Barbodes* cf. *balleroides*	11.40	*Tor tambroides*	16.60
3.	*Leptobarbus melanotaenia*	6.30	*Cyclocheilichthys armatus*	10.40	*Osphronemus septemfasciatus*	13.70
	Tor tambroides	6.30				
4.	*Pangasius* sp.	6.10	*Hemibagrus* cf. *nemurus*	10.00	*Leptobarbus melanotaenia*	13.40
5.	*Hemibagrus baramensis*	6.00	*Lobocheilus* cf. *bo*	8.90	*Tor tambra*	11.00
6.	*Nematabramis everetti*	5.20	*Hemibagrus baramensis*	8.80	*Hemibagrus* cf. *nemurus*	8.50
7.	*Osphronemus septemfasciatus*	5.10	*Leptobarbus melanotaenia*	7.70	*Clarias anfractus*	8.30
8.	*Lobocheilus* cf. *bo*	4.80	*Pangasius* sp.	6.70	*Lobocheilus* cf. *bo*	8.00
9.	*Garra borneensis*	4.30	*Tor tambroides*	6.30	*Cyclocheilichthys armatus*	7.00
10.	*Cyclocheilichthys armatus*	4.14	*Trichogaster trichopterus*	6.20	*Hemibagrus baramensis*	6.70

[2] In Langap four men and four women, ranging from 20 to 55 years old, were interviewed. At the time of the interview all eight were still active in fishing. The interview was held on 18 November 2000.

c) Loreh community[3]

Rank	Catch (Fishes Species)	Average Score	Diet (Fishes Species)	Average Score	Preferred Food (Fishes Species)	Average Score
1.	*Rasbora caudimaculata*	7.00	*Clarias anfractus*	10.00	*Tor tambroides*	15.15
					Neogastromyzon nieuwenhuisii	15.15
2.	*Tor tambroides*	6.75	*Ompok bimaculatus*	9.00	*Pangasius* sp.	14.75
3.	*Leptobarbus melanotaenia*	6.66	*Hemibagrus baramensis*	8.25	*Anguilla nebulosa*	11.00
4.	*Clarias anfractus*	4.75	*Clarias anfractus*	7.66	*Gastromyzon* sp.	10.00
5.	*Lobocheilus* cf. *bo*	4.60	*Glyptothorax platypogonoides*	7.50	*Leptobarbus melanotaenia*	9.75
	Pangasius sp.	4.60	*Lobocheilus* cf. *bo*	7.50		
6.	*Hemibagrus* cf. *nemurus*	4.00	*Barbodes* cf. *balleroides*	7.33	*Trichogaster trichopterus*	9.00
	H. baramensis	4.00			*Ompok bimaculatus*	9.00
	Barbodes sp.	4.00			*Clarias anfractus*	9.00
	Anguilla nebulosa	4.00				
	Channa sp.	4.00				
7.	*Nematabramis everetti*	3.80	*Hemibagrus* cf. *nemurus*	7.00	*Hemibagrus* cf. *nemurus*	7.75
	Osteochilus waandersii	3.80			*Hemibagrus baramensis*	7.75
8.	*Cyclocheilichthys repasson*	3.50	*Pangasius* sp.	6.60	*Parhomaloptera microstoma*	7.00
9.	*Puntius* sp.	3.40	*Neogastromyzon nieuwenhuisii*	6.50	*Lobocheilus* cf. *bo*	6.33
10.	*Glyptothorax platypogonoides*	3.25	*Tor tambra*	6.00	*Nemachilus spiniferus*	6.00

[3] In Loreh, four men and two women, ranging from 20 to 65 years old, were interviewed. At the time of the interview four of them

Table 4. Some favorite species and their abundance in the samples

Species	Indonesian Name	Maximum Size: Weight and Standard Length	Abundance Number of individual (% of total number)		Occurrence[1] (%)	
			1999	2000	1999	2000
Barbodes cf. *balleroides*	Tawes	0.1 kg 18 cm	38 (2.36)	57 (5.55)	15.56	24.14
Barbodes sp.	Tawes	- 9 cm	2 (0.12)	10 (0.97)	4.44	8.62
Hampala macrolepidota	Hampal	- 47 cm	45 (2.79)	27 (2.63)	40.00	27.59
Leptobarbus melanotaenia	Jelawat	1.0 kg 34 cm	14 (0.87)	3 (0.29)	17.78	1.72
Osphronemus septemfasciatus	Gurami	4.1 kg 65 cm	2 (0.12)	0 (0)	4.44	0
Tor tambra	Kancra Sungai	2.6 kg 52 cm	17 (1.05)	12 (1.17)	15.56	8.62
Tor tambroides	Kancra Sungai	2.5 kg 62 cm	1 (0.06)	8 (0.78)	2.22	1.72
Lobocheilus cf. *bo*	Purot	0.3 kg 25 cm	12 (0.74)	1 (0.10)	13.33	1.72

[1] Number of stations where the species is recorded/Total number of stations

Field sampling

Diversity

Over the course of the surveys, 47 species belonging to 32 genera, 13 families and 3 orders were identified in the Seturan watershed (Table 5). The most common families are Carp (Cyprinidae), Hill-stream loach (Balitoridae) and Bagrid catfish (Bagridae) accounted respectively for 68%, 10.63% and 6.38% of the samples. Despite the thoroughness of the sampling, seasonal variation is not well reflected. At least one important genus (*Pangasius*) caught and sold by the local community members was not represented in our sample, as it is a migratory fish that only inhabits the Seturan river during the dry season.

New forms, perhaps new species, of *Puntius* and *Gastromyzon* were discovered during this survey from the Seturan and Rian rivers. In addition, the survey has extended the known range of several species: *Anguilla nebulosa, Neogastromyzon nieuwenhuisii, Protomyzon griswoldi, Nemacheilus selangoricus, Nemacheilus spiniferus, Nemacheilus saravacensis, Nematabramis everetti* and *Osphronemus septemfasciatus,* none of which were previously known to occur in the Seturan river area.

There was no significant differentiation between the fish fauna of the upper and lower parts of the Seturan watershed. The upper part of the watershed was found to have 43 species, while the lower part had 41 species. The actual difference in the species composition between upper and lower rivers seems based on habitat preferences. *Pangio anguilaris, Parhomaloptera microstoma* and *Nemacheilus spiniferus* were only found in fast flowing waters up-river, while *Ompok sabanus* and *Trichogaster trichopterus* were found in muddy waters down-river. However, given the low numbers of individuals involved, this apparent difference should be considered with caution.

A comparison of the present survey with previous ones (Table 6) carried out in similar environments confirms its quality. The most thorough of the previous surveys (Martin-Smith & Hui 1998) shows similar species, genus and family numbers. It seems therefore reasonable to consider that we have now a comprehensive list of the fish fauna of the Seturan catchment.

The complete description of the collected taxa can be found in the Appendix 2 of this report.

Protected species

No species with a formal protected status were found during the survey. As a result of their low reproductive rates and intense local harvesting, *Leptobarbus* spp. and *Tor* spp. deserve careful monitoring (Kottelat *et al*. 1993). It is also important to note that the law prohibits export of individuals less than 5 mm of *Anguilla nebulosa* and *A. borneensis* (Tjakrawidjaja 2001).

Restricted range species

Fifteen of the 47 collected species (32%) have a narrow distributional range: *Garra borneensis, Hemibagrus baramensis, Puntius sealei, Nematabramis everetti, Parhomaloptera microstoma, Protomyzon griswoldi, Leptobarbus melanotaenia, Homaloptera stephensoni, Betta unimaculata*, *Gastromyzon* cf. *lepidogaster, Gastromyzon* sp., *Neogastromyzon* cf. *nieuwenhuisii*, *Clarias anfractus, Awaous* sp. and *Ompok sabanus.* The two genera *Gastromyzon* and *Neogastromyzon* are endemic to Borneo.

Species potentially vulnerable to logging

Several of the surveyed species present specific auto-ecological or biological features that might be of importance in the context of existing logging or coal-mining operations in the region.

Since demersal species live on or near the river bottom and feed on benthic organisms, they could be affected by excessive siltation created by logging infrastructure (culverts, river crossing by heavy equipment, etc.). Eels (*Anguilla*), spiny eels (*Mastacembelus, Macrognathus*), Bagrid or Sisorid catfish and hill-stream loach (*Gastromyzon, Neogastromyzon*, etc.) are all demersal fishes.

Among the demersal species, some have a special apparatus to fix themselves on substratum (rocks, boulders, logs, etc.) in fast flowing waters. A flattened ventral surface and down-turned mouths to graze algae characterise these species. Generally grouped under the generic names of "hill-stream loaches" or "sucker-belly fishes", they belong to three families and are not all loaches:

- Balitoridae (genera *Gastromyon, Homaloptera, Neogastromyzon, Parhomaloptera, Protomyzon*). These are the "true" hill-stream loach. As the name implies, these fishes come from fast flowing streams and rivers. There are dozens of species that range throughout most of Southeast Asia. They have adapted to these fast, turbulent waters by developing suction mechanisms in their bellies and fins, and down-turned mouths to graze the algae beds found there.
- Cyprinidae (genus *Garra*). Species of this genus include *G. borneensis*, one of the most abundant species in our survey, and are often referred to as "stone-lapping minnows" because of an upper-lip modified into a suctional disk.
- Sisoridae (Sisorid catfishes). The only one of these species found in our survey, *Glyptothorax*

Table 5. Summary of the species collected during 1999 and 2000 surveys of the Seturan watershed

No	Species	Distribution	Local Name			English Name
			Merap	Kenyah	Punan	
1	*Anguilla malgumora*	Up & Lp	Telakai	Telakai	Telakai	Freshwater eel
2	*Anguilla nebulosa*	Up & Lp	Telakai	Telakai	Telakai	Freshwater eel
3	*Awaous* sp.*	Up & Lp	Tawo	Ait	Baluh	Goby
4	*Barbodes* cf. *balleroides*	Up & Lp	Hala	Salap Merah	Alap	Barb
5	*Barbodes* sp.	Up & Lp	Hala	Salap Putih	Alap	Barb
6	*Betta unimaculata*	Up	-	Madang	-	Fighting fish
7	*Channa* cf. *lucius*	Up	Dung	Udun	Udun	Snake-head fish
8	*Clarias anfractus*	Up & Lp	Tun	Kati	Utet	Walking catfish
9	*Cyclocheilichthys armatus*	Up & Lp	Turui	Turing	Turing	-
10	*Cyclocheilichthys repasson*	Up & Lp	Turui	Turing	Turing	-
11	*Garra borneensis*	Up & Lp	Paha	Lemak	Ruam	Stone lapping fish
12	*Gastromyzon lepidogaster*	Up & Lp	Kat	Leket	Leket	Hill-stream loach
13	*Gastromyzon* sp.	Up	Kat	Leket	Leket	Hill-stream loach
14	*Glyptothorax platypogonoides*	Up & Lp	Kuyung	Kuyut	Kuyun	Sucking catfish
15	*Hampala macrolepidota*	Up & Lp	Lungau	Baling	Sunau	Silver and red barb
16	*Hemibagrus baramensis*	Up & Lp	Tikien	Teliken	Cike	Bagrid catfish
17	*Hemibagrus* cf. *nemurus*	Up & Lp	Tikien	Teliken	Cike	Bagrid catfish
18	*Homaloptera stephensoni*	Up & Lp	Kat Blow	Leket Bulo	Rungan	Hill-stream loach
19	*Leiocassis* sp.	Up & Lp	Lucau	Lucau	Lucau	Bagrid catfish
20	*Leptobarbus melanotaenia*	Up & Lp	Hanyan	Sayen	Anyen	-
21	*Lobocheilos* cf. *bo*	Up & Lp	Paha	Pasa	Pa/Neha	-
22	*Macrognathus maculatus*	Up & Lp	Lan Kuai	Telan Kuai	La Kuai	Spiny eel
23	*Mastacembelus unicolor*	Up & Lp	Lan Kuai	Telan Kuai	La Kuai	Spiny eel
24	*Nemacheilus saravacensis*	Up & Lp	Tao	Lanya	-	Hill-stream loach
25	*Nemacheilus selangoricus*	Lp	Tao	Lanya	-	Hill-stream loach
26	*Nemacheilus spiniferus*	Up	Tao	Lanya	-	Hill-stream loach
27	*Nematabramis everetti*	Up & Lp	Lelapeh	Lepeh	Cipih	-
28	*Neogastromyzon nieuwenhuisii*	Up & Lp	Kat Blow	Leket Bulo	Leket	Hill-stream loach
29	*Ompok* cf. *bimaculatus*	Lp	Lao	Lao	Tukalo	Sheat fish
30	*Ompok sabanus*	Lp	Lao	Lao	Tukalo	Sheat fish
31	*Osphronemus septemfasciatus*	Up & Lp	Kaloi	Kaloh	Kaluh	Giant gouramy
32	*Osteochilus kahajanensis*	Up & Lp	Pao	Lemak	Pa	
33	*Osteochilus waandersii*	Up & Lp	Pao	Lemak	Pa	Black-banded Osteochilus
34	*Pangio anguillaris*	Up	-	Uak	-	Loach
35	*Parachela ingerkongi*	Up & Lp	Lelempau	Lepeh	Bacan Empu	-
36	*Parhomaloptera microstoma*	Up	Kat	-	Leket	Hill-stream loach
37	*Protomyzon griswoldi*	Up & Lp	Kat Blow	Leket Bulo	Rungan	Hill-stream loach
38	*Puntius binotatus*	Up & Lp	Kuamnie	Betutu Banga	Betutung	Spotted barb
39	*Puntius sealei*	Up & Lp	Lungo	Betutung	Betutung	Barb
40	*Puntius* sp.	Up & Lp	Hala	Kuamenyi	Bunau	Barb
41	*Rasbora argyrotaenia*	Up & Lp	Lalau	Lalang	Lalape	Silver rasbora
42	*Rasbora caudimaculata*	Up & Lp	Betelah	Beteloh	Beteluh	Greater scissortail
43	*Rasbora elegans*	Up & Lp	Lalau	Lalang	Lalape	Elegant rasbora
44	*Rasbora lateristriata*	Up & Lp	Hanyan	Beteloh	Beteluh	-
45	*Tor tambra*	Up & Lp	Perian	Padak	Tengah	Carp
46	*Tor tambroides*	Up & Lp	Perian	Padak	Tengah	Carp
47	*Trichogaster trichopterus*	Lp	Bacan Karok	Karok	Bacan Karok	Climbing perch

* Fish species added during 2000 survey

Up = upper part, Lp = lower part of Seturan watershed

Table 6. Summary of various fish survey in similar environments

Location	Species	Genera	Families	References
Sayap-Kinabalu Park (Sabah, Borneo)	12	7	2	Nyanti (1998)
Kinabalu Park (Sabah, Borneo)	22		5	Abdullah (1990)
Kinabalu Park (Sabah, Borneo)	32			Chin (1978)
Upper Segama river (Danum Valley Field Center, Sabah, Borneo)	47	35	12	Martin-Smith and Hui (1998)
Crocker Range National Park (Sabah, Borneo)	17	9	4	Rahim *et al.* (2002)
Crocker Range National Park (Sabah, Borneo)	10		4	Kavanagh (2002)
Kelabit Highlands (Sarawak, Borneo)	24	19	7	Nyanti (1999)
Seturan water catchment (East Kalimantan, Borneo)	47	32	13	This study

platypogonides, has a specialised adhesive apparatus made of smooth folded skin on its anterior flattened ventral fin that enables it to attach onto rocky surfaces.

Because of their very peculiar biology these species are likely to be vulnerable to increased siltation (destruction of the algae beds and inability to fix themselves onto rocky substrate).

Other potentially vulnerable species are the benthopelagic fishes that feed on micro-algae, diatoms (*Lobocheilos bo*, some *Osteochilus* sp., *Tor* spp.) or forest fruits and plants (*Leptobarbus melanotaenia, Tor* spp.). These fishes can be affected by a reduction in food availability following logging.

Abundance

A total of 1612 and 1027 individuals were caught in 1999 (46 stations) and 2000 (58 stations) respectively. Given the greater number of stations collected in 2000, this shows a sharp decrease in numbers from 1999 to 2000. This decrease is confirmed when comparing only the stations that were both sampled in 1999 and 2000 (37 stations): 1392 individuals in 1999 versus 714 in 2000. Some species have decreased in abundance by more than 80%: *Nemacheilus selangoricus* (37 to 2), *Mastacembelus unicolor* (34 to 2), *Lobocheilos* cf. *bo* (10 to 1), *Rasbora lateristriata* (25 to 3) and *Garra borneensis* (203 to 39); others have increased: *Puntius sealei* (13 to 23), *Leiocassis* sp. (5 to 10), *Macrognathus maculatus* (3 to 8), *Rasbora argyrotaenia* (5 to 21) or *Barbodes* sp. (2 to 10). These numbers, however, could be misleading because of the low number of individuals involved in several cases. We therefore examined if the presence of a species in the stations followed a similar or a distinct pattern to that revealed by abundance. Using only presence/absence data, the overall decreasing trend is confirmed, though somewhat differently for some species: some have sharply decreased in abundance and presence; others have sharply decreased in abundance but not in presence (e.g. *Garra borneensis* individuals dropped by 81% from 1999 to 2000 but presence dropped only by 27%).

It is difficult to explain such a trend with only two surveys. In a first approximation, the decrease could be linked with:

- the low level of water during the majority of the 2000 survey
- human disturbance

To account for the possible disturbance effect we compared the 27 stations that were measured in both years and that were not logged either before or during samplings. Ponds were also excluded as they are generally linked to obstruction of watercourses by logging infrastructures. Even in this case, the same level of decrease in numbers is observed: 1178 individuals collected in 1999 against 571 in 2000. Site-specific species like hill-stream or sucker belly loaches show a somewhat reduced decrease, especially in presence/absence, when using this sub-sample; indicating a possible confounding between logging and low water level effects.

It seems that the lower numbers in 2000 are likely linked to the low level of water or to inter-annual variations in populations rather than to human disturbance. This also implies that we can only readily compare disturbed/undisturbed sites within years without having to devise observation sampling regimes that can take account of temporal sources of variation.

Impacts of logging on fish fauna

Because of the preceding remark, we will study the impact of logging within a single year by comparing stations that were logged a few years before or during the survey and stations that have never been logged, excluding ponds, stations logged more than five years before the survey and specific habitats from the comparison. This gives us the following samples:

- For 1999: unlogged (32 stations), logged either before or during the 1999 survey (9 stations), ponds (4 stations)

- For 2000: unlogged (41 stations), logged either before or during the 2000 survey (10 stations), ponds (3 stations), special habitat (1 station – salt spring)

Comparisons of logged and unlogged stations

The comparison for 1999 (Table 7) shows a sharp difference in the number of potentially vulnerable species both in terms of abundance and presence in the stations. Hill-stream loach and other site-specific demersal species (*Gastromyzon* spp., *Garra borneensis*, etc.) seem the most affected but some benthopelagic herbivorous or frugivorous species (*Lobocheilos bo* and *Tor* spp.) appear absent in logged stations. The difference is less striking for the year 2000 but this may be because six of the studied stations were logged at the time of survey, making it too early to assess impacts. If we compare the areas unlogged in 2000 with the stations logged before the survey, then we find the same pattern as for 1999: smaller numbers and the presence of potentially vulnerable species.

These results are coherent with the life-history of the species present and with the few available published references (Martin-Smith 1998a, b). Given their low mobility, their sensitivity to siltation and their general abundance in undisturbed sites, the sucker-belly loaches (*Gastromyzon, Neogastromyzon, Protomyzon*) and the stone-lapping minnow (*Garra borneensis*) could be used as early warning bioindicators for monitoring logging impact.

Interestingly, *Awaous* sp., a species with a preference for brackish waters was collected in several recently disturbed areas (RKT 2000/2001 and INHUTANI). The banks of these sample plots had been converted into landing sites and were relatively open. Water quality measured in RKT 2000/2001 indicated that water temperature and conductivity was higher, whereas dissolved oxygen content was lower than before disturbance (Table 2a & b). A concurrent decrease of Ostariophysian fish[9] was detected in these logged localities (Table 7). While the presence of *Awaous* sp. might be due to the low water levels experienced during the 2000 survey, their invasion might also be an indicator of disturbed habitats. Monitoring is necessary to determine if *Awaous* sp. is really becoming dominant (following the theory of devoid niche, Myers 1951 *in* Inger and Chin 1962, and *in* Banarescu 1990). *Awaous* sp. is not found in Kayan Mentarang National Park, an undisturbed protected area (Haryono 1992, Tan & Wowor 2000).

Logging ponds

A very depauperate fauna characterises ponds and their outlets. Merging the results of the two surveys, a total of 16 species have been recorded from this type of environment (Table 8). All the vulnerable demersal species are absent except for one specimen of *Anguilla malgumora* at the outlet of one of the ponds. Some species appear, however, to be over-represented in ponds:

- In the 1999 survey: *Cyclocheilichthys armatus* (44% of the individuals were found in ponds), *Nemacheilus saravacensis* (36%), *Puntius sealei* (29%)
- In the 2000 survey: *Cyclocheilichthys armatus* (13% of the individuals were found in ponds), *C. repasson* (29%), *Nemacheilus saravacensis* (25%), *Puntius sealei* (31%)

Betta unimaculata seems to prefer outlets and is absent or rare in the ponds proper. This species is also the only one that was collected in the *mata air asin* station.

[9] Group consisting of the families: Cyprinidae, Bagridae, Cobitidae, Homalopteriidae, Gyrinocheilidae, Siluridae and Pangasidae.

Table 7. Comparison of fish abundance and occurrence between unlogged and logged stations in 1999

Species	Unlogged				Logged over			
	Individuals		Occurrence		Individuals		Occurrence	
	Number	%	Stations	%	Number	%	Stations	%
Nematabramis everetti	127	9.6%	23	71.9%	65	35.5%	9	100.0%
Osteochilus waandersii	146	11.0%	22	68.8%	8	4.4%	6	66.7%
Rasbora elegans	92	6.9%	17	53.1%	4	2.2%	2	22.2%
Hampala macrolepidota	43	3.2%	16	50.0%	1	0.5%	1	11.1%
Hemibagrus cf. *nemurus*	26	2.0%	16	50.0%	11	6.0%	7	77.8%
Mastacembelus unicolor	41	3.1%	15	46.9%	0	0.0%	0	0.0%
Garra borneensis	247	18.6%	14	43.8%	0	0.0%	0	0.0%
Gastromyzon sp.	131	9.9%	14	43.8%	0	0.0%	0	0.0%
Gastromyzon cf. *lepidogaster*	113	8.5%	14	43.8%	4	2.2%	2	22.2%
Nemacheilus selangoricus	31	2.3%	11	34.4%	2	1.1%	1	11.1%
Anguilla malgumora	19	1.4%	11	34.4%	5	2.7%	4	44.4%
Rasbora caudimaculata	21	1.6%	10	31.3%	23	12.6%	7	77.8%
Puntius sp.	18	1.4%	10	31.3%	2	1.1%	2	22.2%
Cyclocheilichthys armatus	22	1.7%	9	28.1%	2	1.1%	1	11.1%
Cyclocheilichhtys repasson	34	2.6%	8	25.0%	1	0.5%	1	11.1%
Puntius binotatus	21	1.6%	8	25.0%	12	6.6%	7	77.8%
Rasbora lateristriata	17	1.3%	8	25.0%	9	4.9%	4	44.4%
Homaloptera stephensoni	13	1.0%	8	25.0%	0	0.0%	0	0.0%
Barbodes cf. *balleroides*	38	2.9%	7	21.9%	0	0.0%	0	0.0%
Tor tambra	17	1.3%	7	21.9%	0	0.0%	0	0.0%
Glyptothorax platypogonoides	10	0.8%	7	21.9%	1	0.5%	1	11.1%
Parachela ingerkongi	13	1.0%	6	18.8%	1	0.5%	1	11.1%
Lobocheilos cf. *bo*	12	0.9%	6	18.8%	0	0.0%	0	0.0%
Leptobarbus melanotaenia	9	0.7%	6	18.8%	3	1.6%	1	11.1%
Ompok cf. *bimaculatus*	7	0.5%	6	18.8%	1	0.5%	1	11.1%
Leiocassis sp.	7	0.5%	6	18.8%	0	0.0%	0	0.0%
Nemacheilus saravacensis	7	0.5%	5	15.6%	0	0.0%	0	0.0%
Rasbora argyrotaenia	6	0.5%	5	15.6%	0	0.0%	0	0.0%
Neogastromyzon nieuwenhuisii	9	0.7%	4	12.5%	0	0.0%	0	0.0%
Hemibagrus baramensis	7	0.5%	4	12.5%	0	0.0%	0	0.0%
Puntius sealei	4	0.3%	3	9.4%	8	4.4%	4	44.4%

Table 8. Fish fauna in ponds

Species	Individuals in ponds		Individuals in total sample		%	
	1999	2000	1999	2000	1999	2000
*Cyclocheilichthys armatus**	19	2	43	16	44.2%	12.5%
Betta unimaculata	14	5	30	12	46.7%	41.7%
Nematabramis everetti	11	1	203	185	5.4%	0.5%
Puntius binotatus	7	6	49	28	14.3%	21.4%
Rasbora elegans	7	4	103	48	6.8%	8.3%
Rasbora caudimaculata	7		51	71	13.7%	0.0%
Puntius sealei	5	10	17	32	29.4%	31.3%
Puntius sp.	5		25	17	20.0%	0.0%
Nemacheilus saravacensis	4	2	11	8	36.4%	25.0%
Nemacheilus selangoricus	4		37	2	10.8%	0.0%
Hemibagrus cf. *nemurus*	2	1	39	18	5.1%	5.6%
Leptobarbus melanotaenia	2					
Nemacheilus spiniferus	2					
Anguilla malgumora	1					
Hampala macrolepidota	1					
*Cyclocheilichthys repasson**		11	31	38	0.0%	28.9%

* There is a possible taxonomic confusion between *Cyclocheilichthys armatus* and *C. repasson*

Conclusion

Seturan water catchment has high fish diversity (contained 47 fish species, 32 genera, 13 families and 3 orders) where these fishes are important to local people as food items, for sale and other purposes.

Local knowledge is clearly underlined by the fact that virtually all species recorded are known and distinguished by local informants.

Some species are vulnerable to local land-use changes (mainly sedimentation).

Properly planned logging activities and good fisheries appear possible at the same time.

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Appendix 1
List and description of sampled stations

Code	UTM	Description 1999	Description 2000
asin	50 N 444895 344103		Shore vegetation primary rain forest. Bank flat. Intermitten small stream. Bottom detritus, clay, woody debris and rock. Depth 0.2 m. Width ±1 m. Water clear.
bela1	50 N 442788 339608		At the mouth of the stream. Young jekau (±4 years old) at the left and the right (at this side mixed with plant crops such as cassava and bamboo). Bank steep, 1-2 m high. Width 4 m. Depth max 0.80 m. Bottom sand, clay and rock. Water turbid.
bela2	50 N 442716 339246		Ladang/padi tugal at the left, old jekau (±6 years old) at right. Bank flat. Bottom gravel and rock. Depth max 0.80 m. Water clear.
bela3	50 N 442716 339244		Old jekau (±6 years old) at the left and right. Up a waterfall of height ±4 m. Bank flat. Depth max 0.75 m. Width 4.5 m. Substrate gravel and rock. Water turbid.
belakau	50 N 445302 339186	Shore vegetation old ladang and primary rain forest. Width ±3 m. Banks steep 1-2 m high. Depth 0.2-0.3 m. Bottom clay, sand and gravel. Flow type riffles.	Shore vegetation shrub and primary rain forest. Bank steep 1-2 m high. Depth 0.2-0.3 m. Bottom sand, gravel rock and woody debris. Water clear.
beng1	50 N 445466 331758	Shore vegetation primary rain forest. Banks steep, ±3 m high. Width ±4.5 m. Depth max 0.20 m (±1 m deep at the mouth). Bottom gravel, rock, sand and woody debris.	Shore vegetation primary rain forest. Bottom sand, detritus and rock. Riffles and pool. Bottom at the mouth silt, sand and detritus. Width ±3.5 m. Depth max 0.72 m (at the mouth of this stream). Bank steep (±2-3 m high). Water clear.
beng2	Not available		Shore vegetation primary rain forest/Bina Benoa Co. camp. Pool and stagnant water. Width ±4.5 m. Bottom silt. Depth max 1 m. Water colour muddy.

biyo	50 N 444190 339889	Shore vegetation primary rain forest. Banks flat - steep, 1.5 m high. Width ±2 m. Depth max 0.4 m. Bottom rock, gravel, woody debris, log. Flow type pools and slowly moving water.	Shore vegetation primary rain forest. Bank flat - steep, ±5 m high. Width ±2-2.5 m. Depth max 0.30 m. Substrate sand, gravel and rock. Water clear.
cif1	50 N 445582 332121	Shore vegetation primary rain forest. Banks steep, 1.5-2 m high. Width 4-5 m. Depth max 0.4 m. Bottom clay, woody debris and log, sand, gravel.	Shore vegetation primary rain forest. At the mouth of the stream width ±4-5 m. Bank flat- steep, 2 m high. Bottom clay, sand and detritus. Depth max. 0.75 m. Water colour muddy.
cif2	50 N 445755 332093	Shore vegetation primary rain forest. Banks steep, 1.5-2 m high. Width 4-5 m. Depth max 0.4 m. Bottom clay, woody debris and log, sand, gravel.	Shore vegetation primary forest. Type of flow riffle and small pools. Width 2-4 m. Bottom sand, gravel and rock. Clay and detritus at the bank. Depth max 0.85 m. Water clear.
cif3	50 N 445755 332093	Shore vegetation primary rain forest. Banks steep, 1.5-2 m high. Width 4-5 m. Depth max 0.4 m. Bottom clay, woody debris and log, sand, gravel.	Shore vegetation primary forest. Type of flow riffle and small pools. Width 2-4 m. Bottom sand, gravel and rock. Clay and detritus at the bank. Depth max 0.85 m. Water clear.
kela	50 N 441400 338506		Old jekau (6 years old) mixed with crop planted at the left and the right. Bank flat. Width 4-5 m. Depth max 1.15 m. Substrate sand and clay. Water turbid.
ken1	Not available	Shore vegetation primary rain forest. Banks flat - steep. Width 5-6 m. Depth max 0.70 m. Bottom clay, silt, log, woody debris, rock and boulder. Type of flow pools and riffles.	Shore vegetation primary rain forest. Bank flat - steep. Width max 6 m. Depth max 0.95 m. Type of flow riffles and pools. Bottom detritus, clay, sand rock and boulder. Water colour muddy.
ken2	Not available	Shore vegetation primary rain forest. Banks flat - steep. Width 5-6 m. Depth max 0.70 m. Bottom clay, silt, log, woody debris, rock and boulder. Type of flow pools and riffles.	Shore vegetation primary rain forest. Bank flat - steep. Width max 6 m. Depth max 0.95 m. Type of flow riffles and pools. Bottom detritus, clay, sand rock and boulder. Water colour muddy.
kujau	50 N 444511 340369		Old jekau (8 years old) at the left and the right. Bank flat. Width ±2-3 m. Depth max 0.45 m. Substrate sand and sticky clay, which was ±60 cm deep. Water turbid.
kurok	50 N 444951 341001	Shore vegetation old ladang (jekau) and primary forest. Banks flat ±2 m high. Width ±1.5 m. Bottom clay, sand, gravel and woody debris.	Old jekau and primary rain forest. Bank steep, 2 m high. Width ±1.5-2 m. Depth max. 0.20 m. Substrate sand, gravel and rock. Water clear.
lirung	50 N 443321 340083	Shore vegetation current ladang and rice field. Banks flat ±2m high. Depth max 0.2 m. Width 2.5 m. Bottom sand, gravel and debris.	Old jekau (7-8 years old) and padi tugal at the left and the right. Bank steep, 2-3 m high. Width 2.5-3 m. Depth max 0.15 m. Substrate sand, rocks, woody debris. Water clear.
lit	50 N 443656 340353	Shore vegetation young jekau. Banks flat ±2 m high. Depth max ±0.5 m. Width ±3 m. Bottom clay and sand. Water colour brown.	Young jekau (4 years old) at the left and right. Bank flat, steep, 2 m high. Width 3 m. Depth max 0.60 m. Substrate clay and sand. Water colour turbid.
men1	Not available	Primary rain forest at the right and the INHUTANI Production camp at the left. Width 1-2 m. Water colour muddy. Depth ±0.2 m.	

men2	Not available	Open area within INHUTANI Production camp, near the bridge. Bank steep, 2-6 m high. Water colour muddy. Width 6-8 m. Bottom silt, clay, log and woody debris. Depth max 1.5 m.	Open area within INHUTANI Production Camp, near the bridge. Bank steep, 2-6 m high. Width ±6-8 m. Bottom silt, clay, sand and rock. Water colour muddy. Depth max 1.5 m.
men3	Not available		Primary rain forest. Width ±6-8 m. Bank steep (up to 4 m high). Bottom sand, rock and boulder. Depth max 0.75 m. Water colour muddy.
nguh	50 N 444895 344103		Shore vegetation shrub and primary rain forest of RKT 1992 (?). Width ±6 m. Depth 0.30 m. Bottom rock, sand and gravel. Silt covered the rocky substrate. Water turbid.
otl9697	50 N 445021 336082	Outlet of big pond. Depth max ±0.5 m. Bottom silt, logs, and woody debris. Water colour muddy.	Shore vegetation primary forest of RKT 1996/1997. Bank flat. Bottom clay and sand. Depth 0.10-0.15 m. Width 0.30-0.50 m. Water colour muddy.
p271	Not available	Shore vegetation primary rain forest (logged area). Banks flat - steep 2-6 m high. Width 2.5-4.5 m. Depth max ±0.3 m. Bottom rock, sand silt, logs, and woody debris. Riffles and pool.	Shore vegetation primary rain forest of RKT 1998/1999. Bank flat. Depth max 0.25 m. Width 4.5 m. Substrate gravel, rock (some were attached by green algae) and detritus. Water clear.
p272	50 N 445433 333208	Shore vegetation primary rain forest (logged area). Banks flat - steep 2-6 m high. Width 2.5-4.5 m. Depth max ±0.3 m. Bottom rock, sand, silt, logs, and woody debris. Riffles and pool.	Shore vegetation primary rain forest of RKT 1998/1999. Bank flat - steep, 6 m high. Depth max 0.80 m. Width 1.5-4.5 m. Substrate gravel rock, silt remain at the bank. Water clear.
p273	50 N 445433 333208	Shore vegetation primary rain forest (logged area). Banks flat - steep 2-6 m high. Width 2.5-4.5 m. Depth max ±0.3 m. Bottom rock, sand silt, logs, and woody debris. Riffles and pool.	Shore vegetation primary rain forest of RKT 1998/1999. Bank flat - steep, 6 m high. Depth max 0.80 m. Width 1.5-4.5 m. Substrate gravel rock, silt remain at the bank. Water clear.
p274	Not available	Shore vegetation primary rain forest (logged area). Banks flat. Width 4 m. Depth max ±0.3 m. Bottom clay, sand, gravel and loggs. Water color clear. In pool, water color muddy. Riffles and pools	
p291	50 N 445216 333324	Shore vegetation primary rain forest (logged area). Banks flat. Width ±3-4 m. Depth max ±0.75 m. Bottom rock, silt and logs. Water colour muddy. Riffles and pools.	Shore vegetation primary rain forest of RKT 1999. Bank flat. Depth max 0.75 m. Bottom clay, sand and rock. Water clear. Siltation (5-20 cm deep) remain at the bank.
p292	Not available	Shore vegetation primary rain forest (logged area). Banks flat. Width ±3-4 m. Depth max ±0.75 m. Bottom rock, silt and logs. Water colour muddy. Riffles and pools.	Shore vegetation primary rain forest of RKT 1999. Bank flat. Depth max 0.75 m. Bottom clay, sand and rock. Water clear. Siltation (5-20 cm deep) remain at the bank.
p321	50 N 450340 330114	Shore vegetation primary rain forest. Width ±4.5 m. Depth max ±0.80 m. Banks flat - steep (±10 m high). Bottom rock, boulders, silt and logs. Flow type small cascades, riffles and pools.	Primary rain forest of RKT 1999. Bank flat - steep, 10 m high. Width ±5 m. Depth max 0.40 m. Substrate rock and boulder. Silt remain at the bank.

p322	Not available	Shore vegetation primary rain forest. Width ±4.5 m. Depth max ±0.80 m. Banks flat - steep (±10 m high). Bottom rock, boulders, silt and logs. Flow type small cascades, riffles and pools.	
p323	Not available	Shore vegetation primary rain forest. Width ±4.5 m. Depth max ±0.80 m. Banks flat - steep (±10 m high). Bottom rock, boulders, silt and logs. Flow type small cascades, riffles and pools.	
p324	50 N 450340 330114	Shore vegetation primary rain forest. Width ±4.5 m. Depth max ±0.80 m. Banks flat - steep (±10 m high). Bottom rock, boulders, silt and logs. Flow type small cascades, riffles and pools.	Primary rain forest of RKT 1999. Bank flat - steep, 10 m high. Width ±5 m. Depth max 0.40 m. Substrate rock and boulder. Silt remain at the bank.
p325	50 N 450340 330114		Primary forest of RKT 1999. Bank steep, ±2 m high. Width ±3 m. Depth max 0.40 m. Bottom silt, rock and boulder (some of them were attached by green algae). Silt remain at the bank. Water clear.
p451	Not available		Shore vegetation primary forest of RKT 2000/2001. Width ±3 m. Bottom sand, gravel, rock and woody debris. Bank steep. Depth max 0.40 m. Water clear.
p452	Not available		Shore vegetation primary rain forest. Width ±6 m. Depth max 0.40 m. Bank steep, 3 m high. Substrate sand, gravel, rock and boulder. Water clear.
patak	Not available		Shore vegetation young jekau (5 years old) mixed with *padi tugal*. Width 3-4 m. Depth max 0.85 m. Bottom clay and sand. Water color turbid. Slowly moving water and stagnant water at the mouth.
pnd27	Not available	At the side of the road (±200 m from plot 29, on direction to the CIFOR camp). Open area. Shallow. Water clear. Bottom sand, clay, woody debris and logs.	
pnd45	50 N 450340 330117		Ponding with area 5 x 12 m². At the logging road. Bottom sticky clay and sand. Water turbid, milkish. Depth max 0.60 m.
pnd9697	50 N 445021 336082	Pond with muddy water, ±3 m max depth, clay, silt bottom.	Shore vegetation primary rain forest of RKT 1996/ 1997. Bottom clay. Water muddy, the level was lower ±1m than 1999's survey.
pndken	50 N 445640 332307	At the entrance to the CIFOR camp. Water colour muddy. Banks flat. Depth max ±1.5 m.	At the entrance to the CIFOR camp. Bottom clay and rock. Depth max ±1.5 m. Water colour muddy.
rian1	Not available	Shore vegetation current ladang, ricefield. Banks steep, ±0.5 m high. Depth max ±0.75 m. Width ±15 m. Bottom sand, gravel, rock. Water colour muddy.	At the mouth of Ulet river. Old jekau (±6 years old) planted with annual plant. Width 10 m. Substrate rock and sand. Depth max 2 m. Water clear.
rian2	Not available	Shore vegetation current ladang, ricefield. Banks steep, ±0.5 m high. Depth max ±0.75 m. Width ±15 m. Bottom sand, gravel, rock. Water colour muddy.	

rian3	Not available	Shore vegetation primary rain forest. Banks steep, 3-10 m high. Depth max 1.5 m. Width ±16 m. Bottom gravel, rock. Water colour brown.	
rian4	50 N 444885 339034	Shore vegetation current ladang and primary forest. Banks steep, 2-5 m high. Width ±12 m. Depth max ±4 m. Bottom sand, gravel and rock.	
rian5	50 N 445282 339260	Shore vegetation primary rain forest. Width ±14 m. Depth max 0.60 m. Bottom rock, gravel. Type of flow riffles and run. Bank flat - steep (±3 m high).	Shore vegetation INHUTANI camp at the left, primary forest and shrub at the right. Width ±14 m. Depth max 2 m. Bank flat - steep (±3 m high). Bottom sand, rock and gravel. Type of flow riffle and run. Water clear.
rian6	50 N 442716 339244		At the mouth of Udun river. Padi tugal at the left, old jekau with crop plants at the right. Width ±15 m. Bank steep, 2 m high. Substrate rock and boulders. Depth max 0.50 m. Water clear.
rian7	50 N 443562 34040		Old jekau (6-7 years old) at the left, young jekau (3 years old) at the right. Bank flat. Width ±20 m. Depth max 0.75 m. Substrate rock. Water clear.
serub	50 N 444508 340370		Old jekau (8 years old) mixed with primary rain forest at the left and the right. Width ±2 m. Bank steep, 3 m high. Depth max 0.75 m. Substrate sand, clay and detritus. Water turbid.
set1lp	50 N 442102 339870	Shore vegetation current ladang. Banks flat - steep (hill). Depth max 2.5 m. Width ±18 m. Bottom gravel, rock. Water colour greenish. Some muddy pools at the bank.	Padi tugal at the left. Old jekau (7 years old) mixed with crop planted such as cassava, banana along the bank and young jekau (3 years old) off the bank. Bank steep, 3 m high. Bottom sand and rock. Depth max 4 m. Water clear - slightly turbid.
set1up	50 N 445138 331572	Shore vegetation primary rain forest. Banks flat. Width ±14 m. Depth max 0.75 m. Bottom sand, rock. Water clear. Flow type riffles and run.	Shore vegetation primary rain forest. These stations flank the ±40 m long delta. Width ±8-14 m. Depth max 1m. Bottom sand, rock. Type of flow run, riffle with small cascades. Water clear.
set2lp	50 N 441379 338696	Shore vegetation current ladang. Banks flat - steep (hill). Depth max 2.5 m. Width ±18 m. Bottom gravel, rock. Water colour greenish. Some muddy pools at the bank.	Young jekau (4-5 years old) at the left and right. Bank flat (the left), very steep, ±10 m high (right). Width ±20 m. Depth max 4 m. Substrate rock. Water slightly turbid.
set2up	50 N 445462 331858	Shore vegetation primary rain forest. Banks flat. Width ±14 m. Depth max 0.75 m. Bottom sand, rock. Water clear. Flow type riffles and run.	Shore vegetation primary rain forest. These stations flank the ±40 m long delta. Width ±8-14 m. Depth max 1m. Bottom sand, rock. Type of flow run, riffle with small cascades. Water clear.
set3lp	50 N 442442 337788	Shore vegetation current ladang. Banks flat - steep (hill). Depth max 2.5 m. Width ±18 m. Bottom gravel, rock. Water colour greenish. Some muddy pools at the bank.	
set3up	50 N 445730 331893	Shore vegetation primary rain forest with grassy bank. Banks flat. Width ±20 m. Depth mostly ± 0.3 m. Flow type runs and riffles. Bottom rock.	Shore vegetation primary rain forest passed by Bina Benoa logging road. Bank flat. Width ±20 m. Depth max ±0.80 cm (lower than 1999's survey). Substrate gravel and rock. Type of flow run, riffle and pool. Water clear.

set4lp	50 N 442470 337827	Primary rain forest (for St.12).	Old jekau at the left, old jekau and primary rain forest at the right. Bank flat - steep, 4 m high. Width ±16 m. Depth max 4 m. Substrate rock. Water slightly turbid.
set4up	Not available	Shore vegetation primary rain forest with grassy bank. Banks flat. Width ±20 m. Depth mostly ± 0.3 m. Flow type runs and riffles. Bottom rock.	Shore vegetation primary rain forest passed by Bina Benoa logging road. Bank flat. Width ±20 m. Depth max ±0.80 cm (lower than 1999's survey). Substrate gravel and rock. Type of flow run, riffle and pool. Water clear.
tana	50 N 443225 339878		Old jekau (7-8 years old) at the left, young jekau (4-5 years old) at the right. Bank flat - steep, 1 m high. Width 1.5 m. Depth max 0.45 m. Substrate sticky clay. Water muddy.
tem1	50 N 445462 331861	Shore vegetation primary rain forest. Banks flat - steep (±10 m high). Width 8-12 m. Depth max ±2 m. Bottom rock, sand, gravel. Flow type riffles, run, pools (logged area).	±50 m from the mouth. Shore vegetation primary rain forest. Bank flat - steep, 1 m high. Width 10-12 m. Depth max 2 m. Substrate gravel and rock. Silt at the bank. Water clear-slightly turbid.
tem2	Not available	Shore vegetation primary rain forest. Banks flat - steep (±10 m high). Width 8-12 m. Depth max ±2 m. Bottom rock, sand, gravel. Flow type riffles, run, pools (logged area).	Shore vegetation primary rain forest. The most up reach station was passed by the logging road of RKT 2001. Width 8-12 m. Bank flat - steep, 2 m high. Depth max 0.45 m. Substrate gravel and rock. Water clear.
tem3	Not available	Shore vegetation primary rain forest. Banks flat - steep (±10 m high). Width 8-12 m. Depth max ±2 m. Bottom rock, sand, gravel. Flow type riffles, run, pools (logged area).	Shore vegetation primary rain forest. The most up reach station was passed by the logging road of RKT 2001. Width 8-12 m. Bank flat - steep, 2 m high. Depth max 0.45 m. Substrate gravel and rock. Water clear.
todok	50 N 448646 333216		Shore vegetation primary rain forest (Recreational Park). Below a waterfall of height 10 m. Width 7.5 m. At left, bank very steep, ±20 m high, containing coal. Bottom rock and boulders. Depth max 0.80 m. Water clear. Type of flow pool and cascades.
udun	50 N 442716 339244		Old jekau (6-7 years old) planted with crop plant (at the right), young jekau (4 years old) at the left. Bank steep, 2 m high. Width 1-1.5 m. Substrate clay. Depth max 0.33 cm. Water clear-turbid.
ulet1	50 N 443252 339604	Shore vegetation old ladang (jekau). Banks flat. Depth max 0.5 m. Width 3-5 m. Bottom sand, gravel and rock. Water clear.	Ladang/padi tugal at the right, young jekau (±1-4 years old) at the left. Bank flat. Width 1-4 m. Depth max 0.60 m. Type of flow riffle and small pool. Substrate sand, gravel, woody debris. Water clear.
ulet2	Not available	Shore vegetation old ladang (jekau). Banks flat. Depth max 0.5 m. Width 3-5 m. Bottom sand, gravel and rock. Water clear.	Ladang/padi tugal at the right, young jekau (±1-4 years old) at the left. Bank flat. Width 1-4 m. Depth max 0.60 m. Type of flow riffle and small pool. Substrate sand, gravel, woody debris. Water clear.
ulet3	50 N 443336 339517	Shore vegetation primary rain forest. Banks flat. Depth max 0.5 m. Width 3-5 m. Bottom sand, gravel and rock. Water clear.	Shore vegetation primary rain forest. Bank flat. Width ±1.5 m. Bottom rock, sand and detritus. Depth max 0.35 m. Type of flow riffle and small pool. Water clear.

Appendix 2
List and characteristic of collected fish

Anguillidae

1. *Anguilla malgumora* (Kaup 1856)
Localities: SWu, SWl, KM[1]
Standard length (SL): Up to 328.7 mm; the smallest specimen collected from the Seturan river was 149.73 mm.
Local name: Telakai (Merap, Kenyah, Punan)
Distribution: Borneo, Sulawesi
Habitat: Moderately fast flowing water[2] of gravel[3] or rock-bottomed rivers; or in sand, silt bottomed streams[4].
Diet: Carnivorous, feeds on crabs and aquatic insects (Inger & Chin 1962).
Comments: Like most freshwater eels, this species is catadromous, which explains the fact that no juvenile or elder were found in the sampled localities.
References: Weber & de Beaufort (1916:247 as part of *A. celebensis*); Inger & Chin (1962:39 as *A. borneensis*); Chin (1990 SC-6 as *A. borneensis*); Kottelat *et al*. (1993:10, Figure 29b).

2. *Anguilla nebulosa* (McClelland 1844)
Localities: SWu, SWl (Malinau river at Langap)
SL: Up to 1300 mm
Local name: Telakai (Merap, Kenyah, Punan)
Distribution: East Africa to Sumatra (The presence of this species in the Seturan watershed extends its known range).
Habitat: Specimens were found in the flooded-grassy area at the bank of Malinau river near Langap village, and in the Seturan river near the CIFOR camp.
Comments: Like *A. malgumora, A. nebulosa* is a catadromous fish.
References: Weber & de Beaufort (1916:244 as *A. elphinstonei*); Kottelat *et al*. (1993:11, Figure 29e).

Belontiidae

3. *Betta unimaculata* (Popta 1905)
Localities: SWu, SWl, KM
SL: Up to 51.80 mm
Local name: Madang (Kenyah)
English name: Howong Betta
Distribution: North East, East and South Borneo
Habitat: Small, shallow pools (10-30 cm deep) in streams, with clear to turbid water on sandy or silty substrate.

[1] SWu refers to locations in upper Seturan river including streams passing through plots 27, 29, 32, 45; and Kenowan, Temalang, Bengahau, Menalat rivers; the unnamed stream behind the CIFOR camp; and the ponds of RKT 1996/1997. SWl refers to locations in the lower Seturan watershed including the tributary of Kelarok river and the larger Rian river with all of its tributaries: Korok, Kujau, Biyo, Serubak, Lit, Lubang Tana, Lirung, Udun, Ulet, Belalang and Patak rivers. KM refers to fish species found in the Kayan Mentarang National Park that were also found in the Seturan watershed (see Haryono 1992, Tan & Wowor 2001).

[2] Current: *slowly moving water* has a velocity of less than 0.25 m/sec.; *moderately moving water* has a velocity of 0.25–0.50 m/sec.; *fast flowing water* has a velocity of 0.51-1 m/sec.; and *very fast moving water* has a velocity >1 m/sec.

[3] Substratum: *gravel* refers to stones between 0.5–5.0 cm in diameter; *rock* 5.1-30 cm in diameter; *boulders* are more than 30 cm in diameter.

[4] The term *river* is used to denote the mainstream of the Seturan and Rian rivers, while *stream* is used for the tributaries of these rivers.

Diet: Carnivorous, terrestrial insects and aquatic invertebrates (Inger & Chin 1962).
Comment: Existence of sexual dimorphism: male has two iridescent coloured scales above and below the eye, and no black mark at the base of the caudal fin. Female has a black mark at the base of the caudal fin but lack iridescent scales.
References: Weber & de Beaufort (1922:355); Inger & Chin (1962:158); Kottelat *et al*. (1993:226 pl.77)

4. *Trichogaster trichopterus* (Pallas 1770)
Localities: SWl
SL: Up to 59.78 mm
Local name: Bacan Karok (Merap); Karok, Tebarin (Kenyah); Bacan Karok (Punan)
English name: Three Spot Gourami
Distribution: Sundaland, Indochina
Habitat: Rice fields
References: Inger & Chin (1962:162); Kottelat *et al*. (1993:228, pl.78)

Gobiidae

5. *Awaous* sp.
Localities: SWu, SWl
SL: Up to 84.31 mm
Local name: Can Tawo (Merap), Ait (Kenyah), Baluh (Punan)
Distribution: Borneo
Habitat: Gravelly or rocky bottomed areas, in moderately fast water.
Comments: Characterised by the presence of a finger-like flap on the shoulder gilder.
References: Kottelat *et al*. (1993:197)

Channidae

6. *Channa* cf. *lucius* (Cuvier *in* Cuvier & Valenciennes 1831)
Localities: SWu, SWl, KM
SL: Up to 860 mm
Local name: Dung (Merap), Udun (Kenyah), Udun (Punan)
Distribution: Sumatra, Borneo
Habitat: Muddy water with clay and sandy substrate.
Diet: Carnivorous on fish, small birds and amphibians (Ng & Lim 1990).
Comments: Black colouration with a series of irregular black dots along side.
References: Weber & Beaufort (1922:322 as *O. bistriatus*, 1922:326 as *O. lucius*); Kottelat *et al*. (1993:230)

Bagridae

7. *Hemibagrus baramensis* (Regan 1906)
Localities: SWu, SWl, KM
SL: Up to 190.75 mm
Local name: Tikien (Merap); Teliken, Bala (Kenyah); Cike (Punan)
Distribution: North Borneo
Frequency/Abundance: Both rare and in low abundance in sampling localities.
Habitat: Various in main streams
Diet: Carnivorous on arthropods and decapod crustaceans (Inger & Chin 1962).
Comments: It is distinguished from *H. nemurus* by the absence of black-mid lateral stripe and black spot at the end of adipose fin.
References: Weber & de Beaufort (1913:338, *Macrones baramensis*); Inger & Chin (1962:139, Figure 70); Robert (1989:122); Kottelat *et al*. (1993: 91, *Mystus baramensis*)

8. *Hemibagrus* cf. *nemurus* (Valenciennes *in* Cuvier & Valenciennes 1840)
Localities: SWu, SWl, KM
SL: Up to 210 mm
Local name: Tikien (Merap); Teliken, Bala (Kenyah); Cike (Punan)
English name: Asian Red Catfish
Distribution: Sundaland, Indochina
Habitat: Various; standing streams with sandy/silty substrate, fast flowing rivers and streams with a rocky substrate, and in turbid ponds within logged areas (particularly adults).
Diet: Omnivorous bottom dweller (Vass 1954 *in* Welcomme 1979); feeds on fish, shrimp, crabs, aquatic and terrestrial insect and vegetation (Inger & Chin 1962).
Comments: This species group needs revision (Tan & Ng 2000).
References: Weber & de Beaufort (1913:341, *Macrones nemurus*); Inger & Chin (1962:138, *Mystus nemurus*); Robert (1989:121, *Mystus nemurus*); Ng & Ng (1995:134); Kottelat & Lim (1995:41-47, Figure 2)

9. *Leiocassis* sp.
Localities: SWu, SWl
SL: Up to 117.02 mm
Local name: Lucau (Merap, Kenyah, Punan)
Frequency/Abundance: Both rare and in low abundance in sampling localities
Habitat: Shallow, slow to fast flowing water of river and stream with rocky substrate.
Comments: This species has a yellow colouration on ventral area, between the posterior of first dorsal fin and the end of adipose fin; and brownish colour that runs from the snout to the base of the caudal. From the dorsal area this colour expands downward into base of ventral fin and above anal fin. Its mouth is inferior; head is narrow and long (3.72-4.05 times in SL). It is similar in form to *Leiocassis* species that was found in the inland water of Sabah and the Segama basin (Martin-Smith & Hui 1998). This sample needs further taxonomic study.

Clariidae

10. *Clarias anfractus* (Ng 1999)
Localities: SWu, SWl
SL: Up to 265 mm
Local name: Tun (Merap), Kati (Kenyah), Utet (Punan)
Distribution: Northeastern Borneo
Habitat: Slow to moderate flowing rivers and streams with a rocky, gravel or silty substrate stranded by dead vegetation. Adult individuals predominated in silty ponds of the logged-over areas.
Comments: The *C. anfractus* found in this survey had a longer head than *C. teijsmanni* as reported by Kottelat *et al*. (1993).
References: Ng (1999:18, Figure 1a, 2a, 3a, 4a)

Balitoridae

11. *Gastromyzon* cf. *lepidogaster* (Robert 1982)
Localities: SWu, SWl
SL: Up to 69.70 mm
Local name: Kat (Merap), Leket (Kenyah), Leket (Punan)
Frequency/Abundance: A common species
Habitat: Clear fast flowing rivers and large streams with rocky bottoms; often found sympatrically with other *Gastromyzon* species.
Comments: Black colouration with 6-8 white vertical bars on its posterior body. In juveniles individuals, these bars were also present on the anterior body. The caudal fin has 2-3 black vertical cross bands.
References: Robert (1982:509, Figure 10 *Gastromyzon lepidogaster*); Chin (1990 SC-23, Figure S22); Smith & Hui (1998:585, Figure 6)

12. *Gastromyzon* sp.
Localities: SWu, SWl, KM
SL: Up to 69.83 mm
Local name: Kat (Merap), Leket (Kenyah), Leket (Punan)
Distribution: Borneo
Habitat: Clear fast flowing water with a rocky bottom; common in the main stream of the Seturan and Rian rivers.
Comments: This is an undetermined species of river loach. It has uniform black colouration with fins marked by thin whitish vertical edge.

13. *Homaloptera stephensoni* (Hora 1932)
Localities: SWu, SWl, KM
SL: Up to 56.65 mm
Local name: Kat Blow (Merap), Leket Bulo (Kenyah), Rungan (Punan)
Distribution: Borneo
Habitat: Slow to fast flowing clear water with rocky substrate.
References: Robert (1989:90, Figure 70); Chin (1990 SC 31, Figure S31); Kottelat *et al*. (1993:73, pl.24)

14. *Neogastromyzon nieuwenhuisii* (Popta 1905)
Localities: SWu, SWl, KM
SL: Up to 41.47 mm
Local name: Kat Blow (Merap), Leket Bulo (Kenyah), Leket (Punan)
Distribution: Sarawak, the presence in the Seturan Watershed extends its known range.
Frequency/Abundance: Rare and in low abundance
Habitat: Clear, moderate to very fast flowing water with rock and gravel bottoms.
Comments: Slender body and narrow light brown vertical bars on body sides (Figure 2).
References: Weber & de Beaufort (1916:4); Inger & Chin (1961:175, *G. nieuwenhuisi*); Kottelat *et al*. (1993:77, pl.26)

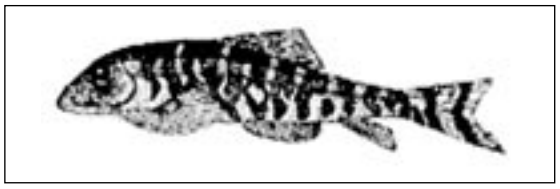

Figure 2. *Neogastromyzon nieuwenhuisii*

15. *Parhomaloptera microstoma* (Boulenger 1899)
Localities: SWu, KM
SL: Up to 42.18 mm
Local name: Kat (Merap), Leket (Punan)
Distribution: Borneo
Frequency/Abundance: Rare, only two specimens recorded
Habitat: One individual was found in the Seturan river and the other in Menalat river, a shallow, fast flowing stream with a rocky substrate.
References: Weber & de Beaufort (1916:20, Figure 5); Silas (1952:225); Inger & Chin (1962:108, Figure 51); Kottelat *et al*. (1993:77, pl.26); Martin-Smith & Hui (1998:587)

16. *Protomyzon griswoldi* (Hora & Jayaram 1952)
Localities: SWu, SWl, KM
SL: Up to 21.73 mm
Local name: Kat Blow (Merap), Leket Bulo (Kenyah), Rungan (Punan)
Distribution: North Borneo, West Borneo (Sarawak and Kapuas Basin). The presence in Seturan watershed extends the known range of the species.
Frequency/Abundance: Very rare
Habitat: Very fast flowing water with rocky substrate; found in the Seturan river, near the mouth of Temalang and Menalat rivers.
References: Silas (1952:239, *Progastromyzon griswoldi*); Inger & Chin (1962:109, Figure 52); Kottelat *et al*. (1993:78, pl.27); Martin-Smith & Hui (1998:588, Figure 10)

Cobitidae

17. *Nemacheilus saravacensis* (Boulenger 1894)
Localities: SWu, SWl, KM
SL: Up to 37.81 mm
Local name: Tao (Merap), Lanya (Kenyah)
Distribution: West Borneo. The presence of this species in the Seturan watershed extends its known range.
Habitat: Moderate to fast flowing rivers or streams with rocky, sandy or gravel substrates.
References: Weber & de Beaufort (1916:40 part of *N. fasciatus)*; Kottelat (1984:236, Figure 9); Kottelat *et al*. (1993:76, pl.26)

18. *Nemacheilus selangoricus* (Duncker 1904)
Localities: SWu, SWl
SL: Up to 44.05 mm
Local name: Tao (Merap), Lanya (Kenyah)
Distribution: Sumatra, North Borneo and Malaya. The presence of this species in the Seturan watershed extends its known range.
Habitat: Variable, moderately flowing stream with silty substrate, fast flowing river with rocky substrate and shallow pond in logged-over area with a sandy and clay substrate stranded by branches.
Diet: Terrestrial and aquatic insects (Inger & Chin 1962)
Comments: Females reaching 44 mm SL were gravid.
References: Inger & Chin (1962:123, Figure 59); Kottelat (1984:254); Kottelat *et al*. (1993:77, pl.26)

19. *Nemacheilus spiniferus* (Kottelat 1984)
Localities: SWu
SL: Up to 47.79 mm
Local name: Tao (Merap), Lanya (Kenyah)
Distribution: West and North West Borneo. The presence of this species in the Seturan watershed extends its known range.
Habitat: Moderate to fast flowing streams with rocky, sandy or silty substrates.
References: Kottelat (1984:250); Kottelat *et al*. (1993:77)

20. *Pangio anguillaris* (Vaillant 1902)
Localities: SWu
SL: Up to 48.12 mm
Local name: Uak (Kenyah)
Distribution: Borneo, Sumatra, Malaya, Indochina
Frequency/Abundance: Very rare, only one specimen found
Habitat: Fast flowing water with rocky substrate in the Seturan river
Diet: Carnivorous on benthic invertebrates
References: Weber & de Beaufort (1916:34, *Acanthopthalmus vermicularis*); Kottelat & Lim (1993:214, Figure 5); Kottelat *et al*. (1993:83, pl.28)

Cyprinidae

21. *Barbodes* cf. *balleroides* (Valenciennes *in* Cuvier & Valenciennes 1842)
Localities: SWu, SWl, KM
SL: Up to 178.49 mm
Local name: Hala (Merap), Salap Merah (Kenyah), Alap (Punan)
Distribution: Borneo, Java, Malaya, Cambodia, Thailand,Vietnam
Habitat: Various, standing to moderately fast flowing streams with clay, sandy substrate, stranded by dead vegetation and fast flowing rivers with gravel and rock substrate.
Diet: Feeds on plants and insects (Inger & Chin 1962)
Comments: Alive, the specimen has a yellowish colouration on pelvic fins, anterior half of the anal fins and at the edge of hollow caudal lobes. It also had a black submarginal stripe along each caudal lobe, with black marking at the tip of dorsal fin. These features agree with the specimen (Kottelat 1994) from the Mahakam Basin that was tentatively identified as *Barbodes* cf. *balleroides*. Fang (1943) in Kottelat (1994) regarded *B. bramoides* as a synonym of *B. balleroides* though Kottelat (1994) stated that *B. balleroides* might be not-yet described taxon, distinct from *B. bramoides*. Females were sexually mature at 150 mm SL (N=10, 119-180.66 mm SL).
References: Weber & de Beaufort (1916:195, *Puntius bramoides*); Robert (1989:61, *P. bramoides*); Kottelat *et al*. (1993:43, pl.5); Kottelat (1994:407, Figure 2)

22. *Barbodes* sp.
Localities: SWu, SWl
SL: Up to 88.74 mm
Local name: Hala (Merap), Salap Putih (Kenyah), Alap (Punan)
Frequency/Abundance: Rare, only two specimens were collected
Habitat: One was collected from shallow, moderately flowing water with rocky substrate, while the other came from a fisherman catch.
Comments: Species confirmation and distribution requires study. This unclassified carp species has a black submarginal stripe along each caudal lobe, reddish colouration at pelvic and anal fins, black stripe on the mid of the first branched anal fin and 16 scales on the circumcaudal peduncle. It has interrupted lateral line above the origin of anal fin, 12 predorsal scales and 7.5 scales between lateral line and dorsal fin.

23. *Cyclocheilichthys armatus* (Valenciennes *in* Cuvier & Valenciennes 1842)
Localities: SWu, SWl
SL: Up to 115.94 mm
Local name: Turui (Merap), Turing (Kenyah), Turing (Punan)

Distribution: Java, Borneo, Malaya, Indochina, Palawan
Habitat: Various, standing to moderate flowing streams, moderate to very fast flowing rivers with approximately 30% of the samples found in turbid ponds of logged-over areas.
Comments: Distinguished from its congeners by the presence of one pair of maxillary barbels, obvious black spots along scales and at caudal base, and 16 circumpeduncular scales.
References: Weber & de Beaufort (1916:159 *C. de Zwaani*, 1916:162 *C. lineatus* and *C. deventeri*); Kottelat *et al*. (1993:46, pl.7)

24. *Cyclocheilichthys repasson* (Bleeker 1853)
Localities: SWu, SWl, KM
SL: Up to 105.26 mm
Local name: Turui (Merap), Turing (Kenyah), Turing (Punan)
Distribution: Sundaland, Indochina
Habitat: Standing to moderate flowing streams with clay and sandy substrate, littered by debris and moderately fast flowing rivers with gravel and rock substrate.
Diet: Omnivorous (Inger & Chin 1962)
Comments: Identified by its two pairs of barbels, 20 circumpeduncular scales and the yellowish colouration at the anal and pelvic fins.
References: Weber & de Beaufort (1916:160); Zakaria-Ismail (1990:117, Figure 5); Kottelat *et al*. (1993:47, pl.8)

25. *Garra borneensis* (Vaillant 1902)
Localities: SWu, SWl, KM
SL: Up to 71.94 mm
Local name: Paha (Merap); Lemak, Tulem (Kenyah); Ruam (Punan)
Distribution: Borneo
Frequency/Abundance: Among the most abundant fish sampled
Habitat: Clear, moderate to very fast moving rivers and streams with rocky substrate with a preference for water with overhanging vegetation.
Diet: Diatoms and plants (Inger & Chin 1962)
Comments: The upper lip of the mouth is modified into a suctorial disk with a flattened ventral surface of head and body. This allows the fish to cling to rocks in fast flowing water.
References: Weber & de Beaufort (1916:228, *Discognathus borneensis*); Inger & Chin (1962:98, Figure 45); Chin (1990 SC-17, Figure S17); Kottelat *et al*. (1993:47, pl.8)

26. *Hampala macrolepidota* (Valenciennes *in* Cuvier & Valenciennes 1842)
Localities: SWu, SWl, KM
SL: Up to 470 mm
Local name: Lungau (Merap), Buleng (Kenyah), Sunau (Punan)
English name: Hampala Barb
Distribution: Sundaland, Indochina
Habitat: Clear, moderate to fast flowing rivers or streams with sandy, gravel and rocky substrate. The larger specimens of this fish lived in deep pools within the Seturan and Rian rivers. A few specimens (2,38%) were found in turbid ponds.
Diet: Larger individuals feed on fish, while small individuals feed on insects (Inger & Chin 1962).
Comments: Has a distinct oblique terminal mouth; and black lateral line at the upper and lower margin of the caudal lobes, and at the edge of the first dorsal fin.
References: Weber & de Beaufort (1916:143, Figure 60); Inger & Chin (1962:78); Kottelat *et al*. (1993: 47, pl.8)

27. *Leptobarbus melanotaenia* (Boulenger 1894)
Localities: SWu, SWl, KM
SL: Up to 340 mm
Local name: Hanyan (Merap), Sayen (Kenyah), Anyen (Punan)
Distribution: Borneo
Habitat: Various, clear, moderate to fast flowing rivers or standing to moderate flowing streams with clay and sand substrate, littered with debris and in turbid ponds within a logged area. Moderately sized individuals were found in turbid ponds within logged areas, while smaller individuals (N=7; 19- 34 mm SL) were found in the clear, shallow parts of the Rian and Seturan rivers.
Diet: Aquatic plants, leaf litter, fallen fruit and seeds (Vaas 1954 *in* Welcomme 1979)
Comments: Distinguished from other *Leptobarbus* species by the presence of a black midlateral line running from the posterior operculum to the base of the caudal fin (Figure 3). Sexual maturity was observed in female specimens of SL=290 mm (from seven individual observed which were 190-340 mm SL).
References: Weber & de Beaufort (1916:97); Inger & Chin (1962:64, Figure 27); Chin (1990 SC-9, Figure S7); Kottelat *et al*. (1993:50, pl.10)

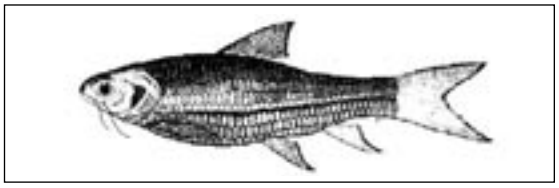

Figure 3. *Leptobarbus melanotaenia*

28. *Lobocheilos* cf. *bo* (Popta 1904)
Localities: SWu, SWl, KM
SL: Up to 250 mm
Local name: Paha (Merap), Pasa (Kenyah), Pa/Neha (Punan)
Distribution: Borneo

Habitat: Slow to fast flowing clear water with a gravel and rocky substrate, in the Seturan river.
Diet: Diatoms, filamentous algae, plant fragments (Inger & Chin 1962).
Comments: Silvery-greenish colour, with pectoral fins longer than the head length, one pair of barbels and 34 scales on linea lateralis.
References: Weber & de Beaufort (1916:221 *Tylognathus bo*); Inger & Chin (1962:84); Chin (1990 SC-13, Figure S14); Kottelat *et al*. (1993:50, pl.10); Martin-Smith & Hui (1998:581)

29. *Nematabramis everetti* (Boulenger 1894)
Localities: SWu, SWl, KM
SL: Up to 100.93 mm
Local name: Lelapeh (Merap), Lepeh (Kenyah), Cipih (Punan)
Distribution: North Borneo. The presence of this species in the Seturan watershed extends its known range.
Frequency/Abundance: The most abundant and widely distributed fish in the sample survey.
Habitat: Various, from slow to very fast flowing rivers, standing to fast flowing streams and in turbid ponds within logged-over areas.
Diet: Insectivore (Inger & Chin 1990)
Comments: Compressed, thin body with pale colouration and a silvery lateral line
References: Weber & de Beaufort (1916:46); Inger & Chin (1962:49, Figure 17); Kottelat *et al*. (1993: 52, pl.11); Smith & Hui (1998:582)

30. *Osteochilus kahajanensis* (Bleeker 1857)
Localities: SWu
SL: Up to 182.8 mm
Local name: Pao (Merap), Lemak (Kenyah), Pa (Punan)
Distribution: Sundaland
Habitat: Varied
Comments: Presence of two well-developed tubercles on the snout and of a black round spot on the caudal peduncle.
References: Weber & Beaufort (1916:130); Karnasuta (1993:85); Robert (1989:49)

31. *Osteochilus waandersii* (Bleeker 1852)
Localities: SWu, SWl
SL: Up to 139.52 mm
Local name: Pao (Merap), Lemak (Kenyah), Pa (Punan)
Distribution: Sumatra, Borneo, Malaya, Indochina
Habitat: Various, from slow to fast flowing rivers and streams, with gravel and rocky substrates and in standing to moderate flowing streams with clay, sandy substrate littered with debris.
Comments: Distinguished by the presence of a conspicuous black-mid lateral strip extending from its gill opening to the end of median caudal fin ray.
References: Weber & de Beaufort (1916:136); Karnasuta (1993:28, Figure 13); Robert (1989:54, Figure 39); Kottelat *et al*. (1993:56, pl.13)

32. *Parachela ingerkongi* (Banarescu 1969)
Localities: SWu, SWl, KM
SL: Up to 117.94 mm
Local name: Lelempau (Merap), Lepeh (Kenyah), Bacan Empu (Punan)
Distribution: Sundaland, Indochina
Frequency/Abundance: Rare, low abundance
Habitat: Moderately to fast flowing rivers and streams with gravel and rocky substrate.
References: Weber & de Beaufort (1916:51 *Chela oxygastroides* Figure 22); Kottelat *et al*. (1993:56, pl.13); Kottelat (1994:410)

33. *Puntius binotatus* (Valenciennes *in* Cuvier & Valenciennes 1842)
Localities: SWu, SWl, KM
SL: Up to 92.29 mm
Local name: Kuamnie (Merap), Betutu Banga (Kenyah), Betutung (Punan)
Distribution: Sundaland, Bali, Lombok, Philippine, Indochina
Habitat: Various, fast flowing water of river; moderate flowing stream over clay with silt and sand substrates littered by dead vegetation and turbid ponds within logged areas.
Diet: Omnivorous (Inger & Chin 1962, Sulastri & Hartoto 1985)
Comments: Small specimens of 64.05 mm SL generally have black dots running longitudinally from the posterior part of operculum to the base of caudal. In larger specimens, however, these black dots disappear. Females of 61.39 mm SL (N=6, 61.39-73.21 mm SL) were found to be sexually mature.
References: Weber & de Beaufort (1916:186, Figure 74); Robert (1989:60); Inger & Chin (1962:71, Figure 32); Kottelat *et al*. (1993:57, pl.15); Herre (1924: 290)

34. *Puntius sealei* (Herre 1933)
Localities: SWu, SWl, KM
SL: Up to 77.30 mm
Local name: Lungo (Merap), Betutung (Kenyah), Betutung (Punan)
Distribution: North East Borneo
Habitat: Small streams with clear water, silty, sandy and gravel substrate littered by woody debris
Diet: Vascular plants, insect and crustaceans (Inger & Chin 1962)
Comments: Distinguished from the somewhat similar *Puntius binotatus*, by having six roundish black spots on the body sides: four are distributed laterally on the middle line of sides, one is at base of the anal fin and one is at base of the dorsal fin. It is endemic to North Borneo.

References: Weber & de Beaufort (1916:191 *P. elongatus*); Inger & Chin (1962:73); Chin (1990 SC-11, Figure S10); Kottelat *et al*. (1993:60, pl.16)

35. *Puntius* sp.
Localities: SWu, SWl
SL: Up to 94.35 mm
Local name: Hala (Merap), Kuamenyi (Kenyah), Bunau (Punan)
Habitat: Various, moderately flowing rivers with gravel and rocky substrate, standing to fast flowing streams and turbid ponds within logged-over areas.
Comments: It could be an undescribed species but this needs confirmation and further distributional investigation. It has 22-23 lateral line scales, two pairs of barbels (mandibulary and maxilary barbels). Fins formulae are D.III - IV. 8½; A.III. 5½. Moreover, it has a triangular black mark running from the dorsal fin insertion downward to ventral area. In the bigger individuals there are series of black spots scattering behind the opercle anterior to the blurred triangular bar. The profile of predorsal is convex ascending from the occipital process to the origin of dorsal.

36. *Rasbora argyrotaenia* (Bleeker 1850)
Localities: SWu, KM
SL: Up to 45.09 mm
Local name: Lalau (Merap), Lalang (Kenyah), Lalape (Punan)
Distribution: Sumatra, Borneo, Java, Philippines
Frequency/Abundance: Rare
Habitat: Moderate to fast flowing streams with silty/ sandy bottoms, and fast flowing rivers with gravel and rocky substrate.
Comments: Has a black mid-lateral line running from the opercula to the base of the caudal, most evident in the posterior half of the body.
References: Weber & de Beaufort (1916:61); Brittan (1954:107); Inger & Chin (1962:59, fig 24); Kottelat *et al*. (1993:60, pl.16)

37. *Rasbora caudimaculata* (Volz 1903)
Localities: SWu, SWl, KM
SL: Up to 79.72 mm
Local name: Betelah (Merap), Beteloh (Kenyah), Beteluh (Punan)
Distribution: Sumatra, Borneo, Malaya
Frequency/Abundance: common
Habitat: Moderate to fast flowing rivers and streams over gravel, rocky substrates and streams that have sandy, silty substrate littered by debris. Many small individuals, (19.03 cm to 40.48 mm SL) were found in a section of stream near a *Eusideroxylon zwageri* tree.
References: Weber & de Beaufort (1916:67 part of *R. trilineata*); Brittan (1954:77, Figure 13); Kottelat *et al*. (1993:62, pl.17)

38. *Rasbora elegans* (Volz 1903)
Localities: SWu, SWl
SL: Up to 93.86 mm
Local name: Lalau (Merap), Lalang (Kenyah), Lalape (Punan)
Distribution: Sumatra, Borneo, Malaya, Singapore
Frequency/Abundance: Common, moderately abundant
Habitat: Various, moderate to fast flowing section of rivers and streams with gravel and rocky substrate; streams with silty, sandy substrate littered with debris; turbid ponds in logged area. Small individuals were found only in streams.
Comments: Distinguished by three black spots: two of which are connected by a black mid-lateral line, located at the base of the caudal fin and below dorsal fin. The third spot, which is small and elongated, is located at the base of the anal fin.
References: Weber & de Beaufort (1916:78 *Rasbora lateristriata* var. *elegans*); Brittan (1954:64); Inger & Chin (1962:54, Figure 20); Kottelat *et al*. (1993: 63, pl.18)

39. *Rasbora lateristriata* (Bleeker 1854)
Localities: SWu, SWl
SL: Up to 63.59 mm
Local name: Hanyan (Merap), Beteloh (Kenyah), Beteluh (Punan)
English name: Yellow Rasbora
Distribution: Sumatra, Borneo, Java, Bali, Lombok, Sumbawa
Habitat: Moderate to very fast flowing rivers with rocky substrate and moderate flowing streams with rocky, sandy and clay substrates.
Diet: Feeds on aquatic insects, plants and detritus (Sulastri & Hartoto 1985)
Comments: Resembles *R. argyrotaenia*, however has a narrower body[5] and faint black marking at the edge of caudal lobes.
References: Weber & de Beaufort (1916; p.76); Brittan (1954; p.37); Kottelat *et al*.(1993; p.60, Figure 16); Herre (1924; p.265)

40. *Tor tambra* (Valenciennes *in* Cuvier & Valenciennes 1842)
Localities: SWu, SWl, KM
SL: Up to 520 mm/TL up to 620 mm
Local name: Perian (Merap), Padak (Kenyah), Tengah (Punan)
Distribution: Sundaland
Habitat: Very fast flowing water with rock and gravel substrate. Smaller individuals are found in shallow water while adults are found in deep river pools.
Diet: Diatom, algae and part of higher plants (Sulastri *et al*. 1985)
Cultural Significance: *Tor tambra* (Figure 4) *is* a

[5] (3.99 – 4.34 times in SL of *R. lateristriata* versus 3.41 – 3.90 times in SL of *R. argyrotaenia*)

highly sought after fish, with a good market price gillnetted when migrating downstream during the rainy season. Given their relatively low reproductive rates, and their high demand, population numbers need to be closely monitored (Kottelat *et al*. 1993). In other areas of Indonesia this fish is already being traditionally conserved, given its cultural and dietary importance (Sabar 1985, Rachmatika 1992).
Comments: Distinguished by a short median lobe on the lower lip, not reaching a line connecting corners of mouth. It is a migratory species and during the flooding of the rainy season moves away from the turbid upland waters to the clearer tributaries down stream where they will spawn.
References: Weber & de Beaufort (1916:152 *Labeobarbus tambra*); Robert (1993:22, Figure 21-24); Robert (1989:80); Kottelat *et al*. (1993:68 pl.22)

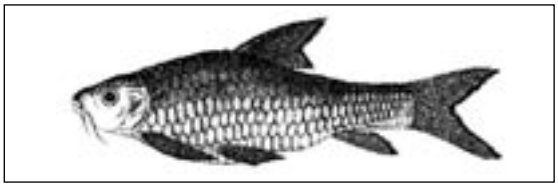

Figure 4. *Tor tambra*

41. *Tor tambroides* (Bleeker 1854)
Localities: SWl, SWu, KM
SL: Up to 620 mm
Local name: Perian (Merap), Padak (Kenyah), Tengah (Punan)
English name: Thai Mahseer
Distribution: Sumatra, Borneo, Java, Burma, Thailand, Laos
Habitat: Fast flowing water with gravel and rocky substrate
Cultural significance: This fish though less common than *T. tambra* is also one of the preferred species of local people.
Comments: Distinguished from *T. tambra* by a longer mental lobe, which reaches the corner of the mouth.
References: Weber & de Beaufort (1916:150 *Labeobarbus tambroides*); Robert (1989:81, Figure 61); Kottelat *et al*. (1993:68, pl.22)

Sisoridae

42. *Glyptothorax platypogonoides* (Bleeker 1855)
SL: Up to 43.28 mm
Localities: SWu, SWl
Local name: Kuyung (Merap); Kuyut, Kiung (Kenyah); Kuyun (Punan)
Distribution: West Sumatra, West Borneo
Frequency/Abundance: Rare and in low abundance
Habitat: Very fast flowing water with rocky substrate
Comments: There are still some problems with the taxonomy of Southeast Asian *Glyptothorax* and formal identification of this species is still tentative (Ng & Rachmatika 1999, Tan & Ng 2000). *G. platypogonoides* has a specialised adhesive apparatus, made of smooth folded skin on its anterior flattened ventral fin, that enables it to attach onto rocky surfaces.
References: Weber & de Beaufort (1913:267); Kottelat *et al*. (1993:107 pl.37); Ng & Rachmatika (1999:182); Tan & Ng (2000:291)

Osphronemidae

43. *Osphronemus septemfasciatus* (Robert 1992)
Localities: SWu, SWl, KM
SL: Up to 490 mm
Local name: Kaloi (Merap), Kaloh (Kenyah), Kaluh (Punan)
Distribution: West, East and North Borneo. The presence of this species in the Seturan watershed extends its known range.
Habitat: Variable, deep river pools, the main stream of the Seturan river and other clear, shallow rivers. Habitat seemed to be size dependent.
Diet: Feeds on vegetal matter and insects (Inger & Chin 1962)
Cultural signifance: a preferred element of local diets and highly sought after.
Comments: *O. septemfasciatus* (Figure 5) differs from the better-known *O. goramy,* which is not found in Seturan, by the number of vertical bars on its side. *O. septemfasciatus* has seven vertical bars, while *O. goramy* has 8-10 bars (Robert 1992). This species exhibits sexual dimorphism.
References: Robert (1992:355, Figure 2); Kottelat *et al*. (1993:221, Figure 316b)

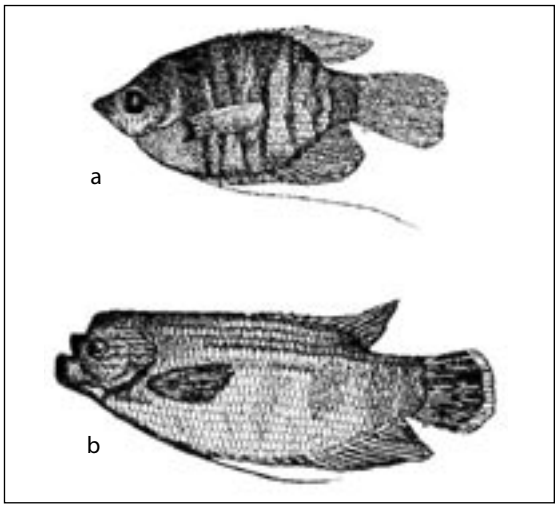

Figure 5. *Osphronemus septemfasciatus*
a. young individual (67,28 mm SL)
b. adult individual (490 mm SL)

Siluridae

44. *Ompok* cf. *bimaculatus* (Bloch 1794)
Localities: SWu, SWl
SL: Up to 187.62 mm
Local name: Lao (Merap), Lao (Kenyah), Tukalo (Punan)
English name: Butter Catfish
Distribution: Sundaland, Indochina, India
Frequency/Abundance: Rare and in low abundance
Habitat: Moderate to fast flowing rivers and streams with banks littered with woody debris.
Comments: Distinguished among Silurids by its lack of dorsal fins, a very long anal fin, nearly straight predorsal and a concave head. It has a brown mottled body and black marking above pectoral fin. Females of 187.62 mm SL were found to be sexually mature.
References: Weber & de Beaufort (1913:202 *Wallago miostoma*; 1913:209 *Callichrous bimaculatus*); Kottelat *et al*. (1993:97 pl.34); Tan & Ng (2000:285)

45. *Ompok sabanus* (Inger & Chin 1959)
Localities: SWl
SL: Up to 134 mm
Local name: Lao (Merap), Lao (Kenyah), Tukalo (Punan)
Distribution: Borneo
Frequency/Abundance: A rare species found in only one site
Habitat: Near stagnant, turbid stream, Patak river
Comments: In comparison to *O. bimaculatus, O. sabanus* is transparent and smaller in size.
References: Kottelat *et al*. (1993:98); Inger & Chin (1962:129); Robert (1989:151)

Mastacembelidae

46. *Macrognathus* cf. *maculatus* (Cuvier *in* Cuvier & Valenciennes 1832)
Localities: SWu, SWl
SL: Up to 110.49 mm
Local name: Lan Kuai (Merap), Telan Kuai (Kenyah), La Kuai (Punan)
English name: Frankelfin Eel
Distribution: Sundaland
Frequency/Abundance: Rare and low abundance, only two specimens found.
Habitat: Fast flowing water, and sand and gravel substrates.
Comments: de Beaufort & Briggs (1962:428); Robert (1989:181, Figure 132c); Kottelat *et al*. (1993:232, pl.80).

47. *Mastacembelus unicolor* (Cuvier *in* Cuvier & Valenciennes 1831)
Localities: SWu, SWl, KM
SL: Up to 227.32 mm
Local name: Lan Kuai (Merap), Telan Kuai (Kenyah), La Kuai (Punan)
Distribution: Sundaland, Burma
Habitat: Clear, moderate to very fast flowing rivers and streams with rocky and gravel substrate; living in crevices amongst the rocks.
References: de Beaufort & Briggs (1962:431); Robert (1989:182, Figure 132a, b); Kottelat *et al*. (1993:232, pl.81)

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