Diversity of fish fauna in the Sembakung river, North Kalimantan, Indonesia

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Abstract. Sembakung river is an important inland fishery in terms of fish production in North Kalimantan, Indonesia. This river is connected to the State of Malaysia, where the upstream part of this river is in the state of Malaysia. The present study was conducted to inform the diversity of fish fauna in the Sembakung river. Fish samples were collected from ten sampling stations of the Sembakung river at Tarakan district in North Kalimantan, Indonesia from March to November 2019. A total of 55 species of fish under 20 orders and 35 families were recorded. Cypriniformes were most leading order constituting 32.73% of the total fish population followed by Siluriformes (18.18%), Anabantiformes (10.91%), Gobiiformes (9.09%), Carangaria (5.45%), Eupercaria (3.64%), and 1.82% for others ordo. Fishes in this river are seriously affected by the various kinds of human development interventions and activities, especially in the areas of agriculture, forestry, fisheries, industries, and transport. Estimates from these indices were indications of low fish species composition and richness and unevenness in the population of fish in the Sembakung river. For sustainability of fishery resources, an adequate knowledge of species composition, diversity, and relative abundance of water bodies must be understood and vigorously pursued. Therefore, there is a need for the conservation and sustainable management of the fisheries resources of the Sembakung water body by relevant agencies.

1. Introduction

Freshwater ecosystems have been claimed the most endangered ecosystems in the world [1]. The particular vulnerability of freshwater fish to global changes reflects the fact that both fish and freshwater are resources humans need and that have been heavily impacted by human usage and regulation [2]. Asia supports over half of the global human population, with enormous consequent pressures on inland waters and freshwater fish biodiversity [3]. Freshwater fishes are important and valued resources for food, sport and ornament [2], and play a key role in economy of many nations [4], as they have been a staple item in the diet of many people. In many parts of the world, Inventories of freshwater biodiversity are incomplete [2], especially the tropics, and rates of species loss may be higher than currently estimated. Nowadays, hundreds of freshwater fish are close to extinction.
Indonesia is the centre of marine biodiversity [5, 6] and the second mega biodiversity country for freshwater fish after Brazil, which is estimated to have around hundreds of fish species in Indonesian territory that have not been discovered and described [7]. According to [8], estimate the number of freshwater fish species in Indonesia is around 1,300 species, which is the highest number in the Asian continent. Fishes are one of the most important biotic components in the aquatic environment [9]. They fill a very specific habitat by meeting a variety of waters substratum. Several studies have mentioned the importance of glittering fish communities in ecosystem processes through trophic relationships with other biotic components [10].

In Indonesia, the distribution of freshwater consists of three groups. Those are Sundaland, Wallacea, and Sahulland. One of the areas Sundaland is Kalimantan, which has the highest diversity of fishes. Several studies of diversity of fishes have been conducted. As like, 21 species in Unarang Reef, Nunukan [11]; 160 species in coral reefs and lagoon at the Maratua Island, East Kalimantan [9]; 95 species at Arut-Kumai, Kabupaten Kotawaringin Barat, Central Kalimantan [12]; 39 species in in Lake Sentarum, West Kalimantan [13].

Sembakung river is an important inland fishery in terms of fish production in North Kalimantan, Indonesia. North Kalimantan is the 34th new Province in Indonesia [14], as a new province, information related to fisheries, especially inland fisheries, in this region is almost non-existent. It is important to describe the diversity of fish in the Sembakung river, in order to develop conservation strategies. This study aimed to inform the fish diversity at the Sembakung river, North Kalimantan.

2. Materials and Methods

2.1. Study site

The method of this research was a survey method by collecting data in the field and analyzing it in the laboratory. This research was carried out from March to November 2019 which was carried out along the Sembakung river by placing 3 fish collection points. The first point representing the downstream part of the Sembakung river, namely in Tepian village; in the middle of the Sembakung river, namely in Atap village; while the upstream of the Sembakung river, namely in Binter village. In the downstream area of the Sembakung river, fish are collected from the villages of Tepian and Plaju. This area represents an area that is still affected by the tides. In the middle area of the Sembakung river, fish are collected from six oxbow lakes. This area represents floodplain waters. While the upstream of the Sembakung river, fish are collected from Masalong and Binter villages. This area has characteristic as a rocky area. The location of the research station could be seen in Table 1 and Figure 1.
Figure 1. Map of sampling sites.

Table 1. Coordinate of sampling sites.

| Station     | Coordinate               |
|-------------|--------------------------|
| Desa Tepian | N:03°44'55.7" E=117°27'54.3" |
| Desa Plaju  | N:03°49'13.5" E=117°15'19.8" |
| Danau 1     | N:03°51'30.3" E=117°02'11.5" |
| Danau 2     | N:03°51'06.0" E=117°02'49.5" |
| Danau 3     | N:03°50'32.7" E=117°04'47.3" |
| Danau 4     | N:03°50'32.7" E=117°04'47.3" |
| Sembakung 1 | N:03°50'47.4" E=117°05'59.5" |
| Sembakung 2 | N:03°50'15.9" E=117°06'07.9" |
| Masalong    | N=03°45'25.1" E=116°45'02.7" |
| Binter      | N= 03°46 ' 25.8" E:115°25 ' 32.8" |
2.2. Fish collection
Fishing is carried out using various fishing gears such as experimental gill nets (jaring), traps (lukah, pekarang, and sempirai), nets (jala), hook and line, and longlines (rawai). Experimental gill nets measuring 1', 1.5', 2', 2.5' and 3', 20 m long and 2 m high were installed in the afternoon (06.00 pm) and then removed in the morning (06.00 am). The traps, especially the sempirai, were set for two days and two nights; while the wounds and yards are installed on the shores of lakes and rivers that enter the lakes and swamps for a day and night. Hook and line and longlines of 1’, 1.5’ and 2’ hook sizes with clover bait and fish pieces are especially used when fishing in flooded swamps and in the bottom area. The fish caught were immediately preserved in 10% formalin solution and grouped according to the fishing ground.

2.3. Fish identification
The fish samples were then identified by species at the Fish Laboratory of the Research Institute for Inland Fisheries and Extension, Palembang. The fish specimens were identified based on references [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, and 30].

3. Results
During the research, 55 fish species were collected, representing 17 orders, 35 families, and 44 genera. Inside 17 orders, Cypriniformes and Siluriformes are the most common orders found along the Sembakung river (17%; 20%, respectively) (Table 2; Figure 2).

![Figure 2. Percentage number of fish Sembakung river’s family in each ordo.](image_url)

However, based on the percentage number of species in each family, the family Cyprinidae is the highest number of species, namely 10 species (18%). Continued by Danionidae, Siluridae, Butidae, and Ospronemidae (9%; 7%; 7%; and 5%, respectively) (Figure 3).
Research on the diversity of fish species in the Sembakung river was carried out along the river by dividing into 3 parts, namely the downstream, middle stream, and upstream. The results showed that the highest diversity of fish families in the Sembakung river was shown in the downstream of the Sembakung river. Meanwhile, the highest diversity of fish species is shown in the middle of the Sembakung river (Figure 4).
3.1. Downstream of Sembakung river
Data collection on fish species in the downstream of the Sembakung river was carried out by placing one enumerator in the village of Tepian during the study. Tepian village is the first village we meet when we enter the waters of the Sembakung river. River waters in this area are still strongly influenced by the tides of sea water, so that most of the fishermen in this area are fishermen who fish in the mouth of the Sembakung river. This is illustrated by the types of fish collected in this area. Inside 25 species of fish collected, 10 of them are estuary fish species, namely: Arius oetik; Caranx sexfasciatus; Lates calcarifer; Paramugil parmatus; Eleotheronema tetradactylum; Ilisha elongate; Scatophagus argus; Johnius trachyccephalus; Dichotomyctere cretamensis; and Taxotes microlepis (table 2). In addition, from the results of the study, it was also identified that the downstream part of the Sembakung river was an area that produced the highest production of giant shrimp (Macrobrachium rosenbergii) compared to other areas in Sembakung river.

3.2. Middle stream of Sembakung river
Atap village is the middle part of the Sembakung river. Around 20 oxbow lakes are found in this area. In this study, two enumerators were assigned to collect fish species in this area. Throughout the research, 26 species of fish were found. 14 of them are types of flooded swamp fish, namely: Butis gymnopomus; Oxyeleotris marmorata; Channa Lucius; Channa striata; Clarias nieuhoii; Laubuka laubuca; Nematabramis steindachnerii; Glossogobius giuris; Helostoma temminckii; Macrognathus aculeatus; Megalops cyprinoides; Betta macrostoma; Trichopodus pectoralis; and Parachela oxygastroides. Others as like Arius oetik; Hemibagrus nemurus; Oreochromis niloticus; Barbonymus gonionotus; Barbonymus schwanenfeldii; Cyclocheilichthys heteronema; Anmatichthys repasson; Rasbora trifasciata; Pangastus djambal; Johnius trachyccephalus; Kryptopterus lais; and Ompok hypophthalmus (table 2) are fishes in the body of river. This area is the highest producer of inland fisheries in North Kalimantan, especially catfish Pangasius djambal and Hemibagrus nemurus.

3.3. Upstream of Sembakung river
The collection of fish to represent this area is carried out by placing enumerator in Binter village. The water conditions in this area are rocky and have swift currents. Collected as many as 17 species of fish from this area, namely: Pseudobagarius pseudobagarius; Anguilla sp; Butis humeralis; Hampala macrolepidota; Hemibagrus mumurus; Kryptopterus cryptopterus; Labiobarbus leptocheilus; Macrobrachium rosenbergii; Nematabramis everetti; Nematabramis steindachnerii; Oreochromis niloticus; Osphronemus gouramy; Osteochilus kahajanensis; Parachela hypophthalmus; Feather puntiopites; Rasbora chrysotaenia; and Tor tambroides (table 2). Almost all the types of fish collected are types of fast-flowing fish. The type of fish that has potential in this area is pelian or semah fish (Tor tambroides) or the surrounding community often also calls it “Dewa” fish.
| No | Familia       | Genus          | Scientific name | Valid name          | Upstream | Middle | Downstream | Threat to humans | IUCN Red List Status |
|----|---------------|----------------|----------------|---------------------|----------|--------|------------|------------------|---------------------|
| 1  | Toxotidae     | Taxotes        | Taxetes microlepis | Taxotes microlepis | v        |        |            | Harmless          | Least Concern       |
| 2  | Akysidae      | Akysis         | Pseudohagarius   | Pseudohagarius pseuohagarius | v        |        |            | Harmless          | Data deficient      |
| 3  | Anguillidae   | Anguilla       | Anguilla marmorata | Anguilla sp          | v        |        |            | Harmless          | Least Concern       |
| 4  | Ariidae       | Arius          | Arius oetik      | Arius oetik         | v        | v      |            | Traumatogenic      | Not Evaluated       |
| 5  | Cyprinidae    | Barbodes       | Barbodes balleroides | Barbonyumus balleroides | v        |        |            | Harmless          | Least Concern       |
| 6  | Cyprinidae    | Barbodes       | Barbodes gonionotus | Barbonyumus gonionotus | v        | v      |            | Harmless          | Least Concern       |
| 7  | Cyprinidae    | Barbodes       | Barbodes schwennenfeldi | Barbonyumus schwennenfeldi | v        |        |            | Harmless          | Least Concern       |
| 8  | Osphronemidae | Betta          | Betta macrostoma | Betta macrostoma    | v        |        |            | Harmless          | Vulnerable (VU)     |
| 9  | Butidae       | Butis          | Butis gymnopomus | Butis gymnopomus    | v        |        |            | Harmless          | Least Concern       |
| 10 | Butidae       | Butis          | Butis kollomadon | Butis kollomadon    | v        |        |            | Harmless          | Not Evaluated       |
| 11 | Butidae       | Butis          | Butis kollomadon | Butis kollomadon    | v        |        |            | Harmless          | Not Evaluated       |
| 12 | Carangidae    | Carank         | Caranx sexfasciatus | Caranx sexfasciatus | v        |        |            | Harmless          | Least Concern       |
| 13 | Channidae     | Channa         | Channa lucius    | Channa lucius       | v        |        |            | Harmless          | Least Concern       |
| 14 | Channidae     | Channa         | Channa striata   | Channa striata      | v        | v      |            | Potential pest     | Least Concern       |
| 15 | Danionidae    | Chella         | Labroula labroula | Labroula labroula   | v        |        |            | Harmless          | Least Concern       |
| 16 | Claridae      | Claris         | Claris nieuhofii | Claris nieuhofii    | v        |        |            | Harmless          | Least Concern       |
| 17 | Cyprinidae    | CyclocheilichthYS | CyclocheilichthYS heteronema | CyclocheilichthYS heteronema | v        | v      |            | Harmless          | Least Concern       |
| 18 | Cyprinidae    | CyclocheilichthYS | CyclocheilichthYS repasson | CyclocheilichthYS repasson | v        |        |            | Harmless          | Least Concern       |
| 19 | Polyomidae    | Eleutheronema   | Eleutheronema tetradactylum | Eleutheronema tetradactylum | v        |        |            | Harmless          | Not Evaluated       |
| 20 | Gobiidae      | Glossogobius   | Glossogobius guris | Glossogobius guris | v        | v      |            | Harmless          | Least Concern       |
| 21 | Gyrinocheilidae | Gyrinocheilus | Gyrinocheilus pastulosus | Gyrinocheilus pastulosus | v        |        |            | Harmless          | Data deficient      |
| 22 | Cyprinidae    | Hampala        | Hampala macrolepidotis | Hampala macrolepidotis | v        |        |            | Harmless          | Least Concern       |
| 23 | Helostomatidae | Helostoma      | Helostoma temminckii | Helostoma temminckii | v        |        |            | Harmless          | Least Concern       |
| 24 | Bagridae      | Hemibagus      | Hemibagus nemurus | Hemibagus nemurus   | v        | v      | v          | Harmless          | Least Concern       |
| 25 | Pristigasteridae | Ilisha    | Ilisha elongata  | Ilisha elongata     | v        |        |            | Harmless          | Least Concern       |
| 26 | Sciaeniidae   | Johnius        | Johnius trachycetus | Johnius trachycetus | v        |        |            | Harmless          | Least Concern       |
| 27 | Stiuridae     | Kryptoperus    | Kryptoperus cryptoperus | Kryptoperus cryptoperus | v        |        |            | Harmless          | Least Concern       |
| 28 | Stiuridae     | Kryptoperus    | Kryptoperus kais  | Kryptoperus kais     | v        |        |            | Harmless          | Least Concern       |
| 29 | Stiuridae     | Kryptoperus    | Kryptoperus limpok | Kryptoperus limpok   | v        |        |            | Harmless          | Least Concern       |
| 30 | Cyprinidae    | Labiobarbus    | Labiobarbus kuhlilii | Labiobarbus kuhlilii | v        |        |            | Harmless          | Least Concern       |
|    |               |                |                |                     |          |        |            |                  |                     |
| 31 | Latidae | Lates | Lates calcarifer | Lates calcarifer | v | Harmless | Least Concern |
| 32 | Mugilidae | Liza | Liza paramutus | Paramugil paramutus | v | Harmless | Not Evaluated |
| 33 | Palaemonidae | Macrobrachium | Macrobrachium rosenbergii | Macrobrachium rosenbergii | v | Harmless | Data deficient |
| 34 | Mastacembelidae | Macrognathus | Macrignathus aculeatus | Macrignathus aculeatus | v | Harmless | Not Evaluated |
| 35 | Megalopidae | Megalops | Megalops cyprinoides | Megalops cyprinoides | v | Harmless | Data deficient |
| 36 | Danionidae | Nematabramis | Nematabramis everetti | Nematabramis everetti | v | Harmless | Not Evaluated |
| 37 | Danionidae | Nematabramis steindachneri | Nematabramis steindachneri | Nematabramis steindachneri | v | Harmless | Not Evaluated |
| 38 | Siluridae | Ompok | Ompok hypophthalmus | Ompok hypophthalmus | v | Harmless | Least Concern |
| 39 | Cichlidae | Oreochromis | Oreochromis niloticus | Oreochromis niloticus | v | Harmless | Least Concern |
| 40 | Osphronemidae | Osphronemus | Osphronemus goramy | Osphronemus goramy | v | Harmless | Least Concern |
| 41 | Osphronemidae | Osphronemus kubachi | Osphronemus kubachi | Osphronemus kubachi | v | Harmless | Least Concern |
| 42 | Butidae | Oxycetra | Oxycetra marmoratus | Oxycetra marmoratus | v | Harmless | Least Concern |
| 43 | Pangasiidae | Pangasius | Pangasius djamal | Pangasius djamal | v | Harmless | Least Concern |
| 44 | Xenocyprididae | Parachela | Parachela hypophthalmus | Parachela hypophthalmus | v | Harmless | Least Concern |
| 45 | Xenocyprididae | Parachela | Parachela oxygastroides | Parachela oxygastroides | v | Harmless | Least Concern |
| 46 | Ambassidae | Parambassis | Parambassis apogonoides | Parambassis apogonoides | v | Harmless | Least Concern |
| 47 | Pseudechididae | Parapleurostomus | Parapleurostomus albolineatus | Parapleurostomus albolineatus | v | Venomous | Not Evaluated |
| 48 | Haemulidae | Pomadoryx | Pomadoryx argenteus | Pomadoryx argenteus | v | Harmless | Least Concern |
| 49 | Cyprinidae | Punoptilus | Punoptilus bulu | Punoptilus bulu | v | Harmless | Least Concern |
| 50 | Danionidae | Rasbora | Rasbora chryseotilapia | Rasbora chryseotilapia | v | Harmless | Data deficient |
| 51 | Danionidae | Rasbora | Rasbora triseriata | Rasbora triseriata | v | Harmless | Data deficient |
| 52 | Scatophagidae | Scatophagus | Scatophagus argus | Scatophagus argus | v | Venomous | Least Concern |
| 53 | Tetraodontidae | Tetraodon | Tetraodon kretamensis | Tetraodon kretamensis | v | Harmless | Not Evaluated |
| 54 | Cyprinidae | Tor | Tor kretamensis | Tor kretamensis | v | Harmless | Data deficient |
| 55 | Osphronemidae | Trichogaster | Trichogaster pectoralis | Trichogaster pectoralis | v | Potential pest | Least Concern |
4. Discussion

Sembakung river has high diversity of fish fauna. The high diversity of fish is related to the spatial heterogeneity of the habitat. The habitat heterogeneity is spatially indicated by the diversity of fish species in each part of the river in this study. Starting from the Tepian area (downstream), Atap area (in the middle), to the Binter area (upstream).

Generally, the dominant family that has found in Sembakung river is Cyprinidae. The large number of members of Cyprinidae family that inhabit waters is common because this family is the largest freshwater fish family in the whole world; except Australia, Madagascar, New Zealand, and South America [24]. The Cyprinidae family is the largest freshwater fish species in Southeast Asia [31] including on Sumatra Island [32].

The research in several rivers and their floodplain on Sumatra showed the same result. As in the waters of Bukit Tiga puluh Siberida, it was found that the family Cyprinidae was the largest population. Then the fish population was followed by catfish (Bagridae, Clarididae, and Pangasidae) [33]. Then in the Rangau river, Riau, found 70 fish species belonging to 44 genera and 21 families with the most caught families being Cyprinidae (17 species) followed by Siluridae (10 species) and Bagridae (8 species) [34]. Furthermore, in the Enim River, Sumatra, 28 species (11 families) of fish fauna were caught, dominated by the Cyprinidae (14 species), Cobiitidae (4 species) and Balitoridae (2 species) families [35]. Meanwhile, in the Tesso Nilo area, Riau, 31 genera of fish were collected from 16 families. The dominant families caught were Cyprinidae (18 species), followed by Bagridae (5 species), Belontiidae, and Siluridae (4 species each) [36].

The diversity of fish species in each representative of the river during the study described the characteristics of their habitat. The downstream of Sembakung river is at Atap village. The condition of this area is influenced by the tides so the results of the study show that 10 of the 25 species of fish caught are estuary fish. Based on the results of field observations and on-site interviews informed that this area has potential as a development area for giant shrimp (*Macrobrachium rosenbergii*). This shrimp has high economic value.

The middle stream of the Sembakung river is floodplain area. There are around 20 oxbow lakes found in this area. This area will increase in during the rainy season (flood season) when fish from the river migrate laterally to floodplain areas and after receding water returns to the main river or settle in oxbow lakes. According to [37] stated that the high diversity of fish fauna found in floodplain areas is a feature of ecological dynamics as a fish response to habitat heterogeneity and fluctuations in water level. Temporarily varying environmental parameters such as depth, current velocity, temperature, substrate and dissolved oxygen play a major role in supporting the diversity of fish groups in floodplain area of the Frazos River, Texas [38]. Several studies have stated that fish communities in tropical floodplain are stochastic assemblages with the main factor being changes in water level [39, 40, 41, and 42]. The results of field observations identified that this area is an area that has the potential as a reserve area to maintain the sustainability of fish resources in North Kalimantan.

The presence of *pelian* fish or *semah* fish in Binter village indicates that the area is part of the upper stream of Sembakung river. This is also supported by the types of fish caught which are the types of fish that live in rocky waters and have fast currents. This area has the potential for the development of rare and economically important fish such as the *pelian* fish (*Tor tambroides*).

Mostly, the fish species found at the study as category of consumption fish which are sold in the form of fresh fish, smoked or salted. The high demand of fish needed will encourage uncontrolled exploitation and it will reduce the fish population. The efforts on control the sustainability of Sembakung river are setting the fishing season and fishing gear [43], determining reserve areas, especially flood swamp areas; domestication and cultivation of fish species native to the Sembakung river [44, 45].

Sembakung river is connected to the State of Malaysia, where the upstream part of this river is in the state of Malaysia. Based on field observations and interviews with local fishers, informed that the condition of the waters of Sembakung river is strongly influenced by activities that
occur in upper stream, namely in Malaysia, especially during flooding or water delivery in Malaysia. Tockner and Stanford [46] stated that the decline on diversity of freshwater fish species is closely related to habitat destruction. The information of Sembakung fish resources is still limited. The results of this study are expected could be used as basic information for inland fisheries management in North Kalimantan, especially in Sembakung river.

5. Conclusion
The Sembakung river is one of the waters that has high diversity fish species, no less than 55 types of fish are found in this area. Each representative of the river has different fishery potential, i.e. the downstream has potential as a giant shrimp (Macrobrachium rosenbergii) development area; the middlestream as a reserve area on preserving fish resources to fish needs (consumption) in North Kalimantan; while the upstream of Sembakung river is a development area for economically important fish whose existence has started to become rare, such as pelian fish (Tor tambroides). Considering that this river is a cross-country river, it is necessary to conduct a more in-depth study related to the impacts arising from all activities sent from the upstream to this river. It is necessary to immediately undertake fisheries management efforts to maintain the preservation of fish fauna in the Sembakung river.

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