



RESEARCH ARTICLE

REVISED Diversity and distribution of fish fauna of upstream and downstream areas at Koto Panjang Reservoir, Riau Province, Indonesia [version 2; peer review: 2 approved]

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Abstract

Background: The capture fishery sectors in the river and reservoir play an important role in the Indonesian economy through increased income and diversification of livelihoods. The present study was conducted to ascertain fish diversity and their distribution pattern in the upstream and downstream areas of Koto Panjang Reservoir, Riau Province-Indonesia.

Methods: Fish samples were collected for a period of 12 months using a variety of fish nets at four sites; Koto Mesjid (KM) and Batu Bersurat (BB), located in the upstream area of Koto Panjang Reservoir and Rantau Berangin (RB) and Kuok (KK), located in the downstream area of Koto Panjang Reservoir. Data obtained were analyzed using standard taxonomic keys based on morphometric characters.

Results: A total of 44 species belonging 19 families and 33 genera were recorded in the study area. Alpha diversity indices showed that fish diversity in this area was quite high (Shannon's index = 2.10 and Simpson-D = 0.21) and evenness was low (evenness H/S = 0.19). The fish in KM and BB sites (upstream) were from eight and 11 families, respectively. In RB and KK sites (downstream), fish were from 16 and 15 families, respectively. In KM, BB, RB and KK sites, the dominant family was Cyprinidae, comprising 33.45%, 50.95%, 43.04% and 39.35% of all fish caught at each site, respectively. Exotic species, especially Nile tilapia, were 20.15%, 14.11%, 5.62%, and 5.34%, respectively. Some differences were also noted between the upstream and downstream reservoirs, with a slight increase in exotic species in the upstream reservoir over the study period (from 11.39% vs. 34.66%), corresponding to decrease of native species (from 88.61% vs. 65.34%).

Conclusions: The diversity and distribution of fish fauna were varied

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in upstream and downstream areas of Koto Panjang Reservoir. The exotic species were found to be dominant in the upstream reservoir areas.

Keywords

Ichthyodiversity, shannon's index, evenness, exotic, reservoir, river

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We have been updated some information in the introduction and discussion. We also updated some references.

Any further responses from the reviewers can be found at the end of the article

Introduction

The capture fishery and aquaculture sectors play an important role in the Indonesian economy through increased income, diversification of livelihoods, supply of animal protein, and foreign exchange earnings. In 2018, the total fishery production of Indonesia was 23,186,442 metric tons, of which 467,821 metric tons was obtained from inland capture fisheries, 6,603,631 metric tons was obtained from marine fisheries, and 16,114,991 metric tons was obtained from aquaculture fisheries production¹. A total of 1,300 fish, including 40 endemic species are known to inhabit in the freshwaters of Indonesia, with 16 exotic species recorded in Indonesia². The production from the inland capture fisheries of Indonesia comes from wetlands (rivers, lakes, swamps, oxbow lakes, floodplains, etc). In Riau Province, one of the rivers that produce freshwater fish from capture fishery is the Kampar Kanan river. Fithra and Siregar³ found 54 species in Kampar Kanan River, while Aryani⁴ reported 40 species. At present, major Cyprinidae species such as *Leptobarbus hoevenii*, *Osteochilus haselti* and *Rasbora argyrotaenia*, along with exotic species, such as common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*), are the available species of fish at local food markets.

According to Mulyadi⁵, Kampar Kanan river is one of the largest rivers in Riau Province. It is approximately 213.5 km long and between 125 to 143 m wide, with significant capture fishery potential. Since 1996, this river has been dammed into a reservoir (Koto Panjang Reservoir) for the operation of a 114 MW hydroelectric power plant. The dam height is 96 m and located at altitude of 85 m above sea level⁶, and at the geographical position 0°17'23.76"N and 100°52'53.39"E. However, at the location of the dam, there is no fishway. The abiotic and biotic characteristics of river ecosystems can be affected by the construction of dams. These conditions have an impact on mortality and failure of fish migration⁶⁻⁹. The hydrologic regime of streams changing from lotic to lentic can influence the water retention in the reservoir. In general, the lentic condition causes a decrease in native species and then an increase in exotic

species^{10,11}. Furthermore, the degradation of aquatic fauna habitats can be caused by an increase in homogeneity of water channels, which has an effect on the seasonal flow variability of river¹². The reduction in river runoff also affects the habitat and distribution of fish fauna.

On the other hand, there are serious threats to the original fish biodiversity in the downstream and upstream regions of the reservoir due to the dam of the hydroelectric power plant, such as sand mining in river, land use change and aquaculture activity with cages, which can affect the depth of river water, food availability, and breeding sites. Amadi *et al.*¹³ state that original biodiversity can be eroded by habitat degradation and alien species impact. Meanwhile, aquaculture heavily impacts the structure and diversity of local fish communities^{14,15}. Hence, it was essential to study fish diversity continuously in different ecosystem areas, including upstream and downstream areas at Koto Panjang Reservoir, Riau Province, Indonesia.

Methods

Ethical statement

There are no required permits from the government of the Republic of Indonesia to capture the species in this study in the upstream and downstream regions of Koto Panjang Reservoir. The study was funded by LPPM (Research and Community Service) University of Riau under Directorate of Research and Community Service, Ministry of Research Technology and Higher Education Republic of Indonesia with contract no. 767/UN.19.5.1.3/PT.01.03/2018. This grant included ethical approval and permits to collect fish samples including native species (endangered and non-endangered) and exotic fish species. Specimens of fish species categorized as non-endangered and exotic were killed once caught. Endangered fish species (*Hemibagrus wyckii*) were returned to the river in good condition following analysis in the field. All efforts were made to ameliorate any animal suffering through anaesthetizing fish with ice water before euthanization.

Sampling sites and methods of specimen collection

Fish sampling was carried out from January to December 2018 at four sites, namely, Koto Mesjid (KM) and Batu Bersurat (BB) (upstream reservoir), Rantau Berangin (RB) and Kuok (KK) (downstream reservoir) (Table 1). Fish samples were randomly collected from the study area using traditional fishing gear (e.g. traps nets, cast nets, gill nets, drag nets, and fishing poles). Data was collected once a month at each site and five pieces of fishing gear were in operation at any one time.

Table 1. Sampling sites in the upstream and downstream areas at Koto Panjang Reservoir.

Sampling Site	Site Code	Areas	Distance from on Dam position (km)	Latitude	Longitude
Koto Mesjid	KM	Upstream Reservoir	1.2	0°17'06.92"N	100°52'31.31"E
Batu Bersurat	BB	Upstream Reservoir	15.5	0°20'12.30"N	100°44'27.26"E
Rantau Berangin	RB	Downstream Reservoir	1.2	0°17'59.79"N	101°54'47.19"E
Kuok	TB	Downstream Reservoir	15.5	0°23'26.88"N	101°25'50.64"E

Trap nets (local name *bubu*) are made from bamboo woven with rattan and have a cylindrical front with a diameter of 80 cm and cone-shaped back, with a length of two meters. Chicken intestine was placed inside the gear as bait. This gear was used between the hours of 18:00 and 06:00 at the bottom of river and reservoir to catch demersal fish such as Bagridae, Pangasidae, Gobiidae, Claridae, Anabantidae, Belontiidae.

Cast nets (local name *Jala*) are a type of active fishing gear made from string, with a length of 2.5 meters and mesh size of 1.5 inches. This gear was used on the river and reservoir sides by fishermen using canoes. This gear was operated during the day from 06.00 until 10.00. The purpose of cast nets is to catch the family of Cyprinidae, Osphronemidae, Notopteridae and Cichlidae.

Gill nets (local name *jaring insang*) are made of rectangular monofilament yarn, are 60 meters in length and 8 meters in depth, with a 2.5 inch mesh size. These were operated passively and transversely on the surface of river from 18.00 until 06.00 to catch pelagic fish such as Cyprinidae, Osphronemidae, Notopteridae and Cichlidae.

A drag net (local name *belad*) is a passive fishing device made from nylon net material with a diameter of 0.15 mm and a mesh size of 0.5 inches. This gear is assisted by bamboo or wood as a cantilever, with a height of 2.5 meters and a length of 100 meters, which was placed parallel to the river coastline from 18.00 until 06.00. The purpose of the drag net is to catch the family of Bagridae, Pangasidae, Gobiidae, Claridae, Anabantidae, Belontiidae and Siluridae.

The fishing pole (local name *rawai*) used consisted of a main line with a length of 50 to 100 cm and a distance from one branch line to another of 1.5 meters. One fishing pole has hooks ranging from 20 to 30 pieces and the hooks are size no. 15. The fishing pole was operated passively on the river bottom between the hours of 18.00 and 06.00 and used chicken intestine as bait. The main purpose of fishing pole is to catch the family of Bagridae, Tetrodontidae, Pangasidae and Channidae.

Samples were classified as endangered, non-endangered and exotic fish species based on the categories described by Kottelat and Whitten¹⁶. Once caught, fish were anaesthetized in ice water at a temperature of 5°C. Euthanization was achieved by piercing part of the brain of the fish. Samples were given an intraperitoneal injection prior to store in a formalin solution. Smaller specimens were stored directly in 5% formalin solution, while the larger specimens were stored in 10% formalin solution. Specimens that were categorized as non-endangered were transported in a cold box (10 °C) to the Fish Biology and Ichthyology Laboratory, Department of the Aquaculture, Riau University for measurement of specimen length, weight, and morphometric characteristics. Endangered fish species such as *Hemibagrus wyckii* were analyzed and measured in the field. Then, the same fish was returned to the river in good condition. The length, body weight and morphometric characteristics were only collected for 10 individual specimens from each species.

Samples from each site were separately packed in labeled plastics jars according to date, site, time, and locality. Each specimen was labeled with a specific number manually. Classification and taxonomic identification of the sampled specimens was completed using standard keys^{17,18} on the basis of morphometric and meristic characters.

Data analysis

The data of different species for abundance and occurrence was calculated for species richness (S), Shannon diversity Index (H'), Simpson diversity index (D), evenness (H/S) and Sorenson's coefficient (CC)¹⁹⁻²¹ using Microsoft Excel 2010 (version 14.0). The accuracy of the data and results were verified by applying all the diversity indices separately according to sampling months and sampling sites.

Results

Monthly occurrence of fish fauna in the upstream and downstream areas at Koto Panjang Reservoir

During the study, forty-four different species of fish were collected from the study area. A total of 8017 specimens of fish were collected from four sites²⁰. The details of the fish species collected on a monthly basis for the period of one year (January to December 2018) are presented in [Table 2](#). The highest number of fish collected during one month was collected during August 2018 (873 specimens), followed by the months of September > July > June > October > May > November > April > March > December > February > January.

Ichthyodiversity in the upstream and downstream areas at Koto Panjang Reservoir

A total of 44 species belonging to 19 families and 33 genera were sampled from the four sites over one year in the upstream and downstream areas at Koto Panjang Reservoir. There were seventeen species which are commercially important, as determined by their high market value. These species including ornamental fish species such as *Chromobotia macranchantus*, *Chromobotia hymenophysa*, *Thrichogaster trichopterus* and *Mystus micrakanthus*. The highest ichthyodiversity in study area was calculated during July and August 2018 (44 species), followed by June and September (42 species), May and October (41 species), April and November (39 species), December (38 species), March (36 species), February (30 species) and January (26 species). Numerically, the most abundant and diverse family was Cyprinidae, comprising of 16 species, followed by Bagridae and Channidae (represented by four species each). The fourth most diverse family was Gobiidae, represented by three species in the study area. The least diverse families were Claridae, Pangasidae, Anabantidae, Mastacembelidae, Osphronemidae, Pristolepididae, Cygnolossidae, Notopteridae, Hemiramphidae and Cichlidae, represented by only one species for each ([Table 2](#)). *Barbodes schwanifeldi*, *Hemibagrus nemerus*, *Ompok hypophthalmus*, *Rasbora argyrotaenia* and *Oreochromis niloticus* were recorded as the most abundant species, comprising 5.88%, 6.20%, 6.71%, 8.76% and 9.80% of all fish caught, respectively. The least abundant were *Channa pleurothalmus*, *Hemibagrus wyckii* and *Pangasius pangasius*, representing 0.06%, 0.08% and 0.09%, respectively.

Table 2. Ichthyodiversity in the upstream and downstream regions of Koto Panjang Reservoir in January to December 2018.

Family/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cyprinidae													
<i>Barbodes schwanifeldi</i>	20	25	30	39	40	42	45	50	57	49	40	35	472
<i>Crossocheilus oblongus</i>	3	5	3	6	5	7	8	12	15	8	4	5	81
<i>Crossocheilus langei</i>	0	0	4	4	8	5	6	8	7	5	3	0	50
<i>Labiobarbus festifus</i>	8	12	10	9	13	15	15	17	21	25	12	11	168
<i>Cyclocheilichthys apogon</i>	3	3	2	5	10	15	18	14	11	8	5	4	98
<i>Hampala macrolepidota</i>	0	0	1	1	0	2	3	2	4	1	1	1	16
<i>Osteochilus hasselti</i>	14	16	20	36	30	39	42	40	40	34	29	25	365
<i>Osteochilus schlegeli</i>	0	0	1	2	5	6	5	8	2	3	2	2	36
<i>Osteochilus vittatus</i>	23	25	20	18	28	21	15	23	26	18	13	10	240
<i>Osteochilus pleurotaenia</i>	15	20	23	29	34	30	35	29	27	22	15	12	291
<i>Oxygaster anomalura</i>	6	7	12	13	9	15	15	17	13	11	9	7	134
<i>Puntioplites bulu</i>	30	31	35	29	28	35	30	24	25	19	32	28	346
<i>Rasbora argyrotaenia</i>	60	40	50	55	60	65	75	70	65	60	52	50	702
<i>Thynnichthys pollepis</i>	15	18	21	25	19	24	26	22	19	21	20	15	245
<i>Leptobarbus hoevenii</i>	0	1	2	3	2	5	4	3	3	2	1	1	27
<i>Cyprinus carpio</i>	0	0	1	3	3	5	2	2	3	1	1	0	21
Bagridae													
<i>Hemibagrus nemurus</i>	32	34	35	38	40	43	38	40	51	58	53	35	497
<i>Hemibagrus wyckii</i>	0	0	0	0	1	1	2	2	1	0	0	0	7
<i>Mystus nigriceps</i>	23	25	22	26	28	30	31	38	32	25	28	20	328
<i>Mystus micracanthus</i>	0	0	0	0	1	5	4	4	3	1	0	1	19
Clariidae													
<i>Clarias teijsmanni</i>	12	15	14	18	21	22	26	29	22	23	17	16	235
Pangasidae													
<i>Pangasius pangasius</i>	0	0	0	0	1	1	1	1	1	1	1	1	8
<i>Pangasianodan hypophthalmus</i>	0	1	2	4	5	5	8	3	2	3	2	2	37
Siluridae													
<i>Ompok hypophthalmus</i>	45	42	45	48	43	51	55	50	45	41	38	35	538
<i>Wallago leerii</i>	10	12	18	23	10	14	24	20	19	16	14	9	189
Gobitidae													
<i>Chromobotia macranchantus</i>	0	0	0	1	2	2	8	5	6	0	0	0	24
<i>Chromobotia hymenophysa</i>	0	1	1	2	2	1	1	3	0	0	0	0	11
<i>Acanthopsis octoactinatus</i>	0	2	1	1	3	1	3	4	6	2	1	2	26
Tetraodontidae													
<i>Tetraodon palembangensis</i>	3	4	2	4	5	12	18	21	18	15	12	5	119
Anabantidae													
<i>Anabas testudineus</i>	0	0	8	12	18	15	21	30	18	17	23	15	177
Belontiidae													
<i>Thrichogaster trichopterus</i>	0	0	0	0	1	2	3	3	2	5	3	2	21

Family/species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Channidae													
<i>Channa lucius</i>	12	14	10	16	21	25	28	31	38	12	9	5	221
<i>Channa striata</i>	19	21	17	25	26	32	38	40	32	29	17	9	305
<i>Channa micropeltes</i>	0	0	1	2	0	4	6	7	5	1	1	0	27
<i>Channa pleurothalmus</i>	0	0	0	0	0	0	2	2	0	1	0	0	5
Eleotridae													
<i>Oxyeleotris marmorata</i>	9	15	14	21	19	16	18	21	19	17	13	8	190
Helostomatidae													
<i>Helostoma temmincki</i>	0	0	0	5	8	11	15	23	29	32	15	11	149
Mastacembelidae													
<i>Mastacembelus unicolor</i>	3	5	6	7	8	8	6	7	12	11	8	8	89
Osphronemidae													
<i>Osphronemus gouramy</i>	0	0	0	4	3	6	7	10	8	13	15	9	75
Pristolepididae													
<i>Pristilepis grooti</i>	5	8	12	11	15	19	13	18	22	23	19	16	181
Cynglossidae													
<i>Cynglossus microlepis</i>	3	9	8	11	15	19	23	21	19	15	14	12	169
Notopteridae													
<i>Chitala lopis</i>	3	5	6	6	8	9	14	13	20	21	16	15	136
Hemiramphidae													
<i>Hemiramphus chrysopunctatus</i>	4	7	8	11	13	9	15	21	19	23	14	12	156
Cichlidae													
<i>Oreochromis niloticus</i>	57	61	69	62	59	60	76	65	67	80	69	61	786
Grand total	437	484	534	635	670	754	848	873	854	772	641	515	8017
Percentage population	5.45	6.04	6.66	7.92	8.36	9.41	10.58	10.89	10.65	9.63	8.00	6.42	
Total species	26	30	36	39	41	43	44	44	42	41	39	37	
Percentage diversity	59.09	68.18	81.82	88.64	93.18	95.45	100	100	95.45	93.18	88.64	86.36	

Table 3 shows different diversity indices used to calculate the species abundance data. The highest species richness was recorded between the months of June and September. Similarly, the highest values for Shannon's diversity index (H') were achieved during October 2018 (2.27), August and November 2018 (2.23), and the lowest values during January and February 2018 (1.74 and 1.91).

The highest Simpson diversity index ($1/D$) was recorded during the months of January (0.25), followed by April (0.23), February, March and May (0.22), and the lowest value was recorded in the months of October and November (0.18). Similarly, the highest values of species evenness (H/S) was recorded in the month of March > December and its least value was recorded during the month of June. Furthermore, the detailed values of different diversity indices on the basis of sampling sites were given in the Table 4. Whereas, the Sorenson's coefficient (CC) between upstream and downstream areas at Koto Panjang Reservoir were presented in Table 5. The commercially important fish species captured in downstream Reservoir were *Hemibagrus wyckii*, *Hemibagrus nemurus*,

Wallago leerii, *Pangasius pangasius*, *Osphronemus gourami*, *Puntioplites bulu*, *Rasbora argyrotaenia*, *Channa striata*, and *Channa micropeltes*. Whereas, in the upstream Reservoir found were *Pristilepis grooti*, *Oxyeleotris marmorata*, *Hemibagrus nemurus* and *Channa striata* and *Oreochromis niloticus*.

The abundance and number of families found between sites was varied. At KM and BB (upstream reservoir), 8 and 11 families were found, respectively, while at RB and KK (downstream reservoir), 16 and 15 families were found, respectively (Figure 1). The dominant families in each site was Cyprinidae, comprising 33.45%, 50.95%, 43.04% and 39.35% of all fish caught at KM, BB, RB and KK, respectively. Whereas, the exotic species, especially Nile tilapia (*O. niloticus*), in each site comprised 14.11%, 20.15%, 5.62% and 5.34% of all fish caught at KM, BB, RB and KK, respectively. Some differences were also noted between the upstream and downstream reservoirs areas (Figure 2), with a slight increase of exotic species in the upstream reservoir (from 11.39% to 34.66%) and a corresponding decrease of native species (from 88.61% to 65.34%).

Table 3. Monthly diversity indices of fish fauna in the upstream and downstream areas at Koto Panjang Reservoir.

Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
No. of individuals	437	484	534	635	670	754	848	873	854	772	641	515	8017
Richness (S)	26	30	36	39	41	43	44	44	42	41	39	37	44
Simpson (1/D)	0.25	0.22	0.22	0.23	0.22	0.22	0.20	0.19	0.19	0.18	0.18	0.20	0.21
Shannon's (H')	1.74	1.91	2.14	2.00	2.07	2.06	2.16	2.23	2.21	2.27	2.23	2.17	2.10
Evenness ($e^{-H/S}$)	0.22	0.22	0.24	0.19	0.19	0.18	0.19	0.21	0.21	0.24	0.23	0.24	0.19

Table 4. Site based diversity indices of study area in the upstream and downstream areas at Koto Panjang Reservoir.

Index	KM	BB	RB	KK	Total
No. of individuals	1701	1370	2135	2811	8017
Richness (S)	18	21	37	35	44
Simpson (1/D)	0.31	0.18	0.22	0.20	0.21
Shanon,s (H')	1.51	1.95	2.00	2.03	2.10
Evenness_ e ^{-H/S}	0.25	0.33	0.20	0.22	0.19

Note: KM = Koto Mesjid, BB = Batu Bersurat, RB = Rantau Berangin, KK = Kuok.

Table 5. Sorenson's coefficient (CC) between sites in the upstream and downstream areas of Koto Panjang Reservoir.

Site	KM	BB	RB	KK
KM				
BB	0.92			
RB	0.65	0.54		
KK	0.57	0.56	0.80	

Note: KM = Koto Mesjid, BB = Batu Bersurat, RB = Rantau Berangin, KK = Kuok.

Discussion

Our results showed that the highest abundance and diversity of fish species collected in June, July and August, which may be due to a lesser water current in the study area during these dry season months. According to Kriauciūnienė *et al.*²² the abundance of fish species in rivers can be affected by river discharge. However, future alterations in river water temperature will have a significantly larger influence on the abundance of fish than river discharge. Overexploitation and illegal sand mining have affected the abundance of fish in the Kampar Kanan river²³. Furthermore, the fundamental measures of aquatic

ecosystems, including species richness and diversity indices, are influenced by the alterations in abiotic factors such as river water temperature and discharge^{24–27}.

Our study also revealed significantly lower species diversity in KM and BB (upstream reservoir) compared to that of RB and KK (downstream reservoir). The overall richness in KM was much lower than that found in RB (18 vs. 37). During the research period, we also recorded a slight increase in exotic species in the upstream reservoir and a decrease in native species. Therefore, the implication of exotic species such as Nile tilapia and common carp have negative effect to native species in the upstream area of Koto Panjang Reservoir. In contrast, in a Portuguese reservoir, it was found that there was a slight increase in exotic species in the downstream reservoir⁶. This result might be a consequence of cumulative impacts of cultivation of fish in floating net cages, such as Nile tilapia and common carp. According to Russel *et al.*²⁸, Nile tilapia cause the extinction of native fish species by preying on eggs, fry and small fish of other species. On the other hand, the decrease in species richness can be influenced by aquaculture activity, such as water quality degradation, intensified competition, invasive species, and habitat fragmentation^{14,29–31}. Koto Panjang Reservoir was categorized as eutrophic, with level index values ranging from 4.6–5.2³². According to Edwards³³, species with high environmental tolerance would be survive in poor environmental conditions, such as high pollution caused by food waste at the reservoir, while the sensitive species will disappear. Furthermore, fish populations in a reservoir can be affected by hydropower dams^{5,6}. In addition, the intensifying competition for food and space between wild species and the large number of cultured species will lead to a decrease in wild fish numbers^{34,35}.

Our study confirmed the existence of three species, *Pangasius pangasius*, *Wallago leerii* and *Chitala hypselonotus*, at Koto Panjang Reservoir that were not found previously by Warsa *et al.*³⁶ and Krismono *et al.*³⁷. The study area also represents the area of the Kampar Kanan river with the largest fish species, including *W. leerii*, *H. wyckii* and *P. pangasius*. The construction of the dam for power generation purposes is posing serious threats to the biodiversity of Kampar Kanan river. After the construction of the Koto Panjang dam on Kampar

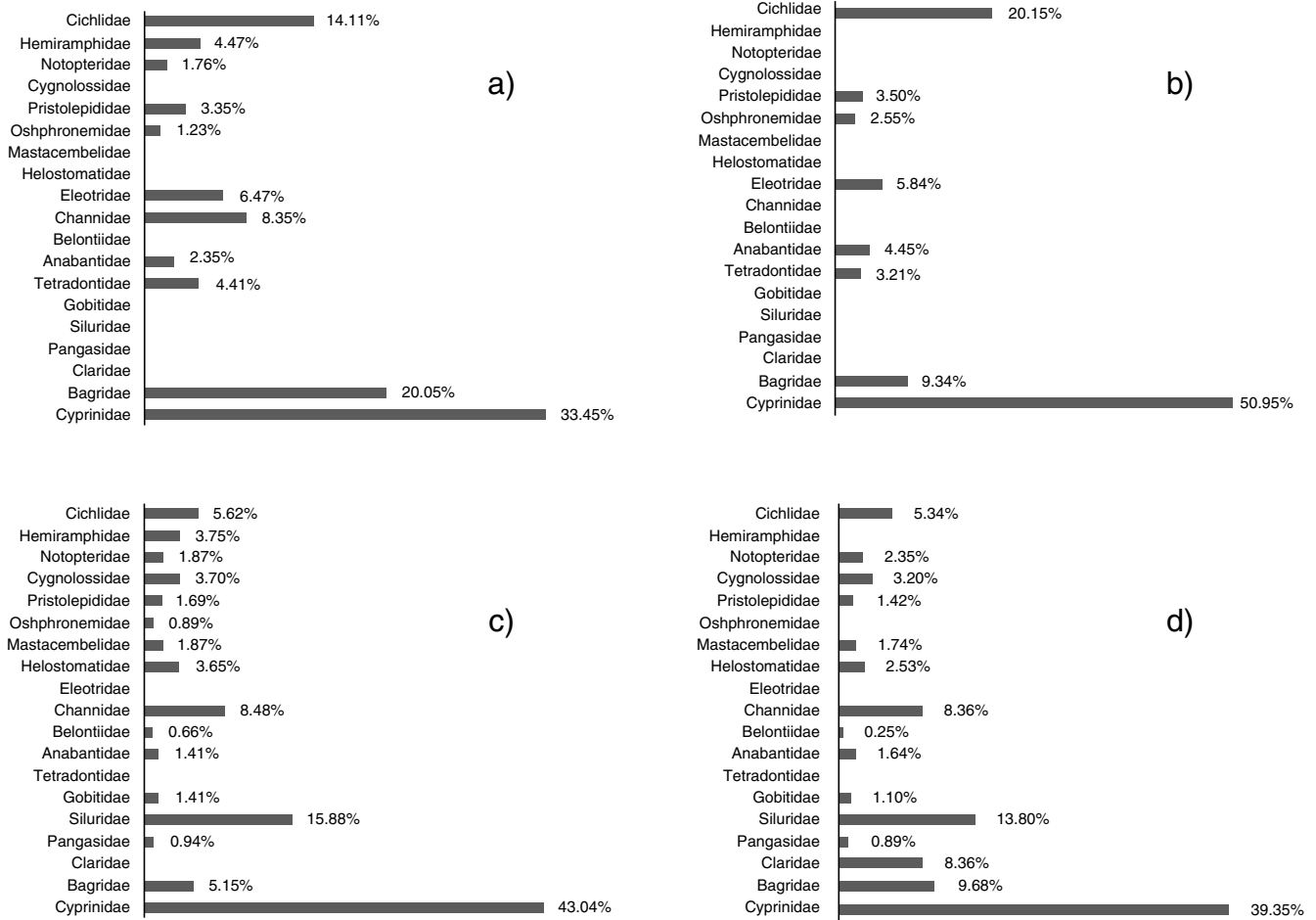


Figure 1. Abundance and composition of aquatic fauna in the upstream and downstream reservoir. a) Koto Mesjid, b) Batu Bersurat, c) Rantau Berangin and d) Kuok.

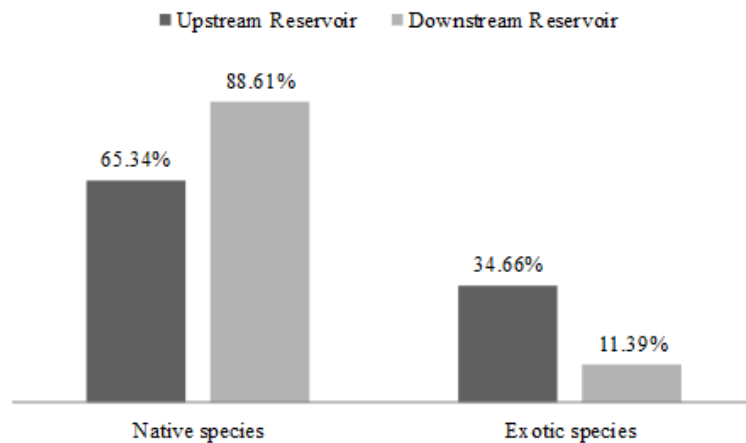


Figure 2. Percentage of individuals of native and exotic fish species in upstream (Koto Mesjid, KM, and Batu Bersurat, BB) and downstream reservoirs areas (Rantau Berangin, RB, and Kuok, KK).

Kanan river, the movement of fish upstream has been restricted. *Osteochilus kelabau* has not been reported at RB in our study although this species has previously been found in this area⁴. Similarly, the population of *H. wyckii* has also been dramatically reduced and restricted between Koto Panjang Reservoir barrages and Kampar Kanan river after the construction of these barrages. *H. wyckii* in the Kampar Kanan river is categorized as ‘vulnerable to endangered’³⁸. According to Piria *et al.*³⁹, the disturbances to the fish assemblage pattern have coincided with the presence of multiple stressors of human origin, such as pollution, flood protection and dam construction. Meanwhile, dams can change the hydrological dynamics, patterns of biological production, loss of native species in the downstream regions and distribution of organisms in space and time^{5,7,12,40,41}.

There are a number of inadvertently introduced fish species in the upstream and downstream Reservoir, such as *O. niloticus*, *Cyprinus carpio*, *Leptobarbus hoevenii* and *Pangasianodon hypophthalmus*, while rest of the 40 species belong to the native fish fauna of the Kampar Kanan river⁴. The unique feature of the abundance data was that the exotic family Cichlidae is well established and its population is increasing day by day, especially in the upstream areas at Koto Panjang Reservoir. In recent years, the Koto Panjang Reservoir has had very important roles, such as housing power plants with a capacity of 114 MW and serving as a fishery capture and aquaculture area with floating net cage farming, especially for the cultivation of *O. niloticus*. Cichlidae was the third most abundant family. These alien fish species represent a significant risk for the local fish community and other aquatic animals. Gu *et al.*³¹ state that the invasion of *O. niloticus* negatively affected the fishery economy and native fish species in the Pearl River of Guangdong Province, China.

In addition to the species richness (S) analysis, Shannon diversity index (H'), Simpson diversity index (D) and evenness (H/S), we also analyzed the Sorenson's coefficient (CC) between the upstream and downstream sites. The Sorenson's coefficient for each site varied between 0.54 and 0.92. The highest value of Sorenson's coefficient was recorded between KM and RB, at 0.92, and the lowest value was recorded between BB and RB, at 0.54 (Table 5). According to Sorenson's coefficient, these communities have quite a bit of overlap or similarity.

The high diversity of native species in the water body will decrease their tolerance in poor aquatic environments. In contrast, the invasive fish species have a high tolerance to poor water quality⁴². The interaction between different species, combined with the limnological and physical properties of the aquatic ecosystem, may influence the diversity and distribution of fish fauna⁴³. In this study, the diversity of fish to be found smaller than Fhitra and Siregar³, who reported 58 fish species belonging to 23 families and 40 genera from Kampar Kanan river. Simanjuntak *et al.*⁴⁴ described 86 species and 21 families in the Kampar Kiri river of the Kampar District. On the other hand, Nurdawati *et al.*⁴⁵ reported 96 species in the Batanghari river, Indonesia. Additionally, Bahri⁴⁶ described 86 species in the Musi river and Kottelat and Whitten⁴⁷ reported 1300 species

of freshwater fish across Indonesia that live in wetlands (rivers, lakes, bogs, oxbow lakes, floodplains, etc.).

Conclusion

The results indicate that the diversity and distribution of fish fauna in upstream and downstream areas of the Koto Panjang Reservoir were varied, and the evenness was low. The abundance and composition of fish in each site was dominated by Cyprinidae families, although exotic species were more dominant in the upstream reservoir compared to the downstream reservoir areas. Therefore, the management of the river and reservoir in a more holistic manner is important, for example, the management of land use, sand mining and aquaculture activity, as well as possible habitat restorations. All the factors above are a prerequisite for the environmental sustainability and conservation of fish diversity in the upstream and downstream areas at Koto Panjang reservoir and other regions.

Data availability

Underlying data

Figshare: Row data fish fauna at upstream and downstream. <https://doi.org/10.6084/m9.figshare.8964284.v1>²⁰

This project contains the following underlying data:

- Tables 2 – 5 (raw data for ichthyodiversity of fish in each site).
- Table 6 (data for abundance and composition of aquatic fauna each sites in the upstream and downstream areas at Koto Panjang Reservoir)
- Table 7 (data for grand total and percentage of families of aquatic fauna in the upstream areas at Koto Panjang Reservoir)
- Table 8 (data for grand total and percentage of families of aquatic fauna in the downstream areas at Koto Panjang Reservoir)
- Table 9 (character morphometric and meristic of fishes of upstream and downstream areas at Koto Panjang Reservoir, Riau Province-Indonesia)
- Table 10 (sample sizes of fish populations (n=10) in the upstream and downstream areas at Koto Panjang Reservoir on January to December 2018)

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/) (CC-BY 4.0).

Acknowledgements

The authors thank the Ministry of Research Technology and Higher Education Republic of Indonesia for supporting this study through the competitive grants scheme (*Riset Dasar Unggulan Perguruan Tinggi*) 2019. The appreciation goes to all of fisherman and students who helped the author during data collection in field.

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Rudy Agung Nugroho 

Animal Physiology, Development and Molecular Laboratory, Department of Biology, Faculty of Mathematic and Natural Science, Mulawarman University, Samarinda, Indonesia

Based on the revised manuscript, I can judge that the article is now better than previous version.

This article can be indexed to improve the visibility and citations.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: My area research is about fish biology, animal physiology, fish nutrition, and fish conservation.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 11 February 2020

<https://doi.org/10.5256/f1000research.23739.r59573>

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Christopher Marlowe A. Caipang

College of Liberal Arts, Sciences and Education, University of San Agustin, Iloilo City, Philippines

I have read the revised version of the manuscript and the authors have addressed the issues that I raised in the ms. I think that this is acceptable for indexing.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 25 November 2019

<https://doi.org/10.5256/f1000research.21583.r56362>

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**Christopher Marlowe A. Caipang**

College of Liberal Arts, Sciences and Education, University of San Agustin, Iloilo City, Philippines

The manuscript presented the results in a straightforward manner. The Introduction should contain studies that had been conducted in the area and the research gap that the authors need to address.

Perhaps the authors could have done statistical analyses to compare the diversity in the sites where the data have been obtained.

In the Discussion section, the authors must clearly explain the implications of their study and the impacts of the results that they had in terms of managing the resources.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Aquaculture; Aquatic biotechnology; health management

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 29 Nov 2019

Netti Aryani, Universitas Riau, Pekanbaru, Riau, Indonesia

Response for Christopher Marlowe A. Caipang Comments:

Introduction: We have been added new references in introduction who conducted research in this area.

Methods: We do not use statistical analysis for calculate the data. All the data was entered into excel 2010 (version 14.0). Then, the data of different species for abundance and occurrence was calculated based on the equation of Shannon diversity Index, Simpson diversity index and Sorenson's coefficient (CC)

Discussion: we have been added the implication of our study and effect to managing fish resources. Such as the implication of exotic species for examples Nile tilapia and common carp have negative effect to native species in the upstream area of Koto Panjang Reservoir.

Competing Interests: No competing interests were disclosed.

Reviewer Report 02 September 2019

<https://doi.org/10.5256/f1000research.21583.r52476>

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Rudy Agung Nugroho

Animal Physiology, Development and Molecular Laboratory, Department of Biology, Faculty of Mathematic and Natural Science, Mulawarman University, Samarinda, Indonesia

In general this project is useful to add important information regarding fish fauna in Indonesia. However, some part in the article, need to be clarified by the author(s). Please see comments below:

Abstract

Conclusion: *Nile tilapia* should be mentioned as exotic species which found in upstream, cause it is a dominant species.

Introduction

1. "In 2015, the total fishery production of Indonesia was 16,954,344 metric tons, of which 455,270 metrics tons were obtained from inland capture fisheries, 6,065,060 metric tons were obtained from marine fisheries, and 10,074,014 metric tons were obtained from aquaculture fisheries production". Use newest statistic data would be better, instead of 2015.

Methods

1. Though endangered species were returned to the river. Please explain on how the author caught this fish? Doesn't hurt the fish?
2. Please also explain on how fish euthanization? Does all fish same treatment using piercing part on their brain?
3. It is stated in the methods that "the length, body weight and morphometric characteristics were only collected for 10 individual specimens from each species. This mean in total 10 individual specimens from over a year? Please explain, because there are some species that have number less than 10 each month, for example *Hemibagrus wyckii*.

Results

1. The name *Pangasius hypophthalmus* in the Table 2, should be changed to *Pangasianodon hypophthalmus*. Please check fishbase.org [here](#).
2. Please also check the fish name for *Pangasius pangasius*.

Overall, this article is well written and has good structure.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: My area research is about fish biology, animal physiology, fish nutrition, and fish conservation.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 09 Sep 2019

Netti Aryani, Universitas Riau, Pekanbaru, Riau, Indonesia

Response for Rudy Agung Nugroho Comments:

Abstract : We would like to clarify that "Nile tilapia as exotic species have been mention in the point of results.

Introduction : the latest data we have in the year 2015, there is no recent data have been found from Indonesian Fisheries Statistics.

Methods :

1. We caught the fish using fishing pole. We have explained in the methods
2. We have been explained in the Methods, yes...all fish are same treatment except for endangered species.
3. Fish caught more than 10 individuals for a year, morphometric measurement for only 10 individual of fish. However, fish caught less than 10 individual, the morphometric analysis were measured for all fish.

Results :

1. We have been check in the fish base. The name of *Pangasius pangasius* is correct.
2. The name of *Pangasius pangasius* is correct. Fishbase.org said that *Pangasius pangasius* spesies for aquaculture in Indonesia, Thailand, and Malaysia. However, *Pangasianodon hypophthalmus* spesies was categorize as endangered spesies and found in Mekong, Chao Phraya, and Maeklong basins.

Competing Interests: No competing interests were disclosed.

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