PEER REVIEW

A1

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Freshwater Fish Diversity in three tributary strems in Serayu Basin, Central Java, Indonesia.

Penulis Jurnal Ilmiah *) : 1 **Suhestri Suryaningsih** (*nama pengusul dicetak tebal)
2 Dian Bhagawati
3 Sri Sukmaningrum
4 Sugiharto
5 I.G.A. Ayu Ratna Puspitasari

Jumlah Penulis : 5

Status Penulis : Penulias ke-1

Identitas Jurnal Ilmiah :

a. Nama Jurnal : BIODIVERSITAS/Journal of Biological Diversity.
b. Nomor ISSN : P-ISSN: 1412-033X, E-ISSN: 2085-4722.
c. Edisi/Volume, Nomor : Desember 2020/Vol. 21 No. 12
d. Penerbit : Universitas Sebelas Maret Surakarta
e. DOI artikel : https://doi.org/10.13057/biodiv/d211244
f. Alamat Web : https://smujo.id/biodiv/article/view/6904/4454
g. Terindeks di : SCOPUS, DOAJ, Q3, SJR 0,27

Kategori Publikasi Jurnal Ilmiah (beri v pada kategori yang tepat) :
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b Ruang lingkup dan kedalaman pembahasan (30%)	30 % x 40 =	12			11,5
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cukup
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5. Indikasi plagiasi : tidak ada indikasi plagiasi (Turnitin 2%)
6. Kesesuaian bidang ilmu : sesuai

Bogor, 19/4/2021 ***) wajib diisi**

Reviewer 2,

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Bidang Ilmu : Ekof
Unit Kerja : FPIK IPB

A1

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4. Kelengkapan unsur kualitas penerbit : Lengkap
5. Indikasi plagiasi : Tidak ada
6. Kesesuaian bidang ilmu : Sesuai

Bogor, 16/4/2021 ***) wajib diisi**

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Bidang Ilmu : Ekofiologi Hewan Air
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FAKULTAS BIOLOGI

Prof. Dr.rer.nat. Imam Widhiono M.Z, M.S.
NIP. 195904201985031002
Unit Kerja : Fakultas Biologi Unsoed

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Total	**40**				39,5
Nilai Pengusul (60 % x Total)	**24**				23,7

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Mengetahui :
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Prof. Dr. rer. nat. Imam Widhiono M.Z, M.S.
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Abstract should not be more than 200 words. **Keywords** is about five words, covering scientific and local name (if any), research theme, and special methods which used; and sorted from A to Z. All important **abbreviations** must be defined at their first mention. **Running title** is about five words. **Introduction** is about 400-600 words, covering the background and aims of the research. **Materials and Methods** should emphasize on the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences, however, for manuscript with long discussion should be divided into subtitles. Thorough discussion represents the causal effect mainly explains for why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences. **Concluding** sentence should be given at the end of the discussion. **Acknowledgments** are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

Figures and Tables of maximum of three pages should be clearly presented. Title of a picture is written down below the picture, while title of a table is written above the table. Colored figures can only be accepted if the information in the manuscript can lose without those images; chart is preferred to use black and white images. Author could consign any picture or photo for the front cover, although it does not print in the manuscript. All images property of others should be mentioned source. **There is no appendix**, all data or data analysis are incorporated into Results and Discussions. For broad data, it can be displayed on the website as a supplement.

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Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds) Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50^{th} annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.) Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from internet:

Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic *Escherichia coli* predator-prey ecosystem. Mol Syst Biol 4: 187. www.molecularsystemsbiology.com

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Freshwater fish diversity in three tributary streams in Serayu Basin, Central Java, Indonesia

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Manuscript received: 7 October 2020. Revision accepted: 27 November 2020.

Abstract. *Suryaningsih S, Bhagawati D, Sukmaningrum S, Sugiharto, Puspitasari IGAAR. 2020. Freshwater fish diversity in three tributary streams in Serayu Basin, Central Java, Indonesia. Biodiversitas 21: 5811-5817.* Determining the diversity of freshwater fish species in Central Java, Indonesia has been confounded by temporal and spatial limitations in past studies. The Serayu Basin is a large watershed in Central Java that is believed to have high freshwater fish diversity. We aimed to determine the diversity and community structure of freshwater fish species in three tributaries of the Serayu, elucidate the factors influencing this diversity, and determine the extent to which these tributaries contribute to the total freshwater fish species richness for southwest Central Java. We conducted gill net sampling from May to August 2018 on the Tulis, Mrawu, and Kali Sapi Rivers located at Banjanegara district Sampling followed a random group technique in upstream, midstream, and downstream river sections of each tributary. In total, we observed 21 freshwater fish species. Broadly, fish species diversity was relatively low in the study area, and water temperature and dissolved oxygen were important in maintaining fish diversity. These three tributaries house 27–46% of the freshwater fish species reported for southern Central Java.

Keywords: Banjarnegara, dissolved oxygen, diversity, fish, Serayu basin, species richness

INTRODUCTION

The Serayu River is one of the major rivers in Central Java, Indonesia. It is 153 km in length, stretching from Wonosobo District to Cilacap District, and is fed by 14 (Krismono et al. 2009) tributaries Major tributaries in Banjarnegara District include the Tulis, Mrawu, and Kali Sapi Rivers, all of which are subject to different land-use types. Understanding fish diversity and population dynamics in the Serayu's tributaries is vital because these smaller rivers play a crucial role in its overall diversity. The diversity of fish species in large rivers is closely related to the diversity of fish in the tributaries that support it (Pander and Geist, 2018; Essien Bok and Isemin 2020). Tributaries can be critical habitats for fish as the aquatic habitat is their habitat and low habitat quality in mainstem rivers (Stegmann et al. 2019). Assessments of freshwater fish richness in the Serayu suggest that richness varies spatially, with some areas having fewer than 30 species. For example, 13 species were reported from upstream areas in Wonosobo (Haryono et al. 2014), 18 species from the Klawing River (Suryaningsih et al. 2018).

The diversity of freshwater fish species is strongly influenced by environmental factors (Beesley and Prince 2010), such as temperature (Mondal and Bat 2020) and environmental factors. Certain factors such as pH, dissolved oxygen, and water velocity were found to significantly predict richness and diversity. Increase in stream depth and width offers more space for individuals and provides more variation in niches, resulting in higher diversity in accordance with species-area relationship. Fish species richness within a river is affected by habitat heterogeneity and other habitat parameters (Jenkins and Jupiter 2011; Huang et al. 2019). Among these, water quality, substrate type, and pollutant burdens can affect the presence of a given species (Lakra et al. 2010), because different species occupy different niches and vary in their environmental tolerances (Costa et al. 2013; Hasyimah et al. 2013; Basavaraja et al. 2014; Ohee 2016). Even within a single river, habitat availability or quality may differ to the extent that there are differences in diversity among the upstream, midstream, and downstream reaches (Guo et al. 2018).

Recent research from several rivers in Java, especially Central Java, has been conducted. (Haryono et al. 2014) reported that in the upstream area of Serayu Wonosobo, 13 fish species were found whereas Suryaningsih et al. (2018) found 18 fish species in the Klawing river. Nuryanto et al. (2012) found 22 fish species of fish in the Cileumeuh river, 19 fish species were discovered in the Cikawung river (Nuryanto et al. 2015); and in the Cijalu river, 19 fish species were identified (Nuryanto et al. 2016). Based on the results of previous research studies, the diversity of fish species in southern part of Central Java varies significantly with some areas having fewer than 30 species. Past research efforts have provided a reasonable estimate of fish species and their distributions within tributaries of the Serayu watershed. Here, we aimed to determine species diversity in three major tributaries and the environmental factors supporting species richness.

MATERIALS AND METHODS

Study area

Our study took place in the upper reaches of the Serayu watershed in three major tributaries in Banjarnegara District, Indonesia: The Tulis, Mrawu, and Kali Sapi Rivers. We sampled at three locations in each river: upstream, midstream, and downstream (Figure 1). Habitat descriptions for each of the nine sampling locations are provided in Table 1.

Field sampling of fish and environmental parameters

Fish samples were collected using gillnets of a 0.5-inch and 1-inch mesh size, 30 m length of net Samples were collected monthly from June to September 2018 during a 12-h sampling event, gill net was setting start at afternoon until morning. which was replicated four times at each sampling location. Fresh samples were transported on ice to a laboratory, where they were washed in running water, placed in a 10% formalin solution for fixation for 48 hours, and then transferred to 70% ethyl alcohol for storage. Specimens were identified based on Kottelat et al. (2013). (Tan and Armbruster 2018).

Table 1. Habitat descriptions for nine sampling locations on three tributaries of the Serayu River in Central Java, Indonesia

Habitat characteristic	Upstream (1)	Midstream (2)	Downstream (3)
Tulis			
Location	7° 24'35" S 109° 15'15.6" E	7° 22'2.9" S 109° 15'15.6" E	7° 23'27.5" S 109° 45'004" E
Elevation (m asl)	506	460	407
Depth (m)	65	66	45
Width (m)	30	30	30
Substrate type	Big stones, gravel	Medium and small stones, sand	Medium and small stones, sand
Mrawu			
Location	7° 29'18.5" S 109°28' 41"E	7° 22'10.5" S 109° 41'35.1" E	7° 48'478" S 109° 47'133"E
Elevation (m asl)	453	430	382
Depth (m)	60	84	92
Width (m)	40	40	45
Substrate type	Big stones	Big stones, sand	Medium and small stones, sand
Kali Sapi			
Location	7° 29'18.5" S 109° 28'41"E	7° 22'10.5" S 109° 41'35.1" E	7° 48'478" S 109° 47'133"E
Elevation (m asl)	257	227	207
Depth (m)	55	65	85
Width (m)	30	28	30
Substrate type	Small stone, sand	Gravel, sand, mud	Mud

Note: Sands: <4mm in diameter, Gravel: 4-37.5 mm in diameter, Small stones: 3.75-7.5 cm in diameter, Medium stones: 75-20 cm in diameter, Big/large stones: > 20cm in diameter

Figure 1. Study area map of the Serayu River and three of its tributaries in Banjarnegara District, Central Java, Indonesia, i.e. Tulis, Mrawu and Kali Sapi rivers. Three sampling locations were established in each tributary, shown as 1, 2, and 3 on the map

The physiochemical parameters measured at each site included river width, substrate type, water depth, temperature, brightness, flow velocity, pH, dissolved oxygen, and dissolved carbon dioxide (Table 2). At upstream sampling locations, the river bank zone was dominated by plantation forest with a substrate of large and medium-sized stones (Sand/sands, diameter <4mm, Gravel/Gravel, 4-37.5 mm diameter, Small stones 3.75-7.5 cm, Medium stones 75-20 cm, Big/large stones> 20cm) Midstream riverbank zones were dominated by open areas, rice fields, and human settlements with a substrate of medium-sized rock and gravel. Land-use types in the river bank zone of downstream sampling locations included open areas, rice fields, sand mining, and human settlements, with a riverbed substrate of gravel, sand, and mud.

Statistical analyses

The average number of individuals, species abundance, diversity, evenness, and dominance were compared among sampling locations and month using two-way analysis of variance with posthoc Fisher's least significant difference tests in SPSS ver. 23 (IBM Corp., Armonk, NY, USA). Species diversity was estimated using the Shannon-Weiner diversity index (H′) (Magurran 2004):

$$H' = \sum_{i=1}^{s} pi \ln pi$$

Evenness (E) was calculated by dividing Shannon's diversity by the logarithm of the number of species:

$$E = \frac{H'}{\ln S}$$

Species dominance was expressed as the Simpson index (D = 1 - S);

$$D = \sum (pi)^2 = \sum \left(\frac{ni}{N}\right)^2$$

All indices were calculated using the statistical software BioDiversity Pro (McAleece et al. 1997).

RESULTS AND DISCUSSION

Species richness among the three tributaries

We collected 574 fish specimens belonging to 21 species in ten families over the survey period (June-August 2018). Of these, 106 individuals of 14 species in five families were collected from the Tulis River, 238 individuals of 13 species in six families were collected from the Mrawu River, and 230 individuals of 16 species in eight families were collected from the Kali Sapi River (Table 3, Figure 2).

Among the three tributaries, the Kali Sapi River had the highest species richness and abundance (16 species, 230 individuals, followed by the Mrawu River (13 species, 238 individuals) and the Tulis river (14 species, 106 individuals). H′ was greatest in the Tulis River (H′ = 2.384), followed by the Kali Sapi (H′ = 1.916) and the Mrawu (H′ = 1.545) (Table 3). These differences in richness and abundance are likely due to environmental conditions.

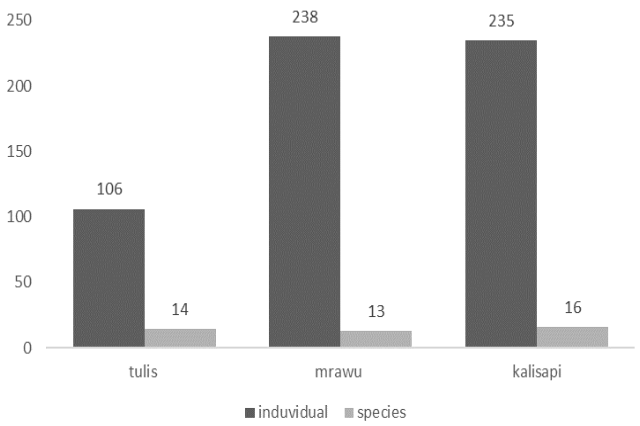

Figure 2. Species richness and abundance of freshwater fish in three tributary rivers in Central Java, Indonesia

Table 2. Environmental condition of the sampling sites

River	Tulis			Mrawu			Kali Sapi		
	US	MS	DS	US	MS	DS	US	MS	DS
Water temperature (°C)	25.1	27.5	25.5	24.3	23.6	24.7	27.7	27.7	28.9
Air temperature (°C)	35	32	33	28	28	32	32	32	32
Humidity (%)	43	53	44	68	74		68	68	57
velocity (m/det)	1.66	8.3	0.55	1.43	0.93	0.58	1.15	0.85	0.7
Depth of visibility (cm)	45	43	40	45	50	10	28	22	25
Acidity (pH)	7		7	7.5	7	7	7	7	6,8
DO (mg/L)	9.45	9.5	9.7	7.8	7.65	7.45	7.3	7.6	7,5
CO2 (mg/L)	0	0	0	0	0	0	0.77	0	0
BOD(mg/L)	3.2	3.12	3.66	2.1	2.86	3.48	4.4	4.28	5.06
COD(mg/L)	140	104	66	30	12	54	78	62	52

Table 3. Species richness, abundance, and distribution of freshwater fish in the Tulis, Mrawu, and Kali Sapi Rivers, Central Java, Indonesia

Family	Species	Tulis	Mrawu	Kali Sapi	Total	Percentage (%)	Distribution (No. of rivers that present)
Cyprinidae	*Systomus rubripinnis*	25	6	101	132	22.99	3
	Hampala macrolepidota	9	14	11	34	5.9	3
	Barbonymus gonionotus	7	0	9	16	2.7	2
	Osteochilus microcephalus	15	0	40	55	9.5	2
	Osteochilus vittata	5	35	21	61	10.06	3
	Rasbora lateristriata	0	1	2	3	0.52	2
	Rasbora argyrotaenia	6	8	1	15	2.6	3
	Rasbora aprotaenia	2	1	0	3	0.52	2
	Tor tambra	5	3	0	8	1.39	2
	Labiobarbus kuhlii	8	0	0	8	1.39	1
Bagridae	*Mystus nigriceps*	4	0	9	13	2.2	2
	Hemibagrus nemurus	3	5	11	19	3.33	3
Cichlidae	*Oreochromis niloticus*	7	3	2	12	2.09	3
	Oreochromis mossambicus	0	7	8	15	2.6	2
Clariidae	*Clarias gariepinus*	0	17	0	17	2.9	1
Sisoridae	*Glyptothorax platypogon*	0	2	0	2	0.3	1
Osprhonemidae	*Trichopodus trichopterus*	9	0	2	11	1.91	2
Mastacembelidae	*Macrognathus aculeatus*	0	0	2	2	0.3	1
Channidae	*Channa striata*	1	0	8	9	1.56	2
Nemacheilidae	*Nemacheilus fasciatus*	0	136	2	138	24.04	2
Siluridae	*Ompok hypophthalmus*	0	0	1	1	0.17	1
No. of individuals		106	238	230	574		
No. of species		14	13	16			
% of total species richness		57	61	76			

Correlation analyses indicated that water temperature and dissolved oxygen had a strong influence on fish diversity and distribution in all three tributaries (R^2 = 0.70 for water temperature and R^2 = 0.78 for dissolved oxygen). Other measured physiochemical parameters did not show significant influences on fish distributions. These results are comparable to those of Basavaraja et al. (2014) and Yagci et al. (2016). Nuryanto et al. (2016) suggested that differences in species distribution patterns are a result of differences in environmental conditions among rivers, particularly dissolved oxygen, free carbon dioxide, pH, and substrate. However, Nsor and Ubaday (2016) found that nitrogen and phosphorus had a strong influence on the occurrence of freshwater fish species in rivers.

Bray-Curtis similarity cluster analysis indicated that the Tulis River shared a more similar fish species community with the Kali Sapi than with the Mrawu (Figure 3).

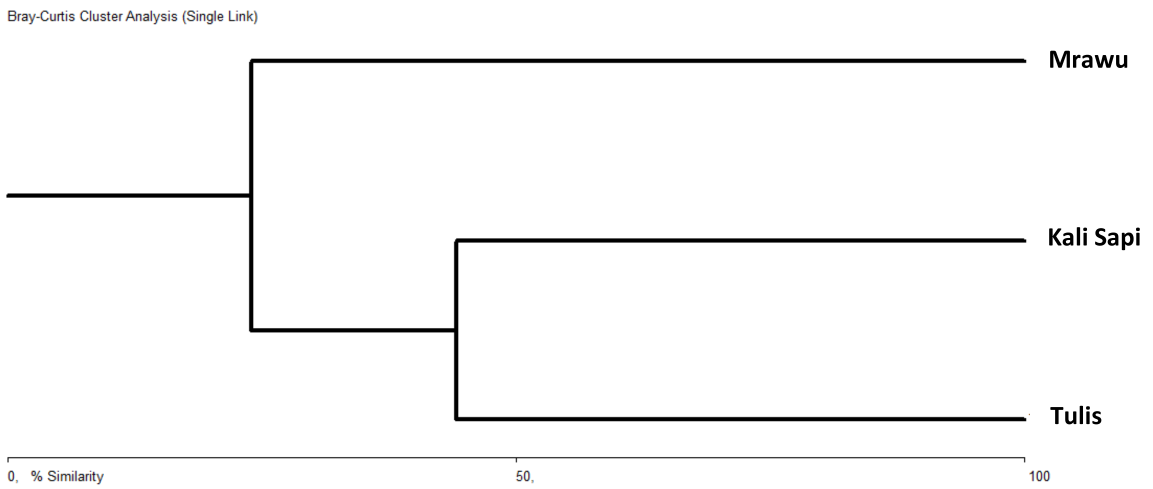

Figure 3. Dendrogram representing similarity in fish species composition among three tributaries based on a Bray-Curtis cluster analysis

Huang et al. (2019) found that the environmental parameters of elevation, velocity, conductivity, and river depth and width influenced the distribution and abundance of freshwater fish species, whereas water temperature, dissolved oxygen, and substrate size were less important. This is likely a product of species niche, wherein species selected for environmental cues that meet their biological or life-history needs. Keller et al. (2018) identified four fish habitat guilds that were predictors of fish diversity; these guilds were determined by river depth, velocity, and structural complexity. The apparent similarity in fish species composition between the Tulis and Kali Sapi Rivers may be related to riverbank conditions; both rivers have forested banks (plantation forest) in their upper reaches. Lo et al. (2020) suggested that forest condition influences the composition of fish species in rivers passing through forested areas. In addition, river velocity and width are important determinants of fish species diversity in rivers (Mondal and Bat 2020). These factors were less influential in our study, likely because the three tributaries considered here were relatively similar in both width and depth (Table 1).

All three tributaries were dominated by one or two species. In the Tulis and Kali Sapi Rivers, *Systomus rubripinnis* was the dominant species, accounting for 23% and 43.9% of all captured individuals respectively, whereas *Nemacheilus fasciatus* was the dominant species in the Mrawu (57% of all captured individuals. This discovery may be caused by a lack of suitable habitat, particularly with respect to the river velocity, the clarity of the water, and the type of substrate (Ridho et al. 2019.; Mondal and Bat 2020).

Within-river variation in species richness

In a river, the species richness varies, in the Tulis river the highest species richness is in the midstream followed by the upstream and the lowest is in the downstream. In the Mrawu river, the number of species is the same between the midstream and the upstream and only slightly decreases in the downstream, while in the Kali Sapi river the highest species are in the midstream and the lowest is in the upstream (Table 1). The results of statistical tests between river sections in the Tulis and Mrawu rivers were not significantly different (P2.8 F> 0.05). This pattern of different species richness was found in the Kali Sapi river (P2.8 F> 0.05). This result is probably due to the habitat conditions in the Tulis and Mrawu rivers which are almost the same, namely the rocky bottom substrate. Whereas in the Kali Sapi river, the mud substrate and the downstream part of the river are deeper than the two rivers. According to Jenkins and Jupiter (2011) and Huang et al. (2019), Fish species richness within a river is affected by habitat heterogeneity, especially substrate type, because different species occupy different niches and vary in their environmental tolerance (Costa et al. 2013; Hasyimah et al. 2013; Basavaraja et al. 2014; Ohee 2016). Even within a single river, habitat availability or quality may differ to the extent that there are differences in diversity among the upstream, midstream, and downstream reaches (Guo et al. 2018). Within river, species richness was H′ also varied within each river system; in the Tulis River it was highest at the midstream sampling location, followed by the upstream and downstream locations, and in the Mrawu and Kali Sapi Rivers it was highest midstream, followed by downstream and upstream locations (Table 4). Fish distributions within the tributaries followed a similar pattern, with the highest richness and abundance at midstream locations, followed by downstream and upstream (Table 4). This pattern was correlated with river depth (R^2 = 0.67) and substrate type. Freshwater fish diversity depends on substrate types, because substrate types provide the prerequisite micro-conditions and can be viewed as an indicator of stream habitat quality. Substrate coarseness and heterogeneity, representing substrate size and microhabitat diversity, may substantially influence stream fish assemblages (Amour et al. 2011; Li et al. 2016). These results echo those of Huang et al. (2019) and Hu et al. (2019), who found that variation in the richness and abundance of freshwater fish was related to elevation and river depth and width.

Table 4. Diversity parameters in the three tributaries

Parameter	Mrawu	Tulis	Kali Sapi
Species richness (S)	13	14	16
No. of individuals	238	106	230
Dominance (D)	0.3602	0.1148	0.2419
Shannon (H′)	1,545	2,384	1,916
Simpson (1 − D)	0.6398	0.8852	0.7581
Evenness (e^H/S)	0.3606	0.7751	0.4245
Equitability (J)	0.6023	0.9035	0.691

Table 5. Diversity parameters for each sampling location (n = 9) within three tributaries. US, MS, and DS refer to upstream, midstream, and downstream sampling locations, respectively

Diversity parameter	Tulis			Mrawu			Kali Sapi		
	US	MS	DS	US	MS	DS	US	MS	DS
Species richness (S)	9	11	6	9	9	8	6	15	10
No. of individuals	27	50	28	86	103	46	44	114	72
Dominance (D)	0.1413	0.1136	0.2602	0.5687	0.4984	0.2297	0.2438	0.2561	0.2612
Shannon (H′)	2.067	2.272	1.517	1.021	1.727	1.135	1.6	1.905	1.679
Simpson (1 − D)	0.8587	0.8864	0.7398	0.4313	0.5016	0.7703	0.7562	0.7439	0.7388
Evenness (e^H/S)	0.8777	0.882	0.76	0.3083	0.3458	0.7026	0.8256	0.4477	0.5362

Only six species were found in all three rivers: *Systomus rubripinnis*, *Hampala macrolepidota*, *Osteochilus vittata*, *Rasbora argyrotaenia*, *Hemibagrus nemurus*, and *Oreochromis niloticus*. Cyprinidae was the most diverse family, with ten recorded species across all rivers, followed by Bagridae and Cichlidae with two species respectively, and Clariidae, Sisoridae, Osphronemidae, Mastacembelidae, Channidae, and Siluridae, with one species, respectively. The prevalence of Cyprinidae is related to the life-history traits that characterise this family; its members often have wide environmental niches and are widely distributed, especially in low-oxygen environments (Das et al.2012; Petsut et al. 2017). In addition, Cyprinidae is the most abundant fish family worldwide, with 1,058 reported species (Paujiah et al. 2019).

Six species were found in two of the tributaries: *Barbonymus gonionotus*, *Osteochilus microcephalus*, *Rasbora lateristriata*, *Rasbora aprotaenia*, *Tor tambra* (Cyprinidae), and *Mystus nigriceps*. *Mystus nigriceps* is typically found in large, slow-flowing rivers with turbid water and a muddy substrate. Species only observed in one tributary included *Labiobarbus kuhlii* (Tulis River), *Clarias gariepinus* (Mrawu River), (introduced African catfish), (*Glyptothorax platypogon*). *Glyptothorax platypogon* is known to occur in the upstream zone of the Serayu River. This species has the distinctive characteristic of using a thoracic adhesive apparatus to secure itself in its torrential river habitat (Lestari et al. 2018.; Haryono 2014).

Broadly, the diversity of freshwater fish observed in the three tributaries was relatively low. Water temperature and dissolved oxygen were important factors influencing this diversity. The fish species observed in the tributaries considered here account for 27-46% of the total number of species reported for southern Central Java.

Based on the result, it can be concluded that small tributaries can support the diversity of Serayu river freshwater fish diversity.

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TURNITIN

Freshwater fish diversity in three tributary streams in Serayu Basin, Central Java, Indonesia

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Freshwater fish diversity in three tributary streams in Serayu Basin, Central Java, Indonesia

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Abstract. *Suryaningsih S, Bhagawati D, Sukmaningrum S, Sugiharto, Puspitasari IGAAR. 2020. Freshwater fish diversity in three tributary streams in Serayu Basin, Central Java, Indonesia. Biodiversitas 21: 5811-5817.* Determining the diversity of freshwater fish species in Central Java, Indonesia has been confounded by temporal and spatial limitations in past studies. The Serayu Basin is a large watershed in Central Java that is believed to have high freshwater fish diversity. We aimed to determine the diversity and community structure of freshwater fish species in three tributaries of the Serayu, elucidate the factors influencing this diversity, and determine the extent to which these tributaries contribute to the total freshwater fish species richness for southwest Central Java. We conducted gill net sampling from May to August 2018 on the Tulis, Mrawu, and Kali Sapi Rivers located at Banjanegara district Sampling followed a random group technique in upstream, midstream, and downstream river sections of each tributary. In total, we observed 21 freshwater fish species. Broadly, fish species diversity was relatively low in the study area, and water temperature and dissolved oxygen were important in maintaining fish diversity. These three tributaries house 27–46% of the freshwater fish species reported for southern Central Java.

Keywords: Banjarnegara, dissolved oxygen, diversity, fish, Serayu basin, species richness

INTRODUCTION

The Serayu River is one of the major rivers in Central Java, Indonesia. It is 153 km in length, stretching from Wonosobo District to Cilacap District, and is fed by 14 (Krismono et al. 2009) tributaries Major tributaries in Banjarnegara District include the Tulis, Mrawu, and Kali Sapi Rivers, all of which are subject to different land-use types. Understanding fish diversity and population dynamics in the Serayu's tributaries is vital because these smaller rivers play a crucial role in its overall diversity. The diversity of fish species in large rivers is closely related to the diversity of fish in the tributaries that support it (Pander and Geist, 2018; Essien Bok and Isemin 2020). Tributaries can be critical habitats for fish as the aquatic habitat is their habitat and low habitat quality in mainstem rivers (Stegmann et al. 2019). Assessments of freshwater fish richness in the Serayu suggest that richness varies spatially, with some areas having fewer than 30 species. For example, 13 species were reported from upstream areas in Wonosobo (Haryono et al. 2014), 18 species from the Klawing River (Suryaningsih et al. 2018).

The diversity of freshwater fish species is strongly influenced by environmental factors (Beesley and Prince 2010), such as temperature (Mondal and Bat 2020) and environmental factors. Certain factors such as pH, dissolved oxygen, and water velocity were found to significantly predict richness and diversity. Increase in stream depth and width offers more space for individuals and provides more variation in niches, resulting in higher diversity in accordance with species-area relationship. Fish species richness within a river is affected by habitat heterogeneity and other habitat parameters (Jenkins and Jupiter 2011; Huang et al. 2019). Among these, water quality, substrate type, and pollutant burdens can affect the presence of a given species (Lakra et al. 2010), because different species occupy different niches and vary in their environmental tolerances (Costa et al. 2013; Hasyimah et al. 2013; Basavaraja et al. 2014; Ohee 2016). Even within a single river, habitat availability or quality may differ to the extent that there are differences in diversity among the upstream, midstream, and downstream reaches (Guo et al. 2018).

Recent research from several rivers in Java, especially Central Java, has been conducted. (Haryono et al. 2014) reported that in the upstream area of Serayu Wonosobo, 13 fish species were found whereas Suryaningsih et al. (2018) found 18 fish species in the Klawing river. Nuryanto et al. (2012) found 22 fish species of fish in the Cileumeuh river, 19 fish species were discovered in the Cikawung river (Nuryanto et al. 2015); and in the Cijalu river, 19 fish species were identified (Nuryanto et al. 2016). Based on the results of previous research studies, the diversity of fish species in southern part of Central Java varies significantly with some areas having fewer than 30 species. Past research efforts have provided a reasonable estimate of fish species and their distributions within tributaries of the Serayu watershed. Here, we aimed to determine species diversity in three major tributaries and the environmental factors supporting species richness.

MATERIALS AND METHODS

Study area

Our study took place in the upper reaches of the Serayu watershed in three major tributaries in Banjarnegara District, Indonesia: The Tulis, Mrawu, and Kali Sapi Rivers. We sampled at three locations in each river: upstream, midstream, and downstream (Figure 1). Habitat descriptions for each of the nine sampling locations are provided in Table 1.

Field sampling of fish and environmental parameters

Fish samples were collected using gillnets of a 0.5-inch and 1-inch mesh size, 30 m length of net Samples were collected monthly from June to September 2018 during a 12-h sampling event, gill net was setting start at afternoon until morning. which was replicated four times at each sampling location. Fresh samples were transported on ice to a laboratory, where they were washed in running water, placed in a 10% formalin solution for fixation for 48 hours, and then transferred to 70% ethyl alcohol for storage. Specimens were identified based on Kottelat et al. (2013). (Tan and Armbruster 2018).

Table 1. Habitat descriptions for nine sampling locations on three tributaries of the Serayu River in Central Java, Indonesia

Habitat characteristic	Upstream (1)	Midstream (2)	Downstream (3)
Tulis			
Location	7° 24'35" S 109° 15'15.6" E	7° 22'2.9" S 109° 15'15.6" E	7° 23'27.5" S 109° 45'004" E
Elevation (m asl)	506	460	407
Depth (m)	65	66	45
Width (m)	30	30	30
Substrate type	Big stones, gravel	Medium and small stones, sand	Medium and small stones, sand
Mrawu			
Location	7° 29'18.5" S 109°28' 41"E	7° 22'10.5" S 109° 41'35.1" E	7° 48'478" S 109° 47'133"E
Elevation (m asl)	453	430	382
Depth (m)	60	84	92
Width (m)	40	40	45
Substrate type	Big stones	Big stones, sand	Medium and small stones, sand
Kali Sapi			
Location	7° 29'18.5" S 109° 28'41"E	7° 22'10.5" S 109° 41'35.1" E	7° 48'478" S 109° 47'133"E
Elevation (m asl)	257	227	207
Depth (m)	55	65	85
Width (m)	30	28	30
Substrate type	Small stone, sand	Gravel, sand, mud	Mud

Note: Sands: <4mm in diameter, Gravel: 4-37.5 mm in diameter, Small stones: 3.75-7.5 cm in diameter, Medium stones: 75-20 cm in diameter, Big/large stones: > 20cm in diameter

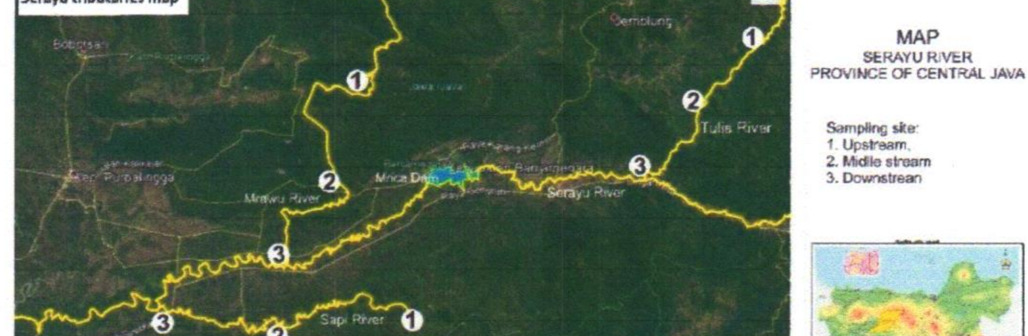

Figure 1. Study area map of the Serayu River and three of its tributaries in Banjarnegara District, Central Java, Indonesia, i.e. Tulis, Mrawu and Kali Sapi rivers. Three sampling locations were established in each tributary, shown as 1, 2, and 3 on the map

The physiochemical parameters measured at each site included river width, substrate type, water depth, temperature, brightness, flow velocity, pH, dissolved oxygen, and dissolved carbon dioxide (Table 2). At upstream sampling locations, the river bank zone was dominated by plantation forest with a substrate of large and medium-sized stones (Sand/sands, diameter <4mm, Gravel/Gravel, 4-37.5 mm diameter, Small stones 3.75-7.5 cm, Medium stones 75-20 cm, Big/large stones> 20cm) Midstream riverbank zones were dominated by open areas, rice fields, and human settlements with a substrate of medium-sized rock and gravel. Land-use types in the river bank zone of downstream sampling locations included open areas, rice fields, sand mining, and human settlements, with a riverbed substrate of gravel, sand, and mud.

Statistical analyses

The average number of individuals, species abundance, diversity, evenness, and dominance were compared among sampling locations and month using two-way analysis of variance with posthoc Fisher's least significant difference tests in SPSS ver. 23 (IBM Corp., Armonk, NY, USA). Species diversity was estimated using the Shannon-Weiner diversity index (H') (Magurran 2004):

$$H' = \sum_{i=1}^{s} pi \ln pi$$

Evenness (E) was calculated by dividing Shannon's diversity by the logarithm of the number of species:

$$E = \frac{H'}{\ln s}$$

Species dominance was expressed as the Simpson index (D = 1 - S);

$$D = \sum (pi)^2 = \sum \left(\frac{ni}{N}\right)^2$$

All indices were calculated using the statistical software BioDiversity Pro (McAleece et al. 1997).

RESULTS AND DISCUSSION

Species richness among the three tributaries

We collected 574 fish specimens belonging to 21 species in ten families over the survey period (June-August 2018). Of these, 106 individuals of 14 species in five families were collected from the Tulis River, 238 individuals of 13 species in six families were collected from the Mrawu River, and 230 individuals of 16 species in eight families were collected from the Kali Sapi River (Table 3, Figure 2).

Among the three tributaries, the Kali Sapi River had the highest species richness and abundance (16 species, 230 individuals, followed by the Mrawu River (13 species, 238 individuals) and the Tulis river (14 species, 106 individuals). H' was greatest in the Tulis River (H' = 2.384), followed by the Kali Sapi (H' = 1.916) and the Mrawu (H' = 1.545) (Table 3). These differences in richness and abundance are likely due to environmental conditions.

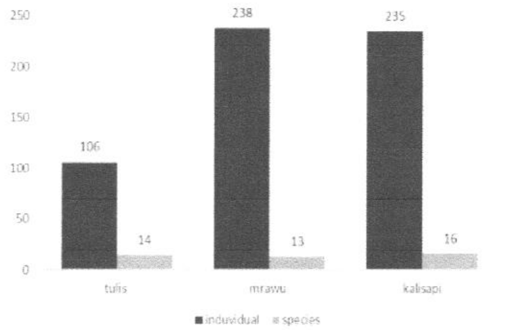

Figure 2. Species richness and abundance of freshwater fish in three tributary rivers in Central Java, Indonesia

Table 2. Environmental condition of the sampling sites

River	Tulis			Mrawu			Kali Sapi		
	US	MS	DS	US	MS	DS	US	MS	DS
Water temperature (°C)	25.1	27.5	25.5	24.3	23.6	24.7	27.7	27.7	28.9
Air temperature (°C)	35	32	33	28	28	32	32	32	32
Humidity (%)	43	53	44	68	74		68	68	57
velocity (m/det)	1.66	8.3	0.55	1.43	0.93	0.58	1.15	0.85	0.7
Depth of visibility (cm)	45	43	40	45	50	10	28	22	25
Acidity (pH)	7		7	7.5	7	7	7	7	6.8
DO (mg/L)	9.45	9.5	9.7	7.8	7.65	7.45	7.3	7.6	7.5
CO2 (mg/L)	0	0	0	0	0	0	0.77	0	0
BOD(mg/L)	3.2	3.12	3.66	2.1	2.86	3.48	4.4	4.28	5.06
COD(mg/L)	140	104	66	30	12	54	78	62	52

Table 3. Species richness, abundance, and distribution of freshwater fish in the Tulis, Mrawu, and Kali Sapi Rivers, Central Java, Indonesia

Family	Species	Tulis	Mrawu	Kali Sapi	Total	Percentage (%)	Distribution (No. of rivers that present)
Cyprinidae	*Systomus rubripinnis*	25	6	101	132	22.99	3
	Hampala macrolepidota	9	14	11	34	5.9	3
	Barbonymus gonionotus	7	0	9	16	2.7	2
	Osteochilus microcephalus	15	0	40	55	9.5	2
	Osteochilus vittata	5	35	21	61	10.06	3
	Rasbora lateristriata	0	1	2	3	0.52	2
	Rasbora argyrotaenia	6	8	1	15	2.6	3
	Rasbora aprotaenia	2	1	0	3	0.52	2
	Tor tambra	5	3	0	8	1.39	2
	Labiobarbus kuhlii	8	0	0	8	1.39	1
Bagridae	*Mystus nigriceps*	4	0	9	13	2.2	2
	Hemibagrus nemurus	3	5	11	19	3.33	3
Cichlidae	*Oreochromis niloticus*	7	3	2	12	2.09	3
	Oreochromis mossambicus	0	7	8	15	2.6	2
Clariidae	*Clarias gariepinus*	0	17	0	17	2.9	1
Sisoridae	*Glyptothorax platypogon*	0	2	0	2	0.3	1
Osprhonemidae	*Trichopodus trichopterus*	9	0	2	11	1.91	2
Mastacembelidae	*Macrognathus aculeatus*	0	0	2	2	0.3	1
Channidae	*Channa striata*	1	0	8	9	1.56	2
Nemacheilidae	*Nemacheilus fasciatus*	0	136	2	138	24.04	2
Siluridae	*Ompok hypophthalmus*	0	0	1	1	0.17	1
No. of individuals		106	238	230	574		
No. of species		14	13	16			
% of total species richness		57	61	76			

Correlation analyses indicated that water temperature and dissolved oxygen had a strong influence on fish diversity and distribution in all three tributaries ($R^2 = 0.70$ for water temperature and $R^2 = 0.78$ for dissolved oxygen). Other measured physiochemical parameters did not show significant influences on fish distributions. These results are comparable to those of Basavaraja et al. (2014) and Yagci et al. (2016). Nuryanto et al. (2016) suggested that differences in species distribution patterns are a result of differences in environmental conditions among rivers, particularly dissolved oxygen, free carbon dioxide, pH, and substrate. However, Nsor and Ubaday (2016) found that nitrogen and phosphorus had a strong influence on the occurrence of freshwater fish species in rivers.

Bray-Curtis similarity cluster analysis indicated that the Tulis River shared a more similar fish species community with the Kali Sapi than with the Mrawu (Figure 3).

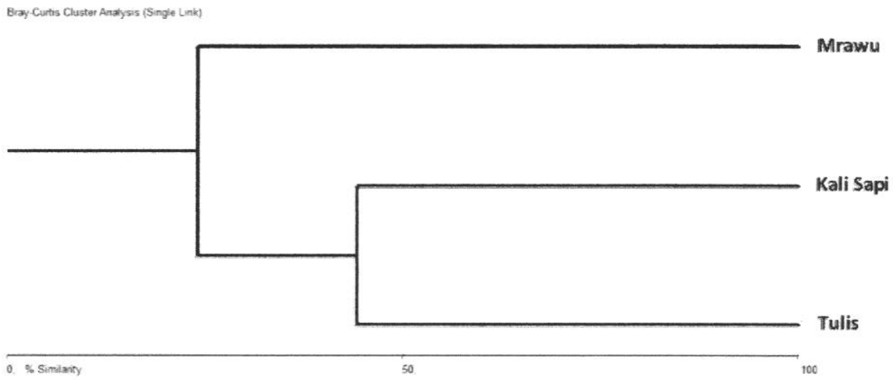

Figure 3. Dendrogram representing similarity in fish species composition among three tributaries based on a Bray-Curtis cluster analysis

Huang et al. (2019) found that the environmental parameters of elevation, velocity, conductivity, and river depth and width influenced the distribution and abundance of freshwater fish species, whereas water temperature, dissolved oxygen, and substrate size were less important. This is likely a product of species niche, wherein species selected for environmental cues that meet their biological or life-history needs. Keller et al. (2018) identified four fish habitat guilds that were predictors of fish diversity; these guilds were determined by river depth, velocity, and structural complexity. The apparent similarity in fish species composition between the Tulis and Kali Sapi Rivers may be related to riverbank conditions; both rivers have forested banks (plantation forest) in their upper reaches. Lo et al. (2020) suggested that forest condition influences the composition of fish species in rivers passing through forested areas. In addition, river velocity and width are important determinants of fish species diversity in rivers (Mondal and Bat 2020). These factors were less influential in our study, likely because the three tributaries considered here were relatively similar in both width and depth (Table 1).

All three tributaries were dominated by one or two species. In the Tulis and Kali Sapi Rivers, *Systomus rubripinnis* was the dominant species, accounting for 23% and 43.9% of all captured individuals respectively, whereas *Nemacheilus fasciatus* was the dominant species in the Mrawu (57% of all captured individuals. This discovery may be caused by a lack of suitable habitat, particularly with respect to the river velocity, the clarity of the water, and the type of substrate (Ridho et al. 2019.; Mondal and Bat 2020).

Within-river variation in species richness

In a river, the species richness varies, in the Tulis river the highest species richness is in the midstream followed by the upstream and the lowest is in the downstream. In the Mrawu river, the number of species is the same between the midstream and the upstream and only slightly decreases in the downstream, while in the Kali Sapi river the highest species are in the midstream and the lowest is in the upstream (Table 1). The results of statistical tests between river sections in the Tulis and Mrawu rivers were not significantly different (P2.8 F> 0.05). This pattern of different species richness was found in the Kali Sapi river (P2.8 F> 0.05). This result is probably due to the habitat conditions in the Tulis and Mrawu rivers which are almost the same, namely the rocky bottom substrate. Whereas in the Kali Sapi river, the mud substrate and the downstream part of the river are deeper than the two rivers. According to Jenkins and Jupiter (2011) and Huang et al. (2019), Fish species richness within a river is affected by habitat heterogeneity, especially substrate type, because different species occupy different niches and vary in their environmental tolerance (Costa et al. 2013; Hasyimah et al. 2013; Basavaraja et al. 2014; Ohee 2016). Even within a single river, habitat availability or quality may differ to the extent that there are differences in diversity among the upstream, midstream, and downstream reaches (Guo et al. 2018). Within river, species richness was H' also varied within each river system; in the Tulis River it was highest at the midstream sampling location, followed by the upstream and downstream locations, and in the Mrawu and Kali Sapi Rivers it was highest midstream, followed by downstream and upstream locations (Table 4). Fish distributions within the tributaries followed a similar pattern, with the highest richness and abundance at midstream locations, followed by downstream and upstream (Table 4). This pattern was correlated with river depth (R^2 = 0.67) and substrate type. Freshwater fish diversity depends on substrate types, because substrate types provide the prerequisite micro-conditions and can be viewed as an indicator of stream habitat quality. Substrate coarseness and heterogeneity, representing substrate size and microhabitat diversity, may substantially influence stream fish assemblages (Amour et al. 2011; Li et al. 2016). These results echo those of Huang et al. (2019) and Hu et al. (2019), who found that variation in the richness and abundance of freshwater fish was related to elevation and river depth and width.

Table 4. Diversity parameters in the three tributaries

Parameter	Mrawu	Tulis	Kali Sapi
Species richness (S)	13	14	16
No. of individuals	238	106	230
Dominance (D)	0.3602	0.1148	0.2419
Shannon (H')	1,545	2,384	1,916
Simpson (1 − D)	0.6398	0.8852	0.7581
Evenness (e^H/S)	0.3606	0.7751	0.4245
Equitability (J)	0.6023	0.9035	0.691

Table 5. Diversity parameters for each sampling location (n = 9) within three tributaries. US, MS, and DS refer to upstream, midstream, and downstream sampling locations, respectively

Diversity parameter	Tulis			Mrawu			Kali Sapi		
	US	MS	DS	US	MS	DS	US	MS	DS
Species richness (S)	9	11	6	9	9	8	6	15	10
No. of individuals	27	50	28	86	103	46	44	114	72
Dominance (D)	0.1413	0.1136	0.2602	0.5687	0.4984	0.2297	0.2438	0.2561	0.2612
Shannon (H')	2.067	2.272	1.517	1.021	1.727	1.135	1.6	1.905	1.679
Simpson (1 − D)	0.8587	0.8864	0.7398	0.4313	0.5016	0.7703	0.7562	0.7439	0.7388
Evenness (e^H/S)	0.8777	0.882	0.76	0.3083	0.3458	0.7026	0.8256	0.4477	0.5362

Only six species were found in all three rivers: *Systomus rubripinnis*, *Hampala macrolepidota*, *Osteochilus vittata*, *Rasbora argyrotaenia*, *Hemibagrus nemurus*, and *Oreochromis niloticus*. Cyprinidae was the most diverse family, with ten recorded species across all rivers, followed by Bagridae and Cichlidae with two species respectively, and Clariidae, Sisoridae, Osphronemidae, Mastacembelidae, Channidae, and Siluridae, with one species, respectively. The prevalence of Cyprinidae is related to the life-history traits that characterise this family; its members often have wide environmental niches and are widely distributed, especially in low-oxygen environments (Das et al.2012; Petsut et al. 2017). In addition, Cyprinidae is the most abundant fish family worldwide, with 1,058 reported species (Paujiah et al. 2019).

Six species were found in two of the tributaries: *Barbonymus gonionotus*, *Osteochilus microcephalus*, *Rasbora lateristriata*, *Rasbora aprotaenia*, *Tor tambra* (Cyprinidae), and *Mystus nigriceps*. *Mystus nigriceps* is typically found in large, slow-flowing rivers with turbid water and a muddy substrate. Species only observed in one tributary included *Labiobarbus kuhlii* (Tulis River), *Clarias gariepinus* (Mrawu River), (introduced African catfish), (*Glyptothorax platypogon*). *Glyptothorax platypogon* is known to occur in the upstream zone of the Serayu River. This species has the distinctive characteristic of using a thoracic adhesive apparatus to secure itself in its torrential river habitat (Lestari et al. 2018.; Haryono 2014).

Broadly, the diversity of freshwater fish observed in the three tributaries was relatively low. Water temperature and dissolved oxygen were important factors influencing this diversity. The fish species observed in the tributaries considered here account for 27-46% of the total number of species reported for southern Central Java.

Based on the result, it can be concluded that small tributaries can support the diversity of Serayu river freshwater fish diversity.

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