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The diversity of freshwater fish in sanenrejo and wonoasri river resorts from meru betiri national park

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The diversity of freshwater fish in sanenrejo and wonoasri river resorts from meru betiri national park

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Abstract: Freshwater fish diversity is the number of fish species found in freshwater areas. This research is an exploratory study aimed at the diversity of freshwater fish in the Sanenrejo and Wonoasri Resort's Rivers of Meru Betiri National Park. Fishes were caught using *gill nets* with mesh sizes 0.5 inch and *handnet*. The level of diversity of freshwater fish in the Sanenrejo and Wonoasri Resorts is classified as being moderate with the diversity index values in the Sanenrejo and Wonoasri Resorts respectively 1.5902 and 2.2323 while the overall index value is 2.4102. Freshwater fish found consisted of 15 species, namely: *Barbodes binotatus*, *Trichopodus trichopterus*, *Neovespicula depressifrons*, *Rasbora lateristriata*, *Planiliza subviridis*, *Oreochromis niloticus*, *Eleotris melanosoma*, *Dermogenys pusilla*, *Periophthalmus argentilineatus*, *Pterygoplichthys pardalis*, *Channa gachua*, *Butis butis*, *Nemacheilus fasciatus*, *Sicyopterus cyanocephalus*, and *Monopterus albus*.

1. Introduction

Pisces or fish are members of poikilothermic (cold blooded) that live in water with locomotion in the form of fins, breathe with gills and a body covered with scales [1]. Indonesia has a high diversity of fresh fish species [2]. The diversity of fish species in Indonesia's freshwater is 1,248 species which will increase frequently with the number of new species discovered [3], while the freshwater fish species in the world are currently recorded at 15,750 species [4]. The diversity of freshwater fish species in Java is 132 species, while in other big islands, such as Sumatra, it reaches 272 species and Kalimantan 394 species [5]. Freshwater fish communities continue to experience pressure as a result of various factors such as increased exploitation, damage and degradation of the quality of fish habitats and the transfer of functions from water bodies to other functions. The decline in the quality of fish habitats is also a result of human (anthropogenic) activities, including pollution, deforestation and habitat fragmentation.



Meru Betiri National Park (TNMB) area has 325 species of fauna consisting of 25 types of mammals (18 species of which are protected mammals), 7 species of reptiles (6 of which are protected), 168 species of birds (68 of which are protected), 35 species of insects, 6 species of bivalves, and 71 species. soil atropod species [6]. TNMB is located in the Jember region consists of four resorts, namely Andongrejo, Bandalit, Sanenrejo and Wonoasri. In 2014, research related to fish in the Sukamade river in Meru Betiri National Park found 13 species of fish belonging to the Order Perciformes from 7 sampling points [7]. Meanwhile, data related to freshwater fish at other resorts such as Sanenrejo and Wonoasri in TNMB does not exist yet. Resort Sanenrejo and Wonoasri.

Meru Betiri National Park is a conservation area and the Sanenrejo and Wonoasri resorts are areas that are used as rehabilitation zones. From the background explanation above, research was carried out to be used as a first step to determine the existence of fish as an effort to support the preservation of freshwater fish species in TNMB to facilitate the national park and the communities around TNMB in identifying freshwater fish species.

2. Sampling stations and methods

2.1 Sampling points

The research was conducted in December 2019 - February 2020. The research procedure started from observing the location to determine the research location. Sampling was conducted river of Resort Sanenrejo and Wonoasri TNMB. The sampling method used was purposive sampling, the location was selected based on several habitat preferences which included residential areas, plantations, primary forests, secondary forests and coastal forests:

- Location 1: River in the Sanenrejo Secondary Forest
- Location 2: River in the Sanenrejo Primary Forest
- Location 3: River in the Sanenrejo Farming Area I
- Location 4: River in the Sanenrejo Farming Area II
- Location 5: River in the Wonoasri Farming Area
- Location 6: River in the Wonoasri Settlement
- Location 7: River in the Wonoasri Primary Forest
- Location 8: River in the Wonoasri Secondary Forest
- Location 9: River in the Wonoasri Coastal Forest

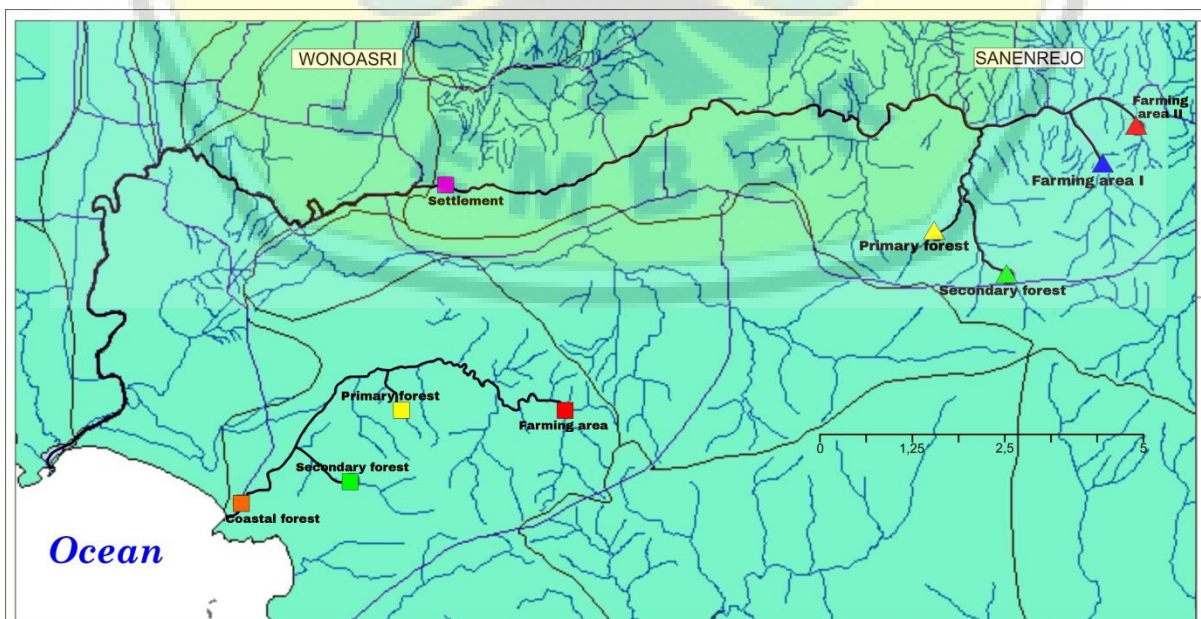


Figure 1. Sampling Points.

2.2 Sampling Techniques

Determination of the sampling location was done purposively, then the technique of taking was road sampling. Harvesting of freshwater fish used *gill nets* with mesh size ± 0.5 inch and *handnet*. Each resort was divided into research locations with the length of each research location, namely 180 meters with the direction of sampling against the current.

2.3 Freshwater Fish Identification

The identification process included morphological observations and fish morphometric measurements [8]. Fish morphometric measurements were carried out using mitutoyo digital calliper with accuracy of 0,1 millimeter. Morphological identification was carried out in the Laboratory of the Biology Education Study Program, at the University of Jember with reference to the identification key book Freshwater Fishes of Western Indonesia and Sulawesi Kottelat *et al* (1993) [3], *Fao Species Identification Guide for Fishery Purposes* Volume 3 (1999) [9], Volume 4 (2000) [10], Volume 5 (2001) [11] and Volume 6 (2002) [12].

2.4 Calculation of Diversity Index

Species diversity index were calculated using the Shannon-Wiener formula [12]. The formula was as follow:

$$H' = - \sum p_i \ln p_i, p_i = \frac{n_i}{N}$$

Note:

- n_i : The number of individuals for the species observed
- N : Total number of individuals
- H' : Shannon-Wiener diversity index

Criteria for diversity index (H') are as follow:

- $H' < 1$: Low diversity
- $1 < H' \leq 3$: Medium diversity
- $H' > 3$: High diversity

3. Result

This research was conducted at two resorts, namely Resort Sanenrejo and ~~Resort~~ Wonoasri. Resort Sanenrejo consist of four types of habitat, namely primary forest, secondary forest, plantation I and plantation II, while Resort Wonoasri consisted of 5 types of habitat, namely, plantations, settlements, primary forest, secondary forest, and coastal forest. Based on the results of the identification of freshwater fish that were successfully collected in the rivers of Resort Sanenrejo and Wonoasri, TNMB, 15 species were found consisting of 12 families. The existence of each freshwater fish species was scattered in a variety of different habitats. At the Sanenrejo Resort, 6 species of freshwater fish were found consisting of 5 families with a total of 27 individuals (table 1). At Wonoasri Resort, 12 families of freshwater fish were found with a total of 40 individuals (table 2).

There were more fish species found at Resort Wonoasri than those found at Resort Sanenrejo. At the Wonoasri Resort, 12 species of freshwater fish were found, namely *Barbodes binotatus*, *Trichopodus trichopterus*, *Neovespicula depressifrons*, *Rasbora lateristriata*, *Planiliza subviridis*, *Oreochromis niloticus*, *Eleotris melanosoma*, *Dermogenys pusilla*, *Periophthalmus argentilineatus*, *Pterygoplichthys pardalis*, *Channa gachua*, and *Butis butis*. Meanwhile, at the Sanenrejo Resort, 6 species were found, namely *Nemacheilus faciatus*, *Barbodes binotatus*, *Sicyopterus cyanocephalus*, *Rasbora lateristriata*, *Channa gachua* and *Monopterus albus*.

Table 1. Results of Identification of Freshwater Fish at Sanenrejo's Resort River

No	Species	Famili	Number of Individuals				N
			L1	L2	L3	L4	
1	<i>Nemacheilus fasciatus</i>	Balitoridae	5	1	3	1	10
2	<i>Barbodes binotatus</i>	Cyprinidae	1	1	0	3	5
3	<i>Sicyopterus cyanocephalus</i>	Gobiidae	2	0	0	0	2
4	<i>Rasbora lateristriata</i>	Cyprinidae	1	0	2	2	5
5	<i>Channa gachua</i>	Channidae	0	1	2	1	4
6	<i>Monopterus albus</i>	Synbranchidae	0	1	0	0	1
Total			9	4	7	7	27

Information :

L1 : Secondary Forest

L2 : Primary Forest

L3 : Farming area I

L4 : Farming area II

Table 2. Results of Identification of Freshwater Fish at Wonoasri's Resort River

No.	Species	Famili	Number of Individuals					N
			L1	L2	L3	L4	L5	
1	<i>Barbodes binotatus</i>	Cyprinidae	0	0	1	0	1	2
2	<i>Trichopodus trichopterus</i>	Osphronomidae	0	0	0	0	1	1
3	<i>Neovespicula depressifrons</i>	Tetrarogidae	0	0	0	0	4	4
4	<i>Rasbora lateristriata</i>	Cyprinidae	2	0	1	1	0	4
5	<i>Planiliza subviridis</i>	Mugilida	0	0	0	0	1	1
6	<i>Oreochromis niloticus</i>	Cichlidae	0	11	0	0	0	11
7	<i>Eleotris melanosoma</i>	Eleotridae	0	0	0	0	4	4
8	<i>Dermogenys pusilla</i>	Zenarchopteridae	0	2	0	0	0	2
9	<i>Periophthalmus argentilineatus</i>	Gobiidae	0	0	0	0	2	2
10	<i>Pterygoplichthys pardalis</i>	Loricariidae	0	4	0	0	0	4
11	<i>Channa gachua</i>	Channidae	1	0	2	1	0	4
12	<i>Butis butis</i>	Eleotridae	0	0	0	0	1	1
Total			3	17	4	2	14	40

Information :

L1 : Farming area

L2 : Settlement

L3 : Primary Forest

L4 : Secondary Forest

L5 : Coastal Forest

3.1 The description of each freshwater fish species found are as follows.

3.1.1 *Nemacheilus fasciatus* (Valenciennes, 1846)

The body character of a small with elongated shape has 9-18 bands (stripes) of irregular dark color on the body with a yellowish body color. The shape of the mouth is like an arc which is located under the muzzle (inferior), has a pair of barrels on the upper jaw and two pairs in the lower jaw and there is a dark almost black spot between the eyes.

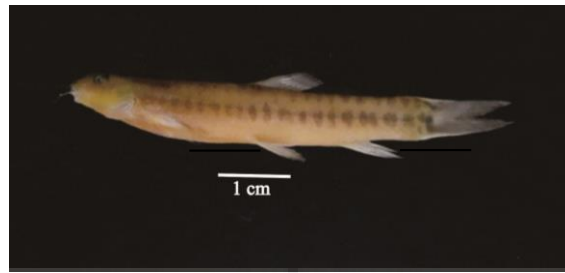


Figure 2. *Nemacheilus fasciatus*

3.1.2. *Barbodes binotatus* (Valenciennes, 1842)

Relatively small, flat body size and fusiform shape with an unbroken lateral line, has two pairs of barrels at the tip of the muzzle with a terminal mouth position, scales with the cycloid type, black eyes with yellowish white edges, all fins are reddish yellow. This fish has two black dots which are located under the dorsal fin and in front of the caudal fin.



Figure 3. *Barbodes binotatus*

3.1.3 *Sicyopterus cyanocephalus* (Valenciennes, 1837)

The colour body is yellow and slightly green and the head is rounded with thick lips which are located inferiorly. The dorsal head is convex with a non-popping mouth. On the body there are bands with a darker color from near the head to the fins and without the lateral line. This fish has a united pelvic fin.



Figure 4. *Sicyopterus cyanocephalus*

3.1.4 *Trichopodus trichopterus* (Pallas, 1770)

Grayish body color with a flat body and a pointed muzzle. There is a dark oblique band and black spots or dots in the middle of the body and near the base of the tail.



Figure 5. *Trichopodus trichopterus*

3.1.5 *Neovespicula depressifrons* (Richardson, 1848)

The body is small and fusiform type with a body color of brown to gray with black spots all over the body. The mouth is located superiorly with the eyes large enough. Linea lateralis clearly visible with the form of an embossed line that starts from the back of the head to the base of the body near the caudal fin. The tips of the fins have poison glands.



Figure 6. *Neovespicula depressifrons*

3.1.6 *Rasbora lateristriata* (Bleeker, 1854)

The position of the mouth is at the tip with a rather small size and there is a weevil that makes up the bones of the lower jaw, the special characteristic of this fish is the absence of a tentacle at the bottom of the mouth. In addition, it has the characteristics of a black stripe and extends from the tip of the operculum to the base of the caudal fin. The next characteristic is the edge of the tail fin is black with yellow dominance.

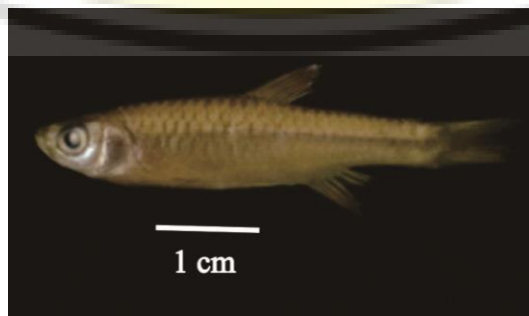


Figure 7. *Rasbora lateristriata*

3.1.7 *Planiliza subviridis* (Valenciennes, 1836)

The body shape is fusiform but the dorsal part after the head is not too elevated with the mouth that is located superior. Yellowish gray body color with a body size that tends to be larger than other fish.



Figure 8. *Planiliza subviridis*

3.1.8 *Oreochromis niloticus* (Linnaeus, 1758)

Elongated and slender fusiform body shape with large ctenoid scales. The eyes are large, protruding and have white edges and a terminal mouth. The number of scales and anal fins have weak fingers but are hard and sharp like thorns and have a vertical line of 9-11 bluish green fruits with the lateral line cut into two parts.



Figure 9. *Oreochromis niloticus*

3.1.9 *Eleotris melanosoma* (Bleeker, 1853)

The body color tends to be brown to dark with a relatively moderate body size. The head is rounded (rounded) with the lower lip slightly protruding from the upper lip and a superior position. On the head near the gill covers, there are sharp spines on the right and left. The body is without lateral linea and has two separate dorsal fins. It has a pair of pectoral fins, a pair of pelvic fins, 1 anal and caudal fin which has black and white stripes with the emarginate type.

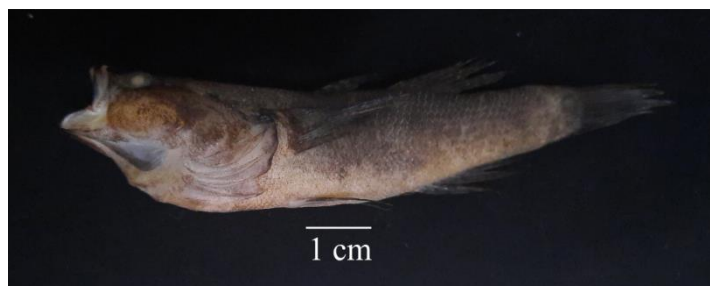


Figure 10. *Eleotris melanosoma*

3.1.10 *Dermogenys pusilla* (Kuhl & Van Hasselt, 1823)

The body is grayish yellow and relatively small in size. The mouth is in the form of an elongated beak with an elongated lower mouth like a snout and is black in color with a superior mouth position. Eyes are large enough with a flat body elongated. The lateral line is visible from the base of the head to the base of the body near the tail and on the dorsal side there is a dark line from near the head to the base of the body.



Figure 11. a) *Dermogenys pusilla*, b) *Dermogenys pusilla* under microscope

3.1.11 *Periophthalmus argentilineatus* (Valenciennes, 1837)

Grayish brown body color. The color of the fins is the same as the body color, but on the dorsal fins there are white spots. The location of the fish's mouth tends to be inferior with a pair of short barbs like snails. Its two eyes protruded above the head and were close together like the eyes of a frog, with a torpedo-like elliptical body. The lateral line is seen as a line that is sunken into the body. This fish has a pair of dorsal fins with a second, longer dorsal fin, a pair of strong pectoral and ventral fins, 1 elongated anal fin, and a rounded caudal fin.



Figure 12. *Periophthalmus argentilineatus*

3.1.12 *Pterygoplichthys pardalis* (Castelnau, 1855)

Head and body widened like an arrow. The surface of the body is covered with hardened skin like thorns with a predominantly black body. The mouth is located at the bottom and is rounded like a sucker and the eyes and nose are slightly protruding. All fins except the caudal fin are preceded by hard spines.



Figure 13. *Pterygoplichthys pardalis*

3.1.13 *Channa gachua* (Hamilton, 1822)

Black body color with a cylindrical (cylindrical) head and fully covered with scales. The *Channa gachua* species has large head scales like the head of a snake (the head scales are larger than the body scales). There are patches that form oblique bands along the body. At the tip of the fin has a black-yellow-black yellow and reddish color combination.



Figure 14. *Channa gachua*

3.1.14 *Butis butis*

Body color tends to be brown. The head is flattened flat with a mouth large enough and located superiorly. Type of ctenoid scales with relatively small size and there are additional scales on the muzzle.

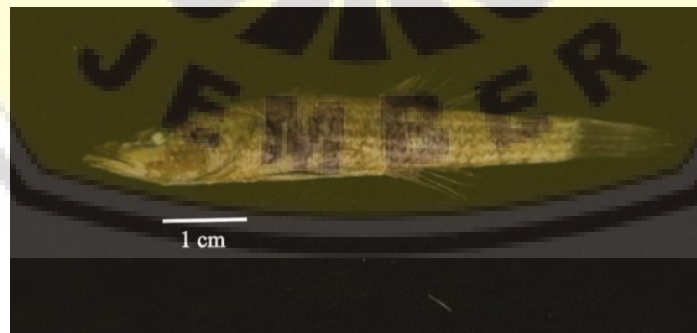


Figure 15. *Butis butis*

3.1.15 *Monopterus albus* (Zuiew, 1793)

The body is an elongated anguilliform shape with a slightly cylindrical cross section which is tapered at the tip, is not scaly and has a lot of mucus on its body surface. Eel skin brownish with black spots all over the body, mouth is equipped with small, conical pointed teeth with lips in the form of a wide fold of skin around the mouth

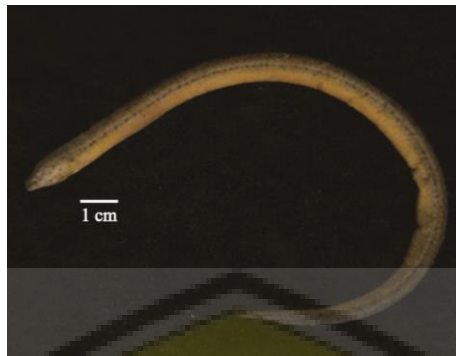


Figure 16. *Monopterus albus*

3.2 Distribution of Freshwater fish

Freshwater fish found in the river of Sanenrejo and Wonoasri resorts have different distribution patterns between species. *Barbodes binotatus*, *R. lateristriata* and *C. gachua* could be found at both resorts but not at all study sites. *Nemacheilus fasciatus*, *S. cyanocephalus* and *M. albus* were only found at Resort Sanenrejo. Meanwhile, *N. fasciatus* could be found in all research locations at Resort Sanenrejo but *S. cyanocephalus* and *M.albus* were only found in a few research sites *T. trichopterus*, *N.depressifrons*, *O. niloticus*, *E. melanosoma*, *D. pusilla*, *P. argentilineatus*, *P. pardalis*, and *B. butis* were freshwater fish species found only at Resort Wonoasri but not in all study locations (table 3).

Table 3. Distribution of Freshwater Fish at The River of Sanenrejo and Wonoasri Resorts

No	Species	Sanenrejo					Wonoasri			
		1	2	3	4	5	6	7	8	9
1	<i>Nemacheilus fasciatus</i>	√	√	√	√	-	-	-	-	-
2	<i>Barbodes binotatus</i>	√	√	-	√	-	-	√	-	√
3	<i>Sicyopterus cyanocephalus</i>	√	-	-	-	-	-	-	-	-
4	<i>Trichopodus trichopterus</i>	-	-	-	-	-	-	-	-	√
5	<i>Neovespicula depressifrons</i>	-	-	-	-	-	-	-	-	√
6	<i>Rasbora lateristriata</i>	√	-	√	√	√	-	√	√	-
7	<i>Planiliza subviridis</i>	-	-	-	-	-	-	-	-	√
8	<i>Oreochromis niloticus</i>	-	-	-	-	-	√	-	-	-
9	<i>Eleotris melanosoma</i>	-	-	-	-	-	-	-	-	√
10	<i>Dermogenys pusilla</i>	-	-	-	-	-	√	-	-	-
11	<i>Periophthalmus argentilineatus</i>	-	-	-	-	-	-	-	-	√
12	<i>Pterygoplichthys pardalis</i>	-	-	-	-	-	√	-	-	-
13	<i>Channa gachua</i>	-	√	√	√	√	-	√	√	-
14	<i>Butis butis</i>	-	-	-	-	-	-	-	-	√
15	<i>Monopterus albus</i>	-	√	-	-	-	-	-	-	-

Information :

- L1 : Sanenrejo Secondary Forest
- L2 : Sanenrejo Primary Forest
- L3 : Sanenrejo Farming Area I
- Sanenrejo Farming Area II
- L5 : Wonoasri Farming Area

- L6 : Wonoasri Settlement
- L7 : Wonoasri Primary Forest
- L8 : Wonoasri Secondary Forest
- L9 : Wonoasri Coastal Forest

3.3 Diversity of Freshwater fish

The diversity of freshwater fish in Resort Sanenrejo and Wonoasri Meru Betiri National Park based on the calculation of the Shannon-Wiener diversity index has a value of 2.4102 and is classified as moderate. Data from the calculation of freshwater fish diversity in the Sanenrejo and Wonoasri rivers Data from the calculation of freshwater fish diversity in the Sanenrejo and Wonoasri can be seen in the following table.

Table 4. Calculation of Freshwater Fish Diversity in The Sanenrejo and Wonoasri River Resorts

No.	Species	Total	H'
1	<i>Nemacheilus faciatus</i>	10	0,2839
2	<i>Barbodes binotatus</i>	7	0,2360
3	<i>Sicyopterus cyanocephalus</i>	2	0,1048
4	<i>Trichopodus trichopterus</i>	1	0,0628
5	<i>Neovespicula depressifrons</i>	4	0,1683
6	<i>Rasbora lateristriata</i>	9	0,2697
7	<i>Planiliza subviridis</i>	1	0,0628
8	<i>Oreochromis niloticus</i>	11	0,2966
9	<i>Eleotris melanosoma</i>	4	0,1683
10	<i>Dermogenys pusilla</i>	2	0,1048
11	<i>Periophthalmus argentilineatus</i>	2	0,1048
12	<i>Pterygoplivhthys pardalis</i>	4	0,1683
13	<i>Channa gachua</i>	8	0,2538
14	<i>Butis butis</i>	1	0,0628
15	<i>Monopterus albus</i>	1	0,0628
Total		67	2,4102

Furthermore, the data from the calculation of freshwater fish diversity in the River Resort Sanenrejo can be seen in Table 5 below.

Table 5. Calculation of freshwater fish diversity in Sanenrejo Resort

No	Spesies	Total	H'
1	<i>Nemacheilus faciatus</i>	10	0,3679
2	<i>Barbodes binotatus</i>	5	0,3123
3	<i>Sycopterus cyanocephalus</i>	2	0,1928
4	<i>Rasbora lateristriata</i>	5	0,3123
5	<i>Channa gachua</i>	4	0,2829
6	<i>Monopterus albus</i>	1	0,1221
Total		27	1,5902

Based on Table 5 above, it is known that the Resort Sanenrejo River has a value of 1.5902 and is classified as moderate freshwater fish diversity. Next is the calculation of the diversity of freshwater fish in the Wonoasri River Resort which can be seen in Table 6 below

Table 6. Calculation of freshwater fish diversity in Wonoasri Resort

No	Spesies	Total	H'
1	<i>Barbodes binotatus</i>	2	0,1498
2	<i>Trichopodus trichopterus</i>	1	0,0922
3	<i>Neovespicula depressifrons</i>	4	0,2303
4	<i>Rasbora lateristriata</i>	4	0,2303
5	<i>Planiliza subviridis</i>	1	0,0922
6	<i>Oreochromis niloticus</i>	11	0,355
7	<i>Eleotris melanosoma</i>	4	0,2303
8	<i>Dermogenys pusilla</i>	2	0,1498
9	<i>Periophthalmus argentilineatus</i>	2	0,1498
10	<i>Pterygoplichthys pardalis</i>	4	0,2303
11	<i>Channa gachua</i>	4	0,2303
12	<i>Butis butis</i>	1	0,0922
Total		40	2.2323

3.4 Abiotic Condition of Sampling Location

The abiotic conditions of each location can be seen in Table 7 below.

Table 7. Abiotic conditions of sampling locations

Location	pH water	Salinity (ppt)	Humidity(%)	Light (lux)	Temperature (°C)	Current (m/s)	Substrate
1	7,2	0	66	900	27	0,2	Rocky, Sand, Soil
2	7,2	0	67	750	26	0,01	Rocky, Soil
3	7,3	0	63	1900	31	0,17	Rocky, Soil
4	7,3	0	64	1600	30	0,125	Rocky, Soil
5	7,4	0	64	1700	30	0,2	Rocky, Soil
6	7,8	0	63	2000	31	0,1	Rocky, Sand, Soil
7	7,8	0	68	700	26	0,02	Rocky
8	7,5	0	64	1700	29	0,02	Rocky
9	8,2	15	60	5000	32	0,04	Mud

4. Discussion

Based on data analysis, index value of freshwater fish diversity at Resort Sanenrejo and Wonoasri TNMB was moderate. The diversity index value was calculated using the Shannon-Wiener diversity index (H') formula (table 4). This was due to several factors, including habitat suitability, habitat variability, water depth, fish introduction, dominance, and fishing. Factors causing differences in freshwater fish diversity were classified into 6 categories, namely due to habitat change, over-exploitation, introduction of foreign fish, pollution, competition for water use, and global warming [13]. In addition, the distribution of species diversity was related to habitat variability and microhabitat presence, substrate composition and water depth [14]. Based on the results of the research, the most fish species were found in the estuary river of the Wonoasri Resort, the estuary ecosystem was generally dominated by a muddy substrate which was rich in organic matter so that it could be a food reserve for estuary organisms. Water depth affected the temperature distribution of a water, the temperature value would decreased with increasing water depth [15].

Another factor that affects diversity is the introduction of fish, this can be seen with the discovery of *O. niloticus* and *P. pardalis* which are introduced fish [16]. The two fish were found in large numbers, this phenomenon is related to the next factor that influences diversity, namely species dominance. The two introduced fish dominate an area because both of them are predators of local fish. The presence of introduced fish suppresses the presence of local fish [17]. The existence of foreign species in a waters can cause various consequences such as predation and also cause competition [18]. Apart from the factors of water quality and food availability, there are other factors in the form of the presence of species that dominate an area which tends to have low diversity due to the strong influence of the dominant species on other species and the high intensity of competition both in terms of obtaining food or controlling habitat.

The last factor that influences diversity is overfishing. Overfishing causes a decline in fish populations to extinction. Catching fish is also often carried out using fish poison, so this causes not only large fish to be poisoned but also small fish to die.

Each sampling location has different abiotic conditions both at the Sanenrejo and Wonoasri Resort Rivers (table 5). Each species has a different tolerance to pH [19]. The degree of acidity (pH) of productive waters and ideal for freshwater biota ranges from 6.8-8.5 [20]. A very low pH can cause the solubility of metals in water to increase and are toxic to organisms. Conversely, high pH can increase the concentration of ammonia in water which is also toxic to organisms [20].

River of resort Sanenrejo and Wonoasri TNMB had a water pH range between 7.2 - 8.2. The lowest pH of 7.2 was in the secondary forest habitat type at Sanenrejo Resort and the highest pH is 8.2 in the Wonoasri coastal forest habitat type. This condition was still able to be tolerated by the fishes. At the highest pH of 8.2, several species were found, namely: *B. binotatus*, *T. trichopterus*, *N. depressifrons*, *P. subviridis*, *E. melanosoma*, *P. argentilineatus*, and *B. butis*. *Barbodes binotatus* was previously found in secondary forest at Resort Wonoasri. This species tended to live in the upstream area [21]. However, because the pH in the coastal forest was still below the maximum pH that could be tolerated by fish, it was possible to find a variety of fish species.

Temperature parameter for aquatic organism life ranges from 26 °C - 31 °C [22]. Meanwhile, the water temperature in the Sanenrejo Resort and Wonoasri TNMB rivers ranges from 26-32 °C. Changes in temperature in the water can cause the type, number and presence of aquatic fauna to change frequently. The effect of temperature on fish growth is related to the poikilothermal nature of fish [23]. Increasing water temperature will increase the solubility of compounds in water, the toxicity of toxic compounds generally increases with increasing temperature [24]. This can be seen in the measurement of the abiotic factor with the lowest temperature, namely 26 °C followed by low light intensity, namely 700 lux at the research location of wonoasri primary forest with quite dense tree conditions. While the highest temperature, 32 °C, is found in the coastal forest habitat type at Wonoasri resort which is a location that is very close to the beach and the condition of the trees which are quite rare but are dominated by mangroves. At this location, *Periopthalmus argentilineatus* or the so-called crayfish can live in temperatures of 23.5 - 35.5 °C [25].

Salinity values for freshwater range from 0 - 0.5 ppt. Salinity at the study sites ranged from 0 - 15 ppt [26]. The highest salinity, which is 15 ppt, is found in the coastal forest habitat type because this location is adjacent to Rowo Cangak beach. High salinity results in a decrease in dissolved oxygen levels in water so that the respiration process will run faster than normal. The higher the water salinity, the more difficult it is for the fish to breathe so that it can cause the fish to collapse (threshold for adaptability) [27].

Rivers based on their current velocity are classified into very fast current (> 100 cm / sec), fast current (50-100 cm / sec), medium current (25-50 cm / sec), slow current (10-25 cm / sec) and very slow current (<10 cm / sec) [28]. The current velocity in the Resort Sanenrejo and Wonoasri rivers varies from 0.01 to 0.2 m / s so that the river flow velocity at the Sanenrejo and Wonoasri Resorts is classified as very slow. Slow currents allow many fish food sources such as food particles carried by currents from upstream to downstream of rivers as well as falling insects and leaf litter that remain

long-term in water bodies [29]. The Family of *Cyprinidae* is able to live both in river areas that have strong currents and weak currents with good water quality [30].

Air humidity does not significantly affect the diversity of freshwater fish, because freshwater fish live in the water during their life. Light humidity is related to light intensity, if the light intensity is high, the air humidity is low and vice versa. The humidity in the Resort Sanenrejo and Wonoasri rivers ranges from 60% - 68%. Light affects the photosynthetic process of phytoplankton as the main food ingredient for fish [31]. The light intensity in the rivers of Resort Sanenrejo and Wonoasri in Meru Betiri National Park ranges from 700 - 5000 lux.

Barbodes binotatus and *R. lateristriata* are both members of the Order of Cypriniformes. Apart from the Cypriniformes Order, there are also the Ordo Perciformes which are commonly found in TNMB. Species of the Order Perciformes due to the characteristics of the waters which are swamp and fish with additional respiratory tools such as labyrinths are able to live in this location [32]. *Barbodes binotatus* was found in both resorts but not in all locations of secondary forest, primary forest and farming area type II habitats at Resort Sanenrejo, while at Resort Wonoasri it was found in locations with primary forest and coastal forest habitat types. This species is found in rivers in the upper middle and lower reaches of the estuary, so in other words this species has a wide home range. *Barbodes binotatus* likes to swim in the middle of the water depth [16]. These fish usually live in the upper reaches of rivers [33], but have been found several times in upstream and downstream locations [34].

Rasbora lateristriata or wader pari is also found in several locations with secondary forest habitat types, farming area I and II Resort Sanenrejo and plantations, primary forest and secondary forest at the Wonoasri Resort. *Rasbora lateristriata* tends to like to swim close to riverbeds which are rather deep but with calm currents [16]. In addition, *Rasbora lateristriata* lives in the upstream area of the river and is rarely found downstream. *Channa gachua* is also found in several locations with habitat type primary forest, farming area I and plantation II Resort Sanenrejo while at Resort Wonoasri it is found in locations with habitat types of primary forest and secondary forest. *Channa gachua* is a type of fish that has a breathing apparatus (breathing organ) [35]. These fish are able to live in waters with the characteristics of acidic pH, relatively low dissolved oxygen and high CO₂ [36]. These fish live in the upstream of rivers, clear springs and rice fields. This species differs from other *Channa* species which tend to live in downstream rivers and swamps.

The fish with the highest number is *O. niloticus*. *niloticus* a type of euryhaline fish and can live in waters with a salinity of 0 ppt - 35 ppt, but the optimal salinity is 0 ppt - 30 ppt [37]. Meanwhile, the optimal temperature range for growing *niloticus* is between 25 °C - 30 °C [38]. *Pterygoplichthys pardalis* or broom fish is only found at Resort Wonoasri with residential habitat types. *Pterygoplichthys pardalis* can live and thrive in waters with low oxygen content and high organic matter. This fish takes oxygen from the air (Facultative air breather) and is detritus [39]. *Pterygoplichthys pardalis* can live in water conditions with poor to polluted water quality with a pH range of 5.5 to 8.

Dermogenys pusilla is also only found in the Wonoasri Resort with residential habitat types. *Dermogenys pusilla* is a member of the Zenarchopteridae family. Its habitat is fresh and brackish waters, which it occupies varies from rivers (mud beds, sand, to estuary areas) [40], habitat of *Dermogenys* sp. is peatland waters that have high acidity. *Nemacheilus fasciatus* was found only at Resort Sanenrejo and at all study sites and is a species of the Order of Cypriniformes. This species is found in locations with habitat types for secondary forest, primary forest, Farming area I and II Resort Sanenrejo. *Nemacheilus fasciatus* is a type of fish that lives in rivers with lots of rocks [41]. The river conditions at the Sanenrejo Resort are composed of many small to medium rocks and are also clear, making it a preferred habitat for *N. fasciatus*. Meanwhile, at the Wonoasri Resort, which is also composed of rocks but with a much larger size and the waters tend to be cloudy.

Trichopodus trichopterus is a septic fish found in the downstream part of the estuary river, which is a type of coastal forest habitat at Wonoasri Resort. This species is a species that lives in swamp areas downstream and likes muddy substrates [35]. *Trichopodus trichopterus* has a labyrinth as an aid in oxygen deprivation [42]. This factor is one of the reasons for the discovery of the species *T.*

trichopterus in the type of coastal forest habitat with a mud substrate with low oxygen. *Sicyopterus cynocephalus* is a freshwater fish species found only at Resort Sanenrejo. *Sicyopterus cynocephalus* is a fish that likes to stay at the bottom of rocky areas because of its habit of sticking to rocks, and immersing itself in sand and gravel [43]. These fish are scattered in marine habitats with temperate and tropical climates [3]. This fish has pelvic fins that unite to form a suction-like disc which functions to attach itself to its position in fast-flowing waters, its size is relatively small but thick.

Periophthalmus argentilineatus or so-called gelodok fish is only found in estuary rivers with the coastal forest habitat type of Resort Wonoasri. These fish live in a typical intertidal muddy habitat (estuary areas that are still affected by tides) [44]. This occurs because of its ability to breathe through the skin of the body and the lining itself in the mouth and throat. The pectoral fins can be bent so that they function like an arm for creeping, crawling or jumping. Adaptation of this fish to live on land by having large eyes that are above the head and round shape, while the mouth is facing downwards which is used for foraging while on the surface of the mud [45]. Another way of adapting it is by digging holes in soft mud which are used as nests [46]. The entire life cycle is in the mangrove forest area (true resident fish) and the feeding habit of the crab fish is generally organic matter in the bottom waters / substrate.

Neovespicula depressifrons is a species found only in estuary rivers with the coastal forest habitat type of Resort Wonoasri. This species has spines on dorsal fin, and informed that spines contains poison glands. *Planiliza subviridis* is also found in the estuary river of the Wonoasri Resort with a coastal forest habitat type. *Planiliza subviridis* is a group of marine fish [47], so that its presence in estuary areas is thought to be a migration in search of nutrients and abundant food in estuary areas. *Butis butis* is only found in the estuary river of the Wonoasri Resort with a coastal forest habitat type. *Butis butis* is often found in estuary areas [48], so it can be concluded that this species is one of the fish that inhabit estuaries or downstream rivers [49].

Eleotris melanosoma is only found in the estuary river of the Wonoasri Resort with the coastal forest habitat type. *Eleotris melanosoma* is spread over the tidal zone in relatively low numbers [50]. So that based on the results and literature, there is a similarity regarding the habitat of *Eleotris melanosoma* which is a tidal area which is a downstream or river mouth bordering the sea. *Monopterus albus* or rice field eels are only found in Sanenrejo Resort, namely in primary forest. Eels do not have fins where the fins turn into fingerless skin puffs [51]. Eel skin is not scaly, slippery and slimy. The mucus that is owned serves as a lubricant to reduce friction on the body surface with water, helps when swimming and helps the body from abrasion when digging nests and eel habitats in muddy areas.

5. Conclusion

The level of freshwater fish diversity index at river of Resort Sanenrejo and Wonoasri Meru Betiri National Park was moderate. The diversity index values at the Sanenrejo and Wonoasri resorts were 1.5902 and 2.2323, respectively. Freshwater fish that were found consisted of 15 species, namely: *Barbodes binotatus*, *T. trichopterus*, *N. depressifrons*, *R.lateristriata*, *P. subviridis*, *O. niloticus*, *E. melanosoma*, *D. pusilla*, *P. argentilineatus*, *P. pardalis*, *C. gachua*, *B. butis*, *N. faciatus*, *S. cyanocephalus*, and *M. albus*. The abiotic conditions of the river in Meru Betiri National Park were ideal for freshwater fish. Water temperature ranges from 26 - 32 °C, water pH ranges from 7.2 - 8.2, air humidity ranges from 60- 68%, light intensity ranges from 700 - 5000 lux, and the current speed was relatively slow ranging from 0.02 - 0 , 2 m / s, salinity ranges from 0 - 15 ppt with substrate of rock, soil, sand and mud.

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