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Diversity studies of freshwater goby species from three rivers ecosystem in Luwuk Banggai, Central Sulawesi, Indonesia

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Abstract. Inland public water areas which include freshwater lakes and several rivers in Sulawesi Island have native and endemic fish species which potential as ornamental fish. One of them is a member of Gobiidae. Several studies have reported the species of freshwater goby in Central Sulawesi Province. However, the information is still lacking, especially in the Luwuk Banggai, Central Sulawesi. Therefore, research is needed to examine the diversity of gobies in this area. Observations were conducted in three rivers (Salodik, Kintom, and Simpong). The results of fish inventory in the three Luwuk Banggai rivers obtained 131 fish specimens, namely 26 specimens from the Salodik river, 29 specimens from the Kintom river, and 76 specimens from the Simpong river. The Simpong River has the highest Shannon-Wiener index (H') followed by the Kintom and Salodik rivers, which are 2.6313, 2.0114, and 1.3656, respectively. Similarity analysis of the three rivers produced 2 clusters. The Salodik River in fish diversity shows differences with the other two rivers, while the Simpong and Kintom rivers are in one cluster. Further research is needed related to the biodiversity of gobies and their relationship to habitat characteristics and river water quality in the Luwuk Banggai.

1. Introduction

Central Sulawesi located in the heart of Sulawesi Island on 2°22' N- 3°48' S and 119°22' E-124°22' E. The equator crosses the province with an area of around 61,841.29 km². One of the potential areas in this province is the potential of inland public water areas which includes freshwater lakes and several rivers. The existence of lakes in this region becomes essential and becomes a source of freshwater for the community [1]. With these waters, the potential of existing fisheries also becomes very important and quite reliable in meeting the needs of animal protein and at the same time becoming a source of livelihood with cultivation and fishing activities that are quite high.



The area that is part of the Wallacea line, ichthyofauna in this area has a high level of endemism in both lake and river waters. Some studies report endemic freshwater goby in Central Sulawesi (*Mugilogobius amadi* and *M. sarasinorum*) is endemic in Lake Poso [2,3]. Furthermore, other reports mention that there are endemic ricefish Adrianichthyidae [4] and halfbeak Zenarchopteridae [5] in Central Sulawesi. The fewer researchers and taxonomists cause the exploration of endemic species in this region is limited. It was stated that scientific reports about endemic, original, and introduced fish had not been well documented [1].

Previous research showed that in the study found 18 families and 27 genera of fish in 11 lakes and 15 species of which are endemic species [1]. These endemic fishes are from the genus *Adrianichthys* (four species), *Oryzias* (six species), *Mugilogobius* (two species), and *Nomorhamphus* (three species). Research in several rivers in Luwuk Banggai Regency has also been carried out by obtaining 20 Gobiidae and six species of Eleotridae. Reported from 10 rivers that have been surveyed, species *Lentipes mekonggaensis* is a species that dominates in the region [6].

Among a number of these species, the Gobi group became very popular and much in demand as an ornamental fish. In the area of Luwuk Banggai Regency, the Gobioidae Order, taxa are relatively less given attention compared to other types of fish as research objects. Many studies that have been reported mention that there are several endemic species from islands around Sulawesi [7]. Some of these species become a source of protein for local people as fish consumption [8]. Some types of gobies that become ornamental fish commodities have attractive colours and have become one of the potential export commodities, although concerns about fish populations in nature need to be aware. Previous studies confirmed that Gobiidae is the second largest freshwater fish in Indonesia after Cyprinidae [9]. However, the Gobiidae Family dominates the Eastern Indonesia region [10].

In this study, three rivers were surveyed to see the potential of gobies in this area. This study began to collect a database of potential gobies as ornamental fish and aquaculture commodities. This research is expected to be carried out in more depth to avoid errors in taxonomy by combining morphological identification with molecular identification which is currently developing very rapidly.

2. Material and methods

2.1. Samples collection and species identification

The study was conducted from December 2019 to February 2020 in three rivers, namely the Salodik River, the Kintom River, and the Simpong River (Figure 1). The specimens were captured with several traditional fishing gears (beach net, gill trawler, fishing line) and were immediately preserved in 90% ethanol and labelled according to location and date of sampling. The photographs have been taken at the laboratory before the morphological identification applied. The samples obtained were then differentiated based on morphological characteristics [4,11,12], and photographic comparisons on an online database on fishbase.org.

2.2. Data analysis

Biodiversity analysis includes the Shannon-Wiener index, the Margalef Index, the Evenness index, which is entirely carried out with Primary-e Version7 Software [13]. Besides, a similarity analysis and heatmap analysis of the potential intensity of the Gobiidae species from the three rivers was generated.

3. Results and discussion

3.1 Results

The results of fish inventory in three Luwuk Banggai rivers obtained 131 specimens, including 26 specimens from the Salodik river, 29 specimens from the Kintom River, and 76 specimens from the Simpong river. Specimens from the Simpong River, *Sicyopus zosterophorus* species predominate from the Family Oxudercidae, while the *Redigobius* sp. (Gobiidae) dominated on the Kintom River, (Figure 1). Based on the width of the river body, the Simpong River is the largest river among others with quite high water compared to others. The results of this study found that Family Oxudercidae /

Sicydiinae dominate in all habitats, and most of them are *Lentipes mekonggaensis* and *Sicyopus zosterophorus* (Table 1).

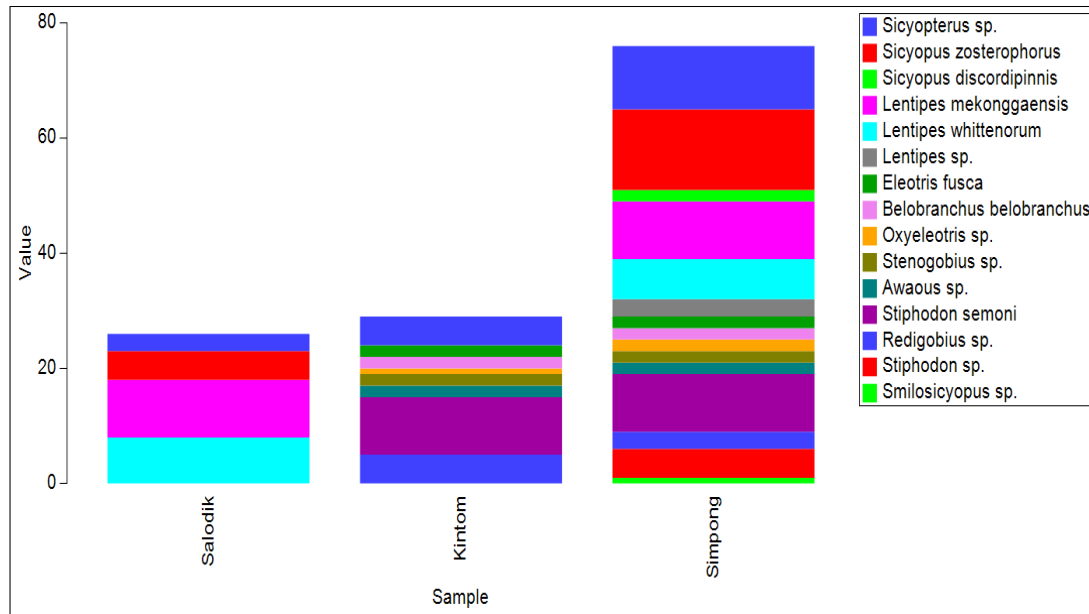


Figure 1. Species composition within three river system in Luwuk Banggai

3.1.1 Diversity analysis

Analysis of the diversity index in all samples in three locations shows significantly that the Simpong River has the highest Shannon-Wiener index (H') followed by the Kintom River and the Salodik River (Table 2). However, the Pielou's Evenness index, which shows the evenness of species in all rivers shows that species are spread evenly with a value of J , which is almost close to 1 point.

3.1.2 Analysis of similarity

By using the Primer®v7 software, the analysis of similarity in the three rivers can be done and get two large clusters. The Salodik River in diversity shows differences with the other two rivers, while the Simpong River and the Kintom River are in one cluster, although each has a bit of uniqueness (Figure 1). The composition of species distributed in the three rivers shows quite diverse patterns. The distribution of fish species in the Simpong River is quite high, with 76 specimens consisting of 6 Eleotridae specimens, 3 Gobiidae specimens, and the remaining 67 specimens from the Oxudercidae family (Figure 2).

Table 1. Species list of freshwater goby species from three river system in Luwuk Banggai

No.	Species name	River		
		Salodik	Kintom	Simpong
Eleotridae				
1	<i>Eleotris fusca</i>	0	2	2
2	<i>Belobranchus belobranchus</i>	0	2	2
3	<i>Oxyeleotris sp.</i>	0	1	2
Gobiidae				
4	<i>Redigobius sp.</i>	0	5	3
Oxudercidae				
5	<i>Awaous sp.</i>	0	2	2
6	<i>Lentipes mekonggaensis</i>	10	0	10
7	<i>Lentipes whittenorum</i>	8	0	7

8	<i>Lentipes sp.</i>	0	0	3
9	<i>Sicyopterus sp.</i>	3	5	11
10	<i>Sicyopus zosterophorus</i>	5	0	14
11	<i>Sicyopus discordipinnis</i>	0	0	2
12	<i>Smilosicyopus sp.</i>	0	0	1
13	<i>Stenogobius sp.</i>	0	2	2
14	<i>Stiphodon semoni</i>	0	10	10
15	<i>Stiphodon sp.</i>	0	0	5

3.1.3 Heat map analysis

Through heatmap analysis between species data and the three rivers that became the study area, it was successfully carried out. In this study found that in Simpong river, the intensity of *Sicyopus zosterophorus* species showed the highest (14 samples), followed by species of *Lentipes mekonggaensis* and *Stiphodon semoni* with the same intensity, e.g. ten samples. Whereas in the Kintom River, only species of *Stiphodon semoni* seem to dominate compared to other species. Unlike the previous rivers, the Salodik river is only dominated by two species of *Lentipes* (*L. mekonggaensis* and *Lentipes whittenorum*) respectively (Figure 3).

Table 2. The diversity index of three river in Luwuk Banggai, Central Sulawesi

Index	Symbol	River		
		Salodik	Kintom	Simpong
Margalef	d	1.4629	2.9116	4.4099
Pielou's Evenness	J	0.9851	0.9673	0.9716
Shannon-Wiener	H'	1.3656	2.0114	2.6313
Simpson	L	0.8492	0.9424	0.9631

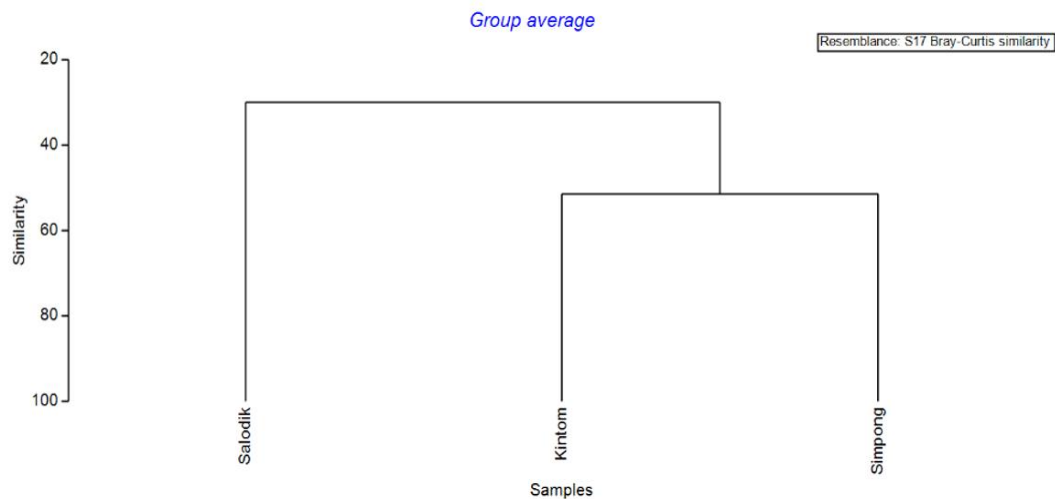


Figure 2. Similarity analysis based on the river system in Luwuk Banggai

3.2 Discussion

Local and international researchers have explored the potential of freshwater fisheries in Central Sulawesi. In some lakes, it even becomes an important area for endemic species and needs to get serious attention. Previous research mentioned that in Lake Poso endemic fish species were found namely *Adrianichthys kruyti*, *A. oophorus*, *A. poptae*, *Oryzias nigrimas*, *O. orthognathus* [14], *A. roseni*, and *O. nebulosus* [15]. *Oryzias soerotoi* in Lake Tiu [16], *O. bonneorum*, and *O. sarasinorum*

in Lake Lindu [4]. Another study has been conducted in seven areas in Central Sulawesi and found 18 families consisting of 27 genera. Among these fishes, 15 species are endemic in 3 lakes namely Poso Lake, Lindu Lake, and Tiu Lake. However, it was found that introducing 23 species of species that are feared to be invasive and can reduce the number of endemic fish in this area [1]. Meanwhile, in other parts of Sulawesi, a variety of endemic species were identified which added a range of important species for conservation purposes. Lake Towuti in South Sulawesi also found the endemic fish *Telmatherina celebensis*, which is a rainbow fish of Sulawesi [17], *Parantherina striata* [18]. Even in the Malili lake complex (which includes Lake Matano, Lake Towuti, Lake Mahalona, Lake Wawantoa, and Lake Masapi), it is also not separated from the presence of endemic species that cannot be ignored [19].

In addition to the inundated ecosystem (lentik), ecosystem flow (lotik) is also an essential area for the distribution of freshwater fisheries which is quite essential. Some rivers in Central Sulawesi also become the habitat for several unique species. Previous studies reported that in two rivers in Central Sulawesi (the breed river and the Koyoan River) there were 17 exotic species of the Gobiidae and Eleotridae family [20]. Furthermore, the study was developed in eight different rivers in the province, which received 20 species of Gobiidae and six species of Eleotridae [6]. In this study, it is expected to complete the database of goby fish in this region.

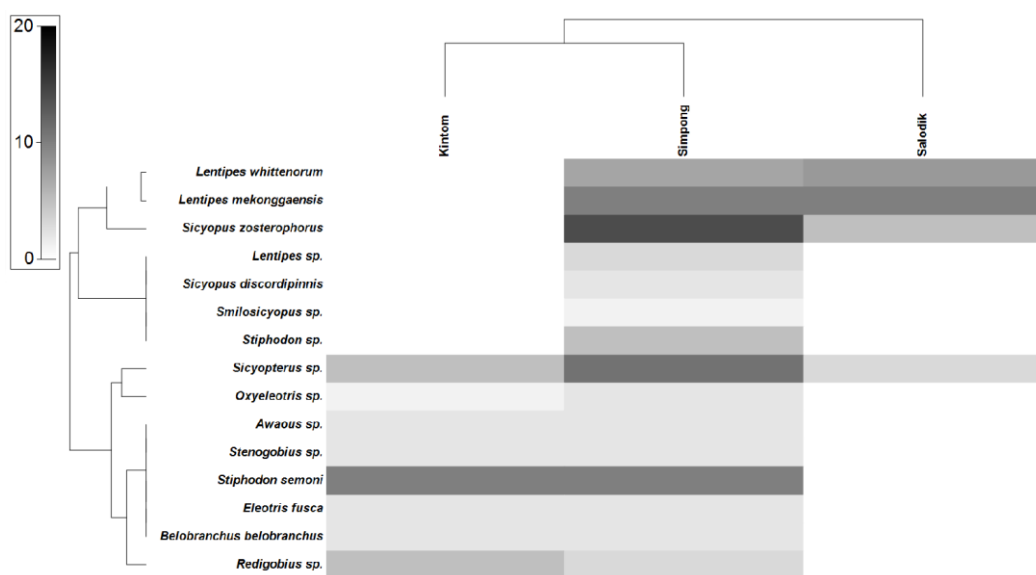


Figure 3. Heatmap analysis between species distribution in three river system in Luwuk Banggai.

In the study in 3 rivers this time, get three fish families, namely Gobiidae, Eleotridae, and Oxudercidae. Oxudercidae dominates more than any other family. In the latest issue of “Fishes of the World”, there are about 2,200 goby-like species scattered throughout the world [21]. Gobiidae fish and their closest relatives have a relatively small body size (generally less than 15 cm) and can adapt in a variety of ecosystems from freshwater to brackish. Some species even can be like an amphibian (mudskippers) and live in association with several types of crabs [22].

In line with previous studies that have been conducted, the Wallacea region is the epicentre of the Gobiidae family compared to the Cyprinidae family, which is more dominant in the Sundaland region [23]. This situation is evidenced by the findings of fish in this study that obtained fish from Gobiidae and Eleotridae (Table 1). Another analysis that we did in this study, that it was the river similarity test. The results showed that each river has unique characteristics and is different from other rivers (Figure 2). Even though the Simpong and Kintong Rivers are in the same cluster, they still have their uniqueness so that a large branch can be seen.



Figure 4. The three rivers of the sampling site with reasonably clear water and rocky sand substrate. (A. Simpong river; B. Salodik river and C. Kintom river)

The characteristics of the Simpong River have a substrate of sandy stone, so the river looks very clear. With the quality of the river water that is still maintained, Luwuk Banggai district has made many rivers a source of PAM (*Perusahaan Air Minum*) or drinking water Company in several areas. However, surface groundwater is also one of the water sources that can be utilized by the people in Central Sulawesi. This groundwater basin area (GBA) consists of four GBAs (Topo, Tomeang, Luwuk, and Sobol), which can be relied upon for freshwater needs [24].

4. Conclusion

Freshwater river fish in Luwuk Banggai successfully collected. There are 131 specimens from three rivers, 26 specimens from the Salodik River, 29 specimens from the Kintom River, and 76 specimens from the Simpong River. The *Sicyopus zosterophorus* species predominate from the Family Oxudercidae, while the *Redigobius* sp. (Gobiidae) is found in the Kintom River. The Simpong River has a high diversity compared to 2 other rivers (Kintom River and Salodik River) with a Shannon-Wiener index (H') value of 2.6313. The characteristics of the Simpong river may have similarities with the Kintom River with a similarity test that is united in one clade, while the Salodik River is unique than other rivers. Further studies are needed regarding the physical and chemical characteristics of all rivers in the study area.

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