Observations of fish species diversity in floating artificial habitats in Koto Panjang reservoirs, Indonesia

Budijono Budijono[1, 2*], *Ridwan* Manda Putra[1, 2], *Muhammad* Fauzi[2], *Eko Pria*nto[2], *Andri* Hendrizal[2], *Rina* D'rita Sibagariang[2], *Isma Mul*yani[2], and *Riska* Aprisanti[2]

[1]Environmental Science, Postgraduate, Universitas Riau
[2]Aquatic Resources Management Department, Faculty of Fisheries and Marine Science, Universitas Riau

Abstract. Monitoring the diversity of fish species in artificial floating habitats that are continuously tested in the waters of the Koto Panjang Reservoir is important to assess the current availability of fish species resources. This study aims to evaluate the increase in fish species in the different artificial floating habitat structures that were tested. This study was conducted from November 2023 to June 2024 in the Koto Panjang Reservoir on 9 existing floating habitat structures. Each structure has 8 attractors with media (raffia rope, plastic rope, packaging bottles) hung at a depth of 2 m. Each structure is equipped with 4 traps to catch fish every month, then counted and identified according to applicable procedures. The catch in all artificial habitats was 189 fish with a total of 21 species from the previous 16 species. The largest number of fish remained in the raffia rope media at 100% and the lowest in the strapping band at 76,2%. Meanwhile, the types of fish found in the reservoir waters were 32 species from the 44 species that had been recorded from previous research. It was concluded that raffia rope media is a media preferred by fish in artificial floating habitats.

1 Introduction

Koto Panjang Reservoir is part of 235 national multifunctional reservoirs with an area of around 124 km^2 [1]. The presence of this reservoir is a new habitat for fish from the main river and tributaries to enter the reservoir's inundation environment. It is recorded that 24-44 types of fish are in this reservoir [2] and it is suspected that there are additional types of fish that need to be evaluated.

The fish resources within the reservoir have been utilized by local fishermen for many years, which has recently led to a decline in the populations of fish species with high economic value. These species include *Chitala lopis*, *Wallago leeri*, *Barbonymus gonionotus*, *Thynnichthys polilepis*, *Channa striata*, *Kryptopterus lais*, *Puntioplites bulu*,

*Corresponding author: budijono@lecturer.unri.ac.id

Rasbora sp., *Clupeichthys goniognathus*, *Channa micropeltes*, *Barbonymus schwanenfeldii*, and *Hemibagrus nemurus* [1], including *Chitala lopis* [2], especially in the transition and lacustrine zones as fishing areas.

The decline in fish resources is caused by intensive fishing, conversion of water catchment areas, gravel mining, and domestic activities which result in a decline in water quality with the presence of pollutants including NO_3^-, PO_4^{3-}, organic compounds, heavy metals, and microplastics [1,3,4,5,6,7,8,9] which can damage fish habitats.

Efforts to restore fish resources in this reservoir have been carried out by implementing horizontal and vertical floating artificial habitats. However, the vertical type was severely damaged o that the horizontal type using raffia rope, plastic bottles and plastic band strapping can be observed to date. Previous research findings only found 16 fish species that utilize artificial habitats. [2]. Monitoring activities for the diversity of fish species in artificial habitats and updating the recording of fish species in this reservoir on an ongoing basis are important so that this breakthrough becomes an alternative to restoring fish resources, in addition to efforts to restock native fish species in addition to local fish restocking efforts.

2 Material and Method

This horizontal floating artificial habitat is located in Koto Panjang Reservoir (coordinates: 0°16'24.6" N; 100°51'53.64" E). Monitoring activities for this project were carried out from November 2023 to June 2024 including sampling of water, periphyton chlorophyll-a and fish.

Due to damage to the vertical structure in the previous year's research, only the design of the horizontal floating artificial habitat (Figure 1) was observed. This design includes six box-shaped sructures, each measuring 4m x 4m, constructed from 3-inch PVC pipes. On each horizontal structure, there are eight iron attractors connected by 3 mm PE nylon rope. Each attractor measures 1m x 1m x 1m and is hung at a depth of 2 m. The materials used in the attractors consist of plastic bottles, raffia rope, and strapped plastic bands. These horizontal habitat structures are spaced approximately 50 meters apart.

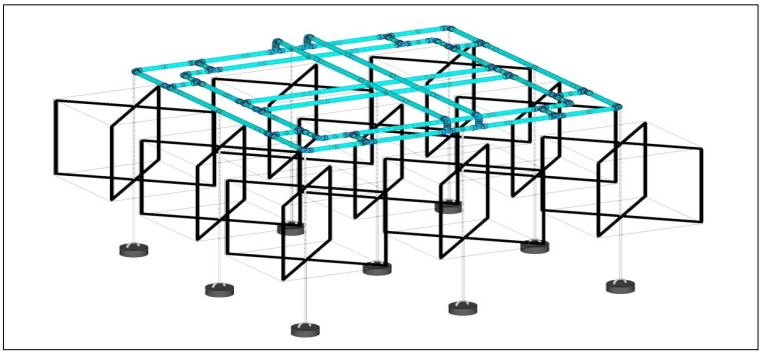

Fig.1. Design of artificial structure of horizontal floating habitat

Monthly in situ water quality observations were conducted, measuring parameters such as temperature, turbidity (using HI88703), brightness (Secchi disk stick), current velocity, pH and total dissolved solids (HI 9813-61), as well as dissolved oxygen (AZ 8403). Meanwhile, total suspended solid, NO_3^-, total nitrogen, PO_4^{3-}, and periphyton chlorophyll-a was analyzed following the method described in [10]. Fish sampling involved 24 traps and each artificial habitat was set with 4 traps, then lifted after 24 hours. Fish caught in each

artificial habitat were then collected in plastic bags and labeled. Furthermore, the length and total weight of the fish were measured, and identified to the species level. [11,12].

Water quality is analyzed descriptively by comparing it with water quality standards [13,14], as well as other relevant references.

3 Results and Discussion

Water quality conditions obtained at all artificial habitat placement sites showed average ranges as follows: temperature from 27.8 to 29.9°C, turbidity between 2.2 and 3.75 FTU, TDS from 10.32 to 18.54 mg/L, and TSS ranging from 8.58 to 22.14 mg/L. The current speed was measured at 0.18 to 0.24 m/sec, pH values ranged from 6.51 to 6.78, and dissolved oxygen (DO) was between 6.23 and 6.56 mg/L. Additionally, nitrate levels were observed between 0.45 and 0.53 mg/L, total nitrogen from 0.51 to 1.36 mg/L, and phosphate levels ranged from 0.15 to 0.37 mg/L. These water quality conditions are generally consistent with the results from previous measurements. [2].

Fluctuations in periphyton chlorophyll-a values were only observed in the floating artificial habitat because the artificial habitat was still intact until this study was conducted, which is presented in Figure 2. The periphyton chlorophyll-a value in raffia rope was the highest with a range of 0.12 - 0.2 µg/cm^2. This value is slightly higher than the results of previous studies which ranged from 0.112 - 0.191 µg/cm^2.

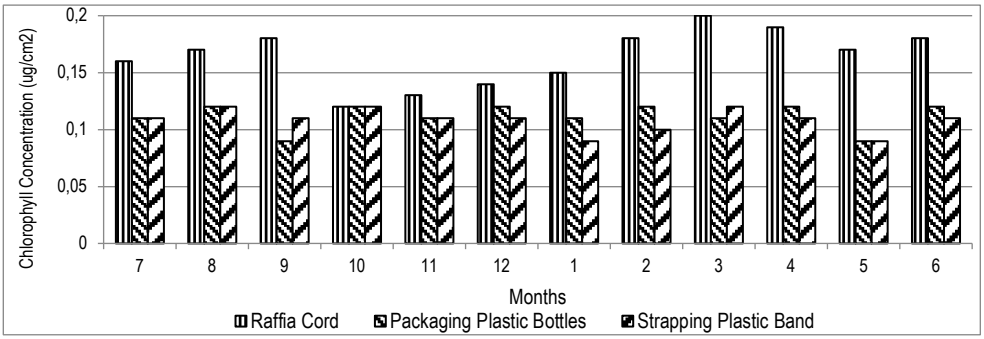

Fig.2. Chlorophyll-a values of periphyton in floating artificial habitats

For fish biota, there was an increase in fish species of 16 species [2] to 21 species, 14 genera, 7 families and 6 orders so that (Figure 3 and Table 1). Based on the differences in media in this structure, the highest number and type of fish were still obtained in the raffia rope media of 109 fish with a capture frequency of 100% and the lowest in the plactic band strapping of 40 fish with a capture frequency of 76.2% (Figure 3). In addition to fish, freshwater shrimp genera were also found, namely: *Caridina* sp as many as 241 fish and *Macrobrachium* sp as many as 177 fish.

Direct findings by researchers during this research were obtained from 32 species of fish in the Koto Panjang Reservoir out of 44 species of fish that had been recorded and 21 species of which had been collected in horizontal floating artificial habitat structures (Table 1).

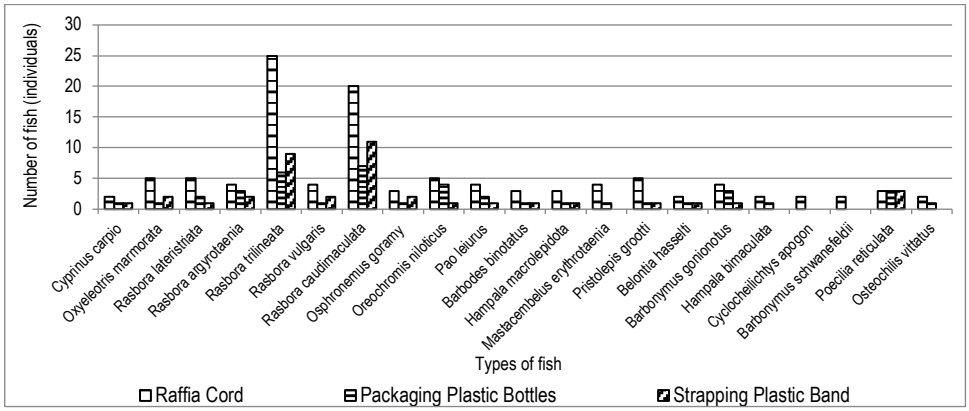

Fig.3. Composition of fish species based on media in horizontal floating artificial habitats

Table 2. Comparison between reservoir fish species found directly and fish caught in artificial habitat

Order	Family	Types of Fish	Live Found Fish	Fish findings in Artificial Habitat
Cypriniformes	Cyprinidae	1. *Cyprinus carpio*	√	√
		2. *Barbodes binotatus*	√	√
		3. *Hampala macrolepidota*	√	√
		4. *Barbonymus gonionotus*	√	√
		5. *Hampala bimaculata*	√	√
		6. *Cyclocheilichtys apogon*	√	√
		7. *Barbonymus schwanefeldii*	√	√
		8. *Thynnichthys polylepis*	√	×
		9. *Puntioplites bulu*	√	×
		10. *Labiobarbus festivus*	√	×
		11. *Osteochilus vittatus*	√	√
	Danionidae	12. *Rasbora lateristriata*	√	√
		13. *Rasbora argyrotaenia*	√	√
		14. *Rasbora trilineata*	√	√
		15. *Rasbora vulgaris*	√	√
		16. *Rasbora caudimaculata*	√	√
Anabantiformes	Helostomatodae	1. *Helostoma temminckii*	√	×
	Pristolepididae	2. *Pristolepis grootti*	√	√
	Osphronemidae	3. *Belontia hasselti*	√	√
	Osphronemidae	4. *Osphronemus goramy*	√	√
	Channidae	5. *Channa micropeltes*	√	×
		6. *Channa striata*	√	×
Cichliformes	Cichlidae	1. *Oreochromis niloticus*	√	√
Siluriformes	Bagridae	1. *Mystus nigriceps*	√	×
		2. *Hemibagrus nemurus*	√	×
	Pangasidae	3. *Pangasius hypoptalmus*	√	×
	Clariidae	4. *Clarias teijsmanni*	√	×
Tetroodontiformes	Tetraodontidae	1. *Pao leiurus*	√	√
Synbranchiformes	Mastacembelidae	1. *Mastacembelus erythrotaenia*	√	√
Cyprinodontiformes	Poeciliidae	1. *Poecilia reticulata*	√	√
Osteoglossiformes	Notopteridae	1. *Chitala lopis*	√	×
Clupeiformes	Ehiravidae	1. *Clupeichthys goniognathus*	√	×

The current water quality conditions are still in accordance with the results of previous studies and still meet the established reservoir water quality standards [13], except for brightness values below 2.5 m and phosphate above 0.1 mg/L which are caused by the

green color phenomenon of phytoplankton as an impact of high nitrate and phosphate values which are included in the eutrophic category [14]. Nitrate and phosphate values above 0.2 mg/L can stimulate algae growth [15,16].

The eutrophic water fertility category based on nitrate and phosphate values has also been confirmed by previous studies at this location, with a recorded range of 0.326 - 1.467 mgL-1 [17] or higher than the Saguling Reservoir with a range of 0.03 - 1.063 mg/L [18]. This condition indicates that the reservoir water carrying capacity has been exceeded [19]. The current water quality conditions at the artificial habitat location are relatively the same as the water quality status assessment conditions in the 2016-2020 and 2021 periods. [1,2].

The chlorophyll-a values of periphyton in artificial habitats with different attractor media fluctuated and the results did not differ from the 2023 research [2]. The chlorophyll-a values obtained provide an overview of the presence of photosynthetic algae-periphyton organisms in each media (raffia rope, plastic ribbon, plastic bottle packaging). The highest periphyton chlorophyll-a value was found in the raffia rope media which had a larger cross-sectional area compared to the strapping plastic band media which had a smaller cross-sectional area. The periphyton community attached to the media can photosynthesize with the influence of sunlight [20], to produce dissolved O_2, energy, absorb CO_2 and provide organic substrates to form a layer of microbial mat or phototrophic mat [21,22,23,24,25,26].

All types of fish obtained from artificial habitats were small in size as in previous studies, except *C. carpio* as an indication that this structure is a nursery and protection area for small fish [2]. The variation of fish species monitored to date in this structure can reflect the food chain cycle based on the diversity of eating habits of each type of fish which can be grouped into carnivores (*O. marmorata, Pao leiurus, M. eritrotaenia, H. macrolepidota, H. bimaculata*), omnivores (*B. schwanefeldii, C. apogon, P. reticulata, O. goramy, B. gonionotus, B. binotatus, C. carpio, Rasbora lateristriata, Rasbora argyrotaenia, Rasbora trilineata, Rasbora vulgaris, Rasbora caudimaculata*) and herbivores (*O. vittatus, B. hasselti, P. grootti*) as in previous research findings. Not only fish, freshwater shrimp are also found in artificial habitat structures, namely: Caridina sp and Macrobrachium sp as members of Crustacea from the Atyidae and Palaemonidae families which function to maintain the balance of the aquatic environment and food for omnivorous and carnivorous fish.

The operation of the floating artificial habitat structure resulted in an increase in the number of species, rising from 36.36% to 47.72% of the 44 fish species. The raffia rope media is the preferred media by fish with a frequency of capture reaching 100% compared to other media ranging from 76.2 - 90.5%. Similar results were also found in previous research so that this finding can further ensure the use of the three media in artificial habitats with more diverse creations so that the periphyton attachment media becomes wider and more numerous. Monitoring and evaluation continue to be carried out until the resistance limit of the applied artificial structure is reached in order to find a design that suits the conditions of this reservoir. The results of this research are better than the results of research by [27] which obtained 11 species of fish in the basic and floating artificial habitats in Gajah Mungkur Reservoir.

4 Conclusion

This research concluded that the floating artificial habitat produced 189 individuals consisting of 21 species, 14 genera, 7 families, and 6 orders, along with 241 *Caridinas* p. and 177 *Macrobrachium* sp., representing 47.72% of the total fish species in the waters and dominated by the Cypriniformes order. All media used in the habitat were effective in

attracting various species, with raffia rope being the most successful. Periodic monitoring and evaluation are recommended to assess the increase in fish species diversity in these waters.

Acknowledgements

Thanks are extended to the Institute for Research and Community Service of Riau University for the research funding support of the Field of Science with contract number: 6466/UN19.5.1.3/AL.04/2023 and the student group from the Department of Water Resources Management.

References

1. B. Budijono, U. M. Tang, R. M. Putra, N. Nofrizal, Dynamic of water fertility in Koto Panjang Reservoir, Riau Province, Indonesia. Aquaculture, Aquarium, Conservation & Legislation. **4**, 2 (2021)
2. B. Budijono, E. Prianto, M. Fauzi, A. Hendrizal, R.D. Sibagariang, R.M. Putra, I. Mulyani, E. Kamaruddin, E. Purwanto, M. P. Pangestu, First report of artificial floating habitat to increase the fish population in Koto Panjang reservoir, Indonesia, in BIO Web Conferences, Pekanbaru, (2023). https://doi.org/10.1051/bioconf/20237404002
3. B. Budijono, I. Suharman, and A. Hendrizal, Dynamics water quality in Koto Panjang Reservoir, Indonesia. in IOP Conference Series: Earth and Environmental Science, Pekanbaru, (2021). https://doi.org/10.1088/1755-1315/934/1/012056
4. B. Budijono, M. Hasbi, Heavy metal contamination in Koto Panjang Dam, Indonesia, in IOP Conference Series: Earth and Environmental Science, Pekanbaru, (2021). https://doi.org/10.1088/1755-1315/695/1/012018
5. M. Edy, B. Budijono, M. Hasbi, Identification of microplastics in water column at Koto Panjang dam, Kampar Regency, Riau Province. Berkala Perikanan Terubuk. **49**, 3 (2021). https://doi.org/10.31258/terubuk.49.3.1353-1362
6. A. Friadi, E. Purwanto, B. Budijono, Kandungan mikroplastik pada air berdasarkan kedalaman di Waduk PLTA Koto Panjang, Kabupaten Kampar, Provinsi Riau. Jurnal Fisika Unand. **12**, 3 (2023). https://doi.org/10.25077/jfu.12.3.437-443.2023
7. L.S. Margaretha, B. Budijono, M. Fauzi, Microplastic identification of tinfoil barb (*Puntius schawanafeldii*) in Koto Panjang dam Kampar Regency Riau Province. Jurnal Perikanan dan Kelautan. **27**, 2 (2022). https://doi.org/10.31258/jpk.27.2.235-240
8. D.A. Ulfa, E. Purwanto, B. Budijono, Identification of microplastics in common carp (*Cyprinus carpio*) at Koto Panjang reservoir Kampar Regency Riau Province. Jurnal Perikanan dan Kelautan. **27**, 2 (2022). https://doi.org/10.31258/jpk.27.2.145-150
9. R. Rahmawati, B. Budijono, E. Sumiarsih, Microplastic content in water using the bongo net sweeping method in Koto Panjang reservoir, Kampar. Berkala Perikanan Terubuk. **5**, 1 (2023). https://doi.org/10.31258/terubuk.51.1.2023-2033
10. W.E. Federation, Standard methods for the examination of water and wastewater, (American Public Health Association (APHA), Washington, DC, USA, 2005)

11. M. Kottelat, A.J. Whitten, S.N. Kartikasari, S. Wirjoatmodjo, Freshwater fishes of western Indonesia and Sulawesi, (Periplus, Jakarta, Indonesia, 1993).
12. M. Kottelat, Fresh-water fishes of Kampuchea. Hydrobiologia. **121**, 3 (1985). https://doi.org/10.1007/bf00017547
13. Peraturan Pemerintah Republik Indonesia Tahun 2021 tentang penyelenggaraan perlindungan dan pengelolaan lingkungan hidup, (Sekretariat Negara Republik Indonesia, Jakarta, 2021)
14. C.R. Goldman, A.J. Horne, Limnology, (McGraw-Hill Higher Education, Chicago, 1994)
15. H.M. Sari, B. Sulardiono, S. Rudiyanti, Kajian kesuburan perairan di Waduk Ir. H. Djuanda Purwakarta berdasarkan kandungan nutrien dan struktur komunitas fitoplankton. Management of Aquatic Resources Journal. **4**, 3 (2015). https://doi.org/10.14710/marj.v4i3.9329
16. A. Mustofa, Kandungan nitrat dan fospat sebagai faktor tingkat kesuburan perairan pantai. Jurnal Disprotek. **6**, 1 (2015). https://doi.org/10.34001/jdpt.v6i1
17. I.F. Hasibuan, S. Hariyadi, E.M. Adiwilaga, Status Kualitas Air dan Kesuburan Perairan Waduk PLTA Koto Panjang, Provinsi Riau. Jurnal Ilmu Pertanian Indonesia **22**, 3 (2017). https://doi.org/10.18343/jipi.22.3.147
18. E. Kartamihardja, K. Krismono, Fenomena, penyebab dan pengendalian kematian ikan serta pengembangan budidaya ikan dalam keramba jaring apung berkelanjutan di perairan waduk dan danau, (Pusat Riset Perikanan Badan Penelitian dan Pengembangan Kelautan dan Perikanan, Jakarta, 2016). (unpublised)
19. P. Sulaiman, P.F. Rachmawati, R. Puspasari, N.N. Wiadnyana, The efforts on prevention and countermeasures of fish mass mortality in lakes and reservoirs. Jurnal Kebijakan Perikanan Indonesia. **12**, 2 (2020). https://dx.doi.org/10.15578/jkpi.12.1.2020.59-73
20. M.M. Bateson, D. Ward, Photoexcretion and fate of glycolate in a hot spring cyanobacterial mat. Applied and Environmental Microbiology. **54**, 7 (1988). https://doi.org/10.1128/aem.54.7.1738-1743.1988
21. H.C. Flemming, Biofilms and Environmental Protection, Water Science and Technology. 27, 7-8 (1993). https://doi.org/10.2166/wst.1993.0528
22. L.J. Stal, H.V. Gemerden, W.E. Krumbein, Structure and development of a benthic marine microbial mat. FEMS Microbiology Letters. **31**, 2 (1985). https://doi.org/10.1016/0378-1097(85)90007-2
23. D. Ward, M. Ferris, S. Nold, M. Bateson, A Natural View of Microbial Biodiversity within Hot Spring Cyanobacterial Mat Communities. Microbiology and Molecular Biology Reviews. **62**, 4 (1998). https://doi.org/10.1128/mmbr.62.4.1353-1370.1998
24. J. Wimpenny, W. Manz, U. Szewzyk, Heterogeneity in biofilms. FEMS Microbiology Reviews. **24**, 5 (2000). https://doi.org/10.1111/j.1574-6976.2000.tb00565.x
25. R. Guerrero, M. Piqueras, M. Berlanga, Microbial mats and the search for minimal ecosystems", International Microbiology. **5**, 4 (2002). https://doi.org/10.1007/s10123-002-0094-8
26. G. Roeselers, M. van Loosdrecht, G. Muyzer, Phototrophic biofilms and their potential applications. Journal of Applied Phycology. **20**, 20 (2008). https://doi.org/10.1007/s10811-007-9223-2

27. A. Riyanto, A. Sudarto, Uji operasional artifisial habitat di perairan umum daratan di Gajah Mungkur. Buletin Teknik Litkayasa Sumber Daya dan Penangkapan. **15**, 2 (2017). https://dx.doi.org/10.15578/btl.15.2.2017.71-78