First report of artificial floating habitat to increase the fish population in Koto Panjang reservoir, Indonesia

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Abstract. The artificial habitat being tested in the Koto Panjang Reservoir is a step to anticipate the emergence of symptoms of a decline in fisheries resources at this time. This study aims to examine the types of artificial media in the artificial habitat structure favored by fish. This research was carried out from June 2022 to August 2023 in the Koto Panjang Reservoir. Artificial habitat is created as many as 10 structures. Each structure has 8 attractors with different media (raffia rope, plastic bonded rope, palm fiber, packing bottles, and coconut leaves, which are suspended at a depth of 2-8 meters. Four units of fish traps are placed on each structure for monthly fish collection, then counted and identified according to applicable procedures. The result shown that were 232 fish caught in all artificial habitats consisting of 16 species, excluding 1 type of freshwater shrimp. On raffia cord media, more types of fish were caught, reaching 56% compared to 12% on packaging plastic bottle media. It was concluded that this artificial floating habitat with different media could be a gathering and foraging place represented by 16 fish species from the 44 fish species recorded in this reservoir.

1 Introduction

Koto Panjang Reservoir in Riau Provinc iis part of 235 Indonesian reservoirs as a result of water resource engineering, namely: the Kampar River. The inundation area of this reservoir is around 124 km2 [1,2,3], which makes it the second largest reservoir in Southeast Asia and Indonesia. This reservoir has an effective submerged capacity of ± 1.545 million km2 with a water holding capacity of ± 1.04 million m3 [4], which is used to provide electrical energy, tourism, capture fisheries and aquaculture.

This reservoir is a gathering place for various types of fish ranging from 24 – 44 of the 114 fish species recorded in the Kampar Kanan River as the main dammed river [5,6,7], including originating from the Batang Mahat, Kapau, Tiwi, Takus, Gulamo, Osang, Cunding, Arau Kecil and Arau Besar Rivers. The diversity and abundance of these fish are important

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for the economy of 400 fishermen in District XIII Koto Kampar [6] and increased to 1168 fishermen in 2017 [8] with the main fishing area in Batu Bersurat waters, Muara Takus, Gunung Bungsu, and Koto Tuo.

The types of fish with high economic value from this reservoir are *Hemibagrus nemurus, Channa striata, Channa micropeltes, Thynnichthys polylepis, Barbonymus schwanenfeldii, Rasbora* sp*, Puntioplites bulu, Clupeichthys goniognathus, Chitala lopis, Kryptopterus lais, Barbonymus gonionotus*, and *Wallago leeri* [1]. The *Chitala lopis* in particular is still a target for capture which should be protected because it is one of Indonesia's original fish species that has been declared extinct [9]. At present, there has been a decrease in the catch of fishermen in District XIII Koto Kampar from 550 tons to 324.2 tons [10]. In recent years there have been fishing nets that have allegedly contributed to threatening the sustainability of fish resources in this reservoir [11]. In addition to other threats, such as (1) high erosion and sedimentation potential from the conversion of catchment area land into oil palm, rubber plantations, and so on; (2) tourism activities; (3) residential/domestic activities; (4) mining of sand and gravel in rivers which are the source of water supply for reservoirs, such as Batang Mahat and the upper reaches of the Kampar River [1,11].

The water quality of reservoirs or lakes decreases until the quality becomes worse, often due to the entry of pollutants from anthropogenic activities on land and in the water body itself, especially from upstream areas. The recorded pollutants that have been researched are high levels of nutrients (N and P) and organic matter, as well as heavy metals with lightly polluted water quality status in 2015-2020 [1,11,12], including the discovery of 3 types of microplastics [13,14] which is thought to contribute to the decline in the sustainability of fish resources in this reservoir. The decline in fish resources is the result of the interaction between increasingly intensive fishing activities and the decreased carrying capacity of waters due to the degradation of important fishing habitats [15,16,17].

Restocking is generally a commonly used option, although sometimes fish species such as *Oreochromis niloticus, Cyprinus carpio, Osphronemus gourami* and *Pangasius hypopthalmus* are introduced inappropriately and these species have been introduced into this reservoir. Efforts to improve the condition of fish resources in inland waters can be done by implementing artificial habitats (floating or submerged) which are still relatively limited in inland waters. An artificial habitat is a building made of plastic with a special structure designed to provide a suitable place for fish to gather, take shelter, find food, and breed/lay eggs [18] aimed at restoring the availability of fish resources [16,17]. Therefore, testing the application of artificial habitat is an important breakthrough in the Koto Panjang Reservoir with the hope that in the future it can help restore aquatic resources by returning fish habitat for the welfare of fishermen.

2 Material and Method

Locations of vertical (0°16'33"N; 100°52'8.4"E) and horizontal (0°16'24.6"N; 100°51'53.64"E) artificial floating habitats in the Koto Panjang Reservoir at a depth range of 25 – 40 m which are placed separately on the coordinates (Figure 1). This research started from August 2022 to July 2023. Water samples were analyzed at the Laboratory of the Faculty of Fisheries and Marine Sciences, University of Riau.

The experimental structural design of vertical and horizontal floating habitats consisted of 5 squares (4m x 4m) each made of 3-inch PVC pipe. Inside each artificial horizontal floating habitat structure contains 9 attractors measuring 1m x 1m x 1m made of iron connected by 3 mm nylon rope which is weighted and suspended at a depth of 2.5m on a PVC pipe. The same thing is also done for the artificial structure of vertical floating habitat which has 3 levels of attractor, namely: 2.5 m, 4 m, and 8 m. In the attractor section of the vertical and horizontal floating artificial habitat structures, each contains 36 media strands of plastic bottle packaging, coconut leaves, palm fiber, strapped plastic bands, and raffia cord. The vertical and horizontal floating habitat artificial structure groups are placed separately with a distance between structures with different media with a distance of 100 m.

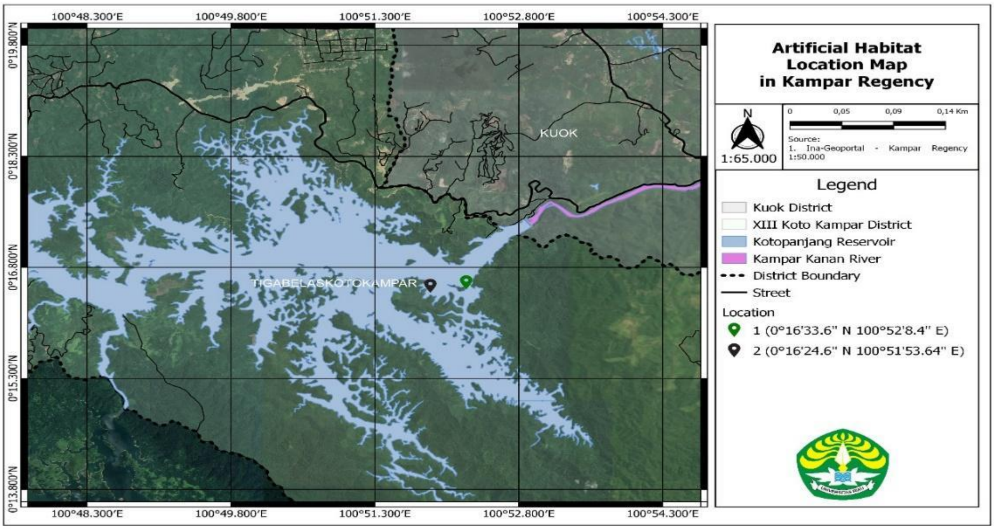

Fig.1. Artificial habitat location map

Water quality observations are carried out every month and the data collected includes temperature (Hg thermometer), turbidity (Martini Mi415), brightness (Secchi disk stick), current speed, pH (Adwa AD132), TDS (Mediatech 9901), DO meter (Lutron DO -5510), except for TSS, nitrate, total N, phosphate and chlorophyll-a of periphyton which were analyzed ex-situ in the laboratory referring to [19]. Meanwhile, fish sampling was carried out using 40 umbrella-shaped traps where 2 traps were placed at each depth of the attractor with different media on vertical and horizontal floating artificial habitat structures. The traps were removed after one day of installation. The caught fish were collected separately in plastic bags and labeled according to the attractor media on the artificial habitat structure being tested and time of observation In the laboratory, measurements of total length and weight as well as species composition were carried out by identifying them from the order to the species level [20,21,22].

Table 1. Parameters and methods

No.	Parameters	Unit	Method	Measurement
1.	Temperature	^oC	Expansion	In-situ
2.	Turbidity	FTU	Light scattering	In-situ
3.	Transparency	M	Secchi disk visualization	In-situ
4.	Water velocity	m/second	current-meter	In-situ
5.	TDS	mg/L	Electrometric	In-situ
6.	TSS	mg/L	Gravimetri	Laboratory
7.	pH	-	Electrometric	In-situ
8.	DO	mg/L	Electrometric	In-situ
9.	Nitrate	mg/L	Colorimetric	Laboratory
10.	Total Nitrogen	mg/L	Spectrophotometry	Laboratory
11.	Phosphate	mg/L	$SnCl_2$	Laboratory

12.	Chlorophyll-a	μg/cm^2	Spectrophotometry	Laboratory

Quality data is analyzed descriptively by comparing it with water quality standards [23] and [24], as well as other literature related to aquatic biota found.

3 Results

The results of water quality measurements recorded at the location of artificial habitat 1 have an average temperature range of 28.5 – 29.7 ºC, turbidity 2.00 – 3.28 FTU, TDS 12.20 – 15.45 mg/L, TSS 8.25 – 20.43 mg/L, current velocity 0.13 – 0.17 m/second, pH 6.68 – 6.88, DO 6.30 – 6.68 mg/L, nitrate 0.47 – 0.55 mg/L, total nitrogen 0.49 -1.31 mg/L and phosphate 0.10 – 0.23 mg/L. While the conditions at location 2 obtained an average temperature range of 27.5 – 29.5 ºC, turbidity 2.14 – 3.8 FTU, TDS 10.20 – 18.42 mg/L, TSS 8.12 – 22.21 mg/L, current velocity 0.11 – 0.14 m/sec, pH 6.53 – 6.75, DO 6.43 – 6.71 mg/L, nitrate 0.51 – 0.55 mg/L, total nitrogen 0.52 -1.34 mg/L and phosphate 0.11 – 0.32 mg/L. The water quality conditions did not differ from those found at the 2 locations where the artificial habitat was placed.

The concentration of chlorophyll-a periphyton in the artificial vertical floating habitat structure fluctuated only up to 6 months of observation due to damage to the PVC pipe as a floated in the structure by the movement of water in the reservoir and being hit by fishing boats so that the whole structure which has different attractor media sank simultaneously. Fluctuations in the average concentration of chlorophyll-a periphyton in the artificial vertical floating habitat structure (Figure 2A) with 3 sinking levels of attractor media (1.5, 4 m and 8 m) sorted from highest to lowest concentration were coconut leaves 14.2 – 24.5 µg/cm2, followed by plastic bottle packaging 12.1 – 22.4 µg/cm2, palm fiber 15.5 – 21.6 µg/cm2, raffia rope 11.4 – 19.9 µg/cm2, and the lowest on media strapping plastic band 9.5 – 17.8 µg/cm2. Overall, the concentration of chlorophyll-a periphyton was found to be highest at a depth of 1.5 m in the attractor media and lowest at a depth of 8 m.

Similar conditions are also experienced in the coconut leaves attractor media in the horizontal floating artificial habitat structure and the rest of the attractor media can be observed for a year with fluctuations in Figure 2B. The average concentration of chlorophyll-a periphyton in the attractor media which was submerged to a depth of 1.5 m sorted from highest to lowest concentration was coconut fronds 11.5 – 22.6 µg/cm2, followed by plastic bottles packaging 8.9 – 20.8 µg/cm2, raffia rope 11.2 – 19.1 µg/cm2, palm fiber 11.1 – 18.5 µg/cm2, and the lowest on the media strapping plastic band 10.1 – 14.6 µg/cm2. The concentration of chlorophyll-a periphyton based on media, especially at a depth of 1.5 m is relatively not much different.

The total species of fish caught in the artificial structure of vertical and horizontal floating habitats were 232 of 16 species (Figure 3) which can be grouped into 12 genera, 7 families (Cyprinidae, Osphronemidae, Pristolepididae, Cichlidae, Mastacembelidae, Tetraodontidae, Butidae) and 6 orders (Cypriniformes, Anabantiformes, Cichliformes, Synbranchiformes, Tetroodontiformes, Gobiiformes). The artificial floating habitat, especially the horizontal type with different media, is a place for gathering and foraging, representing 36.36% of the 44 fish species recorded in this reservoir. In addition, one genus of freshwater shrimp was also found, namely: caridina sp as many as 141 individuals consisting of 44 individuals in the artificial structure of vertical and horizontal floating habitats as many as 97 individuals. The frequency of fish caught on raffia media was higher with a range of 39 – 56% and lowest in plastic bottles ranging from 8 – 12% in the two artificial habitat structures (Figure 3).

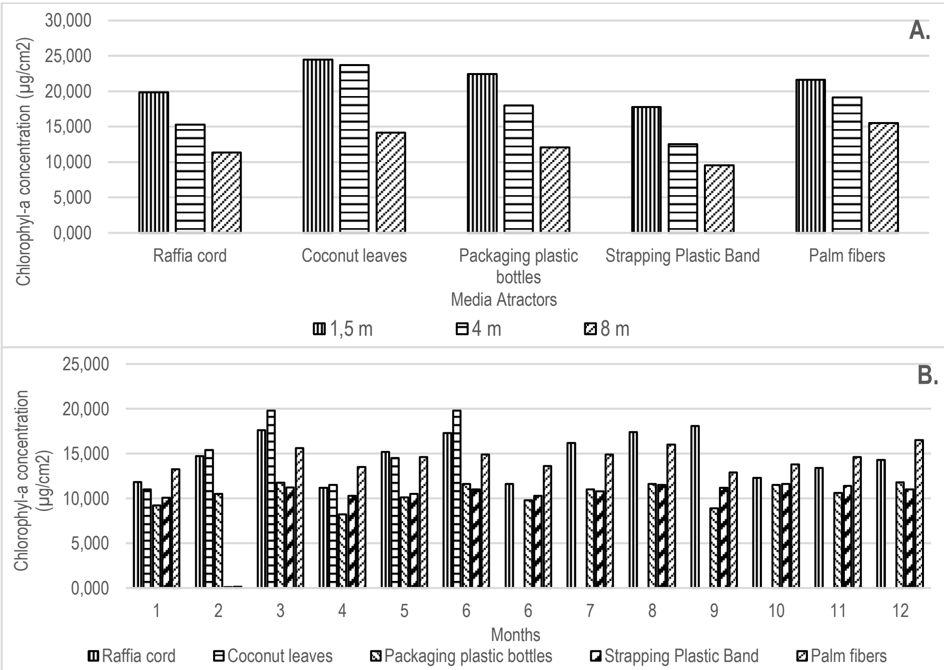

Fig.2. Chlorophyll-a periphyton concentration in vertical (A) and horizontal (B) floating artificial habitat

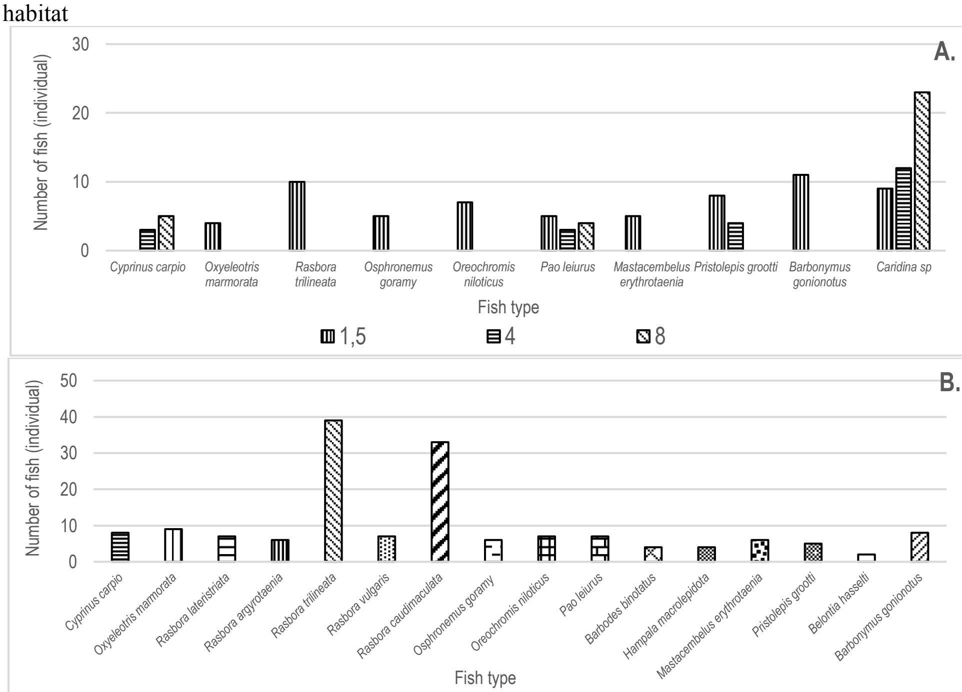

Fig.3. The number and types of fish in the vertical (A) and horizontal (B) floating artificial habitat structures

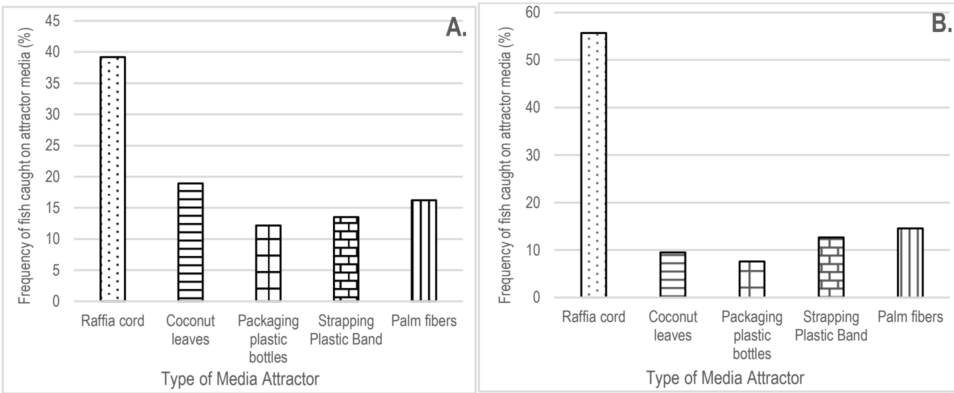

Fig.4. Frequency of fish presence in attractor media in vertical (A) and horizontal (B) floating artificial habitat structures

The water quality conditions recorded at the two vertical and horizontal artificial habitat laying locations were not different and still met the class 2-3 reservoir water quality standards for water temperature parameters which were still normal (3ºC deviation), TDS < 1000 mg/L, TSS < 25 mg/L, pH 6 – 9, DO > 4 mg/L and total nitrogen 0.65 – 1.9 mg/L, except for brightness < 2.5 m and phosphate > 0.1 mg/L [23]. The low brightness value is affected by the green color of the water due to the growth of phytoplankton at this location due to high concentrations of phosphate and nitrate which were also recorded 6-7 years earlier. Nitrate and phosphate are important elements for the growth and development of phytoplankton [25]. Partially, the range of nitrate values obtained is categorized as quite high and classified as eutrophic [24] and nitrate > 0.2 mg/L can result in eutrophication which ultimately stimulates algae blooms [26]. However, this concentration is still below the results of previous research at this location ranging from 0.326 - 1.467 mgL-1 [27] or other locations such as in the Saguling Reservoir ranging from 0.03 - 1.063 mg/L [28]. The same thing for the phosphate parameter with a value above 0.2 mg/L which is categorized as eutrophic according to [24] classification was also found in the results of previous research by [26,27,28,29]. The eutrophic level of these two parameters is an indication that the carrying capacity of water has been exceeded to support aquaculture activities [30]. Overall, the recorded water quality at the artificial habitat location currently obtained is not much different from the description of the previous reservoir water quality conditions for the 2016-2020 and 2021 timeframes [11], except that current velocity and nitrate are not regulated in the standard. water quality of reservoirs or lakes.

The concentration of chlorophyll-a periphyton in both vertical and horizontal floating habitat artificial structures fluctuated and showed the same pattern, that the concentration was highest at a depth of 1.5 m from the water surface and the lowest at a depth of 8 m, even though the water brightness value was below 2 m. Chlorophyll-a was observed as a representation of the presence of periphyton microalgae attached to each attractor media (raffia cord, palm fiber, strapped plastic band, coconut leaves, plastic bottle packaging). [30] described phototrophic periphyton as microbial communities attached to the surface of solid materials underwater and their presence controlled by light energy for the process of photosynthesis. These phototrophic oxygenic microorganisms produce energy and reduce carbon dioxide, providing organic substrates and oxygen in the waters. Another uniqueness is in producing extracellular polymeric substance (EPS) which functions as a binder between algae-biofilms [32,33] by forming a multilayer layer (known as microbial mat or phototrophic mat) [34,35,36,37]. The trend of the highest periphyton chlorophyll-a concentration was in the coconut frond attractor media because the cross-section of coconut leaves was wider and had a rough surface and vice versa in the media straping plastic bands which had a narrower cross-sectional area, relatively smooth surface, and a small number.

Of the total species found, *Oxyeleotris marmorata* (TL 5.3 – 9.4 cm TL), *Cyprinus carpio* (TL 18.4 - 24.3 cm), *Rasbora lateristriata* (TL 4.7 – 5.2 cm), *Rasbora caudimaculata* (TL 4.5 – 6.1 cm), *Rasbora argyrotaenia* (TL 5.1 – 5.8 cm), *Rasbora trilineata* (TL 7.4 – 8.1 cm), *Rasbora vulgaris* (TL 3.8 – 4.3 cm), *Barbodes binotatus* (TL 6.1 – 7.3 cm), *Hampala macrolepidota* (TL 11.3 – 13.4 cm), *Osphronemus goramy* (TL 5.5 – 6.2 cm), *Oreochromis niloticus* (TL 2.4 – 3.3 cm), *Pao leiurus* (TL 4.3 – 6.5 cm), *Mastacembelus erythrotaenia* (TL 3.6 – 4.8 cm), *Pristolepis grootii* (TL 2.2-2.8 cm), *Barbonymus gonionotus* (TL 7.4 – 8.6 cm) and *Belontia hasselti* (TL 5.7 – 6.4 cm). These fishes can be grouped into 12 genera (Cyprinus, Rasbora, Barbodes, Barbonymus, Hampala, Pristolepis, Belontia, Osphronemus, Oreochromis, Pao, Mastacembelus, Oxyeleotris), 8 families (Cyprinidae, Danionidae, Osphronemidae, Pristolepididae, Cichlidae, Mastacembelidae, Tetraodontidae, Butidae) and 6 orders (Cypriniformes, Anabantiformes, Cichliformes, Synbranchiformes, Tetroodontiformes, Gobiiformes). Most tribal members are in the Cypriniformes order as the main inhabitants of this reservoir, followed by the Anabantiformes order, and the lowest in the other 4 orders. Most of these fish species can be classified as native to Indonesia, except for *C. carpio*, *O. niloticus,* and *O. goramy* which are fish introduced into this reservoir.

Based on the size, only the *C. carpio* fish is large compared to other fish species so this small type is thought to be an attractor media in artificial floating habitats to protect from predation and foraging, because among them there are carnivorous fish such as *O. marmorata* [38, 39], *Pao leiurus* [40], *M. erythrotaenia* [41] and *H. macrolepidota* [42,43], while the rest have herbivorous and omnivorous eating habits. Referring to the eating habits of the 16 fish species found can provide an overview of the food chain cycle that takes place in the two operational artificial habitats. Apart from fish, this artificial habitat is also used and perhaps considered to be like its natural habitat by *Caridina* sp as a member of the Crustacea of the Atyidae family which is generally found in lentic (stagnant) or lotic (flowing) waters under leaf litter, on weathered wood, under roots of aquatic plants or around grass and between rocks [44,45]. This shrimp is also part of the diet of fish (omnivores and carnivores).

In the two artificial floating habitat structures that were operationalized, 36.36% of fish species were found out of 44 fish species recorded in this reservoir with the highest species diversity in the horizontal floating artificial habitat structure because the structure was relatively undamaged so that observations of fish took longer than the artificial habitat structure. vertical float. There were more types of fish caught in the raffia media than the two structures because the soft and numerous strands of raffia had a wider cross-sectional area as a place for the attachment of periphyton algae and were densely shaped like the roots of aquatic plants which were thought to be an attraction for fish. In contrast, the attachment of periphyton algae to the plastic bottle media is only on the outer wall and is rigid because the outer side is perforated so that the inner space of the bottle cannot be used by fish when conditions are threatened. Therefore, this ongoing research continues to be evaluated to find the type and form of media preferred by fish as a substitute for natural habitats that have been damaged. A comparison of the results of this research cannot be reviewed further because there are still very few published references to date, especially the use of artificial habitats in inland waters, except for the results of initial research [18]. Overall, the five attractor media used in this research were able to attract the preferences of various species to become alternative habitats in the waters of this reservoir.

4 Conclusion

This research concludes that in artificial vertical and horizontal floating habitats, 232 fish have been caught which can be grouped into 16 species, 12 genera, 8 families, and 6 orders, where the order Cypriniformes has the most species followed by Anabantiformes. The sixteen species made this artificial habitat a place to gather and find food, representing 36.36% of the 44 species recorded in this reservoir with a tendency to choose fish in raffia cord media higher and the lowest in plastic bottles. The five attracting media used in the two artificial habitat structures in this research can be used as alternative habitats that can attract various types of species so they need to be continuously monitored and evaluated to increase fish resources in this reservoir.

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