Biodiversity and community of phytoplankton in the mahseer conservation area at Bungo and Kerinci Regencies, Jambi Province, Indonesia

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Abstract. Mahseer (Tor spp.) conservation programs require information related to habitat characteristics including phytoplankton biodiversity and community structure as biological characteristics. This study aimed to evaluate phytoplankton diversity and community structure in the mahseer habitat, namely the conservation area in Muara Bungo and Kerinci Districts of Jambi Province. This study was conducted four times samplings i.e. December 2018, April 2019, July 2019, and October 2019, at three sites of the protected area, namely in Lubuk Alai, Senamat River, and the protected area of Tarutung Village. Furthermore, the data at the three sites were compared with data outside the protected area. Biological indices of the phytoplankton were calculated. The results showed that the mahseer habitat had a high diversity of phytoplankton. The results showed that the mahseer habitat had 8 genera of phytoplankton diversity, dominated by the Bacillariophyceae class, especially Synedra sp. with a dominance rate of more than 60% at each station. The diversity index ranged from 0.95 to 1.18, the evenness index ranged from 0.40 to 0.82, and the dominance index ranged from 0.39–0.43 in protected areas.

Keywords: conservation area; Jambi; mahseer; phytoplankton; structure community

1. Introduction

The mahseer (Tor spp.) belongs to the Cyprinidae family and is considered as high-economic freshwater fish. This fish is distributed from Indo-Australia and likes waters in the highlands with fairly swift currents [1]. According to research conducted by Subagja et al. [2], fish from the genus Tor are classified as endemic fish species that inhabit the waters of rivers and lakes upstream. The population of mahseer in the wild is decreasing, it is even feared to be nearing extinction. On the other hand, exploitation continues on a large scale and there are no or very limited aquaculture activities. Basic data on biology and ecology are also not well known [3]. Changes in habitat structure is a threat to the sustainability of these fish species. Human exploitation and a decrease in the quality of the headwaters can cause a decrease in the stock of fish in the wild. Therefore, it is necessary to carry out aquaculture of mahseer in an artificial environment that is designed by the natural habitat so that the population of mahseer fish can grow well.
The protected area is a conservation area that was formed by the local community custom and managed by the zoning system [4]. Mahseer fish in the conservation area are prohibited from being caught in certain periods. Whereas Fishery Reserves is an aquatic ecosystem that has a limited area, where all activities of capturing aquatic biota in any way, whenever and by anyone, are prohibited because it has a function as a preservation place for endemic (rare or endangered) endemic fishes, and some protected species.

Efforts to conserve mahseer require information related to the morphology of species and habitat characteristics in nature. The quality and characteristics of the habitat are closely related to the abundance and quality of the growth of biota in these waters. Habitat characteristics are needed in the process of further domestication and cultivation [5]. Previous research related to the habitat of the Tor species was carried out by [6] with different species and habitats in the Ciliwung River and Kuningan Pond. This study aimed to examine the phytoplankton organisms in the reservation and protected area of mahseer habitat in Muara Bungo and Kerinci Regencies, Jambi Province, as an effort to manage endemic fish species sustainably.

2. Methods

2.1. Time and location
A study on the biodiversity of plankton biodiversity was conducted from December 2018 to October 2019 with four sampling times, namely in December 2018, April 2019, July 2019, and October 2019. Samplings and measurements were carried out at three sites, which were at the Lubuk Alai of Beringin Village (site A), Senamat River (site B), and the protected area of Tarutung Village (site C). Furthermore, the data at the three stations were compared with the data at site D which is outside the conservation area. The research sites and its station are presented in figure 1. Water quality of the study area was also observed at the Aquaculture Environment Laboratory, Department of Aquaculture, and identification of plankton was carried out at the Macro Biology Laboratory 1 Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University.

![Figure 1. Research sites of reservation and protected area for mahseer in Bungo and Kerinci Regencies, Jambi Province.](image-url)
2.2. Tools and materials
The tools used in this study were boats, cameras, sample bottles, plankton net, Secchi Disk, DO meter, pH meter, thermometer, large size sample-plastic, Sedgewick-Rafter Counting Cell (SRC), glass cover, identification book, and microscope. The materials were lugol for preservatives and alcohol.

2.3. Data collection
Primary data obtained both in-situ and laboratory analysis results from samples that have been taken. In-situ data measured directly at the study sites were temperature, pH, water transparency, water depth, dissolved oxygen (DO), and river width. While the samples analyzed in the laboratory were for nutrients (NO₃-N, NO₂-N, NH₃-N, and phosphate) and plankton. The types of data and the analytical methods used in the study are described in table 1. Sampling and preservation are based on APHA [7].

Table 1. Types of data and analytical methods used in the study of mahseer habitat characteristics.

| Types of Data       | Unit   | Method of Analysis       | Analysis    |
|---------------------|--------|--------------------------|-------------|
| A. Aquatic Environment |        |                          |             |
| Turbidity           | NTU    | Nephelometric            | Laboratory  |
| TSS                 | mg/L   | Gravimetry               | Laboratory  |
| Temperature         | °C     | DO meter                 | In-situ     |
| Depth               | cm     | Direct measurement       | In-situ     |
| Transparency        | cm     | Visual                   | In-situ     |
| Dissolved Oxygen (DO) | mg/L  | DO meter                 | In-situ     |
| pH                  | -      | pH stick                 | In-situ     |
| Ammonia             | mg/L   | phenate                  | Laboratory  |
| Nitrate             | mg/L   | Cadmium reduction        | Laboratory  |
| Nitrite             | mg/L   | Sulfanilamide            | Laboratory  |
| Total Phosphate     | mg/L   | Ascorbic acid            | Laboratory  |
| B. Biological Component |       |                          |             |
| Plankton            | ind/L  | Abundance and Shannon-Wiener Index | Laboratory |

2.4. Data analysis

2.4.1. Water quality. The results of the analysis of water quality that have been obtained were compared with the water quality standards by the designation class. The reference used was the quality standard according to the Republic of Indonesia Government Regulation No. 82 [8] of Class III quality standards and some literature related to the study of water quality of Tor spp.

2.4.2. Biological condition. Data analysis to determine the biological condition of the study site was calculated on plankton abundance. Plankton abundance is calculated according to the following formula [9]:

\[ N = n \frac{V_r}{V_s} \frac{O_i}{O_p} \]  

(1)

Note:
N = Abundance (cell/L)
n = Number of individuals found
V_r = The volume of filtered water in the sample bottle (mL)
V_s = Volume of filtered water (mL)
Oi = SRC Area (1000 mm$^2$)
Op = Wide field of view (mm$^2$)

The abundance data that has been obtained from the laboratory analysis was then performed by the Shannon-Wiener index calculation. This index consists of diversity, evenness, and dominance indices. The Shannon-Wiener index was calculated based on the following formula:

1. Diversity Index

$$H' = -\sum pi \ln pi$$  \hspace{1cm} (2)

Note:
Pi = ni / N
ni = Number of individual types i
N = Total amount

The range of diversity index values can be classified:
<1 = Low species diversity
1–3 = Medium species diversity
>3 = High species diversity

2. Evenness Index

$$E = H' / H_{max}$$  \hspace{1cm} (3)

Note:
H' = Diversity
H_{max} = \ln S
S = Number of taxa

Evenness index values range from 0 to 1. E values that are close to 0 mean having an uneven distribution of species or low uniformity, and e values close to 1 mean having higher species uniformity [9].

3. Dominance Index

$$D = \sum pi^2$$  \hspace{1cm} (4)

Note:
Pi = ni / N
ni = Number of individual types i
N = Total amount

The criteria for dominance index are as follows [10]:
C ~ 0 = Low dominance or stable community structure
C ~ 1 = High dominance or community structure is less stable because it is under ecological pressure.

2.4.3. Principles Component Analysis (PCA) and habitat grouping. Principles Component Analysis (PCA) is one of the multivariate analysis methods, where this analysis is used for grouping variables [11]. In this study, PCA was used to describe characteristics between components based on water quality and plankton data. PCA analysis uses XLSTAT 2020 software. The results of PCA analysis are presented in a two-dimensional biplot with three types of data grouping namely water quality and plankton diversity. Habitat grouping to see the similarity between stations in the location. The results obtained from the station grouping analysis are dendrograms that will show groups of existing stations. Analysis of habitat grouping used the Minitab Application 19.
3. Result

3.1. Water quality

The habitat characteristics of an aquatic organism can be described by various aspects, one of which is water quality. Water quality results in this study were obtained from in situ measurements in the field and the results of laboratory analysis. The results of water quality presented in table 2 and 3. Based on the results of water quality obtained, it is known that the temperature parameters tend to be higher in the dry season. The lowest temperature during the rainy season was at Station C of 25.7 °C and the highest temperature during the rainy season was at Station B of 27.90 °C. As for the dry season, the lowest temperature was 27 °C, which was at Station A and the highest temperature during the dry season was at Station D at 30.1 °C. Results for stable pH parameters ranged from 6–7. Dissolved oxygen (DO) values ranged from 5.30 to 7.75 mg/L. The depth of the river ranged from 25 cm to 336 cm, while the brightness ranged from 15 cm to 125 cm.

Table 2. Results of water quality at the study sites during the study period.

| Parameters | Unit | December 2018 | April 2019 |
|------------|------|--------------|------------|
|            |      | Station A    | Station B  | Station C  | Station D  |
| Temperature| °C   | 25.80-27.00  | 25.30-28.00| 26.70-27.26| 26.80-28.21| 25.75-26.25|
| pH         | -    | 6-6          | 6-30.50    | 6-26.10    | 6-27.26    | 6-6         |
| DO         | mg/L | 7.35-8.05    | 6.70-7.10  | 6.00±0.783 | 7.55-8.15  | 5.50-6.90   | 6.08-7.48   |
| Transparency| cm  | 80-199       | 10-20      | 104-146    | 110-58     | 11.3±21.69 | 114.7-128.64|
| Depth      | cm   | 80-100       | 97-109     | 113-159    | 81.7±131.17| 117-133.66 | 100.3-138.19|
| Turbidity  | NTU  | 1.00-7.20    | 156-160    | 3.00-9.00  | 22.7-25.4  | 44.7-60.45 | 8.4-32.98   |
| TSS        | mg/L | 11.50-15.60  | 58.00-68.00| 10.8-16.8  | 1.5-8.5    | 3.7-10.81  | 1.2-3.15    |
| Ammonia    | mg/L | 0.1-0.5      | 0.005-0.011| 0.02-0.14  | 0.36-1.17  | 0.3-0.50   | 0.5-0.63    |
| Nitrate    | mg/L | 0.02-0.06    | 0.03-0.04  | 0.02-0.04  | 0.02-0.04  | 0.02-0.03  | 0.03-0.07   |
| Nitrate    | mg/L | 0.04-0.06    | 0.01-0.11  | 0.12-0.44  | 0.26-0.33  | 0.04-0.06  | 0.01-0.07   |
| Total      |      |              |            |            |            |            |             |
| phosphate  | mg/L | 0.2-1.2      | 0.79-0.83  | 0.80-1.80  | 0.7-1.16   | 0.9-1.55   | 0.27-0.71   |

Table 3. Results of water quality at the study sites during the study period.

| Parameters | Unit | July 2019 | October 2019 |
|------------|------|-----------|--------------|
|            |      | Station A | Station A    |
| Temperature| °C   | 28.3-29.10| 27.7-28.70   |
| pH         | -    | 6-6       | 7-7          |
| DO         | mg/L | 5.3       | 6.33-6.50    |
| Transparency| cm  | 83.34-123.81| 24.45-50.45 |
| Depth      | cm   | 110-115   | 53.34-76.16  |
| Turbidity  | NTU  | 1.53-1.67 | 4.06-14.320 |
| TSS        | mg/L | 3.00      | 3.07-0.115   |
| Ammonia    | mg/L | 0.25-3.48 | 0.48-0.52    |
| Nitrate    | mg/L | 0.28-0.33 | 0.12-0.30    |
| Nitrate    | mg/L | 0.04-0.24 | 0.45-0.55    |
| Total      |      |           |              |
| phosphate  | mg/L | 0.16-0.25 | 0.19-0.33    |

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3.2. Biological parameters

The results of plankton identification show that the four stations have different plankton genera compositions. But of the four stations had the same type of dominant plankton that was the genera of plankton from the Bacillariophyceae class. The type of plankton that is only found in station A and not found in other stations was Fragillariophyceae class. While the type of plankton that was only found in station B and not found in other stations was the Ulvophyceae class. Meanwhile, Zooplankton was only found in Station C (figure 2).

The results of the study of biological parameters include plankton abundance along with the Shannon-Wiener Index. The results of the analysis of plankton calculations show that the abundance of plankton at the four stations and each sampling time was different. Station A tends to have a higher abundance of plankton than other stations. The highest abundance was at Station A in July 2019 and October 2019 which was 153.09 cells/L (figure 3).

Figure 2. Composition of plankton at each station collected during the study period.

Figure 3. Dynamics of plankton abundance at each station in the period December 2018 to October 2019.
3.3. Diversity, Evenness, and Dominance Indices
Calculation of the Shannon-Wiener index on plankton produces the value of diversity index \( H' \), Evenness index \( E \), and dominance index \( D \). Based on the calculation results obtained, it can be seen that the diversity index values range from 0.95 to 1.18. The evenness index of the four stations has a high evenness value of more than 0.6. Whereas the dominance value indicates that there is no dominating type because the \( D \) value of the four stations is less than 0.5 (table 4).

| Index          | Time         | Station A | Station B | Station C | Station D |
|----------------|--------------|-----------|-----------|-----------|-----------|
| Diversity \( H' \) | December 2018 | 1.11      | 1.01      | 0.95      | 1.09      |
|                | April 2019   | 1.45      | 1.03      | 1.08      | 1.11      |
|                | July 2019    | 0.89      | 1.04      | 0.98      | 1.01      |
|                | October 2019 | 0.97      | 1.00      | 0.91      | 0.92      |
|                | December 2018| 0.79      | 0.79      | 0.78      | 0.87      |
|                | April 2019   | 0.81      | 0.82      | 0.77      | 0.87      |
| Evenness \( E \) | July 2019    | 0.80      | 0.80      | 0.79      | 0.77      |
|                | October 2019 | 0.75      | 0.76      | 0.76      | 0.78      |
|                | December 2018| 0.40      | 0.44      | 0.48      | 0.38      |
|                | April 2019   | 0.40      | 0.43      | 0.42      | 0.39      |
| Domination \( D \) | July 2019    | 0.39      | 0.44      | 0.39      | 0.42      |
|                | October 2019 | 0.41      | 0.39      | 0.44      | 0.40      |

3.4. Principles Component Analysis (PCA)
The PCA results of the characteristics of the mahseer habitat are visualized in a two-dimensional biplot divided into three groups of parameter types, namely water quality, plankton composition. The results of this PCA are used to determine the main components of each station. The PCA results for the plankton group were visualized in a two-dimensional biplot which showed that the dominant types of plankton at Station A were very many genera. Station B was dominated by plankton from Ulvophyceae, Xanthophyceae, and Euglenophyceae. Zooplankton is dominant in Station C and for Station D there was no dominant type of plankton (figure 4).

![Figure 4. Principles of Component Analysis (PCA) of plankton type.](image)
3.5. Habitat grouping

Based on the analysis of habitat grouping the results obtained in the form of a dendrogram. Habitat grouping is based on the similarity of phytoplankton parameters. The dendrogram results obtained show that overall there are two habitat groups. The first group consisted of Station A and Station B with a similarity level of more than 70%. Whereas the second group consisted of station C and station D with a lower similarity level of less than 40% (figure 5).

Figure 5. Dendrogram of station grouping results based on water quality.

4. Discussion

Lubuk Beringin village is a special fishery sanctuary for mahseer in the form of reservation and is well-known among the people of the Bungo Regency of Jambi Province. In addition to functioning as a conservation area, the Lubuk Beringin is also opened as a tourist area while maintaining the population of the mahseer. Whereas protected area of the Senamat River is a fast-flowing river with not much mahseer fish population in Lubuk Beringin. However, this river basin is included in the mahseer fishery reserve which is a priority of the Livestock and Fisheries Service Office of Bungo Regency, Jambi Province. For Station C is protected area which is located in the Batang Merangin tributary with the water source coming from Lake Kerinci. Station D is a comparison station where the station was outside the fishery sanctuary conservation area.

Reservation and protected areas constitute buffer habitats, fish farming, and other biological conservation. The difference is, the reserved fish contained therein may not be harvested at all, while for the protected area, maybe harvested within a certain period. Both reservation and protected area is a conservation system that is local wisdom of the community. Local wisdom as a starting point for conservation is based on human understanding of the natural environment and resources to support life [12]. In addition to preserving fish species, reservation and the protected area also function to preserve forests, water, and local customs. Communities around the reservoir and river basin ban already have their ingrown values of trust in certain species of fish, including mahseer [13]. A total of 197 reservations and protected areas in Jambi Province, a total of 123 reservations are in the Bungo District (Data of the Livestock and Fisheries Service Office of Bungo Regency 2019).

Habitat characteristics can be assessed from various indicators, such as physical, chemical, and biological indicators. For physical parameters, it was obtained by conducting measurements and observations in-situ. Based on the in-situ data obtained, it is observed that the pH, DO and temperature parameters tend to be the same and we’re still in the normal range. DO measurement results were in the range of 5–7 mg/L, whereas according to Andria and Rahmaningsih [14] the optimum DO for aquaculture is a minimum of 5 mg/L. Therefore, DO in the protected area of mahseer in Jambi was still considered optimum for fish growth. Furthermore, for pH, according to Andria and Rahmaningsih [14] the optimum pH is 4–11, so the results obtained were safe for fish growth.
Biological parameters are represented by the plankton community, showing of dominated of *Synedra* sp. This species is from the Bacillariophyceae group which can be found in almost every water that gets enough sunlight. *Synedra* sp. is also known to have a stronger ability to withstand environmental changes, this is because of its diatomic shape and has strong, layered protective or protective cells. Besides, this type of plankton is also able to accumulate and create nutrient reserves in the form of polymers that are not renewed [15].

According to Odum [10], the domination of Bacillariophyceae in the water are caused by their ability to adapt to the environment, are cosmopolitan, and are resistant to various extreme conditions, and have a high reproductivity rate. The predominance of phytoplankton from Bacillariophyceae class compared to several other phytoplankton groups is a common occurrence in parts of the water that experience mixing and changing waters due to continuous tides.

5. Conclusion

Mahseer (*Tor* spp.) has a habitat in the form of clear waters upstream, with stable water quality and with temperatures that are not too high, ranging between 26–30 °C. The habitat of mahseer has a high diversity of plankton species which is dominated by the Bacillariophyceae group especially the *Synedra* sp. Based on plankton composition grouping, station A and station B tend to have a higher equation, with the main components being genera of plankton.

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