The abundance of alien fish species flowerhorn (*Cichlasoma trimaculatum* (GÜNTHER, 1867)) in its fishing ground area at Lake Mahalona, South Sulawesi

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Abstract. Lake Mahalona is located in Towuti District, South Sulawesi Province. There are 29 species of fish found in Lake Mahalona and most of them are endemic fish. The presence of alien species deliberately or unexpected is one of threats causing the declining of the number of biodiversity in fresh waters. This study aims to determine the relative abundance of alien fish species Flowerhorn in its fishing ground area at Lake Mahalona. The research was conducted from January to June 2021 at six stations. Fish samples were obtained by using gill nets. The total Flowerhorn caught during the study were 15,677, the most caught in January was 3,346 and the least in June was 1,451. The Flowerhorn in January were the most number of fish at Kusapa (735), February and March at Muara (566 and 618), April at Tandumata (593), May and June at Badilla (434 and 375). The highest number and relative abundance of Flowerhorn fish were found at Kusapa in January (735 and 33.23%), while the lowest number and relative abundance of Flowerhorn fish were found at Lengkomali in June (129 and 4.62%). Flowerhorn as a alien fish species is distributed throughout the Lake Mahalona station. Flowerhorn fish occupy a lot of habitats with lots of aquatic plants, sandy and rocky substrates.

1. Introduction

Lake Mahalona is one of the lakes in the Malili Complex area besides Lake Matano, Lake Towuti, Lake Lantoa and Lake Masapi. The three lakes, namely Matano, Mahalona and Towuti are cascades, in the upper part is Lake Matano, in the middle is Lake Mahalona, and in the lower part is Lake Towuti. The outlet of Lake Matano is the Petea River which drains its water into Lake Mahalona. Furthermore, water from Lake Mahalona flows into Lake Towuti via the Tominanga River. In the end, the water from Lake Towuti will flow into Bone Bay via the Larona River.

Lake Towuti and Lake Mahalona are included in the Natural Tourism Park area based on the Decree of the Minister of Agriculture No. 274/Kpts/Um/1979. Lake Matano, Mahalona, and Towuti were formed through tectonic processes during the formation of Sulawesi Island, so that these lakes are known as ancient lakes or categorized as ancient lakes [1].
Mahalona, in East Luwu, is known for its clear and relatively sheltered waters making it a potential tourist attraction. It is a tectonic lake forming an effective widening of the river connecting Lake Matano and Lake Towuti. Its maximum depth is 73 m with a surface area of about 24.4 km and an elevation of 300 m above sea level. The lake is also supplied by several springs. Lake Mahalona is used, among others, as a clean drinking water, bathing, fishing/archery fishing, transportation, washing pepper, recreation, and irrigation.

Lake Towuti and Mahalona are located in Towuti sub-district have very high conservation value because of their high numbers of endemic species. There are 29 species of fish found in Lake Mahalona and most of them are endemic fish derived of the genus Telmatherina, Paratherina, Tominaga, Mugilogobius, Glossogobius (G. matanensis and Glossogobius sp.), and Oryzias. The presence of alien species deliberately or unexpected is one of threats causing the declining of the number of biodiversity in fresh waters [2].

Of the 87 species of Indonesian fish that are threatened with extinction, 66 species (75%) are known to be freshwater fish [3]. Most (68%) of these endangered freshwater fish are endemic [4]. Alien fish species are species that come from outside that enter an ecosystem where previously the species was not in it. Foreign species are also called non-indigenous species [5].

Alien species can enter the waters in various ways, either intentionally or unintentionally by humans. The entry of foreign species does not always provide benefits, it can even cause harm to native and endemic biota that live in the waters, so these species are called invasive alien species. Those species for which the population (biomass) is increasing include the alien introduced species such as Mujair (Oreochromis mossambica), Nila (Oreochromis niloticus) and Louhan (Flowerhorn).

Some of the impacts caused by the entry of foreign fish into the waters are threatening biodiversity which has an impact on decreasing local fish populations, spreading new fish diseases and pests, damaging ecosystem aesthetics, changing the socio-economic life of the community and endangering human safety.

The entry of Flowerhorn fish into the waters of Lake Mahalona will threaten the existence of endemic fish that inhabit Lake Mahalona.

This study aims to determine the abundance of alien fish species Flowerhorn (C. trimaculatum) in its fishing ground area at Lake Mahalona. The results of the study are expected to serve as basic information for policy makers in an effort to support the conservation of endemic fish found in Lake Mahalona against the threat of foreign Flowerhorn fish.

2. Materials and methods

2.1. Study Site

This research was conducted in the waters of Lake Mahalona, South Sulawesi. The research station consists of six stations, namely St.1 Kusapa, St.2 Lengkomali, St.3 Tandumata, St.4 Badilla, St.5 Muara, and St.6 Benu (Fig. 1). The sampling point of the station was determined based on the results of the first survey with consideration of the habitat where the Flowerhorn alien fish population was abundant.
Figure 1. Sampling location of flowerhorn fish in Lake Mahalona  
(Source: Zain, 2021)

2.2. Sampling methods
2.2.1. Fish sampling
Fishing for Flowerhorn (*Cichlasoma trimaculatum*) (Fig. 1) was carried out for 6 months (26 weeks) in January 2021 – July 2021. The catch was carried out five (5) days a week by two fishermen. Selective catching was carried out using gill nets which had previously been implemented in Lake Towuti and was deemed successful by the local government. The type of gill net size used for catching Flowerhorn in Lake Mahalona, namely the gill net for catching is a mesh size of 2 inches, length 200 m, height 1.5 m. Each gill net was operated for 60 minutes daily at six predetermined stations. Arrests started at 07.00 until 10.00 every day (Fig. 2). Introduced fish species that tend to be invasive, such as Flowerhorn, must be controlled through mass catching using a net of at least 2 inches (Flowerhorn fish are gonadally mature and endemic fish such as *Tematherina* sp. are not caught) [6].
2.3. Research Focus
This paper aims to determine the number and relative abundance of foreign flowerhorn fish in the fish-abundant area of Lake Mahalona using quantitative survey methods and the aquatic environment of Lake Mahalona through direct interviews and reference studies.
2.4. Data Collection and Analysis

A survey and descriptive quantitative approach was used as a method of this research. The relative abundance of fish was counted according to [7] based on the presentation of each species.

\[ RB = \frac{ni}{N} \times 100 \]  

(1)

Note:

\( RB \) : Relative abundance (%)

\( ni \) : the amount of individual (species)

\( N \) : total number of species

3. Results and Discussion

3.1. The relative abundance of alien fish species Flowerhorn

The existence of Flowerhorn fish as foreign fish in several public waters in Indonesia has been reported, such as case studies of Flowerhorn fish (\textit{Cichlasoma trimaculatum}) in Sempor Reservoir [8], in Lake Batur [9] and in Lake Matano [10]. Together with other Cichlidae fish species, these fish are able to adapt to every habitat condition, so that the opportunity to live and reproduce in water bodies is higher. As a result, these fish have a high chance of becoming invasive and having a negative impact on native fish communities [11], [12].

Flowerhorn fish observed in this study were different from Flowerhorn fish reported by [13] namely a cross of \textit{Amphilophus x Paraneetroplus}. Flowerhorn fish observed in this research is Flowerhorn fish type \textit{Cichlasoma trimaculatum} is a foreign fish that currently tends to become invasive whose population continues to increase.

Freshwater species consumed include Butini (\textit{G. matanensis}), Boto-boto (\textit{Glossogobius} sp.), Gabus (\textit{Chana striata}), Sepat siam (janggok), Betok/kosan (\textit{Anabas testudineus}), Mujair (\textit{Oreochromis mossambicus}), Nila (\textit{Oreochromis niloticus}) and Flowerhorn (\textit{Cichlasoma trimaculatum}). The consumption fish found in Lake Mahalona are generally introduced fish species. It is possible that this fish can also threaten the existence of the endemic fish of Mahalona Lake.

The utilization of freshwater species by community around Lake Mahalona especially fish species is primarily for family purposes (subsistence) but when the catch exceeds the needs of the family then it is sold (traded) to the community around the lake.

The presence of introduced fish intentionally or unintentionally is one of the threats and causes of biodiversity loss in inland waters [14], [15],[16]. Alien species can pose an important threat to native fish populations [17].

The number and relative abundance of Flowerhorn fish during the study from January to June 2021 can be seen in Fig. 4, 5, 6, 7, 8, 9 and Table 1. Flowerhorn fish caught during the study were very abundant, as many as 15,677 individuals. The number of Flowerhorn fish and the highest relative abundance were found in January both at Kusapa Station, namely 735 fish and 33.23%, while the lowest number of Flowerhorn fish was found at Benu Station as many as 416 fish with the lowest relative abundance at Tandumata Station at 14, 94%.

The number of Flowerhorn fish in February were found at Muara Station as many as 566 fish and the highest relative abundance at 23.88% in Benu Station, while the number of fish and the lowest relative abundance of Flowerhorn fish were found both at Lengkomali Station with 428 fish and 15,34%, respectively.

The number of Flowerhorn fish and the highest relative abundance in March were found both at Muara Station as many as 618 fish and 22.64%, as well as the number of Flowerhorn fish and the lowest relative abundance were also found both at Kusapa Station as many as 444 fish at 20.07%.
Figure 4. Number of Flowerhorn fish in January

![Flowerhorn fish in January](image)

| Location | January |
|----------|---------|
| Kusapa   | 735     |
| Lengkomali | 728  |
| Tandumata | 426    |
| Badilla  | 519     |
| Muara    | 522     |
| Benu     | 416     |

Figure 5. Number of Flowerhorn fish in February

![Flowerhorn fish in February](image)

| Location | February |
|----------|----------|
| Kusapa   | 451      |
| Lengkomali | 428  |
| Tandumata | 553    |
| Badilla  | 503     |
| Muara    | 566     |
| Benu     | 542     |
**Figure 6.** Number of Flowerhorn fish in March

|          | March |
|----------|-------|
| Kusapa   | 444   |
| Lengkomali | 588  |
| Tandumata | 598   |
| Badilla  | 587   |
| Muara    | 618   |
| Benu     | 478   |

**Figure 7.** Number of Flowerhorn fish in April

|          | April |
|----------|-------|
| Kusapa   | 244   |
| Lengkomali | 570  |
| Tandumata | 593   |
| Badilla  | 405   |
| Muara    | 394   |
| Benu     | 349   |
The number of Flowerhorn fish and the highest relative abundance in April were found both at Tandumata Station as many as 593 fish and 20.79%, as well as the number of Flowerhorn fish and the lowest relative abundance were found both at Kusapa Station as many as 244 fish at 11.03%.
The number of Flowerhorn fish and the highest relative abundance in May were found both at Badilla Station as many as 434 fish and 15.37%, as well as the number of Flowerhorn fish and the lowest relative abundance were found both at Kusapa Station with 186 fish at 8.41%.

The number of Flowerhorn fish and the highest relative abundance in June were found both at Badilla Station as many as 375 fish and 13.28%, as well as the number of Flowerhorn fish and the lowest relative abundance were found both at Lengkomali Station with 129 fish at 4.62%. The distribution of Flowerhorn fish caught was found in all research stations (littoral zone) in Mahalona Lake.

| Month | Kusapa | Lengkomali | Tandumata | Badilla | Muara | Benu | Total |
|-------|--------|------------|------------|---------|-------|------|-------|
| January | 33.23  | 26.09 | 14.94 | 18.38 | 19.12 | 18.33 | 21.34 |
| February | 20.39  | 15.34 | 19.39 | 17.82 | 20.73 | 23.88 | 19.41 |
| March | 20.07  | 21.07 | 20.97 | 20.79 | 22.64 | 21.06 | 21.13 |
| April | 11.03  | 20.43 | 20.79 | 14.35 | 14.43 | 15.37 | 16.30 |
| May | 8.41  | 12.44 | 14.55 | 15.37 | 12.16 | 11.23 | 12.56 |
| June | 6.87  | 4.62 | 9.36 | 13.28 | 10.92 | 10.13 | 9.26 |

The distribution of Flowerhorn fish (C. trimaculatum) caught during the study was found in all research stations along the littoral zone of Lake Mahalona. This shows that the littoral zone of Lake Mahalona is a habitat for Flowerhorn fish. Similar conditions are also found in Sempor Reservoir, Central Java, and Matano Lake, South Sulawesi [10].

Flowerhorn fish were found to have a group distribution pattern throughout the body of water, especially in the middle area (main pool) and outlets, especially in the littoral part [18]. However, the distribution intensity of Flowerhorn fish at the research station was not the same. The spread of Flowerhorn fish caught can be found in almost all research stations (littoral zone) in Lake Mahalona.

In Figure 10, it can be seen that there is a decreasing trend in the number of Flowerhorn fish caught during the research from January to June 2021. Efforts made by catching using a 2 inch Gillnet fishing gear are quite effective in reducing the number of Flowerhorn fish in Lake Mahalona.

Introduced fish species that tend to be invasive, such as Flowerhorn, must be controlled through mass catching using nets of at least 2 inches in size (Flowerhorn fish in gonadally mature condition and endemic fish such as Tematherina sp. are not caught), fishing rods, and rifles that can be done by the community through government or private programs. So that louhan fish can be controlled quickly, it can also be done to replace louhan fish catches with incentives [6].
3.2. The aquatic environment of Lake Mahalona

Based on several references and interviews with fishermen in relation to the environment of Flowerhorn fish in Lake Mahalona and other lakes inhabited by these fish, information was obtained, including water quality in Lake Mahalona. According to [19] the level of clarity of the waters of Lake Mahalona (m) ranges from 5.9 to 7.6 m. The level of clarity is influenced by various factors, both physical and biological, which include the production of autochthonous, allochthonous materials, and materials suspended from the bottom of the lake due to wind activity and others [20], [21], and [22].

Chemical Oxygen Demand (COD) values ranged from 37.3 – 48.9 mg/L, water temperature ranged from 29.5 – 30.8 °C, and acidity (pH) ranged from 7.8 -7.9. From the value of the chemical parameters of the waters, the waters of Lake Mahalona are still good. [10] stated that Flowerhorn fish in Lake Matano occupy a wider habitat, namely from the lakeside to a depth of more than 13 m and adult Flowerhorn fish generally prefer habitats with rock substrates. According to information from fishermen in Lake Mahalona, Flowerhorn fish occupy a lot of habitats with lots of aquatic plants, sandy and rocky substrates (personal communication).

According to [23] and [24], Flowerhorn fish are able to adapt well to all types of habitat characteristics and various types of substrates. The dominance of Flowerhorn fish is seen in locations with dominant sandy and rocky bottom substrates with lots of aquatic plants or grass. The southern and lower parts of Lake Matano with predominantly sandy and rocky bottom substrates are the preferred habitat for Flowerhorn fish and support the high abundance of Flowerhorn fish in the region [24] Flowerhorn fish are rarely found in habitats with soft or muddy bottoms, but waters with muddy bottoms are not a barrier or barrier for Flowerhorn fish to spread [13].

Figure 10. Trends in the number of Flowerhorn fish during the study
Chances of catching Flowerhorn fish decrease with increasing depth. However, Flowerhorn fish found at depths of more than 15 m have a large size. [23] also reported that the bottom substrate in the form of rocky sand at a depth of more than 15 m is the main spawning area for Flowerhorn fish in Lake Matano.

4. Conclusion

4.1. Conclusion

The total Flowerhorn caught during the study were 15,677, the most caught in January was 3,346 and the least in June was 1,451. The highest number and relative abundance of Flowerhorn fish were found at Kusapa Station in January, with 735 fish and 33.23%, respectively, while the lowest number and relative abundance of Flowerhorn fish were found at Lengkomali Station in June, with 129 fish and 4.62%, respectively. Flowerhorn as an alien fish species is distributed throughout the Lake Mahalona station. Efforts made by catching using a 2 inch Gillnet fishing gear were quite effective in reducing the number of Flowerhorn fish in Lake Mahalona. Flowerhorn fish were found in all research stations (littoral zone) in Lake Mahalona. The presence of alien flowerhorn fish tends to lead to invasive which will threaten the existence of native and endemic fish in Lake Mahalona. Flowerhorn fish occupy a lot of habitats with lots of aquatic plants, sandy and rocky substrates.

4.2. Suggestions

In introducing fish into waters, care must be taken so as not to impact native or endemic fish. It needs to be done by conducting a study of fish biology first for fish to be introduced in relation to competition opportunities (space, food, genetics) or even predation with native or endemic fish.

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