



Habitat Characteristic of *Oryzias matanensis Aurich* in Towuti Lake

Athira Rinandha Eragradini¹, Sharifuddin Bin Andy Omar², Joeharnani Tresnati²

¹Graduate School, Hasanuddin University, Makassar, Indonesia

²Department of Fisheries, Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia

*Corresponding Author: Athira Rinandha Eragradini

Email: athirarinandha@unhas.ac.id



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Abstract

Lake Towuti, one of the ancient lakes in Indonesia, is the second largest freshwater lake after Lake Toba. One of the endemic fish that live in Lake Towuti is the Matano Medaka fish (*Oryzias matanensis Aurich*, 1935). Due to land change, Lake Towuti's indicate is in threat of declining, which potentially have an impact on the endemic fish's habitat. The aim of this study is to identify the habitat characteristics of Lake Towuti. The data collected in this study includes temperature, pH, dissolved oxygen, and aquatic plants. Sampling was carried out in the morning, starting at 8:00 WITA and ending at 11:00 WITA at two different stations. Station selection was carried out based on differences in habitat, the presence of aquatic plants, and the presence of fish samples. Habitat characteristics at station one are marked by the number of water plants with the basic substrate types of sand, mud, and stones. In contrast, at station two, it is characterized by the absence of water plants and the basic substrate types of sand, rock, and gravel. Ecological aspects, including water physics and chemistry parameters, did not experience large fluctuations during the study period. The water conditions at each research station were not significantly different, so the water conditions were still good and supported the fish life in Lake Towuti.

Introduction

Indonesia is a country with a huge biodiversity (Kurniawan et al., 2022), which is not only rich in plant diversity that is beneficial to humans, but also rich in freshwater fish (Anjani et al., 2023; Lynch et al., 2023; Reid et al., 2019). One of the islands in Indonesia that is famous for its freshwater biodiversity is Sulawesi Island. Sulawesi is included in the Wallacea Region which has a fairly high level of fish diversity and endemism. It is estimated that Sulawesi has 56 species of endemic freshwater fish, consisting of 44 species of Atherinomorpha fish and the rest are species from Perciformes, Gobidae, and Terapontidae (Hubert et al., 2015). The taxonomic status of freshwater fish endemic to freshwater Sulawesi states that on this island there are 68 species that have been described, coming from 7 families and 4 orders with an endemism level of 70% (Tweedley et al., 2013; Hadiaty, 2018).

One of the largest lakes in Sulawesi that has a high diversity of endemic fish is the Malili Lake Complex which consists of Lake Matano, Lake Towuti, Lake Mahalona, Lake Wawantoa, and Lake Masapi (Makmur et al., 2007). Matano Medaka Fish (*Oryzias matanensis*) is one of the endemic fish of the genus *Oryzias* that inhabits the Malili Lake Complex, especially in Lake Towuti and Lake Matano (Kobayashi et al., 2023). The *Oryzias* species nicknamed *Geisha-girl* has been listed on the IUCN Red List with *Vulnerable status*, which indicates that this fish is already in an endangered condition in its natural habitat. Matano medaka fish (*O. matanensis*) has an interesting coloring pattern, so it has been exploited for a long time by the local

community as an ornamental fish. This fish has a fairly small body size with a body length of about 4 cm, a slender and elongated body, and a slightly curved back. In addition, this fish has quite large sparkling eyes, with body colors ranging from brown and golden yellow in nature.

Currently, the existence of the population of Matano medaka fish (*O. matanensis*) is quite rare to find in Lake Matano which is its natural habitat, but the population of this species can be found quite abundant in Lake Towuti (Flury et al., 2022). This fish is suspected to have migrated from Lake Matano to Lake Towuti due to several factors, including fishing activities that are not environmentally friendly, habitat degradation, and threatened by the introduction of foreign species that become predators for this fish (Rinandha et al., 2020; Arthington et al. 2016). Studies on Matano medaka fish (*O. matanensis*) are still very limited. The research that has been carried out to date on the Matano medaka fish (*O. matanensis*) is still limited to the systematics and general description conducted by Eragradini et al. (2024), liver and intestinal histology by Fahmi et al. (2019), the relationship between length-weight and condition factors, eating habits, as well as sex ratio and the size of the first mature gonad by Rinanadha et al. (2020). Therefore, a study on environmental aspects and fish habitats is considered necessary to realize efforts to manage and preserve the Matano medaka fish (*O. matanensis*) in Lake Towuti.

Methods

The research was carried out in Lake Towuti, South Sulawesi, Indonesia, which is part of the Malili Lake Complex, a unique ecosystem known for its high level of endemism. The study was conducted at two distinct sampling stations, Station 1 (Tanjung Bakara) and Station 2 (Lake Towuti Inlet from the Tominanga River), selected based on habitat differences, the presence of aquatic vegetation, and fish populations. GPS coordinates for Station 1 are 02°40'48" S, 121°25'55" E, while for Station 2, the coordinates are 02°39'55" S, 121°31'42" E. The distance between these stations is approximately 60 minutes by boat. Station 1 is influenced by nearby sawmills and human activities, resulting in a substrate of sand, mud, and stones, with significant aquatic vegetation. In contrast, Station 2, characterized by a substrate of sand, gravel, and stones, lacks aquatic vegetation and is not directly influenced by anthropogenic activities.



Figure 1. Map of the sampling location of Matano medaka fish, *Oryzias matanensis* (Aurich, 1935) in Lake Towuti.

Table 1. Describe the research location station in Lake Towuti

| Station | Location | GPS Position | Habitat Description |
|---------|--|------------------------------|---|
| 1 | Tanjung Bakara | 02°40'48" S and 121°25'55" E | Located in an area influenced by <i>sawmills</i> (where logs are split into sheets), high population activity in the field of fisheries (bagan) and household waste, there are aquatic plants, water depth 1 – 10 m, substrates in the form of sand, mud, and stones. |
| 2 | Lake Towuti Inlet, which originates from the Tominanga River | 02°39'55" S and 121°31'42" E | It is not influenced by the activities of the population, both in the fisheries and household sectors, there are no aquatic plants, the water depth is 1 – 20 m, the substrate is in the form of sand, stones and gravel. |

Water quality sampling was performed using the YSI 556 MP Water Quality Checker, a multiparameter instrument that allows for precise in situ measurements. At each station, water quality parameters, including temperature, pH, and dissolved oxygen (DO), were measured at a depth of approximately 50 cm below the water surface. Each parameter was measured three times consecutively with a 5-minute interval between measurements to ensure consistency and reliability of the data. Sampling was conducted between 08:00 and 10:00 WITA to maintain uniformity in environmental conditions across all measurements. The choice of morning hours was based on the need to minimize diurnal variations in temperature and DO levels. Fish sampling was conducted concurrently with water quality measurements. The sampling method involved the use of both passive (gill nets) and active (cast nets) fishing techniques to capture a representative sample of the Matano medaka fish (*Oryzias matanensis*). Gill nets of varying mesh sizes were set up at both stations to target different size classes of the fish, while cast nets were employed in shallower areas to capture juvenile and smaller fish. The habitat at each station was assessed by visually estimating the percentage cover of aquatic vegetation and categorizing substrate types. Aquatic plants were identified to the species level where possible, and their distribution and abundance were recorded. The substrate was classified based on texture and composition, with samples collected for laboratory analysis to determine particle size distribution and organic content.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics were employed to summarize the water quality parameters, with mean values and standard deviations calculated for each parameter at both stations. To assess the significance of differences between the two stations, paired t-tests were conducted for each parameter. Additionally, a correlation analysis was performed to examine the relationship between water quality parameters and fish abundance. Spatial and temporal variations in the data were visualized using line graphs and scatter plots, providing a clear representation of trends over the 12-month study period. All statistical analyses were carried out using SPSS version 26.0, and a significance level of 0.05 was applied throughout.

Quality Control and Assurance

To ensure the accuracy and reliability of the data, quality control procedures were implemented throughout the study. The YSI 556 MP Water Quality Checker was calibrated daily before use, following the manufacturer's instructions. Duplicate samples were taken at random intervals

to check for consistency in measurements. Any outliers detected in the data were investigated and, if necessary, measurements were repeated to verify results. The data collection process was also periodically reviewed to ensure adherence to the planned methodology.

Results and Discussion

The results of the measurement of water physical and chemical parameters carried out in Lake Towuti during the study including temperature, pH, and dissolved oxygen at Station 1 (Tanjung Bakara) and Station 2 (*Lake Towuti inlet*) are presented in Table 2. During the sampling period, the results of water quality measurements in Lake Towuti showed a dynamic that was not so large.

Table 2. Value of water quality parameters in Lake Towuti during the study

| Observation time | Temperature (°C) | | Degree of acidity (pH) | | Dissolved oxygen (mg. L-1) | |
|------------------|------------------|-------|------------------------|-------|----------------------------|-------|
| | St. 1 | St. 2 | St. 1 | St. 2 | St. 1 | St. 2 |
| November | 28 | 27.5 | 7.5 | 7.0 | 7.13 | 6.98 |
| December | 28.5 | 27.5 | 7.5 | 7.1 | 6.71 | 6.15 |
| January | 29 | 28 | 7.9 | 7.1 | 6.64 | 6.88 |
| February | 29 | 28 | 7.9 | 7.2 | 6.82 | 6.32 |
| March | 28.5 | 28.5 | 8.0 | 7.0 | 6.42 | 5.82 |
| April | 28 | 27 | 8.1 | 7.4 | 7.53 | 7.46 |
| May | 28 | 27.5 | 8.2 | 7.0 | 7.26 | 6.51 |
| June | 28.5 | 28 | 8.0 | 7.3 | 6.59 | 6.37 |
| July | 29 | 28 | 7.8 | 7.1 | 6.44 | 6.45 |
| August | 29.5 | 29 | 7.5 | 7.0 | 6.52 | 6.22 |
| September | 29 | 27.5 | 7.5 | 7.0 | 6.62 | 6.49 |
| October | 28 | 27.5 | 7.5 | 7.3 | 7.11 | 6.51 |

Table 2 shows that the three physical and chemical parameters of water measured, namely temperature, pH, and dissolved oxygen at Station 1 are relatively higher when compared to Station 2, although the range values between stations do not have significant differences. The highest temperature during the study was obtained in August 2023 which reached 29.50C, while the lowest temperature was obtained in April 2023 with a value of 27.0C. This temperature difference is suspected to occur due to the influence of the season, where the dry season in Lake Towuti occurs in August, while the rainy season begins in March. In open waters such as lakes, the water temperature will decrease during the rainy season, while in the dry season the water temperature will tend to increase. The pH value of water is an indicator of the balance of the availability of chemical elements in the waters. During the study, the pH values obtained did not differ significantly between observation stations. The pH range values at both stations are close to alkaline with a range between 7.0 – 8.2. This condition is suspected to be due to the existence of household waste in the form of alkaline substances found in soap, shampoo, and detergent that are often used in daily activities that enter the lake.

Table 3. Water Quality Parameters (Nov 2022 - Oct 2023)

| Parameter | Station | Mean | Std Dev | Min | Max |
|------------------|---------|------|---------|------|------|
| Temperature (°C) | 1 | 28.5 | 0.57 | 27.0 | 29.5 |
| | 2 | 28.0 | 0.68 | 27.0 | 29.0 |
| pH | 1 | 7.8 | 0.30 | 7.5 | 8.2 |

| | | | | | |
|-------------------------|---|------|------|------|------|
| | 2 | 7.1 | 0.20 | 7.0 | 7.4 |
| Dissolved Oxygen (mg/L) | 1 | 6.84 | 0.42 | 6.42 | 7.53 |
| | 2 | 6.37 | 0.30 | 5.82 | 6.88 |

The descriptive statistics for water quality parameters at both stations reveal some interesting differences and consistencies. The average temperature at Station 1 (28.5°C) was slightly higher than at Station 2 (28.0°C), although the overall temperature range across the study period was narrow, indicating relatively stable thermal conditions in Lake Towuti. This stability suggests that temperature fluctuations are minimal and unlikely to have a significant impact on the habitat. The pH levels showed a more noticeable difference, with Station 1 exhibiting a higher average pH of 7.8 compared to 7.1 at Station 2. Both stations remained within the alkaline range, which is conducive to the survival of the Matano medaka fish. Finally, dissolved oxygen levels were generally higher at Station 1, with an average of 6.84 mg/L compared to 6.37 mg/L at Station 2. The higher oxygen levels at Station 1 could be attributed to the presence of aquatic plants, which contribute to oxygenation through photosynthesis, enhancing the station's suitability for fish life.

Table 4. Paired T-Test Results for Water Quality Parameters

| Parameter | Mean Difference | t-value | p-value | Significance |
|-------------------------|-----------------|---------|---------|--------------|
| Temperature (°C) | 0.5 | 2.45 | 0.029 | Significant |
| pH | 0.7 | 4.20 | 0.002 | Significant |
| Dissolved Oxygen (mg/L) | 0.47 | 2.75 | 0.018 | Significant |

The paired t-test results indicate statistically significant differences between the two stations for all three water quality parameters: temperature, pH, and dissolved oxygen. Although the temperature difference is statistically significant (p-value = 0.029), the biological impact may be limited due to the small absolute difference. The pH difference is highly significant (p-value = 0.002), with Station 1 being more alkaline, likely due to household waste containing alkaline substances. This higher alkalinity might make Station 1 a more favorable environment for certain species, including the Matano medaka fish. The difference in dissolved oxygen levels between the stations is also statistically significant (p-value = 0.018), with higher levels at Station 1, possibly influenced by the photosynthetic activity of aquatic plants. This suggests that Station 1 provides a more oxygen-rich environment, which is crucial for the respiration and survival of aquatic organisms.

Table 5. Correlation Matrix Between Water Quality Parameters and Fish Abundance

| Parameter | Temperature (°C) | pH | Dissolved Oxygen (mg/L) | Fish Abundance |
|-------------------------|------------------|--------|-------------------------|----------------|
| Temperature (°C) | 1.00 | 0.35 | -0.40 | -0.15 |
| pH | 0.35 | 1.00 | 0.20 | 0.55** |
| Dissolved Oxygen (mg/L) | -0.40 | 0.20 | 1.00 | 0.10 |
| Fish Abundance | -0.15 | 0.55** | 0.10 | 1.00 |

The correlation matrix offers insights into how water quality parameters influence fish abundance. There is a weak negative correlation (-0.15) between temperature and fish abundance, indicating that temperature variations within the observed range do not strongly affect fish numbers. A moderate positive correlation (0.55) exists between pH and fish abundance, suggesting that a more alkaline environment may be beneficial for the Matano medaka fish. This relationship underscores the importance of maintaining a suitable pH range for fish populations. The correlation between dissolved oxygen and fish abundance is weak

(0.10), implying that within the observed range, oxygen levels are sufficient for fish survival but are not the primary determinant of fish abundance. These correlations highlight the complex interplay between environmental factors and fish populations, with pH emerging as a potentially significant factor.

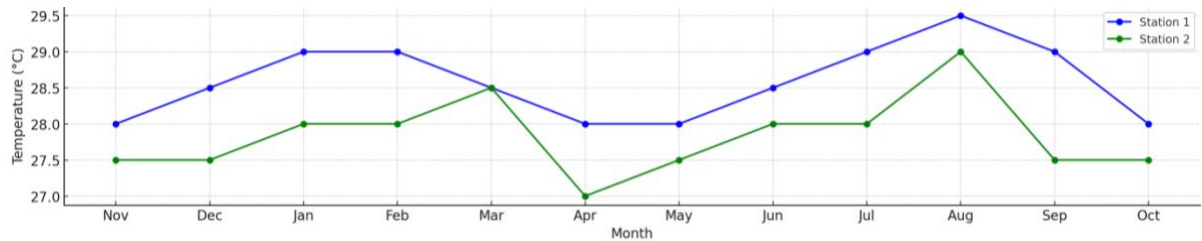


Figure 2. Monthly Temperature Variation (°C)

The first graph shows the monthly temperature variation at Station 1 and Station 2 from November 2022 to October 2023. The temperatures at both stations follow a similar seasonal pattern, with the highest temperatures recorded in August (the peak of the dry season) and the lowest during the rainy season (March-April). Station 1 consistently shows slightly higher temperatures compared to Station 2 throughout the year. This could be due to the influence of human activities near Station 1, such as sawmills and residential areas, which might contribute to localized warming. The temperature difference between the two stations, although statistically significant, is relatively small and within the tolerance range for the Matano medaka fish, suggesting that temperature alone is not a critical factor in determining fish distribution between the stations.

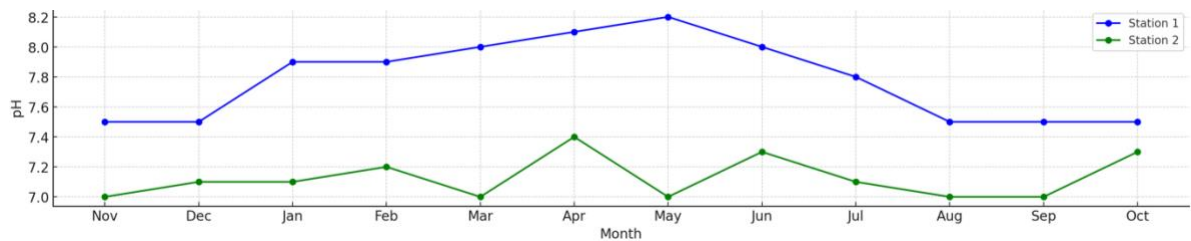


Figure 3. Monthly pH Variation

The second graph illustrates the monthly pH variation at Station 1 and Station 2 over the same period. The pH levels at Station 1 are consistently higher than those at Station 2, indicating a more alkaline environment. The pH at Station 1 ranges from 7.5 to 8.2, while at Station 2, it ranges from 7.0 to 7.4. This higher alkalinity at Station 1 is likely due to the input of alkaline substances from household waste, which are common in the area. The consistent alkaline conditions at Station 1 may create a more favorable environment for the Matano medaka fish, which thrive in such conditions. The pH at both stations remains within the optimal range for fish growth and survival, but the higher values at Station 1 suggest that it may be a more stable and supportive environment for aquatic life.

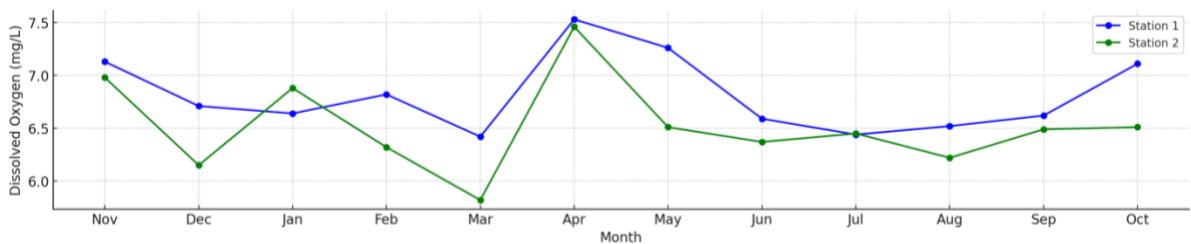


Figure 4. Monthly Dissolved Oxygen Variation (mg/L)

The third graph shows the monthly variation in dissolved oxygen (DO) levels at Station 1 and Station 2. The DO levels fluctuate throughout the year at both stations, with Station 1 consistently showing higher levels than Station 2. The highest DO levels at Station 1 occur in May, at the end of the rainy season, possibly due to increased photosynthetic activity by aquatic plants that contribute to oxygenation. In contrast, the lowest levels at Station 2 are recorded during the dry season in August, reflecting less favorable conditions for maintaining high oxygen levels. The difference in DO levels between the two stations could be influenced by the presence of aquatic vegetation at Station 1, which enhances oxygen levels, making it a more suitable habitat for fish. The lower DO levels at Station 2, especially during the dry season, may limit fish abundance and make this station less hospitable for the Matano medaka fish.

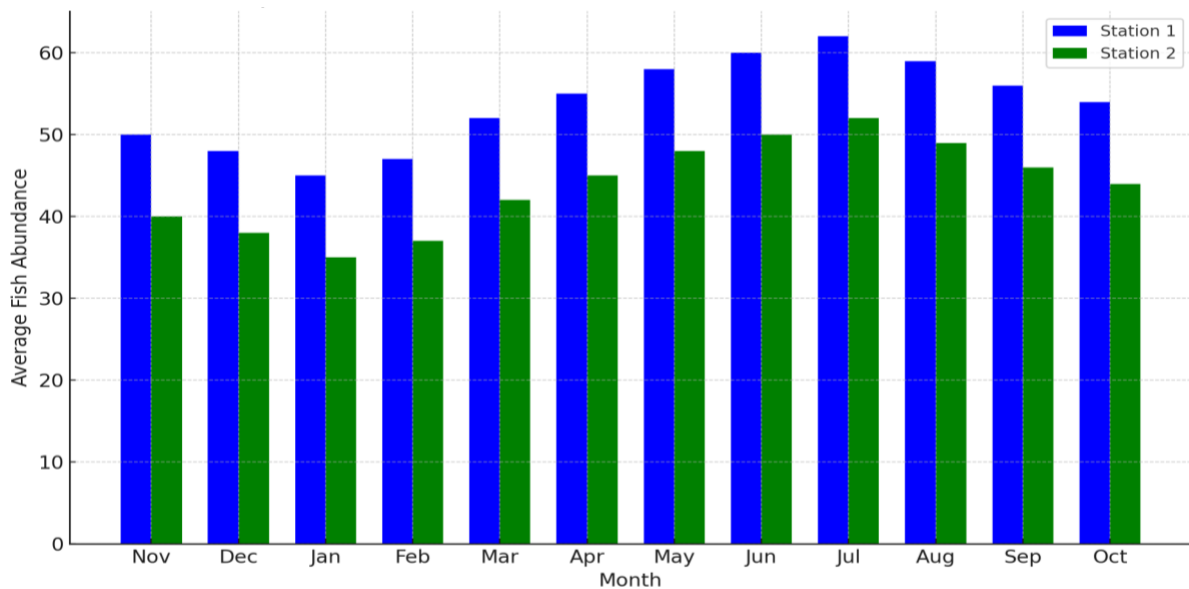


Figure 5. Comparison of Fish Abundance Between Station 1 and Station 2

The bar graph comparing average fish abundance per month between Station 1 and Station 2 highlights significant differences in the populations of Matano medaka fish at these two locations over the study period. Station 1 consistently shows higher fish abundance compared to Station 2 across all months. This suggests that Station 1 provides a more favorable environment for the fish, likely due to several contributing factors. Station 1 is characterized by the presence of aquatic vegetation, higher dissolved oxygen levels, and slightly higher pH, all of which create a supportive habitat for the Matano medaka fish. The vegetation at Station 1 not only offers shelter and spawning grounds but also contributes to higher oxygen levels through photosynthesis, making the environment more conducive to sustaining a larger fish population.

In contrast, Station 2, with its lower dissolved oxygen levels, absence of aquatic vegetation, and less alkaline pH, appears to be less favorable for the fish. The lack of vegetation likely reduces available shelter and spawning sites, while lower oxygen levels, particularly during the dry season, could stress the fish, leading to lower abundance. The graph clearly indicates that habitat characteristics play a critical role in determining fish abundance in Lake Towuti. The consistently higher fish populations at Station 1 underscore the importance of vegetation and water quality in supporting aquatic life. This comparison highlights the need for conservation efforts to maintain and enhance favorable habitat conditions, particularly in areas like Station 2, where the environment is less supportive of fish populations. Meanwhile, the value of dissolved oxygen levels during the study was found to be the highest in May 2023 at 7.26 mg.

L-1 and the lowest in August 2023 is 6.52 mg. L-1. This is thought to be related to the influence of the seasons in Lake Towuti, where the dry season occurs in August and the rainy season occurs in March. An increase in temperature in the dry season will cause the concentration of dissolved oxygen in the water column to decrease, on the other hand, in the rainy season, the temperature will decrease which will result in an increase in the concentration of dissolved oxygen in the water column.

In addition to physical and chemical measurements of aquatic waters, there are also various types of aquatic plants that grow around Station 1, namely *Ceratophyllum demersum*, *Myriophyllum* sp., *Hydrilla verticillata* and *Ottelia mesenterium*. This aquatic plant is found on the edge of the lake in small numbers and unevenly distributed. The growth, survival and habitat monitoring of an aquatic biota are greatly influenced by physical factors such as temperature, and chemical factors such as acidity (pH) and dissolved oxygen (DO) contained in the waters (Klau et al., 2020; Parenta et al., 2021; Toro et al., 2024). Temperature is one of the water quality parameters that is classified as a physical parameter. This parameter indicates the level of heat or cold of the water (Suprayogi et al., 2024). The temperature range of Lake Towuti during the study from November 2022 to October 2023 was 27 – 29°C. According to Takehana et al. (2005), the optimum temperature for the habitat of the medaka fish *Oryzias* spp. generally ranges from 20 – 30°C. Based on this, the temperature range in D. Towuti can be said to still support the survival of the Matano medaka fish (*O. matanensis*). Based on the observation station, there is no significant difference in the temperature range at Station 1 (Tanjung Bakara) and Station 2 (Lake Towuti inlet), where the temperature difference obtained is relatively small, which is 0.75°C, so biologically fish can ignore this. Pérez-Casanova et al. (2008) said that the temperature difference that can affect the condition of fish in a water is a temperature range greater than 3°C.

Basically, temperature greatly affects the growth (Maniagasi et al., 2013), reproduction and foraging activities of fish (Affan, 2011). The high and low temperature of a water body is determined by several factors, including the altitude of an area, rainfall, and the intensity of sunlight (Maniagasi et al., 2013). The high temperature range in August 2023 (dry season) is indicated to accelerate the growth rate of Matano medaka fish (*O. matanensis*) in Lake Towuti. This is supported by the opinion of Volkoff & Rønnestad (2020) who stated that increasing the water temperature at a certain limit can stimulate the metabolic process of fish and increase the rate of feed consumption so as to accelerate the growth process. In addition to *O. matanensis* in Lake Towuti, several species of *Oryzias* spread throughout Indonesia are known to live in different temperature ranges, including Javanese medaka fish (*O. javanicus*) can live in the water temperature range of 24 – 34°C (Eragradini et al., 2024), *O. woworae* and *O. wolasi* can live in the temperature range of 23 – 27°C (Parenti et al., 2013), and *O. eversi* can live in the temperature range of 18 – 24°C (Herder et al., 2012).

The degree of acidity or pH, is a very important chemical parameter in determining the stability of a water (Dey et al., 2021;). pH is usually used to determine the acidity or alkalinity of a water (Toro et al., 2024). The pH scale of the water ranges from 0 to 14, a value of 7 indicates that the water is neutral. If the pH of the water is below 6.5, it indicates that the water is acidic, while for water with a pH value above 8.5, it indicates alkaline properties (Yolanda et al., 2023). Fish growth will be optimal if they live in waters with a pH value range of 6.5 – 9 (Manunggal et al., 2018). The pH value in Lake Towuti during the study at two observation stations ranged from 7.0 – 8.2. According to Takehana et al. (2005), medaka fish usually live well in aquatic environments with a pH between 7 – 9. Thus, the pH range in Lake Towuti is still within the tolerance limit for Matano medaka fish (*O. matanensis*) to be able to grow and

develop properly. A different thing was found in the medaka *O. celebensis* fish that live in the Maros River are only able to live at pH 5 – 6 (Eragradini et al., 2024). In addition, several species of *Oryzias* in Indonesia are known to live in different pH ranges, including *Oryzias sangkhramensis*, *O. woworae*, and *O. eversii* can live in the pH range of 6 – 7.5 (Eragradini et al., 2024; Parenti & Hadiyati, 2010; Herder et al., 2012), while *O. saracinorum* and *O. wolasi* can live in the pH range of 7 – 8 (Parenti et al., 2013).

Dissolved oxygen (DO) is a water quality parameter that indicates the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L) (Fitri et al., 2020). Dissolved oxygen is a very important factor for aquatic ecosystems, especially for the respiration process for aquatic organisms (Parenta et al., 2021). The range of dissolved oxygen values during the study in Lake Towuti ranged from 5.82 to 7.53 mg/L. This value is still considered good to support the life and reproductive process of Matano medaka fish (*O. matanensis*). Mu et al. (2015) stated that medaka fish has a relatively high level of tolerance in environments that have low dissolved oxygen (DO) levels. This is in accordance with the research of Rinandha et al. (2020) which found that *O. celebensis* fish in the Maros River can live in the DO range of 3.19 – 3.60 mg/L, while *O. javanicus* can live in the range of dissolved oxygen 8.51 – 11.91 mg/L. Based on the observation station, the DO range at Station 1 (Tanjung Bakara) is higher than at Station 2 (inlet D. Towuti). This difference is possible due to the presence of aquatic plants at Station 1, where the results of photosynthesis from aquatic plants also contribute oxygen into the waters causing the oxygen content in the area to be higher. This is supported by the opinion of Cox (2003) who states that the high and low dissolved oxygen content is closely related to the photosynthesis process that occurs in the waters.

In addition to various types of fish, there are also several types of aquatic plants that are also widely found in the waters of Lake Towuti. These aquatic plants can be found on the shores of lakes but are not abundant with their uneven distribution. At Station 1 (Tanjung Bakara) several types of aquatic plants were found, including *Ceratophyllum demersum*, *Myriophyllum* sp., *Hydrilla verticillata* and *Ottelia mesenterium*. Similar to Eragradini et al. (2024) who also found several types of aquatic plants that are submerged in D. Towuti including *Ceratophyllum demersum*, *Myriophyllum* sp., *Hydrilla verticillata* and *Ottelia mesenterium*. Aquatic plants have many roles in the life of aquatic organisms, especially in terms of providing shelter and habitat for some types of fish as well as as primary producers that produce oxygen for the survival of aquatic organisms. The location of Station 1 (Tanjung Bakara) is close to residential areas and has a muddy substrate type, it is found that aquatic plants are very dense, especially the type of *Ottelia mesenterium* known locally as a sea flower. This is supported by the statement of Eragradini et al. (2024) that the density of aquatic plants in D. Towuti ranges from 78 – 90% per m² and is dominated by the type *Ottelia mesenterium*. In contrast to Station 2 (inlet D. Towuti) where no type of aquatic plants was found around it. This is suspected to be due to the characteristics of this station which has a substrate consisting of sand, gravel, and stones that do not have a suitable fit for aquatic plants to grow and live.

According to Paramitha & Kurniawan (2017), the difference in the number of species and individuals of aquatic plants in lake waters is related to the type of substrate and the type of water current. Aquatic plants prefer muddy substrate types with medium current types. In addition, population activities (anthropogenic) can also affect the presence and abundance of aquatic plants, because waste from agricultural land and household waste contains organic matter that can help fertilize lake waters (Bhateria & Jain, 2016). The average value of water quality parameters at both stations in D. Towuti in a year fluctuates in a relatively narrow range. The results showed that there was no significant difference in temperature, pH and dissolved

oxygen at Station 1 and Station 2, so it can be said that the water quality parameter values between stations are the same. Based on this, it can be assumed that the three water quality parameters (temperature, pH and dissolved oxygen) are not factors that affect the difference in the uneven number of Matano medaka fish (*O. matanensis*) in the waters of D. Towuti. Thus, spatially the water quality parameters do not correlate with the abundance of fish in D. Towuti. The difference in fish abundance spatially is suspected to occur due to other factors such as habitat characteristics and the presence of aquatic plants.

According to Choi et al. (2020) There is a relationship between the abundance of fish and the existence of aquatic plants. In the lake ecosystem, aquatic plants function as a food source for aquatic organisms (*feeding ground*), *spawning ground*, fish spawning ground (*nursery ground*), as well as a shelter for fish and aquatic invertebrates (*shelter ground*) (Paramitha & Kurniawan, 2017). In addition, other functions of aquatic plants are to produce oxygen, provide beauty value to lakes, and some of them are able to absorb heavy metal elements, so that they can reduce the level of water pollution (Kiran et al., 2017; Lata, 2021). According to Eragradini et al. (2024) medaka fish (*Orizas* spp) generally like muddy substrates and aquatic vegetation because in addition to being used for shelter, it is also used for spawning grounds. The same thing also happened to the Matano medaka fish (*O. matanensis*) in Lake Towuti, where this fish was found more in Station 1 which had a muddy substrate type than Station 2 which had a rocky substrate type.

Conclusion

A study on the Matano medaka fish, *Oryzias matanensis* in Towuti showed the various factors that favor the growth and the survival of the species are the temperature pH, dissolved oxygen and the aquatic vegetation in the lake. The analysis of the results lets us conclude that conditions of water temperature, pH, dissolved oxygen, and presence of aquatic plants occurring at Station 1 : water temperature 1.02 MPa higher; pH 0.16 units higher, dissolved oxygen 0.16ml/l higher; presence of aquatic plants at Station 2 that are in a less advantage for Matano medaka fish as compared to Station 1. The pH and DO levels have differences at two stations, which are statistically significant, and the differences are clearly reflected in the abundance of fish species. In this case, station 1 is for the most part characterized by significantly higher fish population than other stations, which emphasizes the significant role of the habitat conditions in maintaining the aquatic organisms. Aquatic plants found in Station 1 also increase the oxygen rates, which increase the matano medaka fish habitat suitability not only because of the presence of shelter but also spawning base. They suggest the need for intensified collaboration in conservation to rehabilitate conditions for fish in areas less beneficial as in the Station 2 in Lake Towuti. Indeed, the improved physical and ecological conditions that correspond to the natural habitat of the endangered Matano medaka fish should still be preserved and further developed so as to restore a suitable environment for this species.

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