BIODIVERSITAS
Volume 24, Number 9, September 2023
Pages: 5137-5145

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240958

Habitat and food habits of the endemic fish *Oryzias eversi* in Tana Toraja, South Sulawesi, Indonesia

TRISKA LAMBA[1], AMBENG[2], IRMA ANDRIANI[2,♥]

[1]Graduated School, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km. 10, Makassar 90245, South Sulawesi, Indonesia

[2]Departement of Biology, Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km. 10, Makassar 90245, South Sulawesi, Indonesia. Tel./fax.: +62-411-585466, ♥email: irmaandriani@unhas.ac.id

Manuscript received: 3 July 2023. Revision accepted: 29 September 2023.

Abstract. *Lamba T, Ambeng, Andriani I. 2023. Habitat and food habits of the endemic fish* Oryzias eversi *in Tana Toraja, South Sulawesi, Indonesia. Biodiversitas 24: 5137-5145.* The population of the medaka fish species, *Oryzias eversi*, was categorized as Near Threatened by the International Union for Conservation of Nature (IUCN) 2019 due to its restricted distribution and occurrence in a single threatened location. One way to protect this species from extinction is through captive breeding, which requires understanding its habitat conditions and food habits. Therefore, this research aimed to analyze the habitat conditions and food habits of *Oryzias eversi* (Hadiaty & Nolte, 2012) in Tilanga Pool, Tana Toraja. Purposive random sampling was used to obtain fish samples, while habitat conditions were determined by measuring environmental parameters, and the abundance and diversity of plankton. Food habits were analyzed by calculating the Index of Preponderance (IP) and Relative Gut Length (RGL). The results indicated that *O. eversi* inhabited a highly polluted habitat with dissolved oxygen content that ranged from 3.95 to 4.16 mg/L. The abundance of phytoplankton and zooplankton ranged from 185-435 cells/L and 10-25 ind/L, respectively. Phytoplankton diversity was in the moderate category, while zooplankton was low, with average values of Diversity Index (H') ranging from 1.61-1.93 and 0.69-024, respectively. IP and RGL showed that *O. eversi* was an omnivore-carnivore fish. The average IP of zooplankton and phytoplankton ranged from 0.35-61.11% and 0.69-1.04%, respectively. Meanwhile, the RGL ranged from 0.48 to 0.62, respectively. *Cyclops* sp. larvae were identified as the primary food source for *O. eversi* with IP above 40% and *Eurycercus* sp. with IP range of 4-40% as additional food.

Keywords: Conservation, natural diets, *Oryzias eversi*, Tilanga Pool

INTRODUCTION

"Sulawesi Island is the largest island in the Wallacea Region located between the Sunda shelf, Australia and the biogeographical transition zone." In addition to biogeographical ambiguity, endemic fauna is also a characteristic feature of Sulawesi Island because it is one of the centers of species richness in Indonesia (Achmadi et al. 2018). According to Sari et al. (2020), the genus *Oryzias* is most common in the Adrianichthydae family and consists of non-commercial fish that are not recorded as traded animals, resulting in limited distribution. The island of Sulawesi harbors roughly half of the *Oryzias* species currently recognized (Herder et al. 2012; Parenti et al. 2013; Gani et al. 2022). Most of these species were endemic to Sulawesi, including *Oryzias eversi* Herder, Hadiaty & Nolte, 2012, which was first discovered by Hans Georg Evers in 2010 at Tana Toraja, South Sulawesi (Herder et al. 2012).

Based on the etymology, *O. eversi* was derived from the Greek word *Oryza*, meaning rice, due to its association with rice fields, and eversi was taken from the name of its discoverer, Hans Georg Evers (Herder et al. 2012). It was commonly classified as medaka fish, which means big-eyed in Japanese, and the local name is *Bale Todi*. The *O. eversi* exhibits blackish courtship coloration in adult males and live solitary lives whereas the females carry the eggs until the embryos hatch, displaying a conspicuous abdominal concavity and extended pelvic fins that accommodate and hold the clutch of eggs (Herder et al. 2012).

Tilanga Pool is a natural pool located in Tana Toraja, South Sulawesi. It serves as the habitat for *O. eversi*, with a water depth of approximately 4 m, a pool length of 30-40 m, and a width of about 10 m. The water was calm and clear, with a temperature of 21.5°C, and surrounded by karst rocks and rainforest. Other species are found in the *O. eversi* habitat, such as native species of *Nomorhamphus* sp. and introduced *Poecilia reticulata* Peters, 1859 (Herder et al. 2012). Several parts of the pool are used as a "natural swimming pool" for residents and tourists. Activities of local people and tourists in the habitat of *O. eversi* likely impact the species, as the recreational usage of the Tilanga Pool might degrade the natural habitat of *O. eversi*. The exact impact is however not known and the current situation could change rapidly (Mokodongan 2019).

The distribution of medaka fish Toraja (*O. eversi*) was very limited, as it was only found in Tilanga Pool (Herder et al. 2012). According to Mokodongan (2019), *O. eversi* was classified as a Near Threatened species by the International Union for Conservation of Nature (IUCN) 2019 due to its restricted distribution and occurrence in a single threat-based location. Until now, *O. eversi* has not received much attention from researchers and local governments, so there have been no the conservation actions that have been carried out. According to

Mokodongan (2019), research on habitat, ecology, threats and distribution of *O. eversi* was needed to highlight the importance of this endemic species.

Competition between *O. eversi* with introduced fish in obtaining food and using space in the water column is thought to be one of the causes of the decline in the population of this species. Type of food group *Oryzias* sp. generally phytoplankton and zooplankton. This was found in *Oryzias sarasinorum* (Gani et al. 2015) and *Oryzias nigrimas* (Serdiati 2019). According to Serdiati 2019, to prevent the extinction of the *Oryzias* sp. genus, efforts are needed to ensure the existence of this fish in relation to aspects of the aquatic environment and food habits.

The Government of the Republic of Indonesia, by stipulating the Decree of the Minister of Environment and Forestry, number P.106/MENLHK/SETJEN/KUM.1/12/2018. One strategy to prevent fish species from becoming extinct was by captive breeding and cultivating these fish species (Iskandar et al. 2020).

There was currently no information regarding the habitat and food habits of *O. eversi*. For this reason, a strategy was needed to protect and preserve it by analyzing its habitat conditions and food habits to provide basic information for laboratory-scale domestication technology and other related species.

MATERIALS AND METHODS

Research area

This research was conducted at Tilanga Pool in Makale Utara Sub-district, Tana Toraja District, South Sulawesi Province, Indonesia (Figure 1). The geographical location was between 119°53'13.98" E and 3°02'06.43" S.

Procedures

Sampling methods

The determination of the sampling point was conducted using the purposive sampling method. Purposive random sampling is a sampling technique that takes into account certain considerations in accordance with the research objectives (Sugiyono 2016). Sampling was performed using a 2.2 m long net (gill net). The obtained *O. eversi* was then preserved in 4% formalin and stored in a cool box. The total length and weight of the fish were measured before storage. Furthermore, the contents of the stomach and intestines were obtained by spraying the gut with a 1 mL syringe containing sterile distilled water and preserved in 4% formalin. The gut extractions were observed under a trinocular microscope. Sample analysis was carried out in the ecology laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin, and at the genetics laboratory of the Faculty of Science and Engineering, Universitas Islam Negeri Alauddin Makassar, Indonesia.

Water quality measurement

Measurement of water quality in the morning from 06.00-10.00 and in the afternoon from 15.00-18.00. The water quality was analyzed by measuring Dissolved Oxygen (DO), pH, temperature, current speed, salinity, and turbidity, as shown in Table 1. To determine the relationship between Dissolved Oxygen (DO), pH, temperature, current speed, salinity, and turbidity and the abundance of *O. eversi*, this was done using Principal Component Analysis (PCA) with Paleontological STatistics (PAST) 0.8 software.

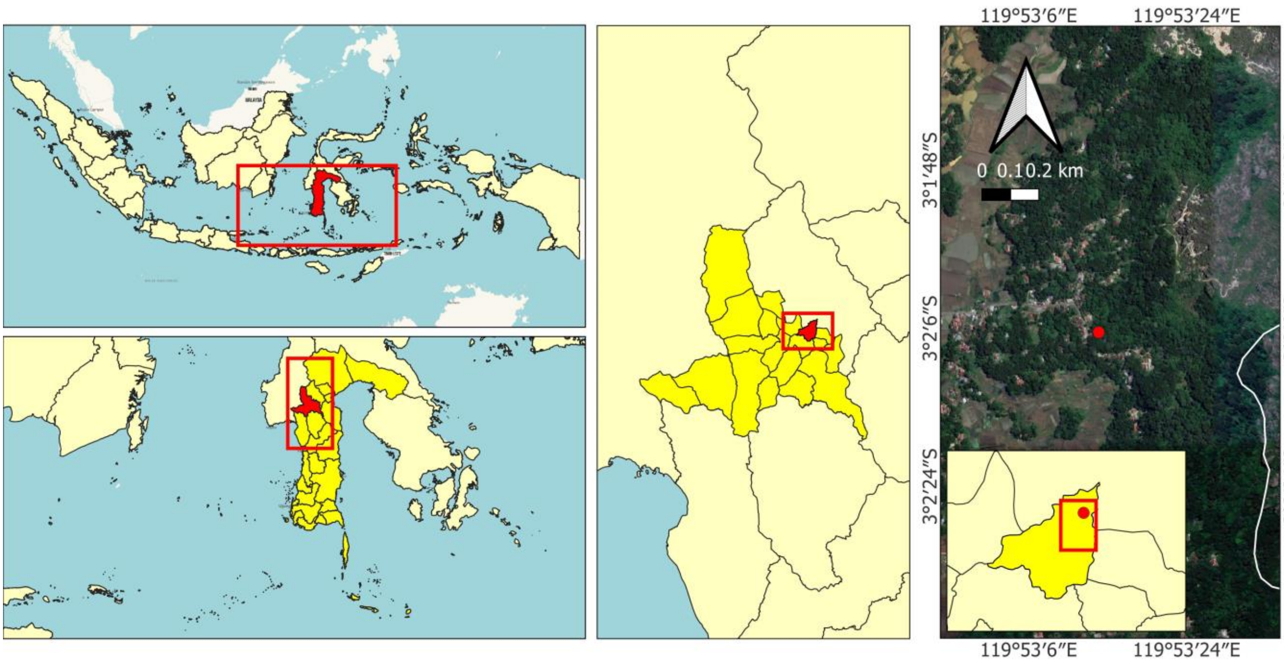

Figure 1. The sampling point location in Tilanga Pool, Tana Toraja, Indonesia

Table 1. Water quality measurement parameters

Parameters	Unit	Materials	Brand	Procedure
DO	ml/L	DO Meter	AZ-8403	Dissolved oxygen measurement is done by immersing the pen DO meter into the water. The value shown on the screen was recorded as the dissolved oxygen value of the water.
Temperature	°C	DO Meter	AZ-8403	Temperature measurements are carried out directly on location, namely by immersing the pen DO meter into the water. The value shown on the screen is recorded as the water temperature value.
pH	-	pH paper	NESCO	The pH measurement was carried out by dipping the pH paper into water, then letting it sit for 1 minute, then matching the color change on the strip paper with the color table, then recording the pH value that matched the color table.
Salinity	ppt	Refractometer	RHH-92ATC	Salinity was measured using a tool hand-refractometer. Measurements were taken by taking one drop of fresh water, then dripping it on top hand-refractometer and seen by directing it to the light. Values are indicated by the blue border.
Current speed	m/d	Stopwatch	Joyko	Current speed was measured using styrofoam tied by mattress threads, then styrofoam which was tied to the kajur thread was placed above the surface of the water, the mattress strap was held so that it does not come off and press the start button on stopwatch, then let it go styrofoam flow until the mattress straps stretch straight.
Turbidity	NTU	Turbidimeter	WGZ-20B	Turbidity measurements were carried out by the method nephelometric method. Sampling using a 100 mL bottle and stored inside coolbox until further analysis process in the laboratory using tools turbidity meter portable.

The abundance and diversity of plankton

Plankton sampling was conducted in the morning an afternoon using a plankton net with 25µm mesh size was used as to filter 20 L water from Tilanga Pool. Samples morning and afternoon were then transferred to 100 mL vials, labeled, and preserved with Lugol. Plankton observation and identification were carried out in the ecology laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin. Plankton were identified to genus according to the guidelines from Sulastri (2018) and Indriyawati et al. (2020). Subsequently, the abundance and Diversity Index (H') were calculated using the following formulas:

Plankton abundance

Plankton abundance was calculated based on a method described by Soeprapto et al. (2023) with the formula as follows:

$$N = Z \, x \frac{x}{y} x \frac{1}{v}$$

Where:

N : Individual abundance of plankton (ind/L)
Z : Individual number of plankton (ind)
X : Volume of filtered water sample (100 mL)
Y : Volume of 1 water drop (1 mL)
V : Volume of filtered water (20 L)

Diversity index

The percentage diversity analysis of plankton using Shannon Diversity Index H' by Shannon and Weaver (1963) in Geng et al. (2022) (Table 2) as follows:

$$H' = -\sum_{n-1}^{s} Pi \ln Pi$$

Where:

H' : Diversity index
Pi : Number of individuals of each species Pi=ni/N
ni : Total individuals in the species
N : Total of all species

Index of Preponderance (IP)

IP was used to determine the various types of food consumed by *O. eversi*. The percentage of the largest part of the organism consumed was analyzed using a combination formula that incorporates the frequency of occurrence and volumetric method. This approach was described by Elfidasari et al. (2020) as follows:

$$IP = \frac{V_i x O_i}{\Sigma(V_i x O_i)} x\,100$$

Where:

IP : Preponderance index
V_i : Amount percentage of one type of food
O_i : Frequency percentage of one type of food occurrence
$\sum (V_i \times O_i)$: Amount of $V_i \times O_i$ of all types of food

The volumetric method was obtained by calculating the average species consumed based on the number of individuals Elfidasari et al. (2020).

$$V_i = \frac{\text{number of individuals in one type of food}}{\text{total of all types of food}} x100\%$$

Where V_i is the volume percentage of one type of food

Table 2. Diversity index value

Uniformity Value	Category
H' < 1	Low diversity
1 < H' < 3	Medium diversity
H' > 3	High diversity

Table 3. The percentage of preponderance index

Index of Preponderance Value	Category
IP> 40%	Main food
IP 4-40%	Supplementary food
IP < 4%	Additional food

The frequency of occurrence is a simple method of data collection based on the contents of the stomach, whether it consists of either a particular or various types of organisms Elfidasari et al. (2020):

$$O_i = \frac{\text{the number of stomach that contain one type of food}}{\text{the total number of the stomach that contains food}} \times 100\%$$

Where: O_i is the occurrence frequency

Based on the percentage of IP, the food was divided into three categories, as shown in Table 3.

Relative Gut Length (RGL)

RGL is the ratio of the digestive tract length to the total body length. It is measured to determine the trophic level of fish. The results from measuring the RGL of the fish are categorized as follows: <1 for fish classified as carnivorous, 1-3 for fish classified as omnivorous, and >3 for fish classified as herbivorous (Zuliani et al. 2016; Serdiati 2019; Elfidasari et al. 2020).

$$RGL = \frac{GL\ (cm)}{TL\ (cm)}$$

Where:
RGL : Relative Gut Length
GL : Gut Length
TL : Total Length

Electivity Index

Based on the presence of plankton in the pool and in the stomatch, the food selection index (Ivlev) and food preference index (index of preponderance) were calculated. We used Ivlev's Electivity Index (Situmorang et al. 2013) was formulated as follows.

$$E = \frac{r_i - p_i}{r_i + p_i}$$

Where:
E : Electivity index
ri : Relative number of types of organisms eaten
pi : Relative number of types of organisms in the water

E values vary between -1 to +1. Positive values indicate selection for a certain food item while negative values indicate avoidance.

RESULTS AND DISCUSSION

Results

Based on the results of research conducted in the Tilanga Pool, Sarira Village, North Makale District, Tana Toraja, 4 *O. eversi* individuals were found as samples in this study. Environmental parameters in the Tilanga Pond are dissolved oxygenthe environmental parameters of dissolved oxygen (3.95-4.16 m/L), temperature (23.5-25℃), pH (7), salinity (0 ‰), current velocity (0 m/s) and turbidity (0.1-0.4 NTU) can be seen in Table 4. The Principal Component Analysis (PCA) showed that temperature in the afternoon had a positive correlation with the abundance of *O. eversi*, as temperature is closest to abundance of *O. eversi*, compared to DO, pH, salinity, current velocity and turbidity factors (Figure 2).

The abundance of plankton in the Tilanga Pool ranged from 185-435 cells/L for phytoplankton and 10-25 ind/L for zooplankton. The Diversity Index (H') of phytoplankton in the morning was 1.61 and 1.93 in the afternoon which was categorized as moderate, while the zooplankton in the morning was 0.69 and 0.24 in the afternoon which was categorized as low. The highest percentage of phytoplankton abundance was in the morning from the Bacillorophyceae class *Synedra* sp. species and in the afternoon from the Chyanophyceae class *Planktothrix agardhii* species, as shown in Figure 4 and Table 5.

Results of measurements of the relative length of the gut *O. eversi* range RGL = 0.45-0.62 categorized as omnivorous-carnivorous fish. Food habits *O. eversi* based on Index of Preponderance (IP) analysis indicates food *O. eversi* phytoplankton and zooplankton ranged between 0.69-1.04% and 0.35-61.11%. The predominant food found in the stomach *O. eversi* that was *Synedra* sp. 1.04% and larvae *Cyclops* sp. 61.11%. Based on main food preponderance index *O. eversi* namely larvae *Cyclops* sp. with IP = >40%, *Eurycercus* sp. as food additives ranges from IP = 4-40% and complementary foods IP <4%, namely: *Hemicypris* sp., unidentified udang larvae, unidentified bivalves larvae, unidentified annelid larvae, *Stylicletodes* sp., *Synedra* sp., *Denticula* sp., *Cymbella* sp., *Undila* sp., and *Cyclops* sp. eggs.

The electivity index, which denote the preference of a *O. eversi* for a specific food item based on its class can be seen in Table 8.

Discussion

Habitat environment

The existence of certain types of medaka fish in an aquatic ecosystem is influenced by several factors, one of which is environmental factors. The habitat conditions of *O. eversi* revealed that the DO value in the morning was 3.95 mg/L and in the afternoon increased to 4.16 mg/L (Table 4). The DO concentrations in the waters can vary hourly, daily, and weekly as a function of the intensity of thermal stratification (Gerling et al. 2014; Jabbari et al. 2019; Matsuzaki et al. 2020). Based on the pollution status, the Tilanga Pool was classified as highly polluted. This was based on the theory presented by Ranaraja et al. (2019), that DO values of 8.0-9.0 mg/L are not polluted; 6.7-8.0 mg/L slightly polluted; 4.5-6 mg/L is moderately polluted and <4.5 mg/L is highly polluted.

The water temperature in the *O. eversi* habitat ranged from 24-25℃, according to Herder et al. (2012), *O. eversi* can be bred at temperatures around 24-25℃. Yusof et al. (2013) also found that medaka fish lived within a water temperature range of 24-28℃. The pH of the *O. eversi* habitat was 7, Parenti et al. (2013), supported this by stating that *O. eversi* can live in the pH range of 6-7.5. Generally, fish requires water pH ranges from 6.5 to 8.5, which is considered as for good growth of fish (Sahu and Datta 2018).

The salinity of the habitat was 0%, which can be attributed to the mountainous topography of Tana Toraja, where there was no sea. The *O. eversi* has not been found in saline waters. According to Takehana et al. (2020), most of the *Oryzias* species inhabit mainly freshwater, while only two species belonging to the *Oryzias* group live in sea- and freshwaters namely *O. javanicus* and *O. dancena* (previously named *O. melastigma*). Differences in the habitat of medaka fish are due to their ability to control osmotic balance (Assas et al. 2020).

The zero current velocity (m/d) in Tilanga Pool waters was a supporting factor for *O. eversi* to survive and reproduce. The turbidity value in Tilanga Pool ranged from 0.1-0.4 NTU, which was relatively low. According to Serdiati (2019), turbidity and sedimentation negatively impact the reproductive process of free-range fish because they directly damage and kill embryos and juveniles.

Temperature plays an important role for the growth and degree of survival of biota in waters. PCA analysis can be seen in Figure 2, showing that the temperature parameter is an important variable that can support the survival of *O. eversi* in the water. According to Herder et al. (2012), *O. eversi* breed in waters with temperatures ranging from 24-25°C. Temperature can affect fish physiology such as affects metabolic rate, behavior, the ability/desire of the fish to obtain food and how they process food through digestion (Volkoff and Rønnestad 2020).

Plankton in Tilanga Pool

The abundance of phytoplankton in Tilanga Pool ranged from 185-435 cells/L (Figure 3.A). This indicates that the pool waters have a low fertility rate and fall into the category of oligotrophic waters. According to Herawati et al. (2021), water fertility is divided into three categories, namely oligotrophic, mesotrophic, and eutrophic comprising phytoplankton of 0-2000, 2000-15.000 and >15.000 cells/L, respectively. The abundance of phytoplankton was higher in the morning than in the afternoon (Figure 3.A). This was influenced by high-intensity sunlight in the morning and low-intensity sunlight in the afternoon, which affected plankton abundance. Phytoplankton community, composition, abundance, and biomass, were influeced by abiotic resources (biogenic structure, pH, sunlight, etc.) in aquatic ecosystems (Jakobsen et al. 2015; Seekell et al. 2015; Gusha et al. 2019; Jia et al. 2020; Li et al. 2021).

The H' of the phytoplankton in the Tilanga Pool was categorized as moderate, with values of 1.61 and 1.93 in the morning and afternoon, respectively (Figure 3.B). According to Jawwad et al. (2021), a moderate diversity index (1<H'<3) which indicates good productivity, balanced ecosystem and medium pressure.

The abundance of zooplankton in the habitat of *O. eversi* ranged from 10-25 ind/L (Figure 3.A), indicating that the Tilanga Pool waters have a medium fertility level or are mesotrophic waters. This is according to Harmilia et al. (2022), which classified water fertility as oligotrophic (zooplankton = 1 ind/L), mesotrophic (zooplankton = 1-500 ind/L), and eutrophic (zooplankton>500 ind/L). The H' value was categorized as low both in the morning (H' = 0.69) and in the afternoon (H' = 0.24) (Figure 3.B). This was caused by zooplankton being the main food for *O. eversi* and other biotas in Tilanga Pool. According to Ningsih et al. (2020), zooplankton usually acts as primary consumers and form the major food source for higher consumers like carnivore fish in the aquatic food chain.

The highest percentage of phytoplankton in the morning was *Synedra* sp. from the Bacillariophyceae class and in the afternoon, it was *P. agardhii* from the Chyanophyceae class which can be seen in Figures 4.A and 4.B and Table 5. Fu et al. (2023) reported that the abundance of phytoplankton was relatively homogeneous in the water. *Synedra* sp. from the Bacillariophyceae class can live in low-nutrient (oligotrophic) environments. This is due to its ability to accumulate nutrients and store them as food reserves in the form of insoluble polymers (Wardhani et al. 2023). Meanwhile, the percentage of zooplankton in the morning is 8% (Figure 4.A) and in the afternoon it is around 8-9% (Figure 4.B), indicating a low population of zooplankton in Tilanga Pool. According to Syafitri et al. (2021), which stated that zooplankton has a lower level of productivity than phytoplankton, therefore of zooplankton will increase after the peak productivity of phytoplankton.

Relative length of gut of Oryzias eversi *from Tilanga Pool*

Table 6 shows that the relative gut length *O. eversi* ranged from RGL 0.45-0.62. Based on the results of the relative gut length analysis, *O. eversi* categorized as omnivore-carnivore fish. According to Zuliani et al. (2016), who stated that the RLG of carnivorous fish is 0.2-2.5 cm, omnivores was 0.6-8 cm, and herbivores was 0.8-15 cm. As for Zuliani et al. (2016) and Serdiati (2019), suggested that the average intestine length of carnivorous fish was less than 1 cm, 1-3 cm for omnivores, and greater than 3 cm for herbivores. RLG is used as an indicator of the feeding habits of fish by comparing its length to the total length (Serdiati 2019).

The length of the intestine in *O. eversi* was shorter than the total body length, as shown in Table 6. This indicates that its digestive process for food does not last long. According to Pratiwy et al. (2022), carnivorous fish have shorter intestines because fleshy foods are easier to digest than plants. Alabssawy et al. (2019), supported this by stating that the length of the intestine was closely correlated with the type of food consumed.

Table 4. Water quality in the *Oryzias eversi* habitat

Parameter	Morning	Variance	Afternoon	Variance
DO	3.95	16.33	4.16	139.33
Temperature	23.5		25	
pH	7		7	
Salinity	0		0	
Current speed	0		0	
Turbidity	0.1		0.4	

Table 5. The composition of the plankton in Tilanga Pond, Tana Toraja, Indonesia

Morning	
Bacillariophyceae	*Gyrosigma anttenuatum, Cymbella cistula, Synedra* sp., *Nitzschia lorensiana, Surirella turpin, Navicula lanceolata*
Euglenophyceae	*Euglena viridis, Lepocinchlis ovum, Spirogyra varians*
Chyanophyceae	*Oscillatoria lutea*
Tubulinea	*Arcella vulgaris*
Copepoda	*Cyclops* sp.
Afternoon	
Bacillariophyceae	*Synedra* sp., *Surirella* sp., *Tabellaria floccusa*
Euglenophyceae	*Lepocinchlis ovum, Trachelomonas* sp.
Chyanophyceae	*Planktothrix agardhii, Oscillatoria lutea*
Chlorophyceae	*Microspora floccosa, Calotrhrix* sp.
Ostracoda	*Hemicypris* sp.

Table 6. Relative gut length in each fish category

Fish code	Fish length (cm)	Fish weight	Fish intestinal length (cm)	RGL
1	5.2	1.15	2.5	0.48
2	3.9	0.7	2.4	0.62
3	4.6	1.13	2.1	0.45
4	3.1	0.4	1.7	0.55

Oryzias eversi *Index of Preponderance in Tilanga Pool*

Table 7 shows that IP analysis revealed that the consumption of phytoplankton and zooplankton by *O. eversi* ranged between 0.69-1.04% and 0.35-61.11%, respectively. The dominant food found in the stomach of *O. eversi* was *Synedra* sp. (1.04%) and *Cyclops* sp. larvae (61.11%). Based on IP, it was found that the main food for *O. eversi* was *Cyclops* sp. larvae, with an IP exceeding 40%. *Eurycercus* sp. served as supplementary food with values that ranged from 4 to 40%, while complementary foods, with IP values below 4%, included *Hemicypris* sp., unidentified udang larvae, unidentified bivalves larvae, unidentified annelid larvae, *Stylicletodes* sp., *Synedra* sp., *Denticula* sp., *Cymbella* sp., *Undila* sp., and *Cyclops* sp. eggs, as shown in Figure 5. According to Elfidasari et al. (2020), the food categories were classified as the main food with IP greater than 40%, additional food with IP 4 to 40%, and complementary food with IP below 4. Larvae *Cyclops* sp. from the copepod order as the main food *O. eversi* which has an important role in aquatic ecosystems. According to Wiradana et al. (2020), naturally, fish will consume zooplankton to support growth especially copepoda, copepoda are better digested the larvae phase.

The diversity of organisms in the Tilanga Pool waters causes a variety of food *O. eversi*. Besides that *O. eversi* which are found to have different sizes so that the amount of food found in the stomach is also different,as shown in Figure 6. According to Pratiwy et al. (2023), some of the factors that influence whether a fish species will eat a food item include food size, food availability, food color, taste, texture, and factor such as age, location, and time of day also affect the type and amount of food consumed by a fish species.

Electivity

The electivity index in Table 8 shows that *O. eversi* preferred zooplankton over phytoplankton, and among the zooplankton, Ostracoda, Copepoda, Bivalvia, Malacostraca, Branchiopoda, Oligochaeta and Maxillopoda include *O. eversi* preferred food with a positive value (0.01-1). The rest of the food groups showed negative values (Table 8).

Copepod class zooplankton was the most preferred food for *O. eversi* in general. Fewer copepod classes are found in nature than in the stomachs of *O. eversi*, this shows that the reduced availability of food preferred by *O. eversi* in Tilanga Pool was one of the causes of the decline in the *O. eversi* population.

Table 7. Index of Preponderance (IP)

Organism	Parameter			
	Index of Preponderance (IP)			
Food type	Vi	Oi	Vi×Oi	$\frac{(Vi \times Oi)}{\sum(Vi \times Oi)} \times 100\%$
Hemicypris sp.	0.04	0.50	0.018	2.78
Larva *Cyclops* sp.	0.40	1	0.400	61.11
Unidentified larva bivalvia	0.16	0.25	0.041	6.25
Unidentified larva udang	0.02	0.25	0.005	0.69
Eurycercus sp.	0.15	1	0.145	22.22
Unidentified larva annelida	0.02	0.25	0.005	0.69
Stylicletodes sp.	0.01	0.25	0.002	0.35
Synedra sp.	0.03	0.25	0.007	1.04
Denticula sp.	0.03	0.25	0.007	1.04
Cymbella sp.	0.02	0.25	0.005	0.69
Undila sp.	0.01	0.25	0.002	0.35
Cyclops sp. eggs	0.07	0.25	0.018	2.78
Total			0.65	100

Table 8. Electivity index of *Oryzias eversi*

Types of Organisms	Relative number of types of organisms eaten (ri)	Relative number of types of organisms in the water (pi)	Electivity Index (E)
Phytoplankton			
Bacillariophyceae	0.08	0.64	-0.79
Euglenophyceae	0	0.17	-1
Chyanophyceae	0	0.06	-1
Chlorophyceae	0	0.06	-1
Zooplankton			
Ostracoda	0.04	0.04	0.01
Copepoda	0.51	0.01	0.97
Bivalvia	0.17	0	1
Malacostraca	0.02	0	1
Branchiopoda	0.15	0	1
Oligochaeta	0.02	0	1
Maxillopoda	0.01	0	1
Tubulinea	0	0.01	-1
Cilliata	0	0.02	-1

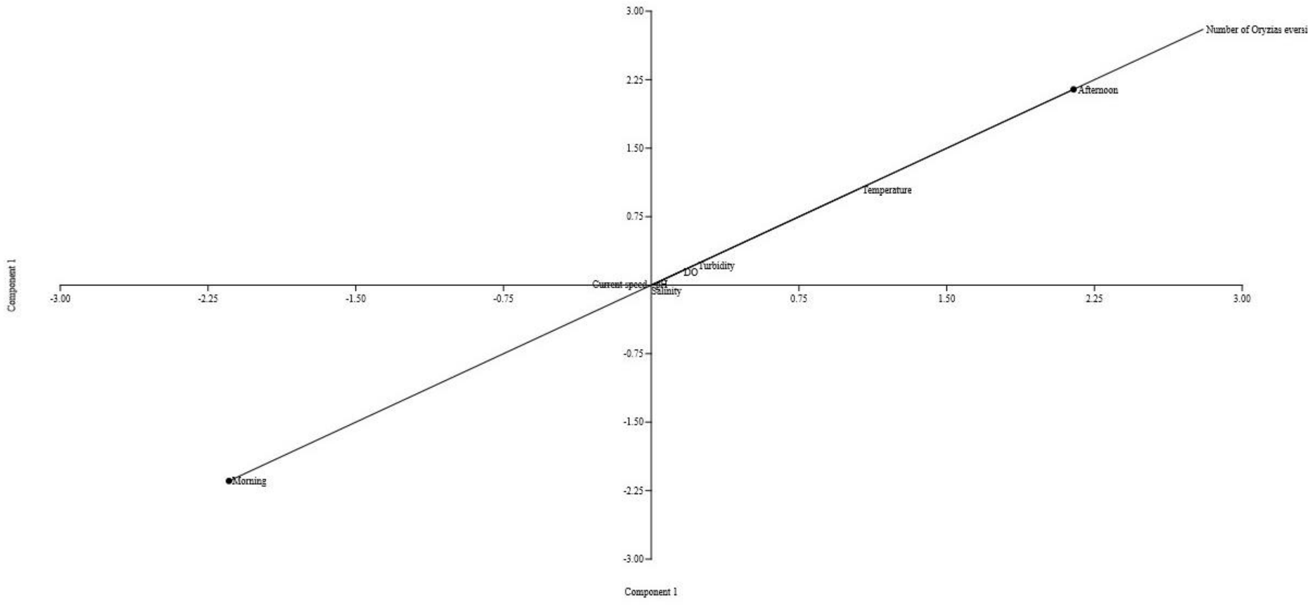

Figure 2. PCA analysis of water quality and abundance of *Oryzias eversi*

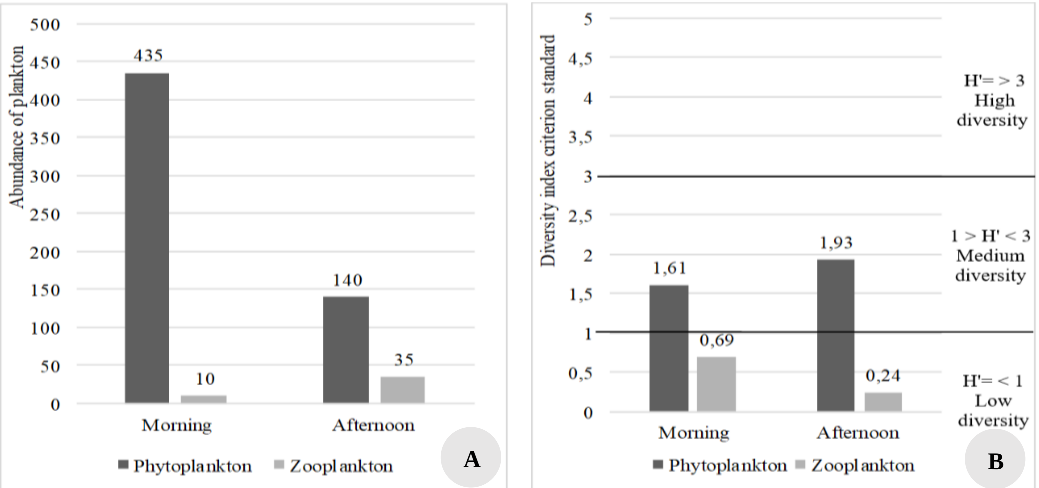

Figure 3. A. Plankton abundance, B. Plankton diversity

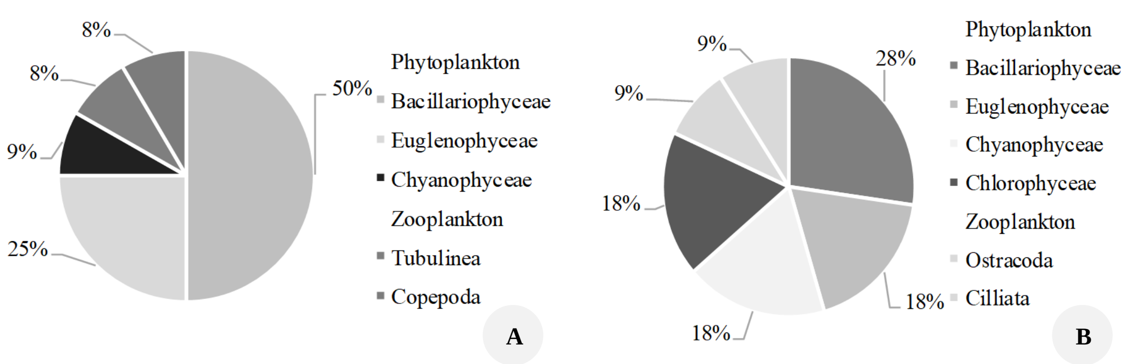

Figure 4. Percentage of plankton in Tilanga Pond, Tana Toraja, Indonesia: A. Morning, B. Afternoon

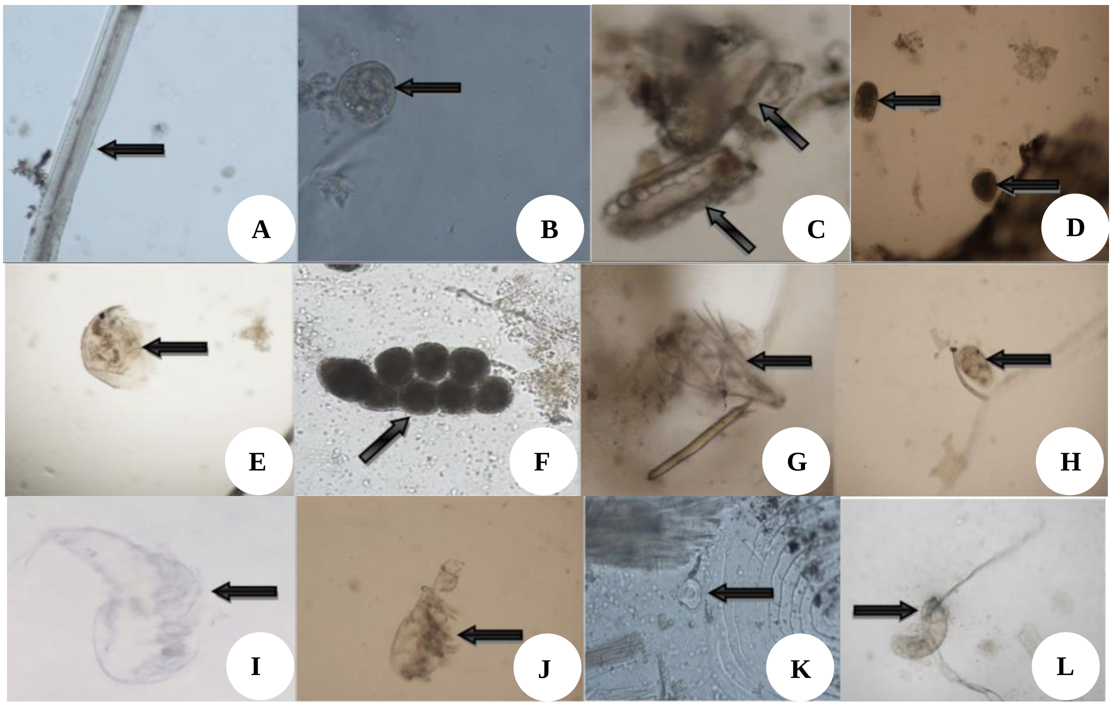

Figure 5. Phytoplankton (No. A-C), Zooplankton (no. D-L). A. *Synedra* sp., B. *Cymbella* sp., C. *Denticula* sp., D. Larva *Cyclops* sp., E. *Eurycercus* sp., F. *Cyclops* sp. eggs, G. *Undila* sp., H. *Hemicypris* sp., I. *Stylicletodes* sp., J. Unidentified larva Udang, K. Unidentified larva Bivalvia, L. Unidentified larva Annelida

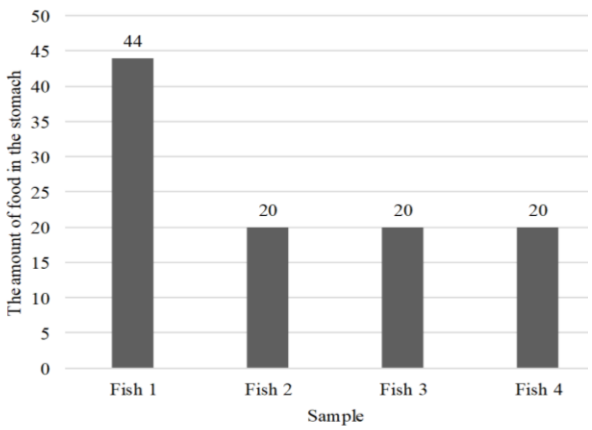

Figure 6. Percentage of *Oryzias eversi* food based on Index of Preponderance analysis

In conclusion, the habitat of *O. eversi* was categorized as highly polluted water based on the DO content that ranged from 3.95 to 4.16 mg/L. The abundance of phyto-plankton and zooplankton ranged from 185-435 cells/L and 10-25 ind/L, respectively. Phytoplankton diversity was categorized as moderate with H' values that ranged from 1.61 to 1.93, while zooplankton showed low diversity with H' values that ranged from 0.69 to 0.24. IP and RGL indicated that *O. eversi* exhibited omnivorous-carnivorous feeding behavior. The average zooplankton and phytoplankton IP values ranged from 0.35 to 61.11% and 0.69 to 1.04%, respectively, while RGL ranged from 0.48 to 0.62. *Cyclops* sp. larvae were identified as the main food for *O. eversi*, with an IP greater than 40% and *Eurycercus* sp. was supplementary food with an IP of 4 to 40%.

ACKNOWLEDGEMENTS

The authors are grateful to the Regional Government of East Luwu District, Indonesia for providing funding through a research completion scholarship with No: 381/A-06/XII/TAHUN 2022. The authors declare no conflicts of interest.

REFERENCES

Achmadi AS, Hamidy A, Maryanto I, Lupiyaningdyah P, Sihotang VBL, Kahono S, Kartonegoro A, Ardiyani M, Mulyaningsih ES, Kanti A. 2018. Ekspedisi Sulawesi Barat: Flora, Fauna, dan Mikroorganisme Gandangdewata. LIPI Press, Jakarta. [Indonesian]

Alabssawy AN, Khalaf-Allah HMM, Gafar AA. 2019. Anatomical and histological adaptations of digestive tract in relation to food and feeding habits of lizardfish, *Synodus variegatus* (Lacepède, 1803). Egypt J Aquat Res 45 (2): 159-165. DOI: 10.1016/j.ejar.2019.05.006.

Assas M, Qiu X, Chen K, Ogawa H, Xu H, Shimasaki Y, Oshima Y. 2020. Bioaccumulation and reproductive effects of fluorescent microplastics in medaka fish. Mar Pollut Bull 158: 111446. DOI: 10.1016/j.marpolbul.2020.111446.

Elfidasari D, Wijayanti F, Sholihah A. 2020. Trophic level and position of *Pterygoplichthys pardalis* in Ciliwung River (Jakarta, Indonesia) ecosystem based on the gut content analysis. Biodiversitas 21 (6): 2862-2870. DOI: 10.13057/biodiv/d210665.

Fu M, Zhao L, Zhang Z, Qu P, Song H, Yi S, Wang Z. 2023. Phytoplankton assemblage distribution patterns under different Yellow River freshwater discharge scenarios. J Sea Res 192: 102348. DOI: 10.1016/j.seares.2023.102348.

Gani A, Nilawati J, Rizal A. 2015. Studi habitat dan kebiasaan makanan (*food habitat*) ikan Rono Lindu (*Oryzias sarasinorum* Popta, 1905). Jurnal Sains Dan Teknologi Tadulako 4 (3): 9-18. [Indonesian]

Gani A, Suhendra N, Herder F, Schwarzer J, Möhring J, Montenegro J, Herjayanto M, Mokodongan DF. 2022. A new endemic species of pelvic-brooding ricefish (Beloniformes : Adrianichthyidae: *Oryzias*) from Lake Kalimpahan, Sulawesi, Indonesia. Bonn Zool Bull 71 (1): 77-85. DOI: 10.20363/BZB-2022.71.1.077.

Geng Y, Li M, Yu R, Sun H, Zhang L, Sun L, Lv C, Xu J. 2022. Response of planktonic diversity and stability to environmental drivers in a shallow eutrophic lake. Ecol Indic 144: 109560. DOI: 10.1016/j.ecolind.2022.109560.

Gerling AB, Browne RG, Gantzer PA, Mobley MH, Little JC, Carey CC. 2014. First report of the successful operation of a side stream supersaturation hypolimnetic oxygenation system in a eutrophic, shallow reservoir. Water Res 67: 129-143. DOI: 10.1016/j.watres.2014.09.002.

Gusha MNC, Dalu T, Wasserman RJ, Mcquaid CD. 2019. Zooplankton grazing pressure is insufficient for primary producer control under elevated warming and nutrient levels. Sci Total Environ 651 (Pt 1): 410-418. DOI: 10.1016/j.scitotenv.2018.09.132.

Harmilia ED, Khotimah K, Ma'ruf I, Pratiwi I. 2022. Dynamics of plankton populations as natural food for fish and a tributary of the Ogan River. Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan 11 (2): 212-222. DOI: 10.13170/depik.11.2.25498.

Herawati EY, Darmawan A, Valina R, Khasanah RI. 2021. Abundance of phytoplankton and physical chemical parameters as indicators of water fertility in Lekok Coast, Pasuruan Regency, East Java Province, Indonesia. IOP Conf Ser: Earth Environ Sci 934 (1): 012060. DOI: 10.1088/1755-1315/934/1/012060.

Herder F, Hadiaty RK, Nolte AW. 2012. Pelvic-Fin brooding in a new species of riverine ricefish (Atherinomorpha: Beloniformes: Adrianichthyidae) from Tana Toraja, Central Sulawesi, Indonesia. The Raffles Bull Zool 60 (2): 467-476.

Indriyawati H, Triajie H, Abida IW. 2020. Buku Identifikasi Digital Fitoplankton di Perairan Bangkalan untuk Mendukung Pembelajaran di Masa Pandemi Covid 2019. Fakultas Manajemen Sumberdaya Perairan Fakultas Pertanian Universitas Trunojoyo Madura, Jawa Timur. [Indonesian]

Iskandar A, Muslim M, Hendriana A, Wiyoto W. 2020. Jenis-jenis ikan Indonesia yang kritis dan terancam punah. Jurnal Sains Terapan 10 (1): 53-59. DOI: 10.29244/jstsv.10.1.53-59. [Indonesian]

Jabbari A, Ackerman JD, Boegman L, Zhao Y-M. 2019. Episodic hypoxia in the western basin of Lake Erie. Limnol Oceanogr 64 (5): 2220-2236. DOI: 10.1002/lno.11180.

Jakobsen HH, Blanda E, Staehr PA, Hojgard JK, Rayner TA, Pedersen MF, Jepsen PM, Hansen BW. 2015. Development of phytoplankton communities: Implications of nutrient injections on phytoplankton composition, pH and ecosystem production. J Exp Mar Biol Ecol 473: 81-89. DOI: 10.1016/j.jembe.2015.08.011.

Jawwad MAS, Pramesti HN, Murti RHA. 2021. Plankton diversity in the coastal waters at Klumpang Beach, East Nusa Tenggara, Indonesia. 2nd International Conference Eco-Innovation in Science, Engineering, and Technology. NST Proceedings 137-141. DOI: 10.11594/nstp.2021.1422.

Jia J, Gao Y, Zhou F, Shi K, Johnes PJ, Dungait JAJ, Ma M, Lu Y. 2020. Identifying the main drivers of change of phytoplankton community structure and gross primary productivity in a river-lake system. J Hydrol 583: 124633. DOI: 10.1016/j.jhydrol.2020.124633.

Li Z, Gao Y, Wang S, Lu Y, Sun K, Jia J, Wang Y. 2021. Phytoplankton community response to nutrients along lake salinity and altitude gradients on the Qinghai-Tibet Plateau. Ecol Indic 128: 107848. DOI: 10.1016/j.ecolind.2021.107848.

Matsuzaki S-IS, Tanaka A, Kohzu A, Suzuki K, Komatsu K, Shinohara R, Nakagawa M, Nohara S, Ueno R, Satake K, Hayashi S. 2020. Science of the total environment seasonal dynamics of the activities of dissolved 137 Cs and the 137 Cs of fi sh in a shallow, hypereutrophic lake: Links to bottom-water oxygen concentrations. Sci Total Environ 761: 143257. DOI: 10.1016/j.scitotenv.2020.143257.

Mokodongan DF. 2019. *Oryzias eversi*. The IUCN Red List of Threatened Species 2019: e.T90980592A90980601. DOI: 10.2305/IUCN.UK.20192.RLTS.T90980592A90980601.en.

Ningsih EN, Aryawati R, Febrianti AA, Supriyadi F. 2020. Comparison of zooplankton density estimation using bongo plankton net and underwater acoustics method. Maspari J 13 (1): 65-72. DOI: 10.56064/maspari.v13i1.13986.

Parenti LR, Hadiaty RK, Lumbantobing D, Herder F. 2013. Two new ricefishes of the genus *Oryzias* (Atherinomorpha: Beloniformes: Adrianichthyidae) augment the endemic freshwater fish fauna of Southeastern Sulawesi, Indonesia. Copeia 2013 (3): 403-414. DOI: 10.1643/CI-12-114.

Pratiwy FM, Haetami K, Sinaga JA. 2023. Exploring fish eating habits: Factors influencing feeding behavior in tropical fish. Asian J Fish Aquat Res 23 (4): 1-7. DOI: 10.9734/AJFAR/2023/v23i4605.

Pratiwy FM, Zallesa S, Sinaga JA. 2022. Eating habits and digestive system of fish. Gob Sci J 10 (2): 1051-1055.

Ranaraja CDMO, Arachchige USPR, Rasenthiran K. 2019. Environmental pollution and its challenges in Sri Lanka. Intl J Sci Technol Res 8 (7): 417-419.

Sari DK, Irma A, Khusnul YN, Sulfi A. 2020. Patologi Ikan Medaka Di Sulawesi. CV. Nas Media Pustaka, Makassar. [Indonesian]

Seekell DA, Lapierre J-F, Ask J, Bergström A-K, Deininger A, Rodríguez P, Karlsson J. 2015. The influence of dissolved organic carbon on primary production in northern lakes. Limnol Oceanogr 60 (4): 1276-1285. DOI: 10.1002/lno.10096.

Serdiati N. 2019. Karakterisasi Ikan Padi *Oryzias nigrimas* (Kottelat, 1990) Sebagai Upaya Pengelolahan Ikan Endemik di Danau Poso Sulawesi Tengah. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Shannon CE, Weaver W. 1963. The Mathematical Theory of Communication. University of Illinois Press, Urbana. DOI: 10.1002/j.1538-7305.1948.tb01338.x.

Situmorang TS, Barus TA, Wahyuningsih H. 2013. Studi komparasi jenis makanan ikan Keperas (*Puntius binotatus*) di sungai AEK Pahu Tombak, AEK Pahu Hutamosu dan Sungai Parbotikan Kecamatan Batang Toru Tapanuli Selatan. Jurnal Perikananan Dan Kelautan 18 (2): 48-58. DOI: 10.31258/jpk.18.2.48-58. [Indonesian]

Soeprapto H, Ariadi H, Badrudin U. 2023. The dynamics of *Chlorella* spp. abundance and its relationship with water quality parameters in intensive shrimp ponds. Biodiversitas 24 (5): 2919-2926. DOI: 10.13057/biodiv/d240547.

Sugiyono. 2016. Metode Penelitian Kuantitatif, Kualitatif dan R&D. PT Alfabet, Bandung. [Indonesian]

Sulastri. 2018. Fitoplankton Danau-Danau di Pulau Jawa: Keanekaragaman dan Perannya sebagai Bioindikator Perairan. LIPI Press, Jakarta. [Indonesian]

Syafitri EM, Srimariana ES, Sulistiono. 2021. Zooplankton community structure in Cengkok Coastal Water and it's around, Teluk Banten. IOP Conf Ser: Earth Environ Sci 744: 012088. DOI: 10.1088/1755-1315/744/1/012088.

Takehana Y, Zahm M, Cabau C, Klopp C, Roques C, Bouchez O, Donnadieu C, Barrachina C, Journot L, Kawaguchi M, Yasumasu S, Ansai S, Naruse K, Inoue K, Shinzato C, Schartl M, Guiguen Y, Herpin A. 2020. Genome sequence of the Euryhaline Java fish Medaka, *Oryzias javanicus*: A small aquarium fish model for studies on adaptation to salinity. Genes Genom Genet 10 (3): 907-915. DOI: 10.1534/g3.119.400725.

Volkoff H, Rønnestad I. 2020. Effects of temperature on feeding and digestive processes in fish. Temperature 7 (4): 307-320. DOI: 10.1080/23328940.2020.1765950.

Wardhani E, Irmansyah AZ, Fitriani NA. 2023. Determining the status of the Setiaman Reservoir ecosystem in Cimahi City of West Java Province. Intl J Geomate 25 (108): 38-49. DOI: 10.21660/2023.108.3787.

Wiradana PA, Anjani S, Yusup DS, Wiryatno J, Melianawati R, Naw SW, Nege AS, Soegianto A. 2020. Copepod growth populations (*Acartia* sp.) in outdoor mass culture tanks: Exploring natural feed potentials for sustainable aquaculture. Ecol Environ Conserv 26 (3): 1383-1388.

Yusof S, Ismail A, Rahman F. 2013. Distribution and localities of Java medaka fish (*Oryzias javanicus*) in Peninsular Malaysia. Malay Nat J 65 (2&3): 38-46.

Zuliani Z, Muchlisin ZA, Nurfadillah N. 2016. Kebiasaan makanan dan hubungan panjang berat ikan Julung-Julung (*Dermogenys* sp.) di Sungai Alur Hitam Kecamatan Bendahara Kabupaten Aceh Tamiang. Jurnal Ilmiah Mahasiswa Kelautan Dan Perikanan Unsyiah 1 (1): 12-24. [Indonesian]