Structure of zooplankton community in Lake Maninjau. Case study in Nagari Sungai Batang - Agam, West Sumatra

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Abstract. The presence of zooplankton plays an important role in the lake ecosystem. This study aimed to investigate the community structure of zooplankton in Lake Maninjau, especially in the area of PN Nagari Sungai Batang. Lake Maninjau contributes greatly to the community and regional economy. This research was conducted in April, July, August, September, October, and November 2018 at 3 sampling stations in Lake Maninjau, Nagari Sungai Batang, West Sumatra. The zooplankton was collected using a vertical zooplankton net from bottom to surface. The samples were preserved in a 5% Lugol’s solution. The zooplankton was identified based on several references under a binocular microscope. The abundance of zooplankton was calculated using Sedgewick Rafter Cell. Some physicochemical parameters of water were also observed. The results of zooplankton analysis found 3 genera of Protozoa, 13 genera of Rotifers, 5 genera of Cladocera, and 1 genus of Copepods and Nauplius. The results showed the diversity of zooplankton in Lake Maninjau was categorized as moderate level, there were no dominant species, and the species was evenly distributed. Predation has occurred in the zooplankton community, which is generally based on body size or ability to move. Generally, the structure of the zooplankton community in Lake Maninjau is influenced by water quality factors in their habitat.

1. Introduction
The existence of the zooplankton community is very important because it serves as a natural food source for fish larvae in the lake. The composition, community structure, and abundance of zooplankton are often associated with the trophic level and fish productivity. Zooplankton is one of the important biotic components in the food cycle in waters, namely as a first-rate consumer and as a natural feed of fish larvae. The abundance and distribution of zooplankton in the lake are related to the presence of phytoplankton. Changes in lake environmental conditions due to increased anthropogenic activity cause changes in the structure of the zooplankton community in a lake [1][2].

Lake Maninjau is located in Tanjung Raya Subdistrict, Agam Regency, West Sumatra Province with the geographical position of N 0°19' and E 100°12'. Lake Maninjau is classified as a type of volcanic lake in the form of a caldera lake which was estimated to have formed about 60,000 years ago. This lake extends from north to south with a maximum length of about 17 km and a width of about 8 km. This lake has one outlet, the Antokan River which flows westward towards the Indian Ocean. The deepest point of the lake is in the southern basin as deep as 169 m. The hydrological condition of the lake area is generally influenced by two main factors, surface water, and groundwater. Surface water in the lake area mostly flows through the channelling patterns that have been formed.
This lake has a multifunction for the surrounding community, as a source of electrical energy, the livelihood of fishermen, supporting the improvement of the economic sector through fish farming the floating net system (KJA). Increased anthropogenic activities in the lake and its surroundings contribute to decreasing the water quality of the lake, for example, the disposal of domestic waste, hotels, restaurants, agriculture, and floating net fish farming [4]. It is estimated that the total amount of organic waste entering the lake from domestic activities (settlements etc.) is around 209.93 kg/day or 75,574 kg/year, while from KJA fishery activities in 2015 reached 17,001.6 tons and from 2001 – 2015 reached 178,889.00 tons [5].

Recently, Lake Maninjau is classified in critical condition due to serious water quality degradation, thus threatening the preservation of native fish that live in the lake. This condition is getting worse with the increased floating net activities in the Lake. According to [4], in 2006, there were 8,995 KJA units, in 2008 it increased to 15,000 units, and in 2014 reached 16,280 units. The negative impact of water quality degradation in Lake Maninjau can cause mass mortality of fish, algae blooms, a decrease of aesthetic value, and disruption to skin and odor. Anticipating these conditions must be done immediately to avoid the threat of loss of fish and aquatic organisms from extinction and the declining value of the lake’s benefits as a natural resource.

Research Center for Limnology, Indonesian Institute of Sciences (LIPI) has developed technologies to improve the lake ecosystem. These technologies have been applied in Lake Maninjau, particularly in Nagari Sungai Batang as a part of Prioritas Nasional (PN) program. Therefore, this study aimed to analyze the community structure of zooplankton and its dynamic in Lake Maninjau, especially in the area of PN Nagari Sungai Batang. The results are expected to be able to become scientific data and information for the development and management of Lake Maninjau in the future.

2. Materials and Methods
This research was conducted in 2018 in Lake Maninjau, Nagari Sungai Batang, Tanjung Raya District, Agam Regency, in West Sumatra Province (figure 1) at 3 sampling stations in April, July, August, September, October, and November. The zooplankton was collected using a vertical zooplankton net from bottom to surface. The three sampling points namely station 1 is beyond the PN area boundary; station 2 in the PN area (an area where technologies installed), and station 3 in front of the Ranggeh River mouth. Samples were preserved in 5% Lugol’s solution.

Figure 1. Map of sampling stations in PN Area, Lake Maninjau, 2018 (Source: https://www.google.co.id/maps/).
The zooplankton was identified to genera level based on A Guide to Identification of Rotifers, Cladocerans and Copepods from Australian Inland Waters [6] and Plankton: A guide to their ecology and monitoring for water quality [7]. The abundance of zooplankton was calculated using the Sedgewick Rafter Cell. The formula to estimate abundance of zooplankton (N), Diversity Index or Shannon-Wiener's Index (H'), Dominance Index (D) and Evenness Index (E) are as follows:

1. **Abundance of Zooplankton (N),** [8]

\[
N = \frac{n \times A_{cg} \times V_t}{A_a \times V_s \times V_T}
\]

- **N**: Abundance of the zooplankton (individuals.mL\(^{-1}\))
- **n**: Number of zooplankton individuals observed
- **A\(_{cg}\)**: Surface area of the cover glass (1000 mm\(^2\))
- **V\(_t\)**: Sample volume filtered in bottles (mL)
- **A\(_a\)**: Observed square area (mm\(^2\))
- **V\(_s\)**: Concentration volume in cover glass (1 mL)
- **V\(_T\)**: Total volume of filtered water samples (L)

2. **Diversity Index or Shannon-Wiener Index (H'),** [9][10]

\[
H' = -\sum_{i=1}^{n_i} (p_i) (\ln p_i)
\]

- **H'**: Diversity Index
- **N**: The sum of all species
- **n\(_i\)**: Number of individual species
- **p\(_i\)**: ni/N

Criteria of H':
- H' > 3.0: high diversity
- H' 1 - 3.0: moderate diversity
- H' < 1: low diversity

3. **Dominance Index of Simpson (D),** [11]

\[
D = \sum \left(\frac{n_i}{N}\right)^2 = \sum p_i^2
\]

- **D**: Dominance Index
- **n\(_i\)**: Number of individual species
- **N**: Number of all species

Criteria of D:
- D approaches 1: occurs or there is dominance of species
- D approaches 0: does not occur or there is no dominance of a particular species

4. **Evenness Index (E),** [12][13]

\[
E = \frac{H'}{H_{max}}
\]

- **H'**: Diversity Index or Shannon-Wiener Index
- **S**: Number of all species found
- **H_{max}**: ln (S); ln = natural logarithm
With a range:
- E <0.3 : low evenness
- E = 0.3 – 0.6 : medium evenness
- E > 0.8 : high evenness

If the value of E is higher, it indicates that the species contained in the community are increasingly spreading.

Furthermore, some water quality parameters were also observed *in situ* or analyzed at the Laboratory of Research Center for Limnology (table 1).

**Table 1.** Measured water quality parameters.

| Parameters                           | Tools and Methods             |
|--------------------------------------|-------------------------------|
| pH                                   | Horiba U-53G *(in situ)*      |
| Temperature (°C)                     | Horiba U-53G *(in situ)*      |
| Dissolved Oxygen (mg.L⁻¹)            | Logger YSI 6000 *(in situ)*   |
| Conductivity (mS.cm⁻¹)               | Horiba U-53G *(in situ)*      |
| Turbidity (NTU)                      | Horiba U-53G *(in situ)*      |
| Oxidation-Reduction Potential (mV)  | Horiba U-53G *(in situ)*      |
| Total Dissolved Solids (mg.L⁻¹)      | Gravimetric (laboratory)      |
| Total Phosphate (mg.L⁻¹)             | APHA 4500 P (laboratory)      |
| Total Nitrogen (mg.L⁻¹)              | APHA 4500 N org C (laboratory) |
| Total Organic Matter (mg.L⁻¹)        | Oximetry (laboratory)         |
| Total Suspended Solids (mg.L⁻¹)      | Gravimetric (laboratory)      |
| Chlorophyll-a                         | Spectrophotometry UV/VIS (laboratory) |
| Ammonia (N-NH₄)                       | APHA4500 NH₃ D (laboratory)    |
| Nitrate (N-NO₃)                       | APHA 4500 NO₃ E (laboratory)   |

Furthermore, Canonical Correspondent Analysis (CCA) in Multivariate Software (MVSP V3.1) package was used to find out the interaction between species of zooplankton and environmental variables (water quality parameters), and season variables (rainy and dry season).

3. Results and Discussion
The results of zooplankton identification in Lake Maninjau found 3 genera of Protozoa, 13 genera of Rotifers, 5 genera of Cladocera, and 1 genus of Copepods and Nauplius (table 2).

**Table 2.** Result of identification, average of abundance (ind.mL⁻¹), and structure of zooplankton community in Lake Maninjau, 2018.

| Number | TAXON      | April | July | August | Sept | Oct | Nov |
|--------|------------|-------|------|--------|------|-----|-----|
|        | PROTOZOA   |       |      |        |      |     |     |
| 1      | *Arcella* sp | 4.0   | 3.2  | 12.3   | 12.3 | 9.0 | 7.0 |
| 2      | *Didinium* sp | 2.7   | 8.9  | 8.7    | 11.7 | 7.7 | 9.0 |
| 3      | *Diflugia* sp | 7.7   | 3.0  | 12.3   | 25.3 | 13.0| 11.3|
|        | ROTIFERS   |       |      |        |      |     |     |
| 1      | *Brachionus* sp | 6.3   | 6.8  | 18.7   | 13.3 | 8.3 | 12.0|
| 2      | *Keratella* sp | 1.3   | 2.8  | 3.7    | 4.7  | 3.7 | 6.0 |
| Number | TAXON            | April | July | August | Sept | Oct  | Nov  |
|--------|------------------|-------|------|--------|------|------|------|
| 3      | *Pompholyx* sp   | 2.3   | 3.9  | 8.0    | 7.3  | 4.3  | 1.7  |
| 4      | *Testudinella* sp| 3.7   | 9.8  | 5.3    | 4.3  | 1.3  | 3.7  |
| 5      | *Tricocerca* sp  | 6.3   | 3.1  | 11.7   | 13.3 | 8.3  | 3.7  |
| 6      | *Ploesoma* sp    | 0.3   | 2.0  | 9.3    | 6.7  | 4.3  | 5.7  |
| 7      | *Polyartha* sp   | 3.0   | 8.8  | 6.3    | 5.7  | 2.3  | 0.3  |
| 8      | *Lecane* sp      | 3.3   | 7.3  | 9.3    | 7.3  | 3.7  | 4.3  |
| 9      | *Monostylla* sp  | 5.0   | 5.1  | 9.7    | 9.7  | 6.7  | 5.3  |
| 10     | *Lepadella* sp   | 3.3   | 6.9  | 6.3    | 7.3  | 4.7  | 2.7  |
| 11     | *Squatinella* sp | 1.7   | 5.3  | 9.7    | 2.7  | 2.3  | 1.0  |
| 12     | *Proales* sp     | 0.0   | 2.7  | 7.3    | 7.0  | 5.0  | 2.7  |
| 13     | *Philodina* sp   | 1.0   | 1.3  | 6.7    | 10.7 | 4.3  | 6.0  |

**CLADOCERA**

|      |                  | April | July | August | Sept | Oct  | Nov  |
|------|------------------|-------|------|--------|------|------|------|
| 1    | *Bosmina* sp     | 3.7   | 6.6  | 11.7   | 12.0 | 6.7  | 8.3  |
| 2    | *Chydrorus* sp   | 0.7   | 5.3  | 9.3    | 8.7  | 6.7  | 7.0  |
| 3    | *Ceriodaphnia* sp| 1.0   | 2.1  | 11.3   | 12.0 | 11.3 | 9.7  |
| 4    | *Diaphanosoma* sp| 0.3   | 6.1  | 6.7    | 5.0  | 5.0  | 5.0  |
| 5    | *Moina* sp       | 1.3   | 2.7  | 8.0    | 8.3  | 8.7  | 7.0  |

**COPEPODA**

|      |                  | April | July | August | Sept | Oct  | Nov  |
|------|------------------|-------|------|--------|------|------|------|
| 1    | *Cyclops* sp     | 2.7   | 7.2  | 8.0    | 14.7 | 11.0 | 12.0 |
| 2    | *Nauplius*       | 4.7   | 15.1 | 11.0   | 14.3 | 13.7 | 15.0 |

|       |                  | Sum   | Sum  | Sum    | Sum  | Sum  | Sum  |
|-------|------------------|-------|------|--------|------|------|------|
|       | **Species**      | 16    | 21   | 21     | 19   | 19   | 18   |
|       | **individual mL**| 68    | 160  | 211    | 224  | 147  | 145  |
|       | **Diversity Index (H)**| 2.63 | 2.51 | 2.21 | 2.55 | 2.25 | 2.44 |
|       | **Dominance Index (D)**| 0.078 | 0.061 | 0.057 | 0.064 | 0.061 | 0.075 |
|       | **Evenness Index (E)**| 0.630 | 0.495 | 0.432 | 0.473 | 0.454 | 0.491 |

In general, the average abundance of zooplankton in Lake Maninjau shows a balanced composition (figure 2).
The population of Rotifers from April to November appear to be declining (figure 3), this is might be due to the predation of Rotifers by Protozoan, Cladocera, Copepods, larvae of fish, and other aquatic organisms [14][15]. Whereas, the Protozoan and Cladocera populations fluctuate and Copepods relatively increases.

There are two food chain groups in the aquatic ecosystem, namely the grazing food chain and the detritus food chain. The two types of food chains complement each other and form a continuous cycle. The grazing food chain starts from the first food transfer process by herbivorous organisms through the grazing process. The first food in the form of phytoplankton and herbivores that make use of phytoplankton is zooplankton [16]. The first link in this food chain is phytoplankton which is the first source for all life in the waters. The end of the food chain is high-level consumers (such as fish and other consumers) and if they die will be detritus in aquatic ecosystems [13]. At the pyramid of food in...
waters (sea or lake) phytoplankton is the first food source of zooplankton or other herbivorous species that utilize phytoplankton. In the zooplankton community predation also occurs which is generally based on body size or ability to move. Protozoa will be preyed by rotifers, rotifers are preyed by cladocerans and also by copepods. Cladocera is preyed by copepods [10] [17] and copepods are preyed by young fish, small fish, or larvae of other aquatic animals. However, small fish or fish larvae not only prey on copepods, because there are types of copepods with the outer layer of the body is a hard skin layer and is not eaten by fish or fish larvae.

Analysis of zooplankton abundance in Lake Maninjau showed a fluctuating amount (figure 4). The existence of the zooplankton community in a habitat is influenced by various factors [1][9][18][19].

![Figure 4. The Abundance of Zooplankton in Lake Maninjau, 2018.](image)

The highest abundance of zooplankton was found in front of Rangge River mouth (Station 3) which ranged from 1.8 to 15.3 individuals.mL\(^{-1}\), while in the PN Area ranged from 0.9 to 11.7 individuals.mL\(^{-1}\) (Station 2) and in the outside PN area (Station 1) ranging from 1.5 to 13.0 individuals.mL\(^{-1}\). The highest abundance of zooplankton at station 3 is thought to be due to the intake of organic material carried from upstream and downstream of the river to the area. The high organic matter (nutrient) causes an increase in phytoplankton populations that serve as food for zooplankton [19][20].

Analysis of composition and structure of zooplankton community in Lake Maninjau (especially in the PN area) showed stable waters (E = 0.432 – 0.630), even distribution of species and found no dominant species (D = 0.061 – 0.078) with the level of species diversity moderate (H' = 2.21 – 2.63) (figure 5).

Generally, data from the analysis of water quality in Lake Maninjau shows conditions that still support zooplankton life (table 3). The pH of Lake Maninjau in the PN Area ranged from 8.08 to 8.68. The pH concentration of water can also affect the plankton and aquatic biota that live in it. At pH 4.5 – 5.5 can affect the composition and diversity of plankton, periphyton, and benthos in waters. In general aquatic biota lives and grows well at pH 7 – 8.5 [20]. The pH in the waters can affect the physiological organisms, including zooplankton, especially in enzymatic reactions in metabolism. Zooplankton can grow in a pH range of 5.6 – 9.4 [21].
The existence of zooplankton in water is very much influenced by the temperature of the water where it lives. Physiologically water temperature can affect fecundity, lifetime, and body size of adult zooplankton, even ecologically the temperature can affect the composition and abundance of zooplankton. Water temperature for zooplankton life ranges from 24 – 32°C with a tolerance of no more than 5°C. Optimal temperatures for zooplankton growth in the tropics generally range from 25 – 30°C [20]. The water temperature in Lake Maninjau ranges from 27.87 to 28.59°C is the ideal temperature to support zooplankton life. Dissolved oxygen is an important factor for the respiration of organisms in waters. The concentration of oxygen in the waters can affect the speed of metabolic reactions. Therefore the concentration of oxygen in the waters is very important for the growth and survival of zooplankton [20]. The concentration of dissolved oxygen in Lake Maninjau ranged from 6.34 to 7.61 mg.L⁻¹ which supports zooplankton's metabolic activity. 

Redox reactions (ORP) in ecosystems that show the activity of electron transfer from oxidants to reductants. At one time with an ORP value, more than 200 mV occurred under aerobic conditions while in anaerobic conditions the ORP value reached 800 mV. At that time, generally, it had an ORP
value in a range between 450 – 520 mV [20][22]. The ORP value at Lake Maninjau looks relatively low (42 – 107.41 mV) due to the high redox activity. ORP value in water systems is strongly influenced by the concentration of dissolved oxygen [23][24]. In redox reactions, oxidation of ions requires oxygen. The greater activity of this reaction is thought to cause a decrease in oxygen concentration which will affect the zooplankton respiration requirements in the lake. The results of the study [5] showed a relationship of redox reactions with the concentration of dissolved oxygen in the waters.

Natural waters have a conductivity value of around 20 – 1,500 μS.cm⁻¹ [22], which is negatively correlated with plankton abundance. Plankton cannot survive in water with high conductivity values and can cause a decrease in plankton abundance [14]. Based on observations, the conductivity values at Lake Maninjau ranged from 0.08 – 1.56 mS.cm⁻¹ (80 – 1,560 μS.cm⁻¹). Zooplankton has tolerance and adaptation to their environmental conditions [18]. Zooplankton also eats organic material (autochtonous), detritus in addition to phytoplankton as an energy source [25], so that zooplankton in lakes can maintain its population.

The value of Total Dissolved Solids (TDS) in Lake Maninjau is in the range of 0.05 – 0.12 mg.L⁻¹. This also shows that in these waters contain less salt in dissolved and ionized state and it is suspected that in the waters more organic material ions are not easily dissociated [20]. TDS value can affect the abundance of plankton especially phytoplankton because the higher TDS in waters will cause reduced light penetration so that the photosynthesis process will be disrupted and decreased abundance of phytoplankton which serves as a food source for zooplankton [26].

Turbidity values in Lake Maninjau range from 3.58 to 21.3 NTU indicating the level of turbidity in these waters. Turbidity in waters is greatly influenced by the number of suspended solids. An increase in turbidity value of 25 NTU in shallow and clear waters can reduce the primary productivity of waters by 13 – 50% and an increase in turbidity of 5 NTU in the lake will be able to reduce the value of primary productivity by 75% [23]. The turbidity value in Maninjau was 21.3 NTU in the front area of the Ranggeh River mouth where the water was relatively turbid because many soil particles and organic materials are carried by the current flowing into the river’s mouth and entering the lake [22]. This can be seen by the high concentration of total organic matter in the area (Station 3) which reaches 13.5 mg.L⁻¹ [4].

The results of the CCA analysis show that generally, almost all zooplankton species tend to cluster or concentrated in the center of the graph (figure 6). This shows that almost all zooplankton influenced by water quality variables in their habitat and there were no dominant zooplankton species found. There were no specific environmental variables that affect certain zooplankton species. It is suspected that there were interactions between variables of sampling time, location, and water quality.

Figure 6. CCA analysis of the interaction of environmental factors with the zooplankton community in Lake Maninjau.
The CCA analysis shows that water sampling outside the PN boundary area (1) and inside the PN area (2) in April is characterized by high pH and temperature and low turbidity and ORP. While in front of the mouth of Ranggeh River (3), it is characterized by high DO and TDS in April and July. Whereas the August water sampling in the PN area and in front of the mouth of Ranggeh River is characterized by high conductivity and turbidity. In general, water quality variables pH, temperature, turbidity, ORP, DO, and TDS affect the zooplankton community structure in Lake Maninjau. Earlier studies [18] [26] [27] state that several factors of lake water quality such as temperature, pH, DO, turbidity, ORP, and nutrition correlate with the presence of zooplankton communities in their habitat.

4. Conclusion

The structure of the zooplankton community in Lake Maninjau with a case study in the waters of the Nagari Sungai Batang consists of 3 genera of Protozoa, 13 genera of Rotifers, 5 genera of Cladocera and 1 genus of Copepods and larvae (Nauplius). Lake Maninjau is categorized to stable waters with moderate diversity, found no species that dominate and are evenly distributed.

5. References

[1] Suryanto and Umi 2009 J.Illmiah Perikanan dan Kelautan 1 pp 7-13
[2] Wulandari J, Afrizal S, and Nurdin J 2014 J. Biologi Universitas Andalas 3 (2) pp 63-67
[3] Nontji A 2017 Danau-Danau Alami Nusantara. Puslit Limnologi LIPI dan MLI, 1st ed. pp 26-33
[4] Syandri H, Azrita and Junaidi 2015 Proc. Pertemuan Ilmiah MLJ (ed.1) pp 1-11
[5] Syandri H 2017 Danau Maninjau Kemilau yang Telah Pudar (Padang: Bung Hatta University Press) p115
[6] Shield R J 1995 A Guide to Identification of Rotifers, Cladocerans and Copepods from Australian Inland Water Indentification Guide No. 3 Murray-Darling Freshwater Research Centre, Co-operative (Research Centre for Freshwater Biology) Presented at The Taxonomy Workshop Held at The Murray-Darling Freshwater Research Centre, Albury 8-10 February 1995, p 144
[7] Sutter M and Rissik D 2009 Plankton. A guide to their ecology and monitoring for water quality pp 157-179
[8] APHA 1992 Standard Methods for the Examination of Water and Wastewater 18th ed. (Washington D.C.: American Public Health Association)
[9] Help C H R, Peter M J H and Soetaert K 1998 J. Océanis 2 (4) pp 61-87
[10] Michael T 1986 Ecological Methods for Field and Laboratory Investigations (USA: Tata McGraw-Hill Publishing)
[11] Odum E P 1993 Dasar-Dasar Ekologi Ed Sriagendro B, translator Samigan T (Yogyakarta: Gajah Mada University Press) p 697
[12] Magurran A E 1988 Ecological Diversity and its Measurement (41 William Street, Princeton, New Jersey: Princeton University Press) p 179
[13] Sheldon A L 1969 J. Ecology 50 (3) pp 466-467
[14] Leony B 2017 J. Limnol. 76 (1) pp 85-93
[15] Fernando C H 1979 J. Bull. Fish. Res. Stn. 29 pp 11-54
[16] Hernández J S, Cobo F and Amundsen A 2015 PLOS ONE-Journal Pone November 16
[17] Gutierrez M F, Floreira R M and Débora A C 2012 J. Marine and Freshwater Behavior and Physiology, 1st pp 1-15
[18] Augusta T S and Evi S U 2014 J. Ilmu Hewani Tropika 3 (2) pp 30-35
[19] Koenraad M K, Declerck S, Geenens V, Van Wiche J, Degans H, Vandekerkhove J, en van der Gucht K, Vloemans N, Rommens W, Rejas D, Urrutia R, Sabke K, Gillis M, Declerck K, De Meester L and Vyverman W 2003 J. Aquatic Ecology 37 pp 137 – 150
[20] Effendi H 2003 Telaah Kualitas Air bagi Pengelolaan Sumber Daya dan Lingkungan Perairan (Penerbit PT Kanisius) p 256
[21] Sunarto 2008 Karya Ilmiah Fakultas Perikanan dan Ilmu Kelautan Universitas Padjadjaran Bandung (Bandung: Universitas Padjajaran) pp 1-39
[22] Boyd C E 1990 Water Quality in Ponds for Aquaculture (Birmingham Alabama: Publishing Co.) p 482
[23] Danielsdottir M G, Brett M T and Arhonditsi G B 2007 J. Hydrobiologia 589 pp 29-41
[24] Simanjuntak M 2009 J. Fish. Sci XI (1) pp 31-45
[25] Toruan R L 2015 J. Limnotek 22 (2) pp 178-188.
[26] Novia R, Adnan and Ritonga 2016 J. Depik 5 (2) p 67-76
[27] Faturohman I, Sunarto and Nurruhwati I 2016 J. Perikanan Kelautan VII (1) pp 115-122

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