ICHTHYOFAUNA OF ENDEMIC FISH IN TOWUTI LAKE, LUWU TIMUR REGENCY, SOUTH SULAWESI, INDONESIA

ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

Aims :The aims of this study to determine the biodiversity of endemic fish in Lake Towuti, Luwu Timur Regency South Sulawesi, Indonesia.
Study Design: The research was conducted by survey
Place and Duration of study :The research was carried out in February until March 2021 in Tanjung Timbala; Tanjung Lengkobutanga; Tanjung Bakara; Tanjung Saone and. Tanjung Tominanga at Lake Towuti, Luwu Timur Regency South Sulawesi, Indonesia.
Methodology : Fish samples were carried out every week using a trap net for 8 weeks. Fish samples obtained from each station were separated according to species. Fish samples were preserved with 4% formalin and then immersed in 70% alcohol before species identification was conducted. Data analysis in this research used descriptive statistics.
Results: The endemic fish species was found is telamtherina bonti *Telmatherina bonti, Telmatherina celebensis, Paratherina striata, Tominanga sanguicauda, Tominanga aurea Oryzias profundicola, Oryzias matanensis, Oryzias marmoratus, Mugilogobius hitam, Glossogobius flavipinnis, Glossogobius matanensis* and *Dermogenys megarhamphus.* The percentage of endemic fish caught at each station on Lake Towuti was different. The water quality parameters obtained are as follows Temperature: 26.40^{0}C-30.30^{0}C, pH: 6.35-9.03, dissolved oxygen (DO):6.25-8.95 mg/L and NO3-N: 0.023-0.066 mg/L.This water quality were suitable for the survival and growth of endemic fish.
Conclusion: Endemic fish families were obtained such as Telmatheridae, Adrianichthyidae, Gobiidae and Hemiramphidae and a total of twelve endemic fish species were found in this study. The number of endemic fish was found to be different at the station. Water quality parameters play an important role in the distribution and existence of endemic fish in Lake Towuti.

Keywords: endemic fish, diversity, ichthyofauna,Towuti Lake,

1. INTRODUCTION

Indonesia is unique and interesting for endemic fish species because it is located along the equator which was influenced by the biogeography of the Asian continent and the Australian continent [1]. The endemic fish in Indonesia have characteristics of different ecologically and climatologically [1,2]. Lake endemics fish in Sulawesi are known from Lakes Poso, Lindu and the Malili Lakes system in Central Sulawesi [3,4,5]. In other regions of Indonesia which are good habitats for various endemic fish species such as Lake Sentani [6].

In Malili Lake Complex at South Sulawesi, Indonesia, three lakes are interconnected in a casacade, namely Matano, Mahalona and Towuti lakes. Lake Matano in the upper reaches, Lake Mahalona in the middle, and Lake Towuti in the lower reaches. Lake Matano and Lake Towuti are ancient lake in South Sulawesi. Lake Towuti were covered an area of 561.1 km^2, maximum depth of 203 m and it was located at an altitude of 293 m asl [7]. There are 15 endemic fish species were found in Lake towuti [8], 20 species [9] and 17 species [5]. These endemic fish were included in the family of Telmatherinidae, Adrianichthyiidae, Zenarchopteridae, Phallostethidae, Eleotridae, Gobiidae, Terapontidae, Anguillidae [4,5]. Endemic fish in Towuti Lake were used as a source of food called "*pangkilang*".

Lake Towuti has become one of the hotspots of biodiversity, it needs attention because it was increased of threatened [4,10]. These condition is caused by several factors such as overfishing and intensive fishing [8], introduced fish or invasive fish [11, 12], the waters of Lake Towuti were polluted. from saw-mill waste and forest logging both legally and illegally [13]. The extinction of freshwater fish stocks in waters is largely due to habitat destruction / loss (35%), the introduction of exotic species (30%) and overexploitation of species (4%) and the rest due to water pollution and global warming [14].

All of these things in the waters of Lake Towuti were reduced the population and diversity of endemic fish and this can lead to extinction [13]. The condition of the endemic fish population in Lake Towuti in 1993 was found 52 species and in 2003 only 28 species were found [12]. In the Malili Lake Complex, 18 endemic fish species were categorized as endangered fish species based on International Union for Conservation of Nature (IUCN), 2001 [10] and need to be protected by law [15] and protection of their species and habitat through conservation [16,17], and domestication [18]. The existence of endemic fish both from an economic and ecological perspective in Lake Towuti is very important, therefore the aims of this study to determine the biodiversity of endemic fish in Lake Towuti, Luwu Timur Regency, South Sulawesi, Indonesia.

2. MATERIAL AND METHODS

2.1. Study area

The research was conducted in Lake Towuti, East Luwu Regency, South Sulawesi Province in February until March 2021. The research stations in Lake Towuti are A: Tanjung Timbala (2'42.5720'S 121'25.7850'E), B: Tanjung Lengkobutanga (2'42.6150'S 121'26.3990'E), C: Tanjung Bakara (2'41.3470'S 121'25.5330'E), D: Tanjung Saone (2'38.5840'S 121'27.7510'E), E: Tanjung Tominanga (2'39.2770'S 121'29.9350'E) (Figure 1).

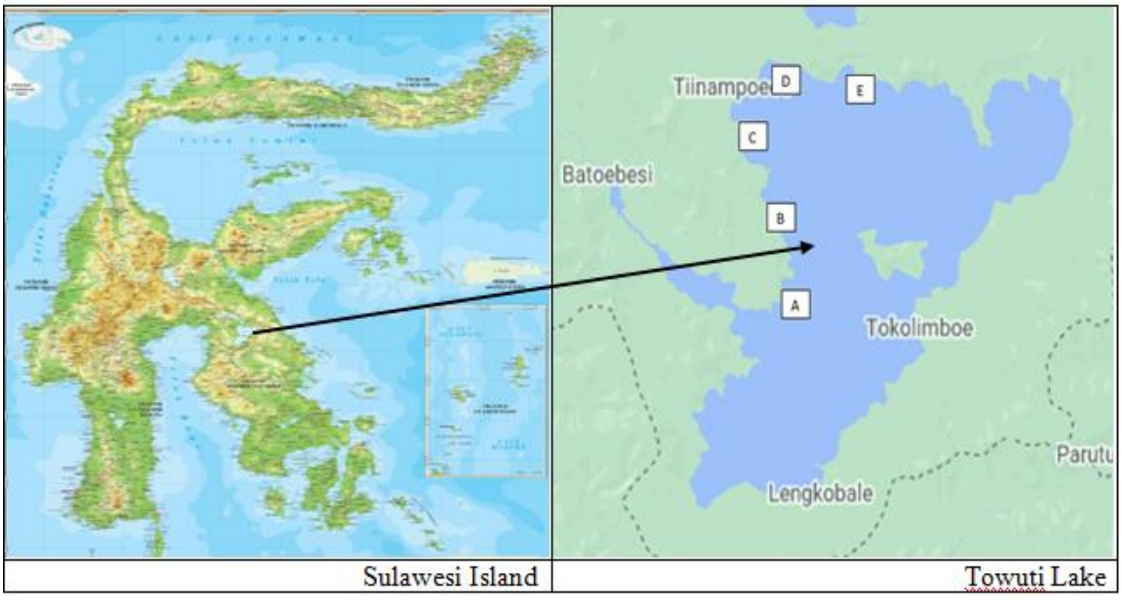

Fig. 1. Research location: A: Tanjung Timbala B: Tanjung Lengkobutanga, C: Tanjung Bakara, D: Tanjung Saone, and E: Tanjung Tominanga

2.2.Materials

The research materials were samples of endemic fish, 4% formalin and 70% alcohol. The equipment used is a boat, seser (fishing gear), a Global Postioning System (GPS), cool box, freezer, zoom (magnifying glass), plastic bags, camera, pH meter and DO meter.

2.3. Methods

Fish samples were taken at each research station in Lake Towuti. Fish samples were caught weekly using a seser is a local name (trap net) for eight weeks. The number of fish species were caught at each station is counted. Fish samples were preserved with 4% formalin and then immersed in 70% alcohol before species identification was conducted. Identification of species was carried out according to [11,19,20,21, 22]. Data analysis in this research used descriptive statistics.

3. RESULTS AND DISCUSSION

3.1. Composition of Endemic Fish Species

The species of fish sampled at the research station in Lake Towuti, the endemic fish that were collected of twelve species belonging to four families (Table 1) and (Figure 2).

Table 1. Endemic fish species at each research station

No	Family	Species	A	B	C	D	E
1	**Telmatheridae**	*Telmatherina bonti*	+	+	+	+	+
2		*Telmatherina celebensis*	+	+	+	+	+
3		*Paratherina striata*	+	+	+	+	+
4		*Tominanga sanguicauda*	+	+	+	+	+
5		*Tominanga aurea*	+	+	+	+	+
6	**Adrianichthyidae**	*Oryzias profundicola*	+	+	+	+	+
7		*Oryzias matanensis*	+	+	+	+	+
8		*Oryzias marmoratus*	+	+	+	+	+
9	**Gobiidae**	*Mugilogobius hitam*	-	+	+	+	+
10		*Glossogobius flavipinnis*	+	-	+	+	-
11		*Glossogobius matanensis*	+	-	+	+	-
12	**Hemiramphidae**	*Dermogenys megarhamphus*	+	+	-	-	-

Station description. A: TanjungTimbala, B: Tanjung Lengkobutanga, C: Tanjung Bakara, and D: Tanjung Saone, E: Tanjung Tominanga

	*Oryzias profundicola* Status IUCN Red List: https://www.iucnredlist. org/species/15578/90980796 Downloaded on 24 April 2021.
	*Oryzias matanensis* Status IUCN Red List: https://www.iucnredlist. org/species/15575/90980691 Downloaded on 24 April 2021.
	*Oryzias marmoratus* Status IUCN Red List:https://www.iucnredlist. org/ species/15574/90980644 Downloaded on 24 April 2021
	Paratherina striata Status IUCN Red List: https://www.iucnredlist. org/species/16195/90979932 Downloaded on 24 April 2021
	Telmatherina bonti Status IUCN Red List:https://www.iucnredlist. org/species/21572/90980062 Downloaded on 24 April 2021
	Telmatherina celebensis Status IUCN Red List:https://www.iucnredlist. org/species/21573/90980085 Downloaded on 24 April 2021
	Tominanga sanguicauda Status IUCN Red List:https://www.iucnredlist. org/species/21980/90980344 Downloaded on 24 April 2021

	Tominanga aure Status IUCN Red List: https://doi.org/10.2305/IUCN.UK.20192.RLTS.T21979A90980310.en . Downloaded on 24 April 2021
	Status IUCN Red List:https://www.iucnredlist.org/species/40707/90982306 Downloaded on 24 April 2021
	*Glossogobius matanensis* Status IUCN Red List:https://www.iucnredlist.org/species/9254/90982434 Downloaded on 24 April 2021
	*Mugilogobius hitam* Status IUCN Red List:https://www.iucnredlist.org/species/90982932/90982936 Downloaded on 24 April 2021
	*Dermogenys megarhamphus* Status IUCN Red List:https://www.iucnredlist.org/species/90981984/90981998 Downloaded on 24 April 2021

Fig. 2. Endemic fish species were found in Lake Towuti

Endemic fish species from the Telmatherinidae family that were found during the study were : *Telmatherina bonti, Telmatherina celebensis, Paratherina striata, Tominanga sanguicauda, Tominanga aurea* in all research stations, while the Adrianichthyidae family included *Oryzias profundicola, Oryzias matanensis*, and *Oryzias marmoratus*. The family Gobiidae included *Mugilogobius hitam* at stations B, C, D, E; *Glossogobius flavipinnis* was found at stations A, C and D; *Glossogobius matanensis* was found at stations A, C and D. The Hemiramphidae family was only found at *Dermogenys megarhamphus* at stations A and B (Figure 1).

The results of research conducted at Lake Towuti by [8] found several endemic fish such as *Glossogobius intermedius, Glossogobius celebius, Glossogobius flavipinnis, Dermogenys megarhamphus, Dermogenys sp, Oryzias marmoratus, Telmatherina bonti, Telmatherina celebensis, Paratherina sp, Telamtherina sp* (red tail), *Telmatherina sp* (yellow tail), and *Tominanga sanguicauda*. Meanwhile, the article report on endemic fish in Lake Towuti by

[10] as follows: *Dermogenys megarhamphus, redigobius penango, Glossogobius flavipinnis, Glossogobius biocellatus, Glossogobius intermedius, Glossogobius celebius, Mugilogobius adeia, Mugilogobius lepidotus, Mugilogobius rexi, Mugilogobius hitam, Telamtherina bonti, Telmatherina celebensis,Telamtherina opudi,Telamtherina sarasinorum, Tominanga aurea, Tominanga sanguicauda, Paratherina cyanea, Paratherina labosa, Paratherina striata, Oryzias hadiatyae, Oryzias profundicola, Oryzias marmoratus*, *Nomorhamphus kolonodalensis, Nomorhamphus magarrhamphus*, *Nomorhamphus towoetii, Nomorhamphus weberi.* The results of barcoding DNA analysis of the Telamatherinidae family found several endemic fish in Lake Towuti, including: *Parathrina striata, Paratherina wolterecki, Paratherina cyanea, Telmatherian celebensis, Telmatherina bonti, Telmatherina opudi, and the genus Tominanga-Tominanga sanguicauda* [23], 2019). Lake Towuti is an Important habitat for endemic fish species in Indonesia [3,4,8,10]

The spatial and temporal distribution of fish is limited by various factors such as behavior in habitat selection, physiological needs, and interactions with the environment [24].Fish distributed from different habitats because of their ability to forage for food and spawning grounds [25].The pH, total phosphorus, total organic matter, aquatic vegetation and suspended solid with sediment play important role for distribution and existence of fish fauna in Lake Towuti [26].

Introduced fish species were found in Towuti Lake such as Oreochromis *mossambicus, Oreochromis niloticus, Chana striata, Cyprinus carpio, Clarias batrachus, Osteochilus hasselti, Osphronemus gouramy* and *Trichogaster trichopterus* [10]. Furthermore, According to [27] introduced fish species were found in Lake Towuti namely *Chana striata, Oreochromis mossambicus,Anabas testudineus, Trichopodus pectoralis and Trichopondus trichopterus.* In addition, endemic crustaceans were found in the Malili Lake Complex, such as: *Caridina dennerly; Caridina woltereckae; Caridina masapi; Caridina holthuisi*. Malili Lake were found endemic crabs such as *Parathelphusa pantherina, Parathelphusa ferruginea, Syntripsa flavichela dan Nautilotelphusa zimmeri*. In addition, there are 28 species of *Tylomelania* of gastropods were endemic in the Malili Lake Complex, including *Tylomelania patriarchalis, Tylomelania. gemmifera and Tylomelania toradjarum* [28].

3.2. Percentage of Endemic Fish

Percentage of endemic fish caught at each station in Lake Towuti in Figure. 3a, b, c, d, e.

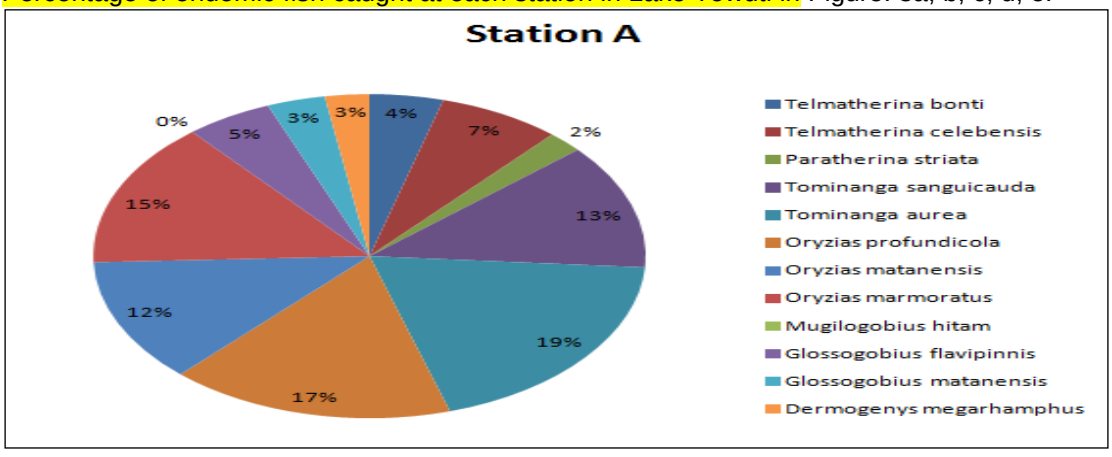

Fig. 3a.Percentage of endemic fish caught at A station in Lake Towuti

Station A, the most endemic fish as follows: *Tominanga aurea> Oryzias profundicola> Oryzias marmoratus> Tominanga sanguicauda> Oryzias matanensis> Telmatherina celebensis> Glossogobius flavipinnis> Telmatherina bonti> Glossogobius matanensis> Dermatherina striogenys megarhampobius hitam.*

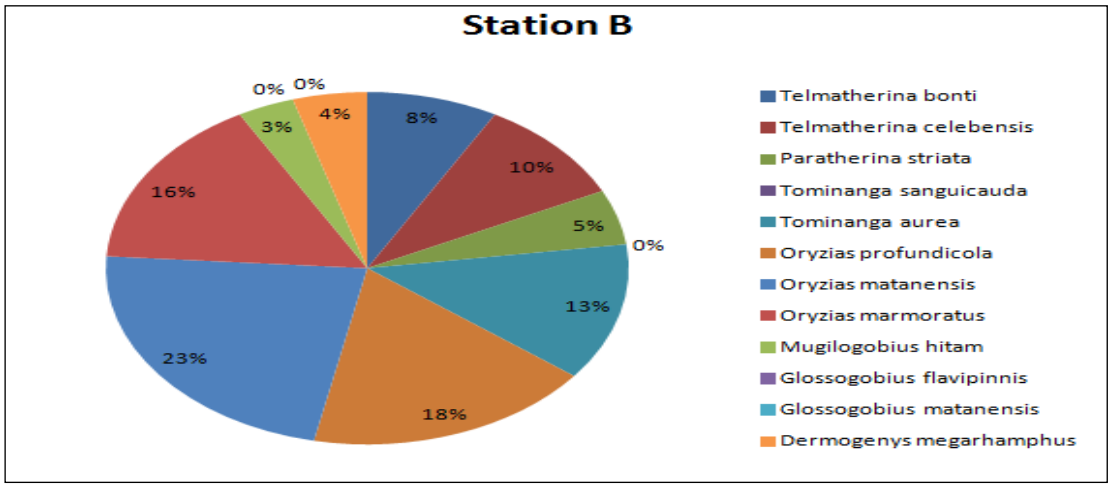

Fig. 3b.Percentage of endemic fish caught at B station in Lake Towuti

Station B, the most endemic fish as follows: *Oryzias matanensis> Tominanga sanguicauda> Oryzias profundicola> Oryzias marmoratus> Tominanga aurea> Telmatherina celebensis> Telmatherina bonti> Paratherina striata> Dermogenys megarhamphus> Mugilogobius hitam*

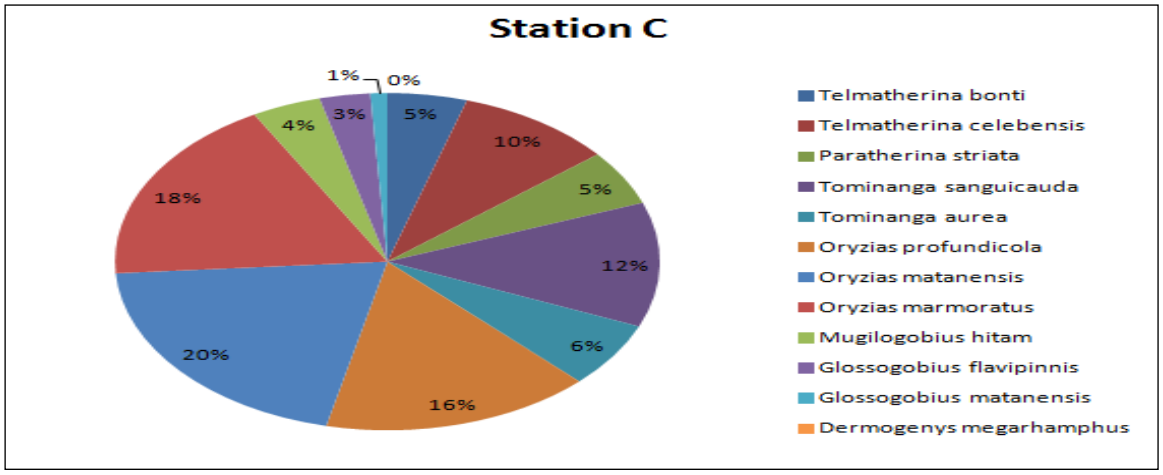

Fig. 3c.Percentage of endemic fish caught at C station in Lake Towuti

Station C (Fig.3c), the most endemic fish as follows: *Oryzias matanensis> Oryzias marmoratus> Oryzias profundicola> Tominanga sanguicauda> Telmatherina celebensis> Tominanga aurea> Paratherina striata> Telmatherina bonti> Mugilogobius hitam> Glossogobiusflavipinnis> Glossogobius matanensis*

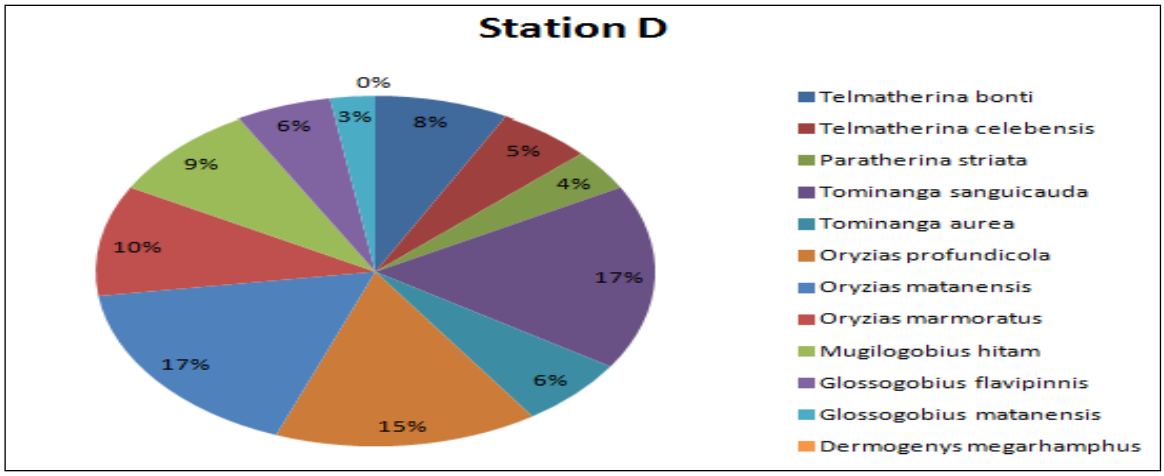

Fig.3d. Percentage of endemic fish caught at D station in Lake Towuti

Station D (Fig.3d), the most endemic fish as follows: *Tominanga sanguicauda> Oryzias matanensis> Oryzias profundicola> Oryzias marmoratus> Mugilogobius hitam> Tominanga aurea> Telmatherina bonti> Telmatherina celebensis = Glossogobius flavipinnis> Glossogobius matanensis.*

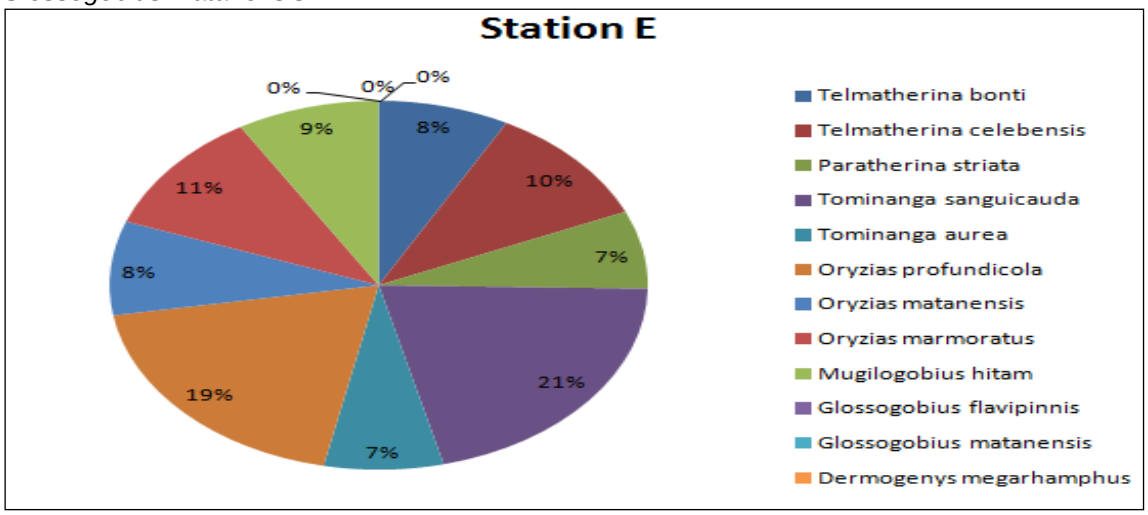

Fig. 3e.Percentage of endemic fish caught at E station in Lake Towuti

Station E (Fig.3e), the most endemic fish as follows: *Tominanga sanguicauda> Oryzias profundicola> Oryzias marmoratus> Telmatherina celebensis> Mugilogobius hitam> Oryzias matanensis> Telmatherina bonti> Tominanga aurea> Paratherina striata*

3.2. Water Quality

The results of water quality measurements at each research station were shown in Table 1.

Table 1. Water quality at each research station

No	Parameter	Stasion A	Stasion B	Stasion C	Stasion D	Stasion E
1	Temperature (^{0}C)	26.40-30.10	27.40-29.50	28,40-30,25	27,50-30,30	28,40-30,10
2	pH (unit)	6.35-7.87	6.67-8.78	7.37-8.27	6.82-9.03	7.35-8.58
3	DO (mg/L)	6.57-8.85	6.25-8.90	6.60-8.85	6.58-8.58	6.57-8.95
4	NO_3-N (mg/L)	0.023- 0.056	0036-0.060	0.044-0.065	0.019-0.034	0.043- 0.066

The results of temperature measurement during the study ranged from 26.40 to 30,30^{0}C (Table 1).The optimum temperature for fish growth in general is around 25-30^{0}C [29] . Temperature is one of the determinants of fish distribution, fish behavior in selecting habitats, and determinants of dissolved oxygen [30,31].

The content of dissolved oxygen parameters during the study ranged from 6.25 to 8.95 mg/l (Table 1).. The content of dissolved oxygen levels in fluidized waters daily and seasonally depends on the mixing and movement of water masses, photosynthesis, respiration and waste that enters the water [32]. Dissolved oxygen is one of the water parameters that determines the quality of a water,
The results of pH measurements during the research at Lake Towuti ranged from 6.35 to 9.03 (Table 1). The degree of acidity or alkalinity (pH) was considered an ecological factor that limits the activity and distribution of aquatic organisms, because changes in pH was associated with changes in other physico-chemical factors [33]. The ideal water pH for fish life ranges from 6.5 to 7.5. Water pH less than 6 or more than 8.5 needs to be watched out because there may be contamination of pollution [32] .

In Lake Towuti, $N0_3$ levels were found to ranged from 0.0019 to 0.066 mg/l (Table 1). In water, the form of nitrogen can be in the form of inorganic and organic nitrogen. Inorganic nitrogen consists of ammonia (NH_3), ammonium (NH_4), nitrite (NO_2), nitrate (NO_3) and nitrogen molecules (N_2) in the gaseous form [32]. Excessive levels of nitrogen compounds in waters can cause pollution problems. Based on the research results, it shows that the water quality of Lake Towuti is suitable for endemic fish.

4. CONCLUSION

Endemic collected fish were belonging to four families namely: Telmatheridae, Adrianichthyidae, Gobiidae and Hemiramphidae and a total of twelve endemic species were recorded in this study. The number of endemic fish was found to be different at the station. Water quality parameters play an important role in the distribution and existence of endemic fish in Lake Towuti.

ACKNOWLEDGEMENTS

All the authors thank you to Mr. Agus Tornando for showing endemic fish locations in Lake Towuti and helping to catch fish samples

COMPETING INTERESTS

There is no conflict of interest among all the authors.

AUTHOR'S CONTRIBUTIONS

This work was carried out in collaboration between all authors. All author designed the study. Author J,N and AM sourced for the samples while authors MNN and AT managed the

analyses. Authors J,H and E wrote the first draft of the manuscript. All authors read and approved the final manuscript.

REFERENCES

1. Herder F , Schwarzer J, Pfaender J. , Hadiaty RK, Schliewen UK. Preliminary checklist of sailfin silversides (Telostei: Telmatherinidae) in the Malili lakes of Sulawesi (Indonesia), with a synopsis of systematics and threats . Verhandlungen der Gesellschaft für Ichthyologie. 2006; 5 , 139 –63.
2. Hutama AA, Hadiaty RK dan Hubert N. Biogeography of Indonesia Freshwater Fishes:Current Progress. Treubia. 2016; 43:17-30
3. Kottelat M. The fishes of the inland waters of southeast Asia: a catalogue and core bibiography of the fishes known to occur in freshwaters, mangroves and estuaries. Raffles Bulletin of Zoology Supplement. 2013; 27: 1-663.
4. Parenti LR. Endemism and conservation of the native freshwater fish fauna of Sulawesi, Indonesia. In: Simanjuntak C P H, Zahid A, Rahardjo M F, Hadiaty KH, Krismono, Haryono and Tjakrawidjaja AH (*eds*). Prosiding Seminar Nasional Ikan VI & Kongres Masyarakat lktiologi Indonesia III. 8-9 Juni 2010, Cibinong.. 2011.
5. Hadiaty RK. Taxonomical status of endemic freshwater ichthyofauna of Sulawesi. Jurnal Iktiologi Indonesia. 2018; 18(2):175-190.
6. Astuti LP, Umar C, Warsa A. Fish diversity in Sentani Lake. Bawal. 2006; 1(3):77-82.
7. Haffner GD, Hehanussa PE, Hartoto DI. The Biologi and Physical Processes of Large of Indonesia: Lakes Matano and Towuti. In.M.Munawar and R.E Hecky (eds). The Great Lakes of The Wolrd (GLOW): Food-web, helath and intergrity. Netherland. 2001;183-192.
8. Samuel, Husna, Makmur S. Capture fisheries in lake of Matano, Mahalona and Towuti, South Sulawesi.Jurnal Penelitian Perikanan Indonesia.2009;15 (1):123-131.
9. Tahyo, DWH, Husnah D, Oktaviani AS, Nastit, SE, Purnamaningtyas, Nugroho D. Research on the biodiversity of fish in inland waters in Sulawesi. Presented at the Fisheries Feed Meeting. Marine and Fisheries Research Agency. Capture Fisheries Research Center. Jakarta 85 pp. 2005.
10. Prianto E, Kartamihardja ES, Umar C, Kasim K. Fish resources management in malili lake system, south sulawesi province. Jurnal Kebijakan Perikanan Indonesia. 2016;8 (1):41-52.
11. Herder F, Schwarzer J, Pfalender J, Hadiaty RK, Schliewen UK. Preliminary Checklist of sailfin silversides (Teleostei:Telamtherinidae) in the Malili Lakes on Sulawesi. Verbandlungen der Gesellschaht for Ichthyologie Band. 2006;5:159-163.
12. Syafei LS, Sudino, S. Invasive Alien Spesies, sustainability aquatic biodiversity challenges. Jurnal penyuluhan perikanan dan kelautan . 2018; 12 (3)145-161
13. Nasution, SH, Lukman, Sulastri, Koeshendrajana, Ridwansyah I, Sugiarti, Nafsyah E. Directions and concentration of fish resources in Lake Towuti, South Sulawesi. Proceedings of the Presentation of Research Results from the Center for Geotechnology Research, LIPI, Directions and Concentration of Fish Resources in Lake Towuti, South Sulawesi. Proceedings of the Presentation of Research Results from the LIPI Geotechnology Research Center, "The Role of Geotechnical Research to Support Sustainable Development in Indonesia. 2014; 615-631
14. Reid WV, Miller KR. Keeping option alive. The Scientific basis for conserving biodiversity.World Recources Institute,Washington D.C.128 p. 989.
15. Suwelo, I.S. 2005. The Rare and Threatened Fish Species Should be Protected by Law).Jurnal ilmu-ilmu perairan dan perikanan Indonesia. 2005;12 (2): https://journal. ipb.ac.id/index.php/j ippi/ issue/view/ Desember%202005

16. Hadie LE, Hadie W Kristanto AH. Implications of Conservation Management in the Development of Endemic Fish Species Cultivation. Proceedings of the National Fish Seminar VI & Indonesian Ectiology Community Congress III Cibinong 8-9 June 2010; 351-357.
17. Syafei LS. Fish biodiversity and conservation in inland waters. Jurnal Penyuluhan Kelautan dan Perikanan Indonesia. 2017;11 (1):48-62.DOI: 10.33 378/jppik. v11i1.85.
18. Jayadi J, Husma A, Nursahran, Ardiansyah, Sriwahidah. Domestication of celebes rainbow fish (*Marosatherina Ladigesi*). AACL Bioflux. 2016; 9(5): 1067–1077.
19. Kottelat M. Saifin silversides (Pisces: Telamtherinidae) of Lake Matano, Sulawesi, Indonesia, With descriptions of six new species. Ichthyological Exploration of Freshwaters. 1991;1(4): 321-344.
20 Kottelat M, Whitten AJ, Kartikasari SN, Wirjoatmodjo S. Freshwater Fishes of Western Indonesia and Sulawesi. Periplus Editions, Hong Kong.1993.
21. Nelson JS. Fishes of the world. 4th ed.Hoboken (USA): Jon Wiley & Sons. 2006.
22. Said DS, Hidayat. Freshwater Ornamental Fish Nusantara. LIPI Pres, Jakarta. 238 pp. 2015
23. Jayadi J, Ilmiah I, Hadijah S, Kasnir M, Roslim DI. DNA barcoding of Telmatherinidae family in Lake Towuti, South Sulawesi, Indonesia. AACL Bioflux. 2019;12(4):1208-1215.
24. Nasution SH, Sulistiono, Syafei DS, Hayani GS. Spatial and temporal distribution of the Rainbow celebensis endemic fish (*Telmatheina celebensis* Boulenger) in Lake Towuti, South Sulawesi. Jurnal Penelitian Perikanan Indonesia. 2007;13(2):95-104.
25. Nur M, Rhardjo MF, Simanjuntak CPH. Iktiofauna di daerah aliran Sungai Maros Provinsi Sulawesi Selatan. SNIP2D JAMBI 2019; 42-52. http://iktiologi-indonesia.org/wp-content/uploads/2020/02/Nur-et-al.-2019.pdf
26. Nasution SH, Sulastri S, Muchlisin ZA. Habitat characteristics of Lake Towuti, South Sulawesi, Indonesia-The home of endemic fishes. AACL Bioflux . 2015; 8(2):213-223.
27. Wirjoatmodjo S, Sulistiono, Rahardjo MF, Suwelo IS, Hadiaty RK. Ecological distribution of endemic fish species in lakes Poso and Malili Complex, Sulawesi Island. Funded by Asean Regional Center fo Biodiversity Conservation and the European Commission, 30 pp. 2003.
28. Von Rintelen TV, von Rintelen K, Glaubrecht M, Schubart CD, Herder F. Aqautic biodiversity hotspots in Wallacea: the species flocks in the ancient lakes of Sulawesi, Indonesia. In (eds. D. J. Gower *et a*l.): Biotic Evolution and Environmental Change in Southeast Asia. University Press. The Systematic Association 2012;290–316.https:// www.zfmk.de/dateien/atoms/files/ rintelenetal ch12_12.pdf
29. Boyd, CE. Water quality management in pond fish culture for aquaculture experimental station. Auburn University. Alabama. 1979.
30. Lagler KF, Bardach JE, Miller RR, Passino DRM. Ichthyology 2nd Ed. John Wiley & Sons, New York. 1977.
31. Krebs CJ. Ecological Methodology. Harper and Row Publisher, New York. 652. 1989.
32. Effendi H. Assessment of Water Quality for Management of Aquatic Resources and Environment.Yogyakarta. Kanisius.2003
33. Boyd, C.E. Water quality in ponds for aquaculture. Agriculture Experiment Station, Auburn University, Alabama, 482 p. 1990.