Biosystems Diversity

ISSN 2519-8513 (Print)
ISSN 2520-2529 (Online)
Biosyst. Divers.

New record of Sumatran barb (*Puntigrus tetrazona*) as an introduced species in Lake Toba, Indonesia: Invasiveness risk

A. S. Batubara*, M. Muliari**, B. Manurung*, H. Sipahutar*, Y. Akmal***, I. Irfannur***, S. Maulizar****, F. M. Nur*****, Y. E. Ritonga*, K. Lubis*

** Universitas Negeri Medan, Medan, Indonesia*
*** Universitas Malikussaleh, Aceh Utara, Indonesia*
**** Universitas Almuslim, Bireuen, Indonesia*
***** Universitas Gadjah Mada, Yogjakarta, Indonesia*
****** Research Center for Biosystematics and Evolution, National Research and Innovation Agency, Cibinong, Indonesia*

Article info
Received 04.12.2024
Received in revised form 21.01.2025
Accepted 15.02.2025

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia. Tel.: +62-852-606-147-36. E-mail: agungsbb@unimed.ac.id

Department of Marine Science, Faculty of Agriculture, Universitas Malikussaleh, Aceh Utara, Indonesia. Tel.: +62-852-601-401-15. E-mail: muliari@unimal.ac.id

Department of Aquaculture, Faculty of Agriculture, Universitas Almuslim, Bireuen, Indonesia. Tel.: +62-852-604-946-48. E-mail: yusrizalakmal@umuslim.ac.id

Graduate Program of Biol-ogy, Faculty of Biology, Universitas Gadjah Mada, Yogjakarta, Indonesia. Tel.: +62-895-601-576-609. E-mail: siti-maulizar22@gmail.com

Research Center for Biosystematics and Evolution, National Research and Innovation Agency, Cibinong, 16911, Indonesia. Tel.: +62-852-479-555-28. E-mail: firmanmn19@gmail.com

Batubara, A. S., Muliari, M., Manurung, B., Sipahutar, H., Akmal, Y., Irfannur, I., Maulizar, S., Nur, F. M., Ritonga, Y. E., & Lubis, K. (2025). New record of Sumatran barb (Puntigrus tetrazona) as an introduced species in Lake Toba, Indonesia: Invasiveness risk. Biosystems Diversity, 33(1), e2504. doi:10.15421/012504

Lake Toba is an important habitat for native Indonesian fish species, but in recent years it has experienced pressure due to invasive introduced fish species. Introduced fish species that have been identified include *Amphilophus labiatus*, *Aplocheilus panchax*, *Cyprinus carpio*, *Mystacoleucus marginatus*, *M. padangensis*, *Oreochromis mossambicus*, *O. niloticus*, and *Parambassis siamensis*, while a newly recorded species has been discovered, namely *Puntigrus tetrazona*. Therefore, data are needed regarding the distribution, density, growth pattern, and risk of invasiveness of this species in Lake Toba as a basis for future management. This research uses an exploratory method. The frequency index value of *P. tetrazona* reached 70%, where absences were found in three locations, namely Ajibata, Silalahi, and Tongging. Population density values show that *P. tetrazona* has average value reaching 0.08 ind./m^2, where the highest density was found in Muara reaching 0.39 ind./m^2. The results of the Fish Invasiveness Screening Test (FIST) analysis showed that *P. tetrazona* was within the moderate risk category for the biodiversity of Lake Toba with frequency distribution (FD) values reaching 50%. The results of the length-weight relationship analysis of *P. tetrazona* showed a value of 3.027 (isometric growth pattern). The relative weight (Wr) condition factor showed a value of 102.96, which indicates a stable condition. The growth pattern values indicate that Lake Toba is a suitable habitat for *P. tetrazona*. Available food sources and a low level of competition are beneficial for *P. tetrazona* in this new habitat. The moderate risk posed by *P. tetrazona* to biodiversity in Lake Toba could possibly turn into a high risk if the *P. tetrazona* population is not controlled. Moreover, if the species that are natural enemies of this fish do not yet exist in Lake Toba, then in the next few years the population of *P. tetrazona* could experience an explosion. This will add pressure and threats to the survival of native fish species in Lake Toba, namely the *Neolissochilus* and *Tor* groups. The results of this research are useful for managing the population of *P. tetrazona* as a newly recorded species in Lake Toba, North Sumatra, Indonesia.

Keywords: native; management; density; biodiversity; condition.

Introduction

Introduced fish species have been brough to Indonesia since the 19th century with the aim of providing commodities for consumption, ornamentation, and eradicating disease vectors (Bondad-Reantaso et al., 2005; Valen et al., 2023). It is recorded that every year introduced fish species continue to increase, especially ornamental fish species (Muchlisin, 2012). This correlates with the pattern of increasing public interest in ornamental fish. So the trade in introduced fish species has an important role in the socio-economics of society.

The existence of introduced fish species is already in an alarming condition in Indonesia. Introduced fish species whose behavior disturbs native fish species and are aggressive turn into invasive fish species (Bajer & Sorensen, 2010). Although some introduced fish species are not a nuisance, under certain conditions they can also become invasive due to uncontrolled population explosions (Lusk et al., 2010). A population explosion can cause introduced fish to require higher food sources and thus become competitors to native fish species (Gozlan et al., 2010). Limited adaptation means that native fish species cannot compete with invasive fish, so native fish species tend to avoid them and turn to other food sources (Mills et al., 2004). Unfortunately, new food sources do not necessarily meet the nutritional needs of native fish species, instead causing growth to be disrupted. This will affect fish reproductive performance and cause fish to have late gonad maturity, decreased fecundity, decreased fertility, and difficulty finding males/females who are ready to spawn (Izquierdo et al., 2001). In the short term, the population of native fish species will decline drastically, and if there are no management efforts, native fish species will become extinct in the long term.

Introduced fish are not only species that enter from outside Indonesia, for native species that enter non-biogeographic habitats are also introduced fish. This has happened in Lake Toba, apart from being invaded by non-native Indonesian fish, it has also been invaded by native fish whose distribution is not in Lake Toba. Non-native fish that have been identified include *Amphilophus labiatus*, *Cyprinus carpio*, *Oreochromis mossambicus*, and *O. niloticus*, while native fish are *Aplocheilus panchax*, *Mystacoleucus marginatus*, *M. padangensis*, and *Parambassis siamensis* (Kartamihardja et al., 2015; Kaban & Wibowo, 2018; Lubis & Ibrohim, 2019; Qomaria, 2023). However, based on the results of the research we have conducted, a new native species has also been introduced in Lake Toba, namely *Puntigrus tetrazona* (Fig. 1). The original range of *P. tetrazona* is recorded in the Muara Bulian Waters, Jambi Province (Apriliawati et al., 2024), Lake Buaya, Bukit Tigapuluh National Park, and Kampar River, Riau Province (Mahyudi et al., 2017; Nakagawa et al., 2021; Nofrizal et al., 2023), as well as the Kelekar River, Komering River, Musi River, and

Lake Ranau, South Sumatra Province (Muthmainah et al., 2015; Muthmainnah & Gaffar, 2017; Atminarso et al., 2023; Muslim et al., 2024). Therefore, data is needed regarding the distribution, density, growth pattern, and risk of invasiveness of this species in Lake Toba as a basis for future management.

Materials and methods

Site and time. This research was conducted at Lake Toba, North Sumatra, Indonesia covering 10 observation locations, namely Ajibata (2.654983º N, 98.934007º E), Porcea (2.43446º N, 99.147743º E), Balige (2.339295º N, 99.062510º E), Muara (2.339295º N, 99.062510º E), Bakti Raja (2.329096º N, 98.820362º E), Pangururan (2.602787º N, 98.700234º E), Onan Runggu (2.465835º N, 98.992870º E), Tomok (2.652845º N, 98.862402º E), Silalahi (2.791610º N, 98.532493º E), and Tongging (2.895650º N, 98.527195º E) from June to August 2024 (Fig. 2). The samples that had been collected were then taken to the Biology Laboratory, Universitas Negeri Medan for further analysis.

Research procedures. This research uses an exploratory method. Fish were caught using casting nets, fishing rods, traps and scoops. Fish samples were placed in a plastic sample containers containing 4% formalin and labeled (Hidayat et al., 2023).

Data analysis. The distribution of fish in Lake Toba is determined by the frequency index. The frequency index is the percentage of fish found at the research location. The frequency index is calculated using an equation based on Muchlisin (2012): $F_i = L_i/L_t * 100$, where F_i is the frequency index, L_i is species frequency at the sampling location, L_t is the total sampling location. Population density and relative density were calculated based on Rosmawati (2011): $D = N/S$, where D is population density, N is number of fish samples, S is habitat space in units of area or volume; $D_r = D\, n_i/Total\ D\, n_i * 100$, where D_r is relative density, $D\, n_i$ is density of a species of fish, $Total\ D\, n_i$ is total density of all fish species. The length-weight relationship was analyzed using the Linear Allometric Model (LAM) based on De-Robertis and William (2008): $W = e^{0.56(aLb)}$, where W is weight, L is total length of fish, a is constant and b is geometric for fish body proportion, e is variance of residuals of LAM, and 0.56 is the correction factor. The relative weight (W_r) condition factor using the formula Rypel & Richter (2008) is as follows: $W_r = (W/W_s) \times 100$, where W_r is the relative weight, W is the weight of the fish body, W_s is the predicted fish based on the LAM. The risk assessment of introduced fish was carried out using the Fish Invasiveness Screening Test (FIST) based on Saba et al. (2020).

Fig. 1. Sumatran barb (*Puntigrus tetrazona* Bleeker, 1855) harvested from Lake Toba, North Sumatra

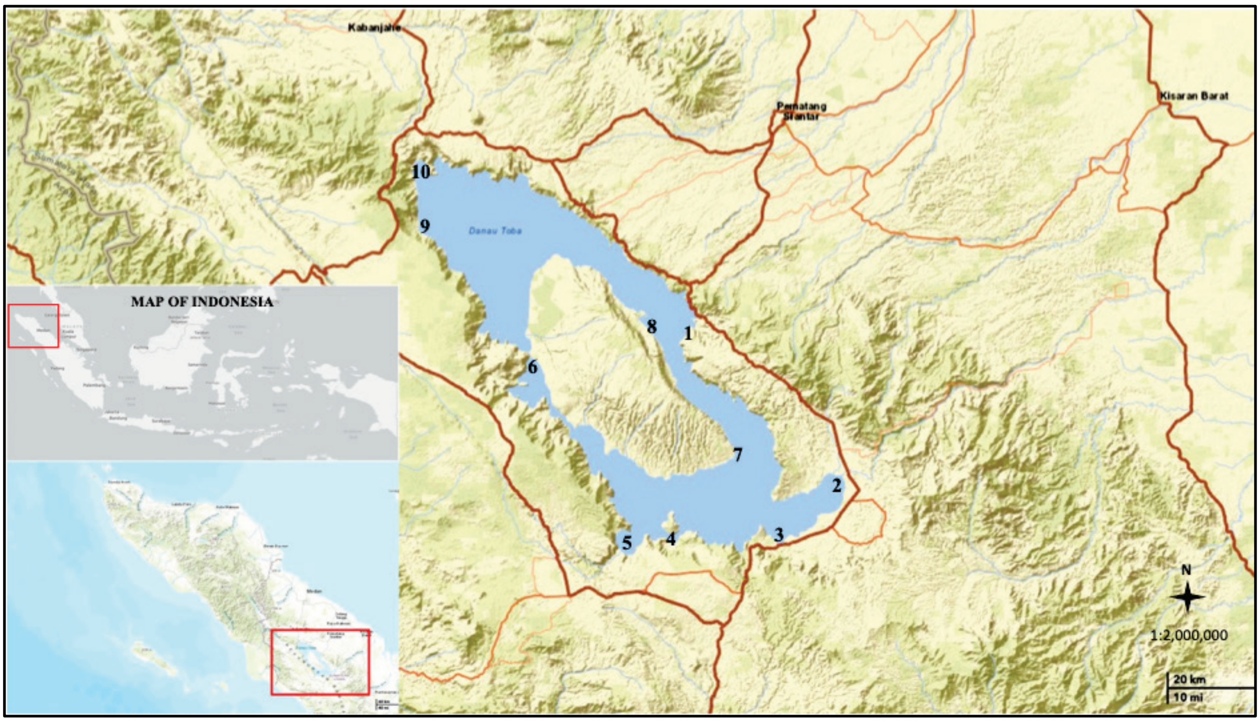

Fig. 2. Map of research locations in Lake Toba:
1 – Ajibata, *2* – Porcea, *3* – Balige, *4* – Muara, *5* – Bakti Raja, *6* – Pangururan, *7* – Onan Runggu, *8* – Tomok, *9* – Silalahi, *10* – Tongging

Results

A total of 95 samples were collected from Lake Toba with a total length ranging from 23–60 mm (mean 45.00 ± 8.70) and body weight 0.30–4.00 g (mean 1.66 ± 0.95). The results of the length-weight relationship analysis of *P. tetrazona* showed a value of 3.027 (isometric growth pattern, Figure 4). The relative weight (W_r) condition factor showed a value of 102.96, which indicates a stable condition. The frequency index value for *P. tetrazona* in the ten locations observed showed a value reaching 70%, with absences in three locations, namely Ajibata, Silalahi, and Tongging (Table 1). Population density values show that *P. tetrazona* has an average value reaching 0.08 ind./m^2, where the highest density was found in Muara reaching 0.39 ind./m^2 (Fig. 3). Based on relative density values, *P. tetrazona* has an average value reaching 2.79%, where Muara is the location with the highest relative density reaching 17.37%. The results of the FIST analysis showed that *P. tetrazona* was of moderate risk category for the biodiversity of Lake Toba with frequency distribution (%FD) values reaching 50% (Table 2). This is based on the details of assessment instruments, including maximum adult length between 20–40 cm, relative frequency between 30.1–100%, history of establishment between 0–7 countries, ability to breed in the wild is high, competition with native species is moderate, feeding plasticity is opportunist / moderately voracious, temperature tolerance is high, and tolerance to low dissolved oxygen.

Discussion

The discovery of new records regarding *P. tetrazona* is an interesting matter regarding the spread of the introduced species in Lake Toba. Recorded introduced fish species that have been identified in Lake Toba include *A. labiatus*, *A. panchax*, *C. carpio*, *M. marginatus*, *M. padangensis*, *O. mossambicus*, *O. niloticus*, and *P. siamensis* (Kartamihardja et al., 2015; Kaban & Wibowo, 2018; Lubis & Ibrohim, 2019; Qomaria, 2023).

Table 1
Population density (ind./m^2), Relative density (%), and frequency index (Fi) of introduced fish species in Lake Toba

Location	Population density, ind./m^2	Relative density, %	Frequency index, %
Ajibata	–	–	–
Porcea	0.03	0.71	+
Balige	0.03	1.56	+
Muara	0.39	17.37	+
Bakti Raja	0.16	2.16	+
Pangururan	0.11	4.72	+
Onan Runggu	0.01	0.34	+
Tomok	0.08	1.08	+
Silalahi	–	–	–
Tongging	–	–	–
Average/Total	0.08	2.79	70

Note: symbol "+" is present, "–" is absent.

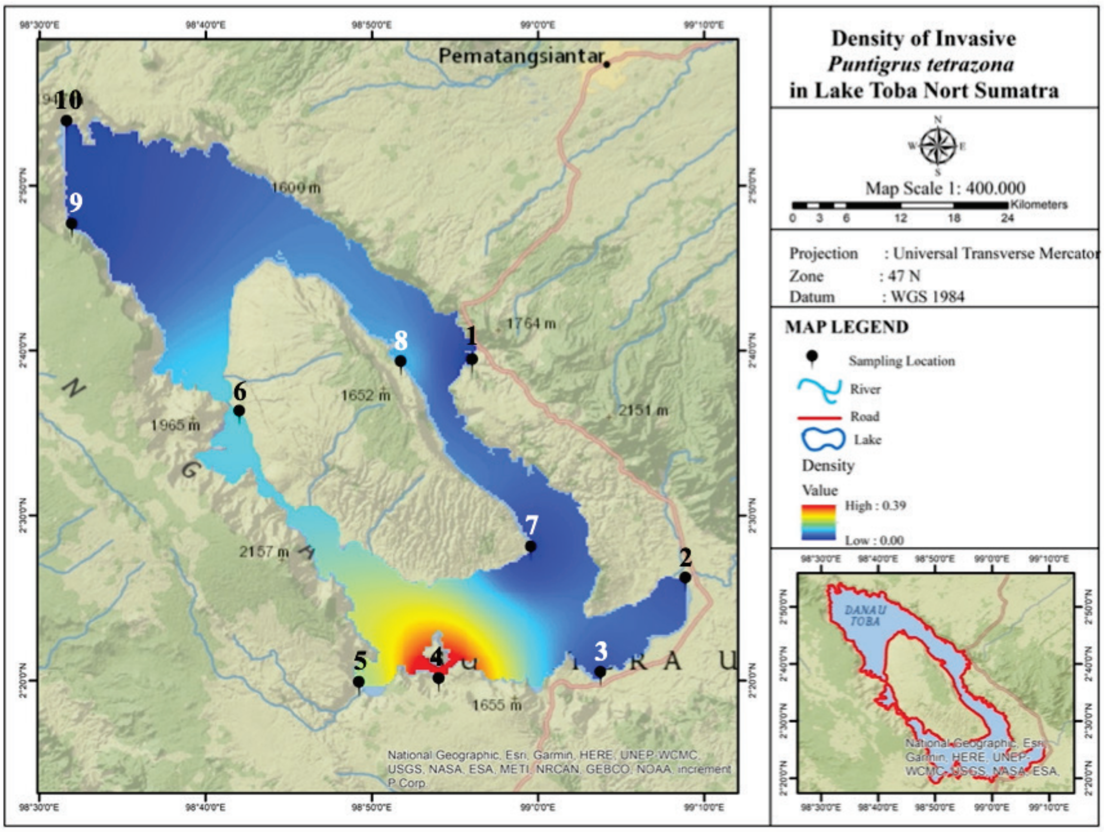

Fig. 3. Map of population density (ind./m^2) of Sumatra barb (*Puntigrus tetrazona*) in Lake Toba:
1 – Ajibata, *2* – Porcea, *3* – Balige, *4* – Muara, *5* – Bakti Raja, *6* – Pangururan, *7* – Onan Runggu, *8* – Tomok, *9* – Silalahi, *10* – Tongging

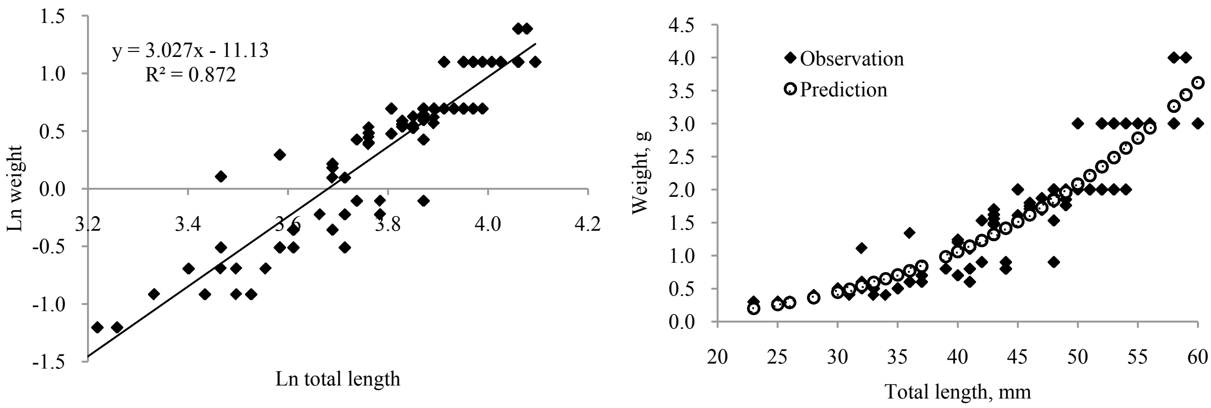

Fig. 4. Analysis of the length-weight relationship (above) and growth patterns (bellow) of *Puntigrus tetrazona* in Lake Toba

Although the natural range of *P. tetrazona*, is on the sland of Sumatra, Lake Toba is not within their original range. The original range of *P. tetrazona* is recorded in the Muara Bulian Waters, Jambi Province (Apriliawati et al., 2024), Lake Buaya, Bukit Tigapuluh National Park, and Kampar River, Riau Province (Mahyudi et al., 2017; Nakagawa et al., 2021; Nofrizal et al., 2023), as well as the Kelekar

River, Komering River, Musi River, and Lake Ranau, South Sumatra Province (Muthmainah et al., 2015; Muthmainnah & Gaffar, 2017; Atminarso et al., 2023; Muslim et al., 2024). Furthermore, previous research reports indicate that this species has also been introduced to Lake Tang, West Borneo (Romini et al., 2023) and Mrica Reservoir, Central Java (Mubarik et al., 2021).

The FIST value (% FD) of *P. tetrazona* shows a value of 50% which represents a moderate risk to aquatic ecology. However, this could change if the *P. tetrazona* population continues to experience a significant increase. Then competition will arise for control of living space, food sources, reproduction and habitat selection (Winfield, 2004; Martin et al., 2010). This will result in native fish species becoming stressed and having difficulty competing, resulting in a significant decline in their population every year. Therefore, it is necessary for researchers to carry out annual monitoring to control the *P. tetrazona* population.

Table 2
Results of fish invasiveness screening test (FIST) analysis of *Puntigrus tetrazona* in Lake Toba, North Sumatra, Indonesia based on Saba et al. (2020)

No	Traits	Criteria	Score	*Puntigrus tentrazona*
1	Maximum adult length	20.0–40.0 cm 40.1–60.0 cm >60.0 cm	+ ++ +++	+
2	Relative frequency	0.0–10.0% 10.0–30.0% 30.1–100.0%	+ ++ +++	+++
3	History of establishment	0–7 countries 8–15 countries > 15 countries	+ ++ +++	+
4	Ability to breed in the wild	low moderate high	+ ++ +++	+++
5	Competition with native species	low/absent moderate high	+ ++ +++	++
6	Feeding plasticity	specialist/not voracious opportunist/moderately voracious generalist/voracious	+ ++ +++	++
7	Temperature tolerance	low moderate high	+ ++ +++	+++
8	Tolerance to low dissolved oxygen	low moderate high	+ ++ +++	+++
% FD = frequency distribution, %				50

The results of field observations show that there is an interesting behavioral pattern in *P. tetrazona*, where this species can interact directly with other invasive introduced species, namely *A. labiatus*. *P. tetrazona* is a schooling fish species that competes for food with *A. labiatus*, which previously dominated in Lake Toba. The authors here speculate that *P. tetrazona* is a natural enemy of *A. labiatus*, and that this may lead to a decline in future *A. labiatus* populations. The natural process of ecological succession continues to occur in Lake Toba due to introduced species, until eventually, when the climax period gains momentum, a new stable ecosystem will reform.

The growth of *P. tetrazona* is shown as stable in Lake Toba based on the b value which reaches 3,027 (isometric). These results indicate that the fish are getting enough food (Batubara et al., 2019; Akmal et al., 2024). Furthermore, the relative weight condition factor value also shows the same thing, where this value represents water conditions that are low in predators and competitors (Wr > 100). Therefore, Lake Toba is an ideal habitat for *P. tetrazona* so that a potential population explosion will occur in the future if the population is not controlled.

Conclusion

Puntigrus tetrazona is a newly recorded species with a moderate risk (% FD = 50%) to biodiversity in Lake Toba. The growth pattern of this fish in Lake Toba is relatively optimal based on the b value of 3,027 (isometric) and the condition factor of Wr > 100. The growth pattern values indicate that Lake Toba is a suitable habitat for *P. tetrazona*. Available food sources and low level of competition are beneficial for *P. tetrazona* in this new habitat. The moderate risk of *P. tetrazona* to biodiversity in Lake Toba could possibly turn into a high risk if the *P. tetrazona* population is not controlled. Moreover, if natural enemies of this fish do not exist in Lake Toba, then in the next few years the population of *P. tetrazona* could explode. This will add pressure and threats to the survival of native fish species in Lake Toba, namely the *Neolissochilus* and *Tor* genera. The results of this research will be useful for managing the population of *P. tetrazona* as a newly recorded species in Lake Toba, North Sumatra, Indonesia.

The author would like to thank the Ministry of Education, Culture, Research and Technology of Indonesia for funding this research through the "Penelitian Fundamental – Reguler" Scheme in 2024 with contract number: 068/E5/PG.02.00.PL/2024; 006/UN33.8/DRTPM/PL/2024.

The authors declare that they have no competing interests in this paper.

References

Akmal, Y., Yunus, M., Plumeriastuti, H., Dhamayanti, Y., Irfannur, I., Muliari, M., Zulfahmi, I., & Batubara, A. S. (2024). Growth patterns and ecological classification of *Tor tambra* (Valenciennes 1842) in the Mamis River, Leuser Ecosystem Area, Aceh Province, Indonesia. Jurnal Ilmiah Perikanan dan Kelautan, 16(2), 485–497.

Apriliawati, A., Sukomono, T., & Nugraha, A. (2024). Biodiversity of ichthyofauna in mainland waters of Muara Bulian District Jambi Province and its new record. BIO Web of Conferences, 101, 03006.

Atminarso, D., Baumgartner, L. J., Watts, R. J., Rourke, M. L., Bond, J., & Wibowo, A. (2023). Evidence of fish community fragmentation in a tropical river upstream and downstream of a dam, despite the presence of a fishway. Pacific Conservation Biology, 30(1), PC22035.

Bajer, P. G., & Sorensen, P. W. (2010). Recruitment and abundance of an invasive fish, the common carp, is driven by its propensity to invade and reproduce in basins that experience winter-time hypoxia in interconnected lakes. Biological Invasions, 12, 1101–1112.

Batubara, A. S., Muchlisin, Z. A., Efizon, D., Elvyra, R., & Irham, M. (2019). Length-weight relationships and condition factors of the Naleh fish, *Barbonymus gonionotus* (Pisces, Cyprinidae) harvested from Nagan Raya Waters, Indonesia. Vestnik Zoologii, 53(1), 75–82.

Bondad-Reantaso, M. G., Subasinghe, R. P., Arthur, J. R., Ogawa, K., Chinabut, S., Adlard, R., Tan, Z., & Shariff, M. (2005). Disease and health management in Asian aquaculture. Veterinary Parasitology, 132(3–4), 249–272.

De-Robertis, A., & William, K. (2008). Weight-length relationship in fisheries studies: The standard allometric model should be applied with caution. Journal of Transactions of the American Fisheries Society, 137(3), 707–719.

Gozlan, R. E., Britton, J. R., Cowx, I., & Copp, G. H. (2010). Current knowledge on non-native freshwater fish introductions. Journal of Fish Biology, 76(4), 751–786.

Hidayat, M., Maulizar, S., Batubara, A. S., Kautsari, N., Latuconsina, H., Nur, F. M., & Zulfahmi, I. (2023). Ichthyofauna of Merbau River, Leuser Ecosystem Area, Indonesia: Species composition, diversity, biometric condition, potency, and conservation status. European Zoological Journal, 90(2), 747–761.

Izquierdo, M. S., Fernandez-Palacios, H., & Tacon, A. G. J. (2001). Effect of broodstock nutrition on reproductive performance of fish. Aquaculture, 197(1–4), 25–42.

Kaban, S., & Wibowo, A. (2018). Genetic diagnosis and reproductive biology of introduced *Mystacoleucus marginatus* in the Toba Lake, North Sumatra. Indonesian Fisheries Research Journal, 24(1), 1–9.

Kartamihardja, E. S., Hedianto, D. A., & Umar, C. (2015). Strategi pemulihan sumber daya ikan bilih (*Mystacoleucus padangensis*) dan pengendalian ikan kaca (*Parambassis siamensis*) di Danau Toba, Sumatera Utara. Jurnal Kebijakan Perikanan Indonesia, 7(2), 63–69.

Lubis, R. E., & Ibrohim, I. (2019). Identification and diversity of organisms in the Lake Toba area. Jurnal Pendidikan IPA Indonesia, 8(3), 361–370.

Lusk, S., Lusková, V., & Hanel, L. (2010). Alien fish species in the Czech Republic and their impact on the native fish fauna. Folia Zoologica, 59(1), 57–72.

Mahyudi, I., Kamal, M., & Sukmono, T. (2017). The structure community of ichthyofauna in the Region Buffer Resorts Suo-Suo of Bukit Tigapuluh National Park, Indonesia. International Journal of Sciences: Basic and Applied Research, 34(1), 1–15.

Martin, C. W., Valentine, M. M., & Valentine, J. F. (2010). Competitive interactions between invasive Nile tilapia and native fish: the potential for altered trophic exchange and modification of food webs. PloS One, 5(12), e14395.

Mills, M. D., Rader, R. B., & Belk, M. C. (2004). Complex interactions between native and invasive fish: The simultaneous effects of multiple negative interactions. Oecologia, 141, 713–721.

Mubarik, A. L., Rosyadi, H., Latrianto, A., Farahdilla, N., Empra, D. E. P., Nurfaiz, A., & Damanik, W. F. (2021). Komunitas iktiofauna di zona litoral Waduk Mrica, Banjarnegara, Jawa Tengah. Universitas Negeri Padang, Padang, Indonesia. Prosiding Seminar Nasional Biologi, 1(2), 823–834.

Muchlisin, Z. (2012). First report on introduced freshwater fishes in the waters of Aceh, Indonesia. Fisheries and Aquatic Life, 20(2), 129–135.

Muslim, M., Irawan, R., Karolina, A., Fahleny, R., Haitami, M. A., & Isawpatita, D. (2024). Conservation and population status of freshwater fishes from Kelekar River, South Sumatra, Indonesia. International Journal of Current Science Research and Review, 7(2), 1247–1255.

Muthmainah, D., Subagdja, S., Makri, M., Atminarso, D., & Makmur, S. (2015). Fishing activities and fishermen income in Ranau Lake, South Sumatra. Indonesian Fisheries Research Journal, 21(1), 19–26.

Muthmainnah, D., & Gaffar, A. K. (2017). Fish and fisheries in floodplain swamp in middle part of Musi River. Indonesian Journal of Environmental Management and Sustainability, 1(1), 1–5.

Nakagawa, H., Osawa, T., Binawan, A., Dewi, K. H., Hasegawa, T., Mandari, D. Z., Prasetyawan, W., & Okamoto, M. (2021). Local names of fishes in a fishing village on the bank of the middle reaches of the Kampar River, Riau, Sumatra Island, Indonesia. Southeast Asian Studies, 10(3), 435–454.

Nofrizal, N., Thamrin, T., Saam, Z., Jonnerie, R., Karnila, R., Fatmawati, R., Ramses, R., & Raza'i, T. S. (2023). Dominant fish species in submerged floodplains and the adjacent river in the Buaya Lake, Indragiri River Basin, Sumatra Island, Indonesia. AACL Bioflux, 16(2), 709–720.

Qomaria, R. (2023). Species diversity of freshwater fish in Lake Toba using Shanon Wiener. Formosa Journal of Applied Sciences, 2(7), 1475–1482.

Romini, R., Riyandi, R., & Yanti, A. H. (2023). Keanekaragaman jenis ikan di Danau Tang Desa Penepian Raya Kabupaten Kapuas Hulu. Life Science, 12(1), 52–61.

Rosmawati, T. (2011). Ekologi perairan. Hilliana Press, Bogor, Indonesia.

Rypel, A. L., & Richter, T. J. (2008). Empirical percentile standard weight equation for the Blacktail Redhorse. North American Journal of Fisheries Management, 28(6), 1843–1846.

Saba, A. O., Ismail, A., Zulkifli, S. Z., Halim, M. R. A., Wahid, N. A. A., & Amal, M. N. A. (2020). Species composition and invasion risks of alien ornamental freshwater fishes from pet stores in Klang Valley, Malaysia. Scientific Reports, 10(1), 1–13.

Valen, F. S., Anugerah, P., Maharani, M. D., Pamungkas, A., Anwar, S., Nomleni, A., Jatayu, D., & Insani, L. (2023). First record of Siamese fighting fish, *Betta splendens* (Regan, 1910) (Anabantiformes: Osphronemidae), in Bangka Island, Indonesia. AACL Bioflux, 16(5), 2671–2677.

Winfield, I. J. (2004). Fish in the littoral zone: Ecology, threats and management. Limnologica, 34(1–2), 124–131.