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A biological perspective for the fishery management of a small urban lake in Indonesia: a case study on the reproductive stage of the red devil (*Amphilopus citrinellus*) in Situ Cilodong, West Java, Indonesia

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Abstract: The presence and establishment of invasive alien fish species is one of the biggest threats to aquatic biodiversity. The red devil, *Amphilopus citrinellus*, is one of the emerging invasive species and its occurrence is massively detected in common water bodies in tropical areas such as Indonesia. However, the topic remains under-reported from the small urban lakes. This study aims to present the reproductive characteristics of the fish in Situ Cilodong, a small urban lake in the country, that can be used as a principal reference for population control. The sampling was conducted in June 2021 and May 2022 using a mix of seven mesh-sized gillnets. The results of the length-weight relationship reveal that both the female and male fish perform isometric growth type. The calculated Gonad Somatic Index (GSI) and the histological analysis confirmed that the fish is a multi-spawner species. The results imply that sustainable population control efforts must include intensive catch and engage a participatory approach between the legal authority and the local fishers.

Keywords: alien fish species, invasive fish, reproduction, biodiversity, small lake management

1. Introduction

Both globally and nationally, the biodiversity of freshwater fisheries is undergoing massive threats such as hydrological alteration, habitat degradation, overfishing, pollution, and invasive species domination (Dudgeon *et al*., 2006). The last threat, invasive species, is mostly caused by anthropogenic factors and has generated economic, ecological, and health disturbances (Krantzberg, 2019).

To mitigate such impacts, a structured population control method must be established, such as by preventing their translocation movement (Gherardi, 2010). However, if the species has been established in a new location, gradual eradication is advisory, such as by conducting intensive fishing on the sexually matured fish (Gherardi, 2010; Dina *et al*. 2022). Therefore, knowledge of their reproductive biology becomes important information that should be obtained by the resource managers.

In this study, we use the red devil (*Amphilopus citrinellus*) as a case study to show the importance of the knowledge of reproductive biology in planning a sustainable population control plan. The red devil, previously a valuable ornamental fish, is selected due to its rapid growth and establishment in common water bodies (Umar *et al*., 2015; Hedianto *et al*., 2022).

The fish originally from Nicaragua, Central America (Colombo *et al*., 2013), has been

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reported to massively proliferate in tropical common water bodies such as in Indonesia (Dina *et al.*, 2022). Its ability to adapt to new environments because of its phenotypic plasticity (Salzburger & Meyer, 2004; Machado-Schiaffino *et al.*, 2014) makes the fish categorized as an invasive species that can be harmful by The Regulation of The Minister of Marine and Fishery no. 19/ 2020 (MoMF, 2020).

There has been various research on the reproductive biology of the red devil in Indonesia; for examples: Jatiluhur reservoir (Purnamaningtyas & Tjahjo, 2010), Situ Panjalu (Warsa & Purnomo, 2013), Kedung Ombo Reservoir (Adjie & Fatah, 2015), Lake Sentani (Ohee *et al.*, 2020), Sangiran Reservoir (Santoso, 2019), and Sermo Reservoir (Hedianto, 2023). Nevertheless, those studies did not provide a histological assessment of the fish's gonad development. Furthermore, the study on the topic of urban small lakes is currently absent from academic literature although these types of lakes are crucial to support the livelihood and welfare of marginalized urban people.

Besides, providing water and livelihood for the locals. The urban lake in our case study also serves as a habitat for native fish species such as *Barbodes binotasus* and *Rasbora argyrotaenia* (Phadmacanty *et al.*, 2023). Therefore, the presence of the red devil may generate an adverse impact on biodiversity and human welfare, making thorough planning on the red devil population control vital. We expect that our results can provide basic information and reference for the development of such a plan considering the significance of the information on their reproductive biology.

2. Materials and Methods

2.1. Study site

Situ Cilodong is administratively located in Kalibaru County, Depok Municipality, West Java (Figure 1). Its extent reached a 9.5 ha area with a maximum depth of 3 meters (Pratiwi, 2013). The situ is surrounded by housing and agricultural areas (Figure 1).

The fish sampling was conducted in June 2021 and May 2022 by horizontally setting a 25 x 1.8 m gillnet with a mix of mesh-sized (¾, 1, 1¼, 1½, 2, 2½, and 3 inches) in the outlet area. The sampling site was selected to mitigate its disturbance on the tourism boat while still representing the extent and depth of the situ.

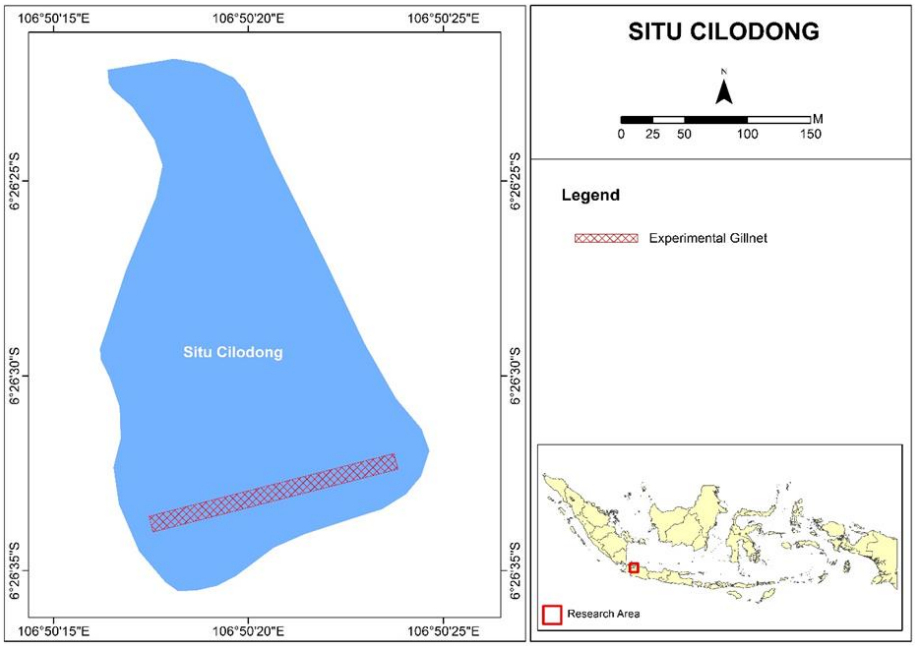

Figure 1. Study site and sampling location

2.2 Sample preservation and laboratory observation

The sampled fish was preserved in a 10% Formaldehyde solution (Silvano *et al.*, 2009), and then in the laboratory, they were wind-dried before being weighed and measured. Then, the samples were dissected to take their gonad to estimate their Gonad Maturity Level/ GML (Effendie, 1997).

Meanwhile, a 5% Formaldehyde solution was used to preserve a total of 15 gonad samples for the histological analysis, and hematoxylin-eosin (HE) was applied to color the specimens (Zulfadhli *et al.*, 2016). The specimens were observed referring to the work of Longenecker *et al.* (2020).

2.3 Data analysis

The length-weight relationship was calculated referring to the formula created by Pauly (1984) (Equation 1).

$$W = a\,L^b \quad \text{....Eq. 1}$$

where; W = fish weight (gram), L = fish length (mm), a and b= Constanta. The obtained b constant is further tested with the 95% confidence level t-test with the H_0: b=3 and H_1: b ≠ 3.

Gonad Somatic Index/GSI (Equation 2) was calculated following the work of (GSI) (Ohta *et al.*, 1996).

$$GSI = \frac{gonad\ weight}{body\ weight} \times 100 \quad \text{....Eq. 2}$$

3. Results and discussion

The range of the length of the fish samples was 66 – 185 mm and 65 – 200 mm for females and males respectively. Meanwhile, their body weighed 6.3 – 135 grams for female fish and 5.4 – 177 grams for males. These measurements show that the fish are larger than the fish sample obtained from Sermo Reservoir (see Hedianto *et al.*, 2022), which implies that the red devil in Situ Cilodong is currently in the reproduction and establishment stage (see Lawson & Hill, 2021).

From the length-weight relationship and the following t-test (Figure 2, Table 1), it can be concluded that the red devil follows isometric growth–equal growth between length and weight (Effendie, 1997). The growth pattern of fish is affected by age, body shape, GML, seasons, temperature, salinity, and food availability (Thulasitha & Sivashanthini, 2012). We suggest that the stable tropical environment and the abundance of food because of the situ's eutrophic condition are the principal factors affecting fish growth in the study area (see Aisyah *et al.*, 2021).

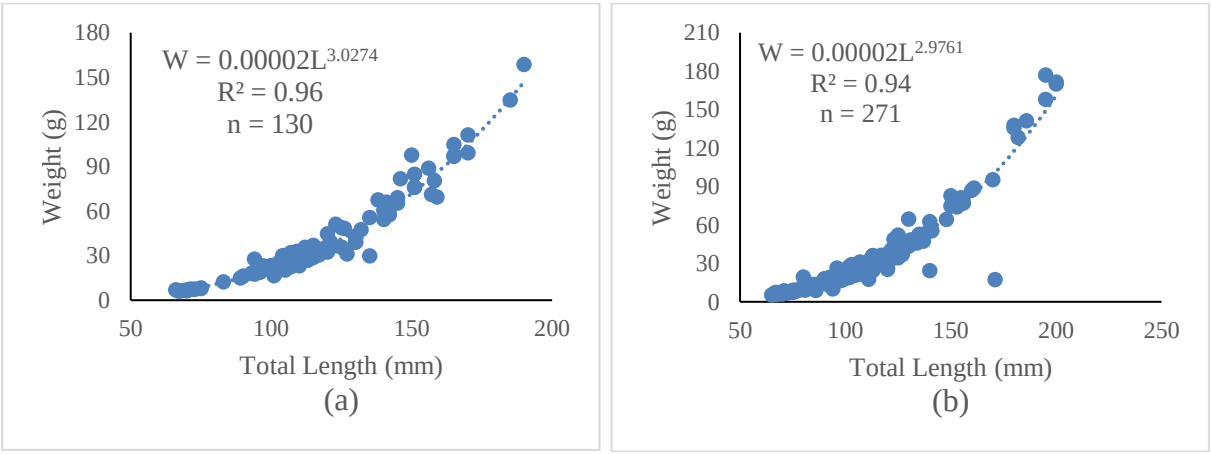

Figure 2. The length-weight relationship of the red devil in Situ Cilodong (a) Females, (b) Males

Table 1. t-test results for the red devil b-Constanta

Sex	t_{stat}	$t_{critical}$	Decision
Female	0.8033	1.9785	Failed to reject H_0: b = 3
Male	0.8553	1.9688	Failed to reject H_0: b = 3

Table 2. Length, weight, GML, and GSI of the red devil in Situ Cilodong

GML	n	Length (mm)	Weight (g)	GSI (%)
I	♂:80	♂: 89 ± 16	♂: 16.28 ± 8.87	♂: 0.02 ± 0.02
	♀:35	♀: 99 ± 19	♀: 22.18 ± 11.41	♀: 0.04 ± 0.02
II	♂:94	♂: 107 ± 13	♂: 25.78 ± 8.66	♂: 0.06 ± 0.04
	♀:37	♀: 109 ± 8	♀: 27.3 ± 5.94	♀: 0.09 ± 0.06
III	♂:30	♂: 135 ± 23	♂: 57.14 ± 30.64	♂: 0.12 ± 0.07
	♀:13	♀: 136 ± 21	♀: 57.28 ± 24.34	♀: 0.32 ± 0.26
IV	♂:3	♂: 198 ± 3	♂: 172.8 ± 3.7	♂: 0.35 ± 0.04
	♀:17	♀: 149 ± 19	♀: 77.31 ± 28.19	♀: 1.85 ± 0.87

The calculated GSI for female fish is bigger than the male's (Table 2), which is a common phenomenon (Effendie, 1997). Further, the GSI data also reveal that the fish is a multi-spawner species since their GSI is smaller than 20% (Bagenal, 1978). Moreover, the data in the table confirm that four maturity levels are found in the sample, which also aligns with the histological observation (Figure 3 and 4).

According to the criteria proposed by Longenecker *et al*. (2020) and Nurhidayat *et al*., (2017), the histological results elaborate four GML for the female fish: GML I (Figure 3A), characterized by lots of primary oocytes; GML II (Figure 3B), exhibited more second-stage oocytes, thickened nucleus, and epithelial cells; GML III (Figure 3C), identified by the occurrence of third stage oocytes; and GML IV, hinted by the dominance of large sized oocytes.

The histological results for the male fish elucidate that: GML I (Figure 4A), hinted by the abundance of the spermatogonia and the primary spermatocytes; GML II (Figure 4B), shown by the emergence of both the primary and secondary spermatocytes; GML III (Figure 4C), identified with the occurrence of spermatid; and GML IV (Figure 4D), characterized by the spermatozoa equipped with flagella (ibid).

The histological analysis presents that the female red devils undergo asynchronous gonad development referring to the fact that there are several oocyte stages in the same GML. Thus, the fish is considered a multi-spawner species (Muchlisin, 2014; Purnamaningtyas & Tjahjo, 2010). This result corroborates the study conducted by Adjie & Fatah (2015), who observed the reproductive biology of the red devil in Kedung Ombo Reservoir.

Contextualizing our results with the study area, we suggest that eradication of the red devil in this situ using intensive catch as the most appropriate control program. Further, it is advised that the catch should be conducted at various times within a year considering that the fish can perform several spawning seasons. The use of selective fishing gear such as gillnet with appropriate mesh size is also recommended. In this case, there should be further discussion regarding the governance process because, in the current situation, the locals are only allowed to use hooks. Therefore, we recommend that the Watershed Agency of the Ministry of Public Works and Housing take the lead in the population control process. Furthermore, we advise the endorsement of a participatory approach connecting the government agencies and the local fishers.

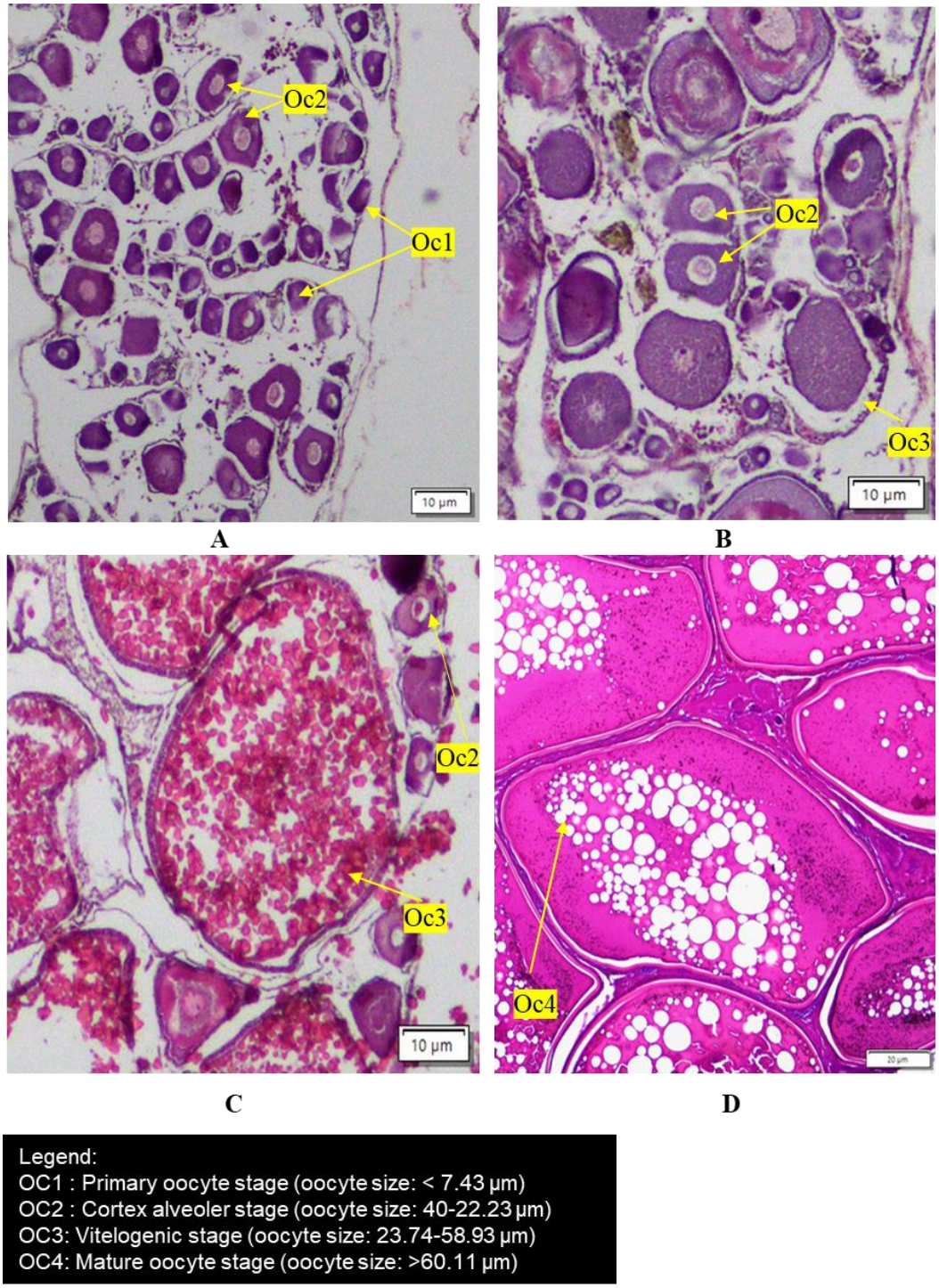

Figure 3. Histological observation on the female red devil: (A) GML I (*immature*), (B) GML II (*develop*), (C) GML III (*mature*), (D) GML IV (*ripe*)

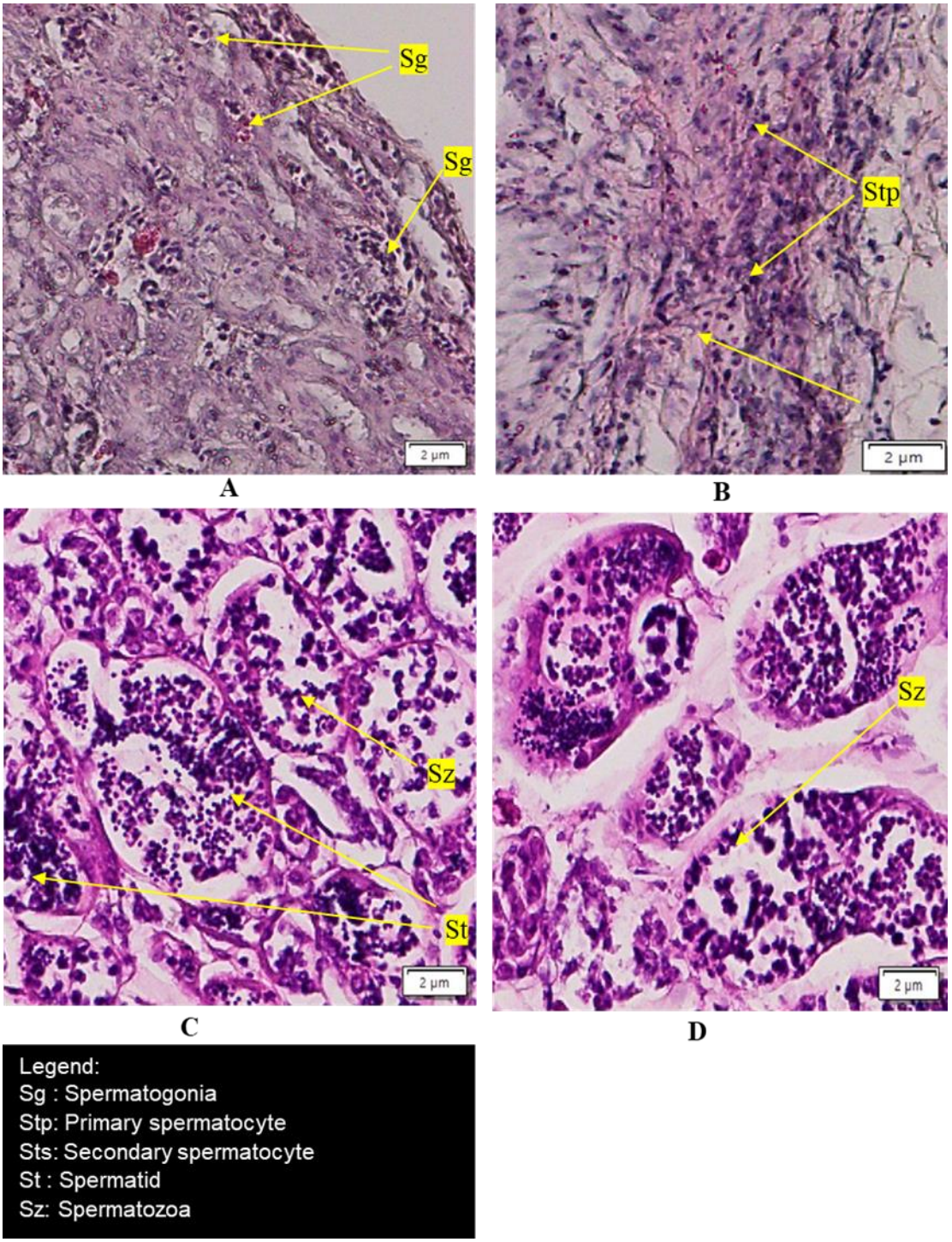

Figure 4. Histological observation on the female red devil: (A) TKG I (*immature*), (B) TKG II (*develop*), (C) TKG III (*mature*), (D) TKG IV (*ripe*)

4. Conclusion

We attribute the red devil as a multi-spawner species with several spawning seasons. Hence, there is a tendency that the fish can be a great biodiversity threat in the study area. We extend this knowledge can be a trend in other water bodies in Indonesia considering its climatic suitability. We suggest that a coordinated action plan can be performed by the authorities and local people to mitigate the impacts. Our main recommendations also include intensive catch and continuing monitoring programs in the area where the presence of the red devil has been acknowledged.

Data availability statement

We declare that all required data have been written and stated in this manuscript.

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Conflict of interests

The authors declare that there is no conflict of interest.

Author Contributions

IA and **RD** designed the topic and method of this research. **IA**, **GW**, and **AW** assisted in the fieldwork and data collection. **FSL**, **EN**, and **DO** processed the data and compiled articles. **IA**, **RD**, and **GW** helped improve the manuscript.

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References

Adjie S, Fatah K. 2015. Biologi reproduksi ikan red devil (*Amphilopus labiatus*) dan (*Amphilopus citrinellus*) di Waduk Kedung Ombo, Jawa Tengah. *Bawal* 7(1): 17-24. DOI: 10.15578/bawal.7.1.2015.17-24

Aisyah S, Sulastri, Dina R, Widoretno MR. 2021. Physical-chemical characteristic and trophic status of some in Ciliwung watershed, West Java Indonesia. *Indonesian Journal of Limnology* 2(2): 1-8. DOI: 10.51264/inajl.v2i2.15

Colombo M, Deipeveen ET, Muschick M, Santos ME, Indermaur A, Boileau N, Barluenga M, Salzburger W. 2013. The ecological and genetic basis convergent thick-lipped phenotypes in cichlid fishes. *Molecular Ecology* 22: 670-684. DOI: 10.1111/mec.12029

Dina R, Wahyudewantoro G, Larashati S, Aisyah S, Lukman, Sulastri, Imroatushshoolikhah, Sauri S. 2022. Distributional mapping and impacts of invasive alien fish in Indonesia: an alert to inland water sustainability. *Sains Malaysiana* 51(8): 2377-2401. DOI: http://doi.org/10.17576/jsm-2022-5108-04

Dudgeon D, Arthington, AH, Gessner MO, Kawabata Z-I, Knowler DJ, Lévêque C, Naiman RJ, Prieur-Richard A-H, Soto D, Stiassny ML, Sullivan CA. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews* 81(02): 163-182. DOI: 10.1017/s1464793105006950

Effendie MI. 1997. *Biologi Perikanan*. Yayasan Pustaka Nusatama: Yogyakarta. 163 p.

Gherardi, F. 2010. Invasive crayfish and freshwater fishes of the world. *Revue Scientifique et Technique de l'OIE* 29(2): 241-254. DOI: 10.20506/rst.29.2.1973

Hedianto DA. 2023. Karakterisasi populasi ikan red devil (*Amphilopus* spp.) sebagai dasar pengendalian ikan invasif di Waduk Sermo, Yogyakarta. *Thesis*. Institut Pertanian Bogor. Unpublished.

Hedianto DA, Kamal MM, Taryono, Nurfiarini A. 2022. Status stok dan laju eksploitasi ikan red devil (*Amphilophus* spp.) sebagai dasar pengendalian ikan invasif di Waduk Sermo, Yogyakarta. *BAWAL* 14(3): 119-134. DOI: 10.15578/bawal.14.3.2022.119-134

Krantzberg G. 2019. Alien invasive species impacts on large lake ecosystems and their economic value. *Earth & Environmental Science Research & Reviews* 2(5): 1-6. DOI: 10.33140/EESRR

Lawson KM, Hill JE. 2021. Predicting successful reproduction and establishment of non-native freshwater fish in peninsular Florida using life history traits. *Journal of Vertebrate Biology*

70(4): 21041.1-17. DOI: https://doi.org/10.25225/jvb.21041

Longenecker K, Pauahi B, Museum B, Langston R, Franklin EC. (2020). Standard operating procedure for histology-based rapid reproductive analysis of tropical fishes. 87 p. DOI: 10.13140/RG.2.2.32587.21288/2

Machado-Schiaffino G, Henning F, Meyer A. 2014. Species-specific differences in adaptive phenotypic plasticity in an ecologically relevant trophic trait: hypertrophic lips in midas cichlid fishes. *Evolution: International Journal of Organic Evolution* 68(7): 2086-2091. DOI: 10.1111/evo.12367

Muchlisin ZA. 2014. A general overview on some aspects of fish reproduction. *Aceh International Journal of Science and Technology* 3(1): 43-52. DOI: 10.13170/AIJST.0301.05

Nurhidayat L, Arviani FN, Retnoaji B. 2017. Indeks gonadosomatik dan struktur histologis gonad ikan uceng (*Nemacheilus fasciatus*, Valenciennes in Cuvier and Valenciennes, 1846). *Biosfera* 34(2): 67-74. DOI: 10.20884/1.mib.2017.34.2.456

Ohee HL, Mote N, Rice MA, Sujarta P. 2020. Sex ratio and reproduction of invasive red devil, (*Amphilophus labiatus*: Cichlidae) in Lake Sentani, Indonesia*. Lakes & Reservoirs: Science, Policy and Management for Suistainable Use* 25(3): 334-345*.* DOI: 10.1111/lre.12332

Ohta H, Kagawa H, Tanaka H, Okuzawa K, Hirose K. 1996. Milt production in the Japanese eel *Anguila japonica* induced by repeated injections of human chorionic gonadotropin. *Fisheries Science* 62(1): 44-49. DOI: 10.2331/fishsci.62.44

Phadmacanty NLPR. Yulianto, Dina R, Wahyudewantoro G, Aisyah S, Prawira AY. 2023. Histopathological study of fish gills in Situ Cikaret and Situ Cilodong, West Java. *IOP Conf. Series: Earth and Environmental Science* 1191 012006. DOI: 10.1088/1755-1315/1191/1/012006

Pauly D. 1984. *Fish population dynamics in tropical waters: A manual for use with programmable calculators*. ICLARM: Manila. 325 p. Available at: https://digitalarchive.worldfishcenter.org/handle/20.500.12348/3445

MoMF. 2020. Peraturan Menteri Kelautan dan Perikanan No. 19/2020 tentang Larangan Pemasukan, Pembudidayaan, Peredaran, dan Pengeluaran Jenis Ikan yang Membahayakan dan/atau Merugikan ke dalam dan dari Wilayah Pengelolaan Perikanan Negara Republik Indonesia

Pratiwi RH. 2013. Distribusi bakteri coliform di Situ Cilodong Depok Jawa Barat. *Faktor Exacta* 6(4): 290-297. DOI: 10.30998/faktorexacta.v6i4.240

Purnamaningtyas SE, Tjahjo DWH. 2010. Beberapa aspek biologi ikan oskar (*Amphilophus citirnellus*) di Waduk Ir. H. Djuanda, Jatiluhur, Jawa Barat. *Bawal* 3(1): 9-16. DOI: 10.15578/bawal.3.1.2010.9-16

Salzburger W, Meyer A. 2004. The species flocks of East African cichlid fishes: recent advances in molecular phylogenetics and population genetics*. Naturwissenschaften,* 91(6): 277-290*.* DOI:10.1007/s00114-004-0528-6

Santoso. 2019. Aspek biologi ikan red devil (*Amphilopus labiatus*) dari waduk Sangiran, Ngawi, Jawa Timur. *Undergraduate thesis*. Universitas Brawijaya. Unpublished.

Silvano RAM, Ramires M, Zuanon J. 2009. Effect of fisheries management on fish communities in the floodplain lakes of a Brazilian Amazonian Reserve. *Ecology of Freshwater Fish* 18: 156-166. DOI: 10.1111/j.1600-0633.2008.00333.x

Thulasitha WS, Sivashanthini K. 2012. Growth pattern and length-weight relationship of *Scomberoides lysan* (Pisces: Carangidae) from the northern waters of Sri Lanka. *Journal of Fisheries and Aquatic Science* 7(1): 57-64. DOI: 10.3923/jfas.2012.57.64

Umar C, Kartamihardja ES, Aisyah. 2015. Dampak invasif ikan red devil (*Amphilophus citrinellus*) terhadap keanearagaman ikan di perairan umum daratan di Indonesia. *Jurnal Kebijakan Perikanan Indonesia* 7(1): 55-61. DOI: 10.15578/jkpi.7.1.2015.55-61

Warsa A, Purnomo K. 2013. Selektivitas jaring insang monofilament dan aspek biologi ikan Oscar (*Amphilopus citrinellus*) di Situ Panjalu, Ciamis. *Jurnal Penelitian Perikanan Indonesia* 19(2): 65-72. DOI: 10.15578/jppi.19.2.2013.65-72

Zulfadhli, Wijayanti N, Retnoaji B. 2016. Perkembangan ovari ikan wader pari (*Rasbora lateristriata* Bleeker, 1854): Pendekatan histologi. *Jurnal Perikanan Tropis* 3(1): 32-39. DOI: 10.35308/jpt.v3i1.34