©Journal of Aquatropica Asia
e-issn: 2721-7574; p-issn: 2407-3601
Volume 10, Nomor 2, Tahun 2025
Jurusan Akuakultur, Universitas Bangka Belitung

BIODIVERSITY ASSESSMENT AND REINTRODUCTION – BASED CONSERVATION OF FRESHWATER FISHES IN THE ANCIENT RIVER, BELITUNG ISLAND, INDONESIA

PENILAIAN KEANEKARAGAMAN HAYATI DAN KONSERVASI REINTRODUKSI IKAN AIR TAWAR DI SUNGAI PURBA, PULAU BELITUNG, INDONESIA

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Abstract

Freshwater fish biodiversity on Belitung Island has significantly declined due to intensive tin mining and rapid oil palm plantation expansion. To address these ecological threats, a biodiversity assessment was carried out in 2024 within the Lenggang River system—an ancient freshwater ecosystem in East Belitung, Indonesia. The survey recorded a remarkable richness of ichthyofauna, comprising 54 fish species, including both native and endemic taxa. This diversity highlights the ecological importance of the river and provides a foundation for conservation planning. From this assemblage, 36 native species were selected for reintroduction based on ecological roles, conservation status, endemism, and adaptability to rehabilitated habitats. Priority species include *Gymnochanda verae* (a rare endemic of the Belitung Island), *Desmopuntius sp., Osteochilus spilurus, Osteochilus flavicauda, Eirmotus cf. insignis, Brevibora cheeya*, and *Aplocheilus armatus*. The reintroduction program aimed not only to restore declining populations but also to reinforce genetic and ecological diversity within native fish communities. All reintroduced species were historically recorded in the Lenggang River system. The strategy integrated habitat restoration, local stakeholder involvement, and long-term monitoring. Early outcomes show positive acclimatization in restored habitats, affirming the role of species reintroduction as a viable method for conserving freshwater biodiversity in tropical ancient rivers. This study contributes essential baseline data and presents a replicable model for integrated freshwater conservation in Southeast Asia.

Keywords: Endemic species; Gymnochanda verae; Species reintroduction; Belitung Island; Genetic diversity; Conservation strategy

Abstrak

Keanekaragaman hayati ikan air tawar di Pulau Belitung mengalami penurunan yang signifikan akibat aktivitas penambangan timah terbuka serta alih fungsi lahan menjadi perkebunan kelapa sawit. Sebagai respons terhadap tekanan ekologis tersebut, maka dilakukan kajian keanekaragaman hayati yang dilaksanakan pada tahun 2024 di perairan Sungai Lenggang, yang merupakan sebuah ekosistem air tawar purba yang terletak di Belitung Timur, Indonesia. Tujuan utama penelitian ini adalah untuk mendokumentasikan spesies ikan asli dan endemik asal Belitung, serta merumuskan strategi konservasi berbasis reintroduksi yang disesuaikan dengan konteks ekologi sungai tersebut. Hasil penelitian mencatat kekayaan iktiofauna yang luar biasa di Sungai ini, mencakup 54 spesies ikan, termasuk taksa asli dan endemik. Tingginya keanekaragaman ini menegaskan pentingnya nilai ekologis sungai tersebut serta menjadi dasar bagi perencanaan konservasi yang terintegrasi. Dari keseluruhan spesies tersebut, 36 spesies asli dipilih untuk program reintroduksi berdasarkan peran ekologis, status konservasi, tingkat endemisme, dan kemampuan adaptasi terhadap habitat yang telah direhabilitasi. Salah satu spesies prioritas adalah Gymnochanda verae, spesies langka dan endemik yang hanya ditemukan di perairan Belitung. Selanjutnya, spesies lain yang terpilih meliputi Desmopuntius sp., Osteochilus spilurus, Osteochilus flavicauda, Eirmotus cf. insignis, Brevibora cheeya, dan Aplocheilus armatus sebagai ikan asli sungai tersebut. Inisiatif reintroduksi ini tidak hanya

bertujuan untuk memulihkan populasi yang menurun, tetapi juga untuk memperkaya keanekaragaman genetik komunitas ikan asli. Seluruh spesies yang direintroduksi telah dikonfirmasi sebagai spesies yang secara historis terdapat dan berasal dari sistem Sungai Lenggang. Strategi konservasi ini didukung oleh upaya restorasi habitat, pelibatan masyarakat lokal, serta pemantauan populasi jangka panjang. Hasil awal menunjukkan tingkat aklimatisasi yang positif di zona-zona yang telah direstorasi, yang menegaskan potensi reintroduksi spesies sebagai alat konservasi yang efektif bagi keanekaragaman hayati air tawar di sistem sungai tropis purba. Studi ini menyediakan data dasar yang penting serta menawarkan model konservasi terintegrasi yang dapat direplikasi untuk pelestarian ekosistem air tawar di kawasan Asia Tenggara.

Kata Kunci: Keanekaragaman hayati air tawar; Spesies endemik; Gymnochanda verae; Reintroduksi spesies; Pulau Belitung; Keanekaragaman genetik; Strategi konservasi

INTRODUCTION

Indonesia is recognized as one of the countries with the highest freshwater fish diversity in the world, with over 1,200 documented freshwater species (Robin *et al.,* 2023; Akbar *et al.,* 2025) and hundreds of endemic taxa distributed across its many islands and ecological niches (Hubert *et al.,* 2015). However, this remarkable biodiversity is under serious threat due to land-use conversion, habitat degradation, and unsustainable exploitation of aquatic resources (South *et al.,* 2025). In the Bangka–Belitung Archipelago, freshwater ecosystem quality has been further diminished by extensive tin mining and the rapid expansion of oil palm plantations (Syarif *et al.,* 2023). These disturbances have led to habitat fragmentation, species habitat loss, river pollution, and the decline of local fish populations, including endemic and vulnerable species (Valen *et al.,* 2025).

Belitung Island, located off the eastern coast of Sumatra, is home to ancient river systems such as the Lenggang River, which hold high ecological value due to their unique geological history and relatively isolated freshwater habitats (Hasan *et al.,* 2023). These ancient waters serve as important refugia for native and endemic fish species, many of which remain poorly documented and understudied in current conservation literature (Kurniawan *et al.,* 2021). One such species is *Gymnochanda verae*, a miniature, translucent fish known to occur only in the Lenggang River, East Belitung (Kurniawan *et al.,* 2019; Khanati *et al.,* 2023). Despite its ecological significance, systematic assessments of freshwater fish diversity and species recovery efforts in this region remain scarce (Hasan & South, 2023).

Recent freshwater conservation strategies increasingly highlight the role of species reintroduction (Harding *et al.,* 2025; Nath *et al.,* 2025), not only as a tool for restoring depleted populations, but also as a means of enriching genetic diversity (Tracy *et al.,* 2011; Keller *et al.,* 2012) and enhancing the ecological resilience of aquatic communities (Geist & Hawkins, 2016). Reintroduction efforts are most effective when focused on species that are historically native to a given habitat and are supported by habitat restoration and long-term monitoring (Geist & Hawkins, 2016; Stoffers *et al.,* 2022). However, such approaches are still rarely implemented in Indonesian river ecosystems, particularly in small island regions with unique biogeographic characteristics.

This study presents a comprehensive assessment of freshwater fish biodiversity in the Lenggang River, conducted in 2024, and proposes a species reintroduction-based conservation framework. The objectives of this research are to: (1) document the diversity of native and endemic fish species; (2) identify candidate species for reintroduction based on ecological relevance, conservation status, and historical presence; and (3) evaluate the initial outcomes of reintroduction efforts within rehabilitated sections of the river. The study contributes new insights into island riverine conservation and provides essential baseline data for safeguarding freshwater biodiversity in Belitung and the broader Bangka–Belitung ecoregion.

MATERIALS AND METHODS

Study Area

This study was conducted in the Lenggang River, an ancient freshwater system located in East Belitung, Indonesia (Figure 1). The river is characterized by blackwater conditions, acidic pH (4.5–6.0), low conductivity, and a heterogeneous habitat structure consisting of riffles, pools, submerged root systems, and leaf-litter beds. Owing to its relative isolation and limited anthropogenic modification, the Lenggang River serves as an appropriate reference site for evaluating native freshwater fish biodiversity and implementing targeted conservation and reintroduction programs.

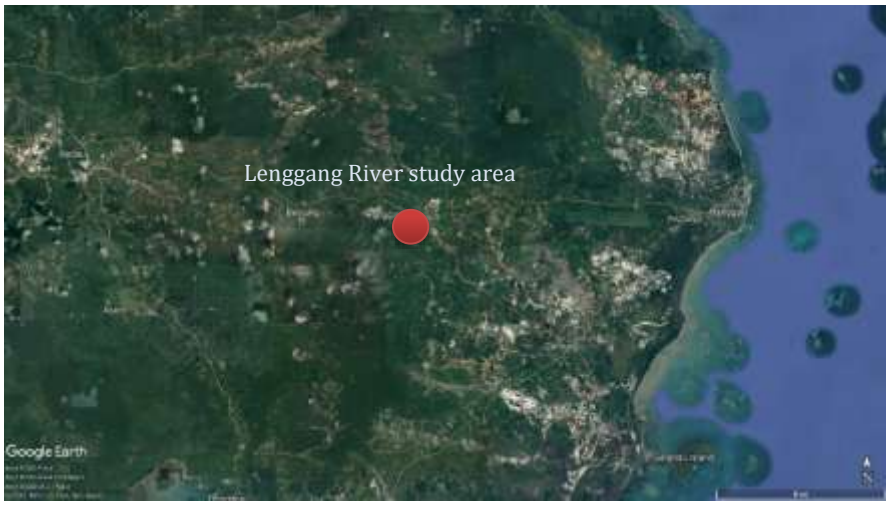

Figure 1. Map of the Lenggang River study area, East Belitung, Indonesia.

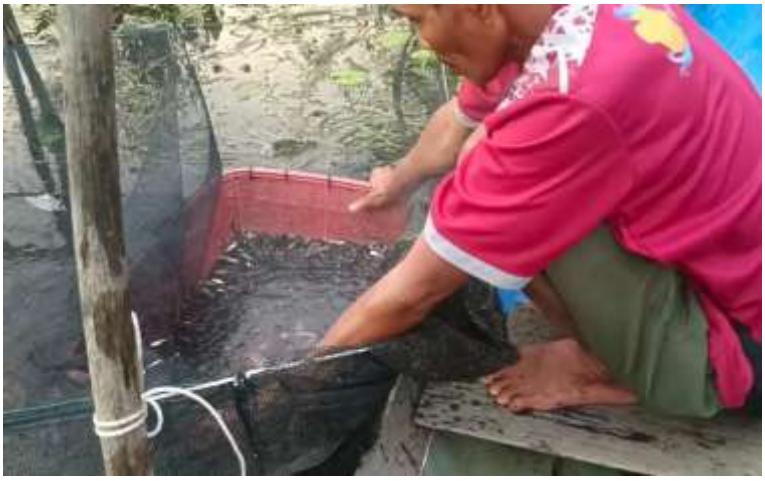

Figure 2. Sample collections

Biodiversity Assessment

Fish sampling was conducted throughout 2024 to document species composition within the riverine ecosystem (Figure 2). Sampling activities were carried out at several stations representing upstream, midstream, and downstream segments of the river. Collection methods included dip-netting, gill- and cast-netting, fish traps, and angling. All captured specimens were morphologically identified and subsequently released following a catch-and-release protocol to minimize disturbance to wild populations.

Captured fish were photographed and identified to the species level based on external morphological characters using taxonomic keys and meristic traits (Kottelat & Yeo, 2005; Ilmia *et al.,* 2025). One individual per species was retained as a voucher specimen and deposited in the Aquaculture Laboratory, Universitas Bangka Belitung (UBB), for verification and further taxonomic reference.

Species Identification

Captured fish were photographed and identified to the species level based on external morphological characters using taxonomic keys and meristic traits (Kottelat & Yeo, 2005; Ilmia *et al.,* 2025). One individual per species was retained as a voucher specimen and deposited in the Aquaculture Laboratory, Universitas Bangka Belitung (UBB), for verification and further taxonomic reference.

Selection of Reintroduction Species

Candidate species for reintroduction were selected based on the following criteria: (1) confirmed historical occurrence in the Lenggang River; (2) native or endemic status; (3) ecological importance or functional role; (4) declining population trends; and (5) feasibility for rearing and release. A total of 30 species met these criteria, including *Gymnochanda verae*, *Desmopuntius gemellus, Osteochilus spilurus* and *Osteochilus flavicauda.*

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Table 1. Summarizes the complete list of fish species identified in the Lenggang River along with their respective reintroduction status.

No.	Scientific Name	Genus	Reintroduction Status	Conservation Status
1	*Scleropages formosus*	Osteoglossidae	No	Endangered (EN)
2	*Notopterus notopterus*	Notopteridae	No	Least Concern (LC)
3	*Barbodes sellifer*	Cyprinidae	No	Least Concern (LC)
4	*Cyclocheilichthys apogon*	Cyprinidae	Yes	Least Concern (LC)
5	*Desmopuntius sp.*	Cyprinidae	Yes	Least Concern (LC)
6	*Eirmotus cf. insignis.*	Cyprinidae	Yes	Least Concern (LC)
7	*Osteochilus spilurus*	Cyprinidae	Yes	Least Concern (LC)
8	*Osteochilus flavicauda*	Cyprinidae	Yes	Least Concern (LC)
9	*Oryzias javanicus*	Adrianichthyidae	No	Least Concern (LC)
10	*Gymnochanda verae*	Ambassidae	Yes	Endangered (EN)
11	*Barbucca diabolica*	Barbuccidae	No	Least Concern (LC)
12	*Sphaerichtys sp.*	Osphronemidea	Yes	Least Concern (LC)
13	*Anabas testudineus*	Osphronemidea	No	Least Concern (LC)
14	*Belontia sp*	Osphronemidea	No	Least Concern (LC)
15	*Betta cf. renata*	Osphronemidea	Yes	Vulnerable (VU)
16	*Betta edithae*	Osphronemidea	Yes	Least Concern (LC)
17	*Parosphromenus sp.*	Osphronemidea	Yes	Vulnerable (VU)
18	*Luciocephalus pulcher*	Osphronemidea	Yes	Least Concern (LC)
19	*Trichopodus trichopterus*	Osphronemidea	No	Least Concern (LC)
20	*Channa bankanensis*	Channidae	Yes	Near Threatened (NT)
21	*Channa cf. limbata*	Channidae	No	Least Concern (LC)
22	*Chaca bankanensis*	Chacidae	Yes	Near Threatened (NT)
23	*Channa sp.*	Channidae	No	Least Concern (LC)
24	*Channa striata*	Channidae	Yes	Least Concern (LC)
25	*Channa marulioides*	Channidae	Yes	Least Concern (LC)
26	*Chaca bankanensis*	Chachidae	No	Near Threatened (NT)
27	*Clarias leiacanthus*	Clariidae	No	Least Concern (LC)
28	*Clarias sp.*	Clariidae	No	Least Concern (LC)
29	*Kryptopterus sp.*	Siluridae	No	Near Threatened (NT)
30	*Silurichthys hasselti*	Siluridae	Yes	Least Concern (LC)
31	*Wallagonia sp.*	Siluridae	No	Least Concern (LC)
32	*Pseudomystus sp.*	Bagridae	No	Least Concern (LC)
33	*Leiocassis micropogon*	Bagridae	Yes	Least Concern (LC)
34	*Hemibagrus hoevenii*	Bagridae	No	Least Concern (LC)
35	*Brevibora cheeya*	Danionidae	Yes	Least Concern (LC)
36	*Rasbora bankanensis*	Danionidae	Yes	Least Concern (LC)
37	*Rasbora cephalotaenia*	Danionidae	Yes	Least Concern (LC)
38	*Trigonopoma gracile*	Danionidae	Yes	Least Concern (LC)
39	*Trigonopoma pauciperforatum*	Danionidae	Yes	Least Concern (LC)
40	*Monopterus albus*	Synbranchidae	No	Least Concern (LC)
41	*Macrognathus sp*	Synbranchidae	Yes	Least Concern (LC)
42	*Macrognathus maculatus*	Synbranchidae	No	Least Concern (LC)
43	*Mastacembelus notophthalmus*	Synbranchidae	No	Least Concern (LC)
44	*Mastacembelus erythrotaenia*	Synbranchidae	Yes	Least Concern (LC)
45	*Pangio semicincta*	Synbranchidae	Yes	Least Concern (LC)
46	*Kottelatlimia sp.*	Synbranchidae	No	Vulnerable (VU)
47	*Neohomaloptera sp.*	Synbranchidae	No	Least Concern (LC)
48	*Nandus nebulosus*	Nandidae	Yes	Least Concern (LC)
49	*Nemacheilus sp.*	Nemacheilidae	Yes	Least Concern (LC)
50	*Dermogenys sp.*	Zenarchopteridae	Yes	Least Concern (LC)
51	*Hemirhamphodon phaiosoma*	Zenarchopteridae	Yes	Least Concern (LC)
52	*Aplocheilus armatus*	Aplocheilidae	Yes	Least Concern (LC)
53	*Phenacostethus sp.*	Phallostethidae	No	Least Concern (LC)
54	*Oxyeleotris marmorata*	Eleotridae/Butidae	No	Least Concern (LC)

Reintroduction Strategy

The reintroduction program was implemented in the upstream and midstream sections of the Lenggang River. Selected species were reared ex situ for 6–8 weeks under semi-natural conditions prior to release. Environmental parameters, including water pH, temperature, dissolved oxygen, and current velocity, were monitored weekly to ensure habitat suitability. Release activities were carried out gradually by introducing small groups at multiple sites to reduce stress during acclimatization and to enhance overall survival rates.

RESULTS

Species Composition and Diversity

The 2024 biodiversity assessment conducted in the Lenggang River, East Belitung, documented a total of 54 freshwater fish species, representing 23 families. Species identification was performed using a combination of morphological and molecular approaches across the upstream, midstream, and downstream segments of the river. The recorded taxa included several ecologically significant groups, notably Cyprinidae, Osphronemidae, Channidae, Siluridae, and Mastacembelidae, which collectively contributed to the majority of species richness in the system.

Endemic Species Reintroduced

Among the 54 identified species, 23 families, one endemic taxon, and several important native species were recorded, including *Gymnochanda verae* (endemic to Belitung), *Parosphromenus sp*, and *Rasbora bankanensis*. Several species also exhibited high conservation value due to their restricted distribution or declining populations in natural habitats, such as *Chaca bankanensis, Chaca bankanensis,* and *Kottelatlimia sp.*

Based on ecological assessment, conservation status, and historical distribution records, a total of 30 species were designated as candidates for reintroduction. The selection criteria included: 1. Documented historical presence in the Lenggang River; 2. Native or endemic status; 3 Ecological function or importance; 4. Evidence of population decline; and 5. Feasibility of ex-situ maintenance and release.Table 2. Endemic and native species selected for reintroduction. The selection criteria included: 1. Documented historical presence in the Lenggang River; 2. Native or endemic status; 3 Ecological function or importance; 4. Evidence of population decline; and 5. Feasibility of ex-situ maintenance and release.

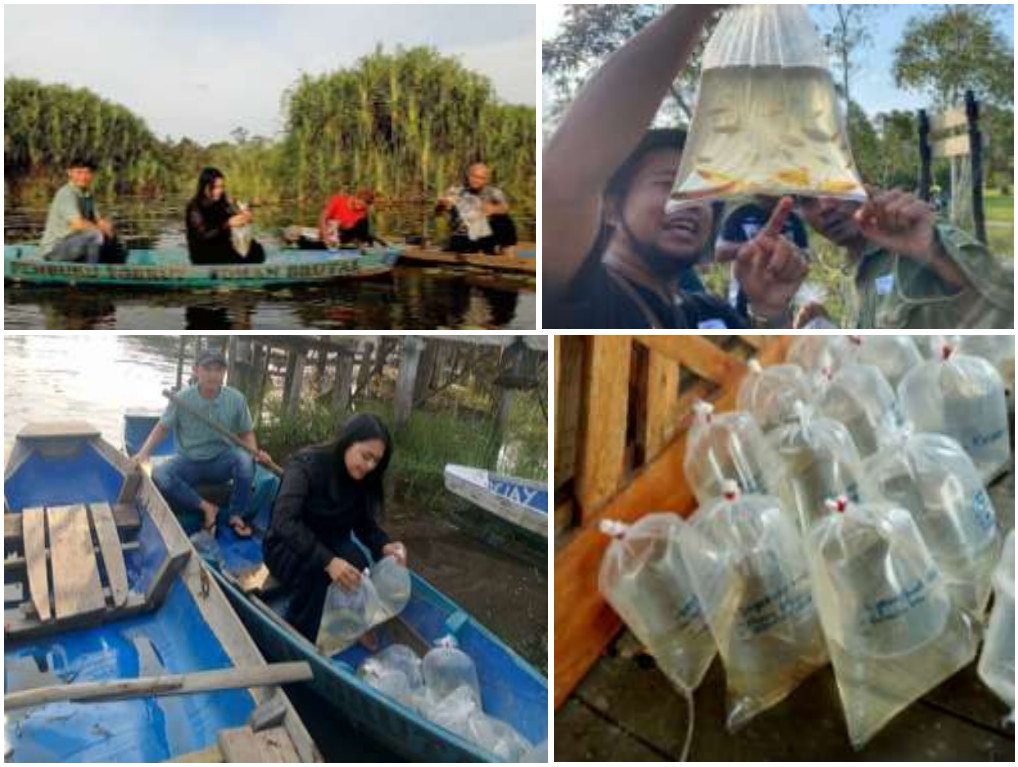
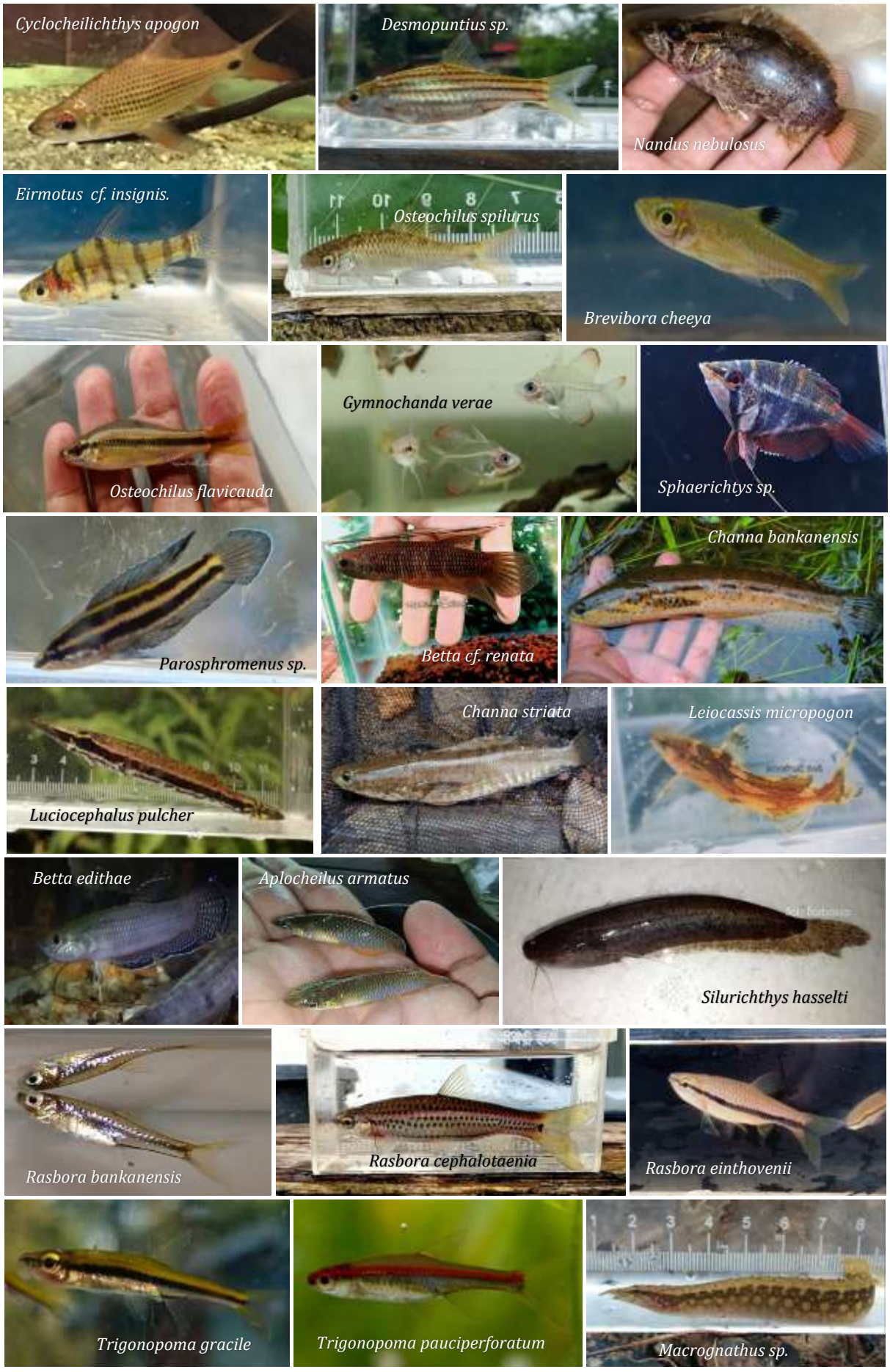


Figure 3. Reintroduction endemic and native fish in Lenggang River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Desmopuntius sp.
Nandus nebulosus
Eirmotus cf. insignis.
Osteochilus spilurus
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Osteochilus flavicauda
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Sphaerichtys sp.
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Leiocassis micropogon
Betta edithae
Aplocheilus armatus
Silurichthys hasselti
Rasbora bankanensis
Rasbora cephalotaenia
Rasbora einthovenii
Trigonopoma gracile
Trigonopoma pauciperforatum
Macrognathus sp.

Figure 4. Endemic and native species selected for reintroduction.

Reintroduction Implementation and Early Response

The reintroduction program was conducted in two phases (August and October 2024) across three locations along the Lenggang River. A total of 30 species were released, with an initial stocking density of 50–100 individuals per species (Figure 2). Early monitoring results (1 and 3 months post-release) indicated relatively high survival rates, exceeding 70% in most species. *Betta edithae*, *Rasbora cephalotaenia*, and *Luciocephalus pulcher* demonstrated positive behavioral adaptation, including active habitat exploration and territory establishment. Conversely, species such as *Glyptothorax* sp. and *Mastacembelus erythrotaenia* exhibited slower adaptation, likely due to suboptimal substrate conditions or competitive interactions with other species.

DISCUSSION

Species reintroduction into their natural habitats not only serves to restore declining populations (Jachowski, *et al.,* 2016) but also plays a critical role in enhancing the genetic diversity of local fish communities (Storfer *et al.,* 1999; Salmenkova *et al.,* 2008; Lut z*et al.,* 2021). In the context of the Lenggang River, the reintroduction of 30 native species, many of which are native species or historically represents a significant initial effort toward strengthening ecosystem integrity and improving the genetic resilience of freshwater assemblages (Kitanishi, *et al.,* 2013; Buckley *et al.,* 2024).

Genetic diversity forms the foundation for a population's adaptive capacity in the face of environmental changes and ecological stressors such as pollution, climate change, and biological invasions (Paul s*et al.,* 2013; Erwin, 2024; Zha n*et al.,* 2025). Fish populations subjected to habitat fragmentation, demographic bottlenecks, or isolation often experience reduced genetic variability, which may lead to inbreeding, reduced fitness, and a higher risk of local extinction (Sadler, *et al.,* 2023; Pavlova, *et al.,* 2024; Blanton *et al.,* 2025; Pavlova, *et al.,* 2025;). Carefully managed reintroduction of individuals from ex situ sources can help enrich the genetic pool, minimize inbreeding risks, and support the evolutionary potential of target species (Jacques *et al.,* 2023; Trzcińska *et al.,* 2023).

In this study, several reintroduced species such as *Betta edithae*, *Luciocephalus pulcher*, and *Rasbora bankanensis* demonstrated promising behavioral responses to rehabilitated environments, including territoriality and habitat exploration. These results indicate that the ecological conditions of the Lenggang River remain sufficiently intact to support population recovery, provided that habitat structure and water quality are maintained (Febryanti *et al.,* 2021; Bidayani *et al.,* 2023).

Beyond enhancing genetic diversity, reintroduction also contributes to increased population abundance and ecosystem stability (Lut z*et al.,* 2021; Terui *et al.,* 2023; He *et al.,* 2024). The return of species with specific ecological functions, such as micro-predators, herbivores, and periphyton grazers, can restore trophic structure, strengthen food web interactions, and improve key ecosystem processes such as nutrient cycling and alga control (do Nascimento Filho *et al.,* 2021; Jacinto *et al.,* 2023).

However, the long-term success of reintroduction depends on several critical factors, including Habitat suitability (substrate composition, riparian vegetation, water quality) (Graziano *et al.,* 2022; Lim & Do, 2023), Genetic origin of reintroduced individuals (to avoid outbreeding depression) (Lut z*et al.,* 2021; Buckley *et al.,* 2024; Smith *et al.,* 2024; Pavlova, *et al.,* 2024), Timing and method of release, and Adaptive long-term monitoring that allows for

dynamic management interventions (Marshall *et al.,* 2022; Strayer, 2024).

By applying evidence-based conservation principles, the reintroduction program in the Lenggang River demonstrates a scalable and replicable model for freshwater biodiversity restoration in tropical island ecosystems, particularly in Indonesia, where inland waters are under growing anthropogenic pressure.

CONCLUSION

This study provides a comprehensive overview of freshwater fish diversity in the Lenggang River, Belitung Island, and demonstrates an applied conservation strategy through the reintroduction of native and endemic species. A total of 54 species were successfully identified, reflecting a taxonomically rich fish community of high ecological value, including several taxa with restricted distribution and declining population trends. Of these, 30 species were selected for reintroduction based on their ecological relevance, conservation urgency, and historical occurrence within the river system. Early monitoring results indicate that the reintroduction effort has produced positive signs of adaptation and survival, with several species exhibiting territorial behavior and successful integration into rehabilitated habitats. These findings highlight that reintroduction programs not only support the recovery of declining populations, but can also enhance genetic diversity and ecological stability in freshwater communities. Furthermore, this study emphasizes the importance of integrating species-focused interventions with habitat restoration, long-term monitoring, and community involvement as critical components for achieving sustainable conservation outcomes. The reintroduction framework developed here can serve as a replicable model for freshwater biodiversity recovery, particularly in tropical island ecosystems facing intensifying anthropogenic pressures. Future research is recommended to monitor genetic variation, post-reintroduction reproductive success, and long-term ecological impacts to evaluate program effectiveness comprehensively.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Ministry of Higher Education, Science, and Technology for providing financial support through the Community Partnership Empowerment Program (Program Pemberdayaan Kemitraan Masyarakat), Fiscal Year 2024, under Contract Number 1691/UN50/L/PM/2024. We also extend our sincere appreciation to Universitas Bangka Belitung (UBB) and the Research and Community Service Institute (LPPM UBB) for institutional support, research facilities, and field coordination during the implementation of this project.

We thank the Aquaculture Department academic team, field survey assistants, and collaborating local communities for their contributions to species monitoring, ecological assessment, and conservation fieldwork. The authors also acknowledge the valuable comments and suggestions from anonymous reviewers, which have greatly improved the manuscript's clarity and scientific quality.

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