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CHAPTER 11

Freshwater fish of Malaysian Borneo

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Abstract: This chapter focuses on taxonomic richness of freshwater fish of Malaysian Borneo which include endemism, research status, conservation effort, and investment needs. Freshwater ecosystems in Borneo support one of Southeast Asia's most distinctive fish assemblages, influenced by ancient geology, diverse habitats, and long-term river isolation. In Sarawak and Sabah, over 300 valid freshwater fish species are recorded, with high species richness from the order Cypriniformes, Siluriformes, Anabantiformes, and Gobiiformes. Endemism is a defining feature, with many lineages occurring in only a single basin or habitat, particularly peat swamps and elevated headwater streams, and most members of the family Gastromyzontidae occur nowhere else. The earliest freshwater fish collections from Borneo date to the 1820s, and the number of species described from the island has since increased from just over a hundred to more than 600 species today, driven by a steady rise in new species descriptions over the past decade. Yet major gaps persist, as peat swamps remain undersampled, upstream watersheds lack long-term datasets, and many historical type localities have been altered by land-use change. The continual discovery of new taxa indicates that true species richness is still underestimated and reinforces the importance of integrative taxonomy that combines morphology, genetics, and ecological data. Conservation needs are urgent since freshwater habitats are threatened by land conversion, river modification, presence of invasive species, and habitat impoundment. Peat swamps are particularly threatened, which affects narrow-ranged species such as *Paedocypris micromegethes*, and *Betta chini*. Ongoing efforts involve protected areas, riparian buffers, captive breeding and community-managed *Tagang* systems, however implementation has not been consistent in the region. To improve the conservation of freshwater fish in the future, basin-wide biodiversity surveys and updated Red List assessments are needed, as well as the identification and protection of important peat swamp habitats, headwater streams, molecular reference libraries for eDNA and building capacity with local researchers and communities. In the future, trans-border co-operation with Indonesian Kalimantan and Brunei Darussalam will also increase knowledge of inter-watershed connectivity. Malaysian Borneo retains its reputation for freshwater fish diversity, and the conservation of this part of natural heritage requires science integration, sound management, and continued commitment.

INTRODUCTION

Malaysian Borneo, comprising Sarawak and Sabah, is often celebrated for its towering dipterocarp forests, charismatic wildlife, and vast river systems. Yet beneath the surface of its rivers, streams, and peat swamps lies a lesser-known, but equally remarkable world: an extraordinary diversity of freshwater fish. These aquatic communities, shaped by millions of years of geological events and ecological isolation, represent one of Southeast Asia's most distinctive biological treasures. Today, this diversity faces mounting pressure from rapid environmental change. Understanding the richness, uniqueness, and vulnerability of Malaysian Borneo's freshwater fish is therefore essential not only for scientists, but also for policymakers, conservationists, and the public.

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The diversity of freshwater fish in Malaysian Borneo is deeply rooted in its geological and ecological history. The island's rivers have evolved across ancient landscapes marked by shifting tectonic plates, fluctuating sea levels, and long periods of isolation. These processes have divided river systems into distinct basins (e.g., Rajang, Baram and Kinabatangan), limiting connectivity and allowing species to evolve independently over time. As a result, Malaysian Borneo is recognised as an evolutionary hotspot, with freshwater systems ranging from blackwater peat swamps to fast-flowing hill streams and large meandering lowland rivers. Each habitat supports specialised fish communities adapted to unique environmental conditions. Peat swamp forests, for instance, are characterised by acidic, tannin-stained waters with low nutrient and oxygen levels. In contrast, highland streams are cool, oxygen-rich, and structurally complex (Figure 1). This environmental heterogeneity is a key driver of species diversity, enabling a wide range of ecological niches to coexist.

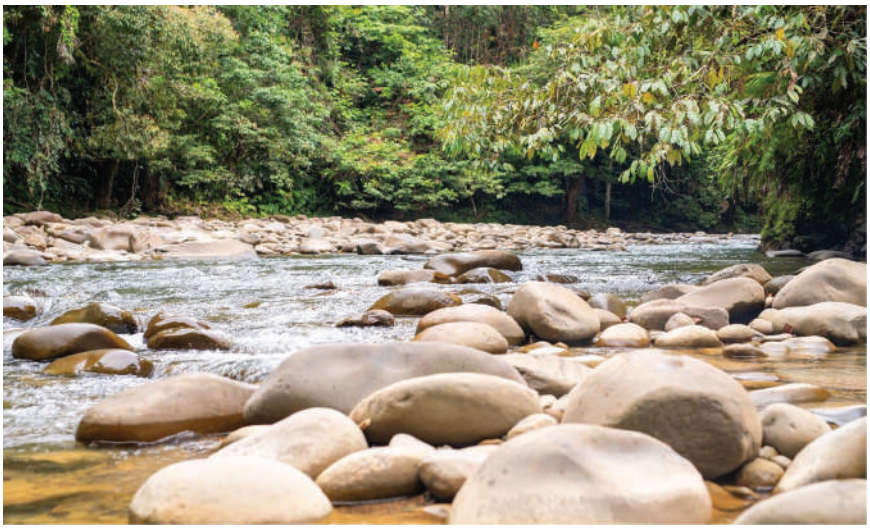

Figure 1. Typical habitat of upper river reaches, characterised by fast-flowing, well-oxygenated streams associated with hillstream loaches.

Richness Beneath the Surface and endemism

More than 300 valid freshwater fish species have been recorded in Malaysian Borneo, with Cypriniformes (carps and minnows) dominating the assemblage, followed by Siluriformes (catfishes), Anabantiformes (gouramies), and Gobiiformes (gobies) (see fishbase.org; Kottelat *et al.* 1993; Inger and Chin 2002). When considering the entire island of Borneo, the number exceeds 600 species, and continues to grow as new taxa are described. This diversity is not merely numerical, it reflects a wide array of ecological roles and adaptations. Some species, such as hillstream loaches (especially Gastromyzontidae) (Figure 2), possess dorso-ventrally flattened bodies with enlarged pectoral and pelvic fins that allow them to cling to rocks in fast-flowing waters. Others, like labyrinth fishes, have evolved accessory breathing organs to survive in oxygen-poor environments. Recent decades have seen a surge in species discoveries, with approximately 70 new species described from Borneo in the past 15 years alone. Advances in sampling techniques and molecular tools have revealed cryptic diversity, species that are morphologically similar but genetically distinct, highlighting how much remains unknown.

One of the most striking characteristics of Malaysian Borneo's freshwater fish fauna is its high level of endemism. Many species are restricted to a single river basin, or even to specific microhabitats within a basin. This pattern reflects the long-term isolation of river systems and the limited dispersal ability of freshwater fishes. Peat swamp ecosystems

are particularly notable for hosting stenotopic species (Figure 3). The miniature fish *Paedocypris micromegethes* (Figure 4), among the smallest vertebrates in the world, is confined to acidic blackwater habitats that may span only a few square kilometres. Similarly, several species of *Betta* and *Parosphromenus* are restricted to highly specific environmental conditions. Highland streams also harbour endemic species, particularly among loaches and cyprinids, often confined to headwaters of major basins such as the Rajang, Baram, and Kinabatangan. In some cases, closely related species occur in adjacent basins but nowhere else, illustrating the role of geographic isolation in driving speciation. Such restricted distributions make these species inherently vulnerable. The loss of a single habitat can result in the extinction of an entire lineage.



Figure 2. The hillstream loach, *Gastromyzon fasciatus*, serves as a useful indicator of the disappearance of high-quality habitats in the upper reaches of many river systems.



Figure 3. Oxbow lake is a common feature in downstream areas of Baram River in Sarawak.



Figure 4. One of the smallest freshwater fishes, *Paedocypris micromegethes*, reaches a maximum length of only about 10 mm.

A legacy of exploration

The study of freshwater fish in Borneo dates back to the early 19th century, when naturalists such as Pieter Bleeker and Albert Günther began documenting the island's biodiversity. Early collections gradually expanded knowledge on freshwater fish diversity, from just over 100 species to the more than 600 recognised (unpublished data) today for the entire island. Modern ichthyological research has accelerated since the 1990s, driven by collaborations among regional and international institutions. Researchers have increasingly focused on previously under-explored habitats, such as upland streams and peat swamps, leading to significant taxonomic advances. Despite this progress, major knowledge gaps remain. Many peat swamp systems are still poorly sampled, and long-term ecological data for upper watersheds are scarce. Furthermore, some historical type localities have been altered or degraded, complicating efforts to reassess species distributions.

The freshwater ecosystems of Malaysian Borneo are still undergoing rapid transformation. Land conversion, particularly for oil palm plantations, has led to widespread deforestation and drainage of peat swamps. These activities alter hydrological regimes, increase sedimentation, and cause degradation of water quality. Sedimentation, for example, can disrupt fish reproduction by reducing water clarity, smothering spawning substrates, and altering microhabitats required for egg development. Such changes are especially detrimental to species adapted to clear, stable environments, including many endemic cyprinids and loaches. River modification presents another major challenge. Channelisation, road crossings, and dam construction fragment habitats and disrupt natural flow regimes. Hydropower projects, while important for energy production, can significantly alter river connectivity and ecological processes.

Invasive species further compound these pressures. Introduced fishes such as *Channa micropeltes* can outcompete or prey upon native species (unpublished data from Batang Ai reservoir; Figure 5), altering community structure and ecosystem dynamics. Climate change adds an additional layer of uncertainty, with shifts in rainfall patterns and temperature likely to affect river hydrology and habitat stability.



Figure 5. Two cohorts of *Channa micropeltes* recently collected from the Batang Ai Reservoir, suggesting successful establishment following a suspected introduction around 2016. Scale: 1 cm

Among all freshwater habitats in Malaysian Borneo, peat swamps are the most threatened. These lowland ecosystems have experienced rapid decline due to drainage, logging, and agricultural expansion. Peat swamps are not only unique in their physical characteristics, but also in their biological communities. They support a suite of highly specialised, stenotopic species (Figure 6), organisms adapted to narrow environmental conditions. Many of these species are found nowhere else on earth. The degradation of peat swamps therefore has disproportionate consequences. The loss of even small habitat patches can lead to the disappearance of entire species, particularly those with extremely limited distributions. The decline of peat swamp habitats underscores the urgent need for targeted conservation efforts focused on these ecosystems. For example, our long-term monitoring of *Paedocypris micromegethes* at its type locality indicates a likely local disappearance, with only a single isolated habitat remaining where the species still persists.



Figure 6. A benthic stenotopic species *Kottelatlimia pristes* endemic to Borneo.

CONSERVATION EFFORTS: PROGRESS AND GAPS

Efforts to conserve freshwater fish in Malaysian Borneo are underway, but remain uneven in implementation. Protected areas, including national parks and water catchments, provide some level of habitat protection. Riparian buffer zones are increasingly recognised as essential for maintaining water quality and ecological integrity, although enforcement varies. Community-based management systems, such as *Tagang* in Sarawak (or *Tagal* in Sabah), have shown promising results in certain regions. These systems involve local communities regulating fishing activities to allow fish populations to recover, demonstrating the potential of participatory conservation approaches. Captive breeding programmes are also being developed for selected species, such as *Tor tambra*, while emerging technologies like environmental DNA (eDNA) and acoustic monitoring offer new tools for biodiversity assessment. Despite these efforts, significant knowledge gaps remain. Conservation initiatives are often fragmented, and many endemic species lack updated assessments of their conservation status. There is also a shortage of trained taxonomists, which limits the capacity to identify and describe new species.

Addressing these challenges requires a coordinated and forward-looking approach. Basin-wide biodiversity surveys are needed to provide comprehensive data on species distributions and population trends. Such surveys should prioritise underexplored habitats, including peat swamps and headwater streams. Updating IUCN Red List assessments is equally important, particularly for endemic species that may be at risk but remain poorly studied. Molecular tools, including DNA barcoding and metabarcoding, can help build reference libraries that support species identification and monitoring. Strengthening local capacity is another critical priority. Training the next generation of taxonomists and ecologists will ensure that expertise remains within the region, enabling sustained research and conservation efforts. Transboundary collaboration with Kalimantan (Indonesian Borneo) is also essential, as many river systems extend beyond national borders. Cooperative management can enhance understanding of ecological connectivity and improve conservation outcomes at a landscape scale.

Malaysian Borneo's freshwater fish diversity is globally significant. The region ranks among the richest in Southeast Asia in terms of species diversity per unit area, and its high level of endemism reflects a unique evolutionary history. Beyond their intrinsic value, freshwater fishes play vital ecological roles. They contribute to nutrient cycling, regulate food webs, and support livelihoods through fisheries. For many local communities, rivers are central to cultural identity and daily life. The loss of freshwater biodiversity therefore has far-reaching consequences, not only for ecosystems, but also for human well-being.

Malaysian Borneo can be viewed as a natural laboratory for understanding freshwater ecosystems. Its diverse habitats, complex biogeography, and ongoing environmental changes provide opportunities to study ecological and evolutionary processes in real time. At the same time, this uniqueness brings responsibility. Protecting freshwater fish diversity requires integrating scientific research with effective management and community engagement. It also demands a shift in perspective from viewing rivers as resources to recognising them as dynamic ecosystems that sustain life.

CONCLUSION

The freshwater fish of Malaysian Borneo represent an extraordinary yet vulnerable component of the region's natural heritage. High species richness, remarkable endemism, and ongoing discoveries highlight both the ecological significance and the incomplete state of current knowledge. However, rapid environmental change poses serious threats, particularly to specialised and narrowly distributed species. Conservation efforts, while promising, must be strengthened through coordinated action, improved data, and greater investment in research and capacity building. Ultimately, safeguarding this diversity will depend on our ability to balance development with ecological integrity. In doing so, Malaysian Borneo can continue to serve as a global reference point for freshwater biodiversity, and as a reminder of the intricate connections between nature and society.

REFERENCES

Anonymous. 2016. SE-UNIMAS collaborative research: Aquatic ecology and biodiversity studies. Sarawak Energy Berhad's Hydropower Environmental Sustainability Program. [Unpublished report].

Atack, K. 2006. *A field guide to the fishes of Kuching rivers: Sarawak, Malaysian Borneo*. Kota Kinabalu: Natural History Publications (Borneo). 207 pp.

Bleeker, P. 1855. Achtste bijdrage tot de kennis der ichthyologische fauna van Borneo. Zoetwatervisschen van Bandjermasin. *Natuurkundig Tijdschrift voor Nederlandsch Indië* 8: 151–168.

Choy, S.C. and Chin, P.K. 1994. Freshwater fishes from the headwaters of the Belalong-Temburong river system, Brunei Darussalam, Borneo. *Raffles Bulletin of Zoology* 42(4): 757–774.

de Bruyn, M., Nugroho, E., Hossain, M.M., Wilson, J.C. and Mather, P.B. 2005. Phylogeographic evidence for the existence of an ancient biogeographic barriers: The Isthmus Kra Seaway. *Heredity* 94: 370–378.

de Bruyn, M., Rüber, L., Nylinder, S., Stelbrink, B., Lovejoy, N.R., Lavoué, S., Tan, H.H. *et al*. 2013. Paleo-drainage basin connectivity predicts evolutionary relationships across three Southeast Asian biodiversity hotspots. *Systematic Biology* 62(3): 398–410. https://doi.org/10.1093/sysbio/syt007

Doi, A., Iwata, T., Inoue, M., Miyasaka, H., Mohamad Shahbudin, S. and Nakano, S. 2001. A collection of freshwater fishes from the Rayu basin of western Sarawak, Malaysia. *Raffles Bulletin of Zoology* 49(1): 13–17.

Froese, R. and Pauly, D. 2025. FishBase. https://www.fishbase.org

Grinang, J. 2013. Fish and macroinvertebrates of Padawan limestone, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology* 3(2): 1–14.

Grinang, J. and Lim, K.K.P. 2004. Fishes. *Sarawak Bau limestone biodiversity*, H.S. Yong, F.S.P. Ng and E.E.L. Yen (Eds.). *Sarawak Museum Journal* 59(80, Special Issue No. 6): 285–298.

Inger, R.F. and Chin, P.K. 2002. *Freshwater fishes of North Borneo with a supplementary chapter by Chin Phui Kong*. Kota Kinabalu: Natural History Publications (Borneo). 346 pp.

Kottelat, M. 2013. The fishes of the inland waters of Southeast Asia: A catalogue and core bibliography of the fishes known to occur in freshwater, mangroves and estuaries. *Raffles Bulletin of Zoology Supplement* 27: 1–663

Kottelat, M., Whitten, A.J., Kartikasari, S.N. and Wirjoatmodjo, S. 1993. *Freshwater fishes of Western Indonesia and Sulawesi*. jakarta: Periplus Editions.

Kottelat, M. and Lim, K.K.P. 1996. Freshwater fishes of Sarawak and Brunei Darussalam: A preliminary annotated check-list. *Sarawak Museum Journal* 48: 227–256.

Kottelat, M., Britz, R., Tan, H.H. and Witte, K-E. 2006. *Paedocypris*, a new genus of Southeast Asian cyprinid fish with remarkable exual dimorphism, comprise the world's smallest vertebrate. *Proceedings of the Royal Society B* 273: 895–899.

Lim, K.K.P. and Wong, A. 1994. Fishes of the Kinabatangan basin, Sandakan district, Sabah, East Malaysia. *Sabah Museum Journal* 1(2): 39–71.

Martin-Smith, K.M. and Tan, H.H. 1998. Diversity of freshwater fishes from eastern Sabah: Annotated checklist for Danum Valley and a consideration of inter- and intra-catchment variability. *Raffles Bulletin of Zoology* 46(2): 573–604.

Ng, C.K.C., Abdullah, F., Biun, H., Ibrahim, M.K., Mustapha, S. and Sade, A. 2017. Review: A working checklist of the freshwater fish diversity for habitat management and conservation work in Sabah, Malaysia, North Borneo. *Biodiversitas* 18(2): 560–574.

Nyanti, L. and Bali, J. 2004) *Fish fauna of Maludam National Park, Betong Division, Sarawak*. Joint Working Group Malaysia-The Netherlands: Development and Management of Maludam National Park. Kuching: Sarawak Forest Department, Alterra Green World Research and Sarawak Forestry Corporation. 50 pp.

Nyanti, L. and Grinang, J. 2007. *Fish fauna of Pulong Tau National Park*. ITTO Project PD 224/03 Rev.1(F): Transboundary Biodiversity Conservation – The Pulong Tau National Park, Sarawak, Malaysia. International Tropical Timber Organization (ITTO) and Sarawak Forest Department. 115 pp.

Nyanti, L., Ghaffar, M.A. and Samad, A. 1995. An ichthyological survey of Tawau Hills Park, Sabah. In *A scientific journey through Borneo: Tawau Hills Park, Sabah*, G. Ismail, S. Omar and L. Din (Eds.), pp. 173–189. Petaling Jaya: Pelanduk Publications.

Nyanti, L., Sayok, A.K. and Efransjahi, E. 2006. Fish fauna of Loagan Bunut National Park, Sarawak. In *Scientific Journey through Borneo: Loagan Bunut*, A.A. Tuen, A.K. Sayok, A.N. Toh and G.T. Noweg (Eds.), pp. 102–129. Kuching: Sarawak Forest Department, Institute of Biodiversity and Environmental Conservation, and Universiti Malaysia Sarawak.

Parenti, L.R. and Lim, K.K.P. 2005. Fishes of the Rajang basin, Sarawak, Malaysia. *Raffles Bulletin of Zoology Supplement* 13: 175–208.

Parenti, L.R. and Meisner, A.L.D. 1995. Fishes of the Belair River. *Brunei Museum Journal* 10: 17–54.

Rahim, K.A.A., Long, S.M. and Abang, F. 2002. A survey of freshwater fish fauna in the upper rivers of Crocker Range National Park Sabah, Malaysia. In *A scientific journey through Borneo: Crocker Range National Park Sabah. Volume 1. Natural ecosystem and species components*, G. Ismail and L. Ali (Eds.), pp. 119–130. Bangi: ASEAN Academic Press.

Rahim, K.A.A., Siti Khalijah, D., Siti Shapor, S., Aziz, A., Yuzine, E. and Eza Rena, I. 2009. Freshwater fish diversity and composition in Batang Kerang floodplain, Balai Ringin, Sarawak. *Pertanika Journal of Tropical Agricultural Science* 32(1): 7–16.

Roberts, T.R. 1989. The freshwater fishes of Western Borneo (Kalimantan Barat, Indonesia). *Memoirs of the California Academy of Sciences* 14.

Sulaiman, Z., Tan, H.H. and Lim, K.K.P. 2018. Annotated checklist of freshwater fishes from Brunei Darussalam, Borneo. *Zootaxa* 4379(1): 24–46.

Tan, H.H. 2006. The Borneo suckers: Revision of the torrent loaches of Borneo (Balitoridae: Gastromyzon, Neogastromyzon). Kota Kinabalu: Natural History Publications (Borneo).

Wilkinson, C.L., Yeo, D.C.J., Tan, H.H., Fikri, A.H. and Ewers, R.M. 2018. Land-use change is associated with a significant loss of freshwater fish species and functional richness in Sabah, Malaysia. *Biological Conservation* 222: 164–171.

Voris, H.K. 2000. Maps of Pleistocene sea levels in Southeast Asia: Shorelines, river systems and time durations. *Journal of Biogeography* 27: 1153–1167.