ISA Journal of Multidisciplinary (ISAJM)

Homepage: https://isapublisher.com/isajm/

Volume 3, Issue 2, March-April, 2026 ISSN: 3049-1851

A Review of Alien Fish Species (AFS) Introductions in Nigerian and Tanzanian Aquatic Systems

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Received: 21.03.2026 | **Accepted:** 05.04.2026 | **Published:** 07.04.2026

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DOI: *10.5281/zenodo.19455927*

Abstract **Review Article**

The introduction of alien fish species (AFS) into freshwater ecosystems is a major driver of biodiversity loss with important implications for African inland fisheries. This review analyses introduction pathways, establishment patterns, ecological impacts and management responses for AFS in Nigerian and Tanzanian waters. In Nigeria, aquaculture, mosquito biocontrol, ornamental fish trade and accidental releases have promoted the establishment of species such as Gambusia affinis and Poecilia reticulata in urban and disturbed systems, where they compete with native fishes and alter trophic dynamics. In Tanzania, stocking of Lates niloticus in Lake Victoria caused severe declines in endemic cichlids, restructured food webs and reshaped fisheries production and export markets. Anthropogenic disturbance, weak regulation and limited monitoring have facilitated AFS spread in both countries. The review highlights the need for stronger risk assessment, biosecurity, surveillance and regional policy harmonisation to balance food security goals with conservation of native fish biodiversity.

Keywords: Alien Fish Species, Invasive Species, Freshwater biodiversity, Aquaculture and biosecurity, Nigeria inland waters, Tanzania inland waters.

1.0 Introduction

An alien or non-native species is defined solely by its occurrence outside its native range as a result of human-mediated translocation (Welcomme, 1988). Globally, the introduction of alien fish species (AFS) into new aquatic environments has primarily been driven by the desire to boost productivity in aquaculture and capture fisheries, as well as to support the ornamental fish trade (FAO, 2018; Welcomme, 1988). Non-native fish species that are

intentionally or accidentally introduced into ecosystems different from their native range are regarded as AFS (Welcomme, 1988; Ita, 1993). Although these introductions can generate considerable economic benefits, they can also pose significant ecological risks because, once established, some alien fishes may become invasive, threatening native biodiversity through competition and predation, altering ecosystem functioning via disease transmission and genetic pollution, and negatively affecting local livelihoods (Pringle, 2005; Welcomme, 1988; Ita, 1993).

In Africa, freshwater ecosystems such as rivers, lakes, and wetlands are highly vulnerable because of their rich native biodiversity and long history of human use, particularly for fisheries, aquaculture, and mosquito-biocontrol programmes (Cairns *et al.*, 2024; Convention on Biological Diversity [CBD], 2004). A recent continent-wide review showed that several non-native poeciliid fishes, including mosquitofish (*Gambusia spp*.), guppy (*Poecilia reticulata*), and other aquarium species, are now established in at least 25 African countries, spanning both West and East African waters (Cairns *et al.*, 2024). These introductions have mainly arisen through mosquito-biocontrol initiatives, aquaculture activities, and the ornamental fish trade (Cairns *et al.*, 2024).

In Nigeria, several fish species, including Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*), mosquitofish (*Poecilia reticulata*, *Gambusia spp*.), and cultured African bonytongue (*Heterotis niloticus*), have already entered open inland waters as alien fish species (AFS) mainly via aquaculture escapes and mosquito-biocontrol pathways (Dagoudo *et al.,* 2025; Oladimeji *et al.,* 2022; Wikondi *et al.*, 2023). At present, however, there is a clear knowledge gap in Nigeria regarding alien freshwater fishes: the distinction between native and non-native taxa remains poorly documented, introduction events are rarely recorded in detail, and most scientific and management discourse still emphasises potential future invasiveness rather than well-documented invasion histories and quantified ecological impacts.

Comparatively, one of the most extensively documented cases of alien fish species (AFS) introduction in East Africa is the stocking of Nile perch (*Lates niloticus*) into Lake Victoria in the 1950s. The subsequent population explosion of Nile perch has been widely linked to the dramatic decline and probable extinction of hundreds of endemic haplochromine cichlid species, fundamentally restructuring the lake's trophic dynamics (Pringle, 2005; National Invasive Species Strategy and Action Plan, 2019). Although this introduction contributed to the development of a lucrative export fishery that substantially increased Tanzania's foreign exchange earnings, it also altered local livelihoods, drove shifts in fishing technologies, and intensified pressure on the remaining native species (National Invasive Species Strategy and Action Plan, 2019).

Similarly, the spread of aquaculture-based Nile tilapia (*Oreochromis niloticus*) beyond its native range in Tanzania has raised concerns about genetic introgression, competitive displacement of indigenous tilapiine species, and broader ecosystem-level impacts (Witt *et al.,* 2020). In several Tanzanian water bodies, introduced tilapias have hybridized with native species, potentially threatening the genetic integrity of locally adapted populations (Witt *et al.,* 2020). National and global registers now flag Nile perch, Nile tilapia, other introduced tilapiines, poeciliids, and additional ornamental or aquaculture species as the principal alien fish groups in Tanzanian inland waters (Cairns *et al.,* 2024; National Invasive Species Strategy and Action Plan, 2019).

Taken together, the introduction of alien fish species into Nigerian and Tanzanian aquatic systems represents a serious ecological concern, rooted largely in attempts to boost aquaculture production and commercial fisheries yields. While these initiatives have produced notable financial gains, they have also coincided with steep declines, and in some cases probable extinctions among native fish populations, alongside irreversible shifts in the structure and functioning of distinct freshwater ecosystems.

2.0 Methodology

This review compiles and synthesizes existing information on alien fish species (AFS) introductions in Nigeria and Tanzania, highlighting documented species, their impacts, and major ecological concerns in each country's aquatic ecosystems. A systematic literature search combined with a qualitative synthesis was used to evaluate AFS introductions in Nigerian and Tanzanian inland waters between 2000 and 2024. Relevant studies were retrieved from major electronic databases, including Web of Science, Google Scholar, and ScienceDirect. Targeted keyword searches and Boolean operators were applied using terms such as "alien fish species", "invasive species", "Nigeria", "Tanzania", "biodiversity", "African invasive species", and "poeciliid fish".

3.0 Concept of Alien Fish Species (AFS)

Alien fish species are fish that humans have moved outside their natural ranges, either deliberately or accidentally, to new habitats at national or sub-national scales (Welcomme, 1988; FAO, 2018). Freshwater systems are particularly prone to receiving such non-native fishes because many introduced species tolerate a wide range of conditions and are often associated with economic benefits such as aquaculture, fisheries enhancement, or the ornamental trade (Gozlan *et al.*, 2010). Non-native fishes can be classified by their introduction pathways (intentional releases for aquaculture or ornamental use versus unintentional escape or transfer) and by their ecological roles once established. While some are introduced on purpose for farming or display, others arrive unintentionally via inter-basin water transfers, ship ballast water, or escape from culture facilities, and may either remain at low abundance or successfully colonize and spread through recipient ecosystems.

In ecological terminology, the concepts alien, exotic, and invasive are related but not interchangeable. "Alien" (or non-native) refers solely to the biogeographic status of a species, indicating that it occurs outside its native range as a result of human-mediated transport, without implying any particular impact on the recipient ecosystem (Richardson *et al.*, 2000; FAO, 2018). "Exotic" is commonly used in fisheries and aquaculture literature in a manner similar to alien, likewise without presuming ecological harm. "Invasive" fish, by contrast, represent a subset of alien species that establish self-sustaining populations, spread rapidly, and cause demonstrable ecological, economic, or social harm in the areas they invade (Gozlan *et al.*, 2010; Blackburn *et al.*, 2011). Many alien fishes never become invasive; only a fraction achieve high abundances or wide distributions, typically aided by traits such as high reproductive output, broad environmental tolerance, and superior competitive ability relative to native species (Mack *et al.*, 2000).

These distinctions are particularly important in the context of Nigeria and Tanzania, where non-native fishes introduced primarily for aquaculture, fisheries enhancement, or stock improvement frequently escape from culture systems into natural water bodies. Although some alien species remain confined to managed ponds or reservoirs, others have become established in rivers, lakes, and artificial impoundments, raising concerns about their invasion potential and long-term effects on native aquatic communities, ecosystem functioning, and local fisheries (Ajani *et al.*, 2015).

3.1 Alien Fish Species (AFS) Introduction in Nigeria

AFS introductions in Nigeria are not isolated occurrences but reflect cumulative events driven by sustained propagule pressure through major pathways such as aquaculture, stock enhancement programs, recreational angling, and the ornamental fish trade. The frequency of releases, as much as the number of individuals introduced, significantly increases the likelihood of establishment and long-term survival (Welcomme, 1988). Similar invasion dynamics are observed across West and Central Africa; for instance, Tiogué *et al.* (2017) reported that intentional transfers and accidental escapes were the primary vectors of AFS in Cameroon's Mbô Floodplain Rivers.

The key ecological risks linked to AFS in Nigerian inland waters include competitive exclusion of native species for food and habitat resources, predation on indigenous fish by introduced piscivores, the introduction of previously absent pathogens and parasites, and hybridization that undermines the genetic integrity of native populations (Welcomme, 1988). Consequently, reliable identification and differentiation between native, endemic, and alien species remain fundamental to Nigerian ichthyological research and biodiversity conservation. For example, the African knifefish *Xenomystus nigri* is a native species recorded from ecosystems such as the Lagos Lagoon (Idodo Umeh, 2003; FAO, 2020). In contrast, the Niger tetra *Arnoldichthys spilopterus*, an endemic species with a restricted distribution, faces conservation threats from overexploitation in the ornamental fish trade (Goldschmidt *et al.*, 1993). This comparison underscores the need for stringent management of species introductions and trade activities to safeguard Nigeria's unique freshwater ichthyofauna.

3.2 Examples of Alien and Introduced Aquatic Species in Nigeria

Several alien fish species have been documented in Nigerian aquatic ecosystems, with varying levels of establishment and ecological impact.

3.2.1. Blackchin Tilapia (*Sarotherodon melanotheron*)

The blackchin tilapia is a well-documented example of a successful invasive species in Nigerian inland waters. Studies conducted in the Eleiyele Reservoir of Southwest Nigeria provide evidence of its establishment and ecological effects on local fish communities (FAO, 2020). Comparative analyses with the native Nile tilapia (*Oreochromis niloticus*) show that both species are generalist feeders primarily consuming algae. However, *S. melanotheron* exhibits a broader dietary niche and has been observed preying on fish eggs and larvae, key resources for native populations (FAO, 2020). The significant dietary overlap between the species suggests intense competition for food, while predation on early life stages of native fish further promotes the invasion success of *S. melanotheron* and may contribute to the gradual displacement of *O. niloticus* from the reservoir ecosystem (FAO, 2020).

3.2.2. African Bony Tongue (*Heterotis niloticus*)

Although native to parts of Africa, *Heterotis niloticus* has been introduced beyond its natural range into new river basins in Nigeria, such as the Cross River basin (Oluwale & Ugwumba, 2022). Following its accidental introduction, the species demonstrated successful establishment and was found in significant proportions of local fish landings, particularly between July and October, a pattern associated with high phytoplankton abundance (Oluwale & Ugwumba, 2022). The study reported competitive dominance between *H. niloticus* and indigenous *Chrysichthys* species, especially during the wet season in lower river reaches. These findings suggest that the introduced bony tongue not only persists but also actively competes with native fish, potentially altering local community structure and energy flow (Oluwale & Ugwumba, 2022).

3.2.3. Mudflat Goby (*Butis koilomatodon*)

The mudflat goby represents an example of a marine alien fish species whose introduction into Nigerian inland waters is closely linked to maritime trade and shipping activities (Ekwu & Udoidiong, 2024). The FAO reports that this goby was introduced from an unknown origin and is likely established in the wild. However, its specific ecological interactions with native species and socio-economic effects remain largely undocumented (Ekwu & Udoidiong, 2024). The case underscores the need for improved biosecurity measures and monitoring of ballast water discharge as potential vectors for aquatic biological invasions.

3.2.4. Giant Tiger Prawn (*Penaeus monodon*)

Although a crustacean rather than a fish, the giant tiger prawn constitutes a major case of alien aquatic species introduction along the Nigerian coastline. First recorded in the Gulf of Guinea in 1999, the species has since been found reproducing in the wild and contributing to increasing commercial catches (Olaosebikan & Raji, 2013). Its presence likely originated from accidental introductions related to regional fisheries operations (Olaosebikan & Raji, 2013). As a large, predatory prawn, *P. monodon* may influence local food webs and compete with native crustaceans, with potential consequences for coastal ecology and fishery sustainability.

3.3 Alien Fish Species (AFS) Introduction in Tanzania

Unlike Nigeria where alien fish species (AFS) introductions are less documented and have had more limited ecological fallout, Tanzania's experiences are dominated by the highly publicized cases of Nile perch (*Lates niloticus*) and various tilapia species, particularly Nile tilapia (*Oreochromis niloticus*).

3.3.1. The Nile Perch (*Lates niloticus*) Introduction

The introduction of the Nile perch into Lake Victoria during the 1950s by British colonial officials aimed to enhance fisheries productivity (Pringle, 2005). However, the predator's lack of natural enemies led to the collapse of native fish populations, especially among the diverse cichlid species endemic to the lake. Researchers estimate that around 200 cichlid species went extinct due to this predation pressure. While the Nile perch fishery created a profitable export industry, it brought significant ecological disruption and social challenges. The boom in commercial fishing benefited some communities economically but led to long-term concerns about sustainability, inequality, and ecosystem degradation (Banks *et al.*, 2019).

3.3.2. The Introduction of Tilapia Species

The introduction of Nile tilapia (*Oreochromis niloticus*) into various Tanzanian lakes, including Lake Rutamba, resulted in genetic hybridization with native tilapia such as *Oreochromis korogwe*. Studies have shown that these hybrids are fertile, posing a serious threat to the genetic integrity of the endemic Korogwe tilapia (Blackwell *et al.*, 2021).

Beyond genetics, this introduction aggravated ecological imbalances, accelerating the loss of native diversity through competition, hybridization, and possibly disease transmission. Scholars like Pringle (2005) emphasize that the combined impacts of overfishing and alien species introductions in Lake Victoria are now largely irreversible, having permanently altered the lake's ecological structure.

Alien Fish Species Comparison Table

Table: Major Alien Fish Species in Nigerian and Tanzanian Aquatic Systems

Species	Scientific Name	Country	Introduction Pathway	Ecological Impact
Nile Perch	Nile perch	Tanzania	Introduced for fisheries enhancement	Predation caused collapse of endemic cichlids in Lake Victoria

African Bonytongue	African bonytongue	Nigeria	Aquaculture and stocking programs	Competition with native species
Mozambique Tilapia	Mozambique tilapia	Tanzania	Aquaculture introduction	Hybridization with native tilapia
Nile Tilapia	Nile tilapia	Tanzania	Fisheries and aquaculture	Genetic introgression with local species
Guppy	Guppy	Nigeria & Tanzania	Mosquito biocontrol	Alters food web dynamics
Mosquitofish	Western mosquitofish	Nigeria	Biological control	Aggressive competition with native fish
Common Carp	Common carp	Tanzania	Aquaculture introduction	Habitat disturbance and turbidity increase

The introduction of alien fish species in Nigeria and Tanzania has been largely driven by fisheries enhancement programs, aquaculture expansion, and biological control initiatives. For example, the introduction of the predatory Nile perch into Lake Victoria resulted in significant ecological changes, including the decline of numerous endemic haplochromine cichlid species. Similarly, aquaculture-related introductions of tilapia species such as Nile tilapia have led to hybridization and genetic introgression in native fish populations. These cases illustrate how anthropogenic species translocations can significantly reshape freshwater ecosystems.

4.0 Comparative Summary

Here's a comparative summary table highlighting the key differences in alien fish species (AFS) introductions between Nigeria and Tanzania, based on the documented cases discussed.

4.1 AFS Comparison Table

Aspect	Nigeria	Tanzania
Primary ASF	Less documented; fewer emblematic cases	Nile perch (*lates niloticus*), Nile tilapia (*Oreochromis niloticus*)
Key Locations	Scattered, limited ecological records	Lake Victoria, Lake Rutamba
Ecological impacts	Limited recorded fallout; reversible in parts	Dramatic, irreversible (200+ cichlid extinctions, hybridization,

		biodiversity loss(Witte *et al.*, 2000))
Introduction era	Varied, less centralized	1950s (colonial fisheries boost)
Economic outcomes	Minimal large-scale fishery booms	Lucrative but unsustainable exports; social costs
Documentations	Sparse, generalized reports	Well-studied (Pringle 2005; Banks *et al.* 2019; Blackwell *et al.* 2021)

The provided comparative table on alien fish species (AFS) between Nigeria and Tanzania effectively highlights disparities in documentation and impacts, but it also underscores significant gaps in knowledge that limit a full understanding of AFS dynamics in both countries.

4.2 Documentation Gap

Tanzania's AFS cases, particularly Nile perch and tilapia, are extensively studied with specific timelines (1950s introductions), locations (Lake Victoria, Lake Rutamba), and quantified outcomes (e.g., 200+ cichlid extinctions (Witte *et al.*, 2000)). In contrast, Nigeria's entry as "less documented" and "sparse reports" reveals a critical knowledge void: without named species, precise sites, or longitudinal studies, it's unclear if impacts are truly milder or simply underreported.

4.3 Impact Assessment Gap

The table contrasts Tanzania's "irreversible" ecological restructuring (predation, hybridization) with Nigeria's "limited fallout," yet lacks evidence on Nigeria's native fish diversity losses, genetic threats, or disease vectors. This suggests potential under-detection in Nigeria's rivers/lakes (e.g., Niger River, Lake Kainji), where monitoring infrastructure may be weaker, masking comparable biodiversity crises.

4.4 Research and Policy Gap

No data exists in the table on introduction drivers, enforcement, or mitigation efforts in Nigeria, unlike Tanzania's well-traced colonial origins and economic trade-offs. Filling these gaps requires targeted surveys, genetic analyses, and comparative studies to determine if Nigeria's AFS situation reflects genuine ecological resilience or data deficiency. Addressing this would enable better regional AFS management.

5.0 Conclusion

The comparison reveals two different contexts of AFS introduction. In Tanzania, the introductions are historical, and their devastating ecological consequences are well-documented, serving as a classic case study in invasion biology. In Nigeria, the information points more towards an awareness of the potential risks associated with AFS, particularly for aquaculture, but lacks the detailed, large-scale case studies of invasion impacts seen in Tanzania.

A significant research gap exists for Nigeria: detailed field studies are needed to assess whether any introduced species have become invasive and to quantify their actual ecological and genetic impacts on native fish communities. For Tanzania, ongoing monitoring and management of the existing impacts in Lake Victoria and other water bodies remain a priority to prevent further biodiversity loss.

Ultimately, the experiences of both nations underscore the importance of strict regulations and risk assessments to prevent the introduction of alien species, as such changes can be socially and ecologically irreversible.

5.1Recommendations

Nigeria can draw critical lessons from Tanzania's well-documented AFS experiences to avoid

repeating ecological disasters while advancing aquaculture and fisheries.

5.1.1 Pre-Introduction Risk Assessment

Tanzania's 1950s Nile perch release into Lake Victoria, intended as a fisheries boost, lacked thorough ecological modeling, leading to 200+ cichlid extinctions (Witte *et al.*, 2000). Nigeria should mandate multi-disciplinary risk evaluations (predation potential, genetic compatibility) before approving any AFS for aquaculture in systems like the River Niger or Kainji Lake.

5.1.2 Long-Term Monitoring Protocols

Post-introduction, Tanzania's delayed response allowed irreversible hybridization (e.g., Nile tilapia with *Oreochromis korogwe* in Lake Rutamba). Nigeria can adopt proactive surveillance, genetic sampling, population tracking, early warning systems to detect invasions early, preventing the "irreversible" restructuring seen in Lake Victoria.

5.1.3 Regulatory and Policy Frameworks

Tanzania's colonial-era lax oversight evolved into partial management (e.g., fishery quotas), but economic short-termism prevailed. Nigeria should enact stricter biosecurity laws, ban high-risk species outright, and integrate AFS controls into national aquaculture policies, learning from Tanzania's export boom-social cost imbalance.

5.1.4 Stakeholder Education and Transboundary Cooperation

Tanzania's experiences highlight community reliance on invasive species post-collapse. Nigeria can prioritize fisher awareness campaigns and regional pacts (e.g., with Niger Basin states) to curb accidental AFS spread via trade or escapes, filling its current documentation gaps with targeted research.

6. Conflict of Interest

The authors declare no conflict of interest.

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