Fish biodiversity in the River Benue Basin, Nigeria: A structured review and implications for aquaculture development

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Abstract

The River Benue and its associated tributaries support diverse freshwater fish assemblages that contribute substantially to inland fisheries, food security, livelihoods, and aquatic ecosystem functioning in Nigeria. However, increasing fishing pressure, habitat modification, pollution, land-use change, and hydrological alteration threaten the sustainability of these resources. This study reviewed published information on fish biodiversity reported from selected locations within the River Benue basin and examined the implications of the observed species composition for aquaculture development in Nigeria. A structured literature search was conducted using Google Scholar and Bing with combinations of keywords related to fish biodiversity, fish abundance, River Benue, River Taraba, Lower Niger River, and aquaculture. Eighteen potentially relevant publications were identified, of which four studies conducted in Adamawa, Taraba, Benue, and Kogi States were selected for detailed synthesis based on their geographic relevance and availability of species-composition information. The four studies reported substantially different levels of species richness, reflecting differences in sampling locations, sampling periods, fishing gears, and study objectives. Across the 20 most abundant taxa extracted from each study, 42 fish species representing 17 families were identified. *Clarias gariepinus* and *Synodontis schall* occurred among the most abundant taxa reported in all four study areas. Other frequently reported taxa included *Alestes baremoze*, *Alestes nurse*, *Schilbe mystus*, *Oreochromis niloticus*, *Tilapia zillii*, *Heterotis niloticus*, and *Citharinus citharus*. The recurrent occurrence of several species across geographically separated locations indicates their ecological importance within the basin, but occurrence and relative abundance alone are insufficient to establish aquaculture suitability. The review highlights *C. gariepinus*, *O. niloticus*, and selected indigenous species as priorities for further comparative studies of reproductive performance, growth, feed utilization, disease resistance, environmental tolerance, and economic feasibility. Conservation of wild populations should accompany any domestication programme to prevent depletion of natural stocks and maintain genetic diversity. Future research should employ standardized sampling protocols, molecular or voucher-based species identification, and systematic monitoring to improve knowledge of fish biodiversity in the River Benue basin.

Keywords: Fish biodiversity, River Benue, Freshwater fishes, Species composition, Inland fisheries, Aquaculture, Nigeria, Conservation

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Introduction

Freshwater fish constitute an important component of aquatic biodiversity and provide food, income, employment, and ecosystem services to human communities (Welcomme, 2001; National Research Council, 2005; FAO, 2022). Inland fisheries are particularly important in many developing countries, where fish contribute substantially to animal-protein supply and support the livelihoods of fishing-dependent households (Welcomme, 2001; FAO, 2022). In Nigeria, inland rivers, floodplains, wetlands, lakes, and reservoirs support diverse fish communities and provide an important resource base for both capture fisheries and aquaculture development (Welcomme, 2001; Brummett *et al*., 2008; FAO, 2022).

Freshwater fish communities are influenced by interacting biological, physicochemical, hydrological, and anthropogenic factors. Changes in water quality, flow regime, habitat structure, floodplain connectivity, fishing pressure, pollution, land-use change, and climate can alter species composition, abundance, recruitment, and distribution (Fu *et al*., 2003; Arthington *et al*., 2016; Guo *et al*., 2018). Consequently, assessment of fish biodiversity is important not only for conservation but also for identifying species and ecological resources that may contribute to sustainable fisheries and aquaculture.

The River Benue is one of the major rivers of Nigeria and an important tributary of the Niger River. It originates in the highlands of Cameroon and enters Nigeria before flowing westward toward its confluence with the River Niger at Lokoja, Kogi State. Within Nigeria, the Benue River and its tributaries traverse several ecologically and socioeconomically important regions, including Adamawa, Taraba, Benue, and Kogi States. Tributaries such as the Gongola, Taraba, Donga, Katsina-Ala, and other smaller rivers contribute to the hydrological and ecological complexity of the basin (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

The basin has experienced substantial anthropogenic pressure. Agricultural expansion, deforestation, wetland modification, water abstraction, urban development, pollution, and fishing pressure can modify aquatic habitats and affect fish populations (Arthington *et al*., 2016; Abiodun and John, 2017; Guo *et al*., 2018; Iber and Ojutiku, 2018; Modibbo, 2022; Danba *et al*., 2020). Floodplain ecosystems, including the Fadama areas, are particularly important because they provide spawning, nursery, feeding, and refuge habitats for many freshwater fishes (Welcomme, 2001; Mayomi *et al*., 2013).

Published studies have documented considerable fish diversity in different sections of the Benue basin. For example, a study in the River Benue Valley of Adamawa State reported 37 species belonging to 15 families, while a study of River Taraba, an important tributary of the Benue, recorded 50 species belonging to 20 families. Similarly, the River Fete study in Benue State reported 28 species, while the

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Lower Niger River study at Idah, Kogi State, reported 42 species belonging to 18 families (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022). These differences demonstrate the importance of geographic location, sampling effort, sampling season, and methodology when interpreting biodiversity data.

Aquaculture provides an opportunity to reduce pressure on capture fisheries while increasing fish production (Brummett *et al*., 2008; FAO, 2022). Nigeria has a well-established freshwater aquaculture sector in which African catfish and tilapias are particularly important (Madu and Aliko, 2004; Brummett *et al*., 2008; FAO, 2022). *Clarias gariepinus* is widely recognized as an important African aquaculture species because of its growth performance, environmental tolerance, and market acceptance, while Oreochromis niloticus is also extensively cultured (Viveen *et al*., 1985; de Graaf and Janssen, 1996; Madu and Aliko, 2004; Brummett *et al*., 2008). However, the existence of a species in natural waters or its high abundance in catches does not automatically demonstrate aquaculture suitability.

Therefore, the present review aimed to synthesize published information on fish biodiversity reported from selected locations within the River Benue basin and to identify recurrently reported species that warrant further investigation for conservation, fisheries management, and potential aquaculture development.

Materials and methods

Review design

A structured literature review was conducted to synthesize published information on fish species composition and relative abundance in selected areas of the River Benue basin in Nigeria. Because the available literature was heterogeneous in terms of sampling design, study duration, geographic coverage, fishing gears, and reported biodiversity metrics, a qualitative synthesis rather than a meta-analysis was undertaken (Page *et al*., 2021).

The review was organized around the following questions:

1. Which freshwater fish species have been repeatedly reported from selected sections of the River Benue basin?
2. Which species occur among the most abundant taxa across multiple study locations?
3. Which recurrent species may warrant further investigation for aquaculture development and domestication?
4. What biodiversity and management implications can be derived from the available evidence?

Literature search

Literature searches were conducted using Google Scholar and Bing. Search terms included combinations of the following keywords: “River Benue”, “fish biodiversity”, “fish abundance”, “fish species composition”, “River Taraba”, “River Fete”, “Lower Niger River”, “Kogi”, “Benue”, “Taraba”, “Adamawa”, “Nigeria”, and “aquaculture”.

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The search identified 18 potentially relevant publications. The detailed synthesis was restricted to four studies representing locations within the broader River Benue–Lower Niger system: the River Benue Valley in Adamawa State, River Taraba in Taraba State, River Fete in Benue State, and the Lower Niger River at Idah in Kogi State (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

Eligibility criteria

Studies were considered eligible when they:

- Reported fish species composition, abundance, or biodiversity;
- Were conducted within the River Benue basin or its directly connected river system in Nigeria;
- Provided sufficient information to identify fish taxa at least to the species level;
- Were published in English; and
- Were available as peer-reviewed journal articles.

Studies unrelated to the River Benue basin, studies without fish biodiversity information, unpublished materials, and publications for which species-level information could not be established were excluded.

Data extraction and synthesis

For each selected study, information was extracted on study location, sampling period, species richness, taxonomic composition, and relative abundance where reported. Because the four studies did not use identical sampling designs or biodiversity metrics, direct statistical comparison of abundance among studies was not attempted (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

To provide a comparable qualitative synthesis, the 20 most abundant taxa reported in each study were extracted and compared across the four study areas. Species occurring in multiple studies were identified as recurrent taxa.

It should be emphasized that the 42 species reported in the comparative analysis represent the union of the 20 most abundant taxa extracted from the four selected studies and should not be interpreted as the total fish richness of the entire River Benue basin.

Assessment of aquaculture relevance

Potential aquaculture relevance was assessed qualitatively based on repeated occurrence in the reviewed studies and previously documented importance in Nigerian aquaculture (Madu and Aliko, 2004; Brummett *et al*., 2008). Repeated occurrence was considered an indicator of ecological presence and potential availability for further investigation, rather than direct evidence of culture suitability.

Results

Characteristics of the reviewed studies

The four selected studies covered different sections of the River Benue basin and associated Lower Niger system. The Adamawa study investigated fish biodiversity in the River Benue Valley during 2020/2021

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and reported 37 species belonging to 15 families. The River Taraba study was conducted from November 2017 to April 2019 and reported 50 species belonging to 20 families. The River Fete study was conducted monthly from January to December 2016 and recorded 28 species belonging to 23 families. The Lower Niger River study at Idah was conducted from November 2014 to June 2015 and recorded 42 species belonging to 18 families. The variation in reported species richness should be interpreted cautiously because the studies differed considerably in sampling duration, fishing gears, sampling locations, and analytical approaches (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

Fish species represented across the four studies

The comparative extraction of the 20 most abundant taxa from each study resulted in 42 species representing 17 families. The recurrent taxa included species from Clariidae, Mochokidae, Cichlidae, Mormyridae, Bagridae, Claroteidae, Alestidae, Schilbeidae, Cyprinidae, Citharinidae, Osteoglossidae, Centropomidae, Channidae, Distichodontidae, Gymnarchidae, and Protopteridae. Among the recurrent taxa, *Clarias gariepinus* and *Synodontis schall* were represented among the 20 most abundant species in all four reviewed studies. Several other species occurred in three of the four studies, including *Alestes baremoze*, *Schilbe mystus*, *Alestes nurse*, *Clarotes laticeps*, *Synodontis nigritta*, *Tilapia zillii*, *Clarias anguillaris*, *Heterotis niloticus*, and *Citharinus citharus* (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022) (Table 1).

Dominant species by study area

In the River Benue Valley in Adamawa State, the most abundant taxa reported were Alestes baremoze, Schilbe intermedius, Hydrocynus forskalii, Oreochromis niloticus, and Synodontis schall. The study itself reported Alestes baremoze as the dominant species (Modibbo, 2022). In River Taraba, the dominant species included Tilapia galilaeus, Mormyrus rume, and other taxa representing Cichlidae, Mormyridae, Clariidae, Distichodontidae, Mochokidae, and Schilbeidae. The study reported 50 species and identified Cichlidae as the numerically dominant family (Danba *et al*., 2020).

In River Fete, Benue State, 28 species were reported. Cichlidae dominated the fish assemblage, while Mormyridae and Bagridae were also important components of the fish community. Heterotis niloticus and Barbus occidentalis were identified by the authors as species of conservation concern (Iber and Ojutiku, 2018). At Idah in the Lower Niger River, 42 species belonging to 18 families were recorded. Mormyridae had the highest contribution to species diversity, while Hyperopisus bebe was reported as the dominant species by number in the study (Abiodun and John, 2017). Two fish species as observed in Table 2

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(highlighted in red) namely; Clarias gariepinus and Synodontis schall were discovered to be readily available in all four articles reviewed in this study.

Table 1: 20 most abundant fish species compiled from from four Articles.

S/N	River Benue Valley, Adamawa State[16]		Riverine wetlands Mayo Ranewo,Taraba State[17]		River Fete Benue State[18]		Confluence, Kogi State[19]	
	Species	percent	Species	percent	Species	percent	Species	percent
1	*Alestes baremoze*	*9.24%*	*Synodontis gambiensis*	*11.77%*	*Tillapia zilli*	*5.22%*	*Hyperopisus bebe*	*13.25%*
2	*Schilbe intermedius*	*9.12%*	*Siluranodon auratus*	*10.32%*	*Heterotis niloticus*	*5.16%*	*Citharinus citharinus*	*11.84%*
3	*Hydrocynus forskali*	*8.26%*	*Mormyrus rume*	*9.45%*	*Auchenoglanis biscutatus*	*5.09%*	*Distichodontus rostratus*	*9.82%*
4	*Oreochromis niloticus*	*8.22%*	*Schilbe mystus*	*8.91%*	*Tilapia guntheri*	*5.09%*	*Clarias garienpinus*	*9.13%*
5	*Synodontis schall*	*7.76%*	*Labeo senegalensis*	*7.38%*	*Mormyrus rume*	*5.05%*	*Alestes baremoze*	*5.87%*
6	*Schilbe mystus*	*7.28%*	*Synodontis clarias*	*5.43%*	*Oreochromis niloticus*	*5.05%*	*Lates niloticus*	*5.48%*
7	*Labeo coubie*	*6.81%*	*Distichodontus rostratus*	*4.89%*	*Mormyrops deliciosus*	*5.04%*	*Alestes nurse*	*5.06%*
8	*Barbus macrops*	*6.37%*	*Bagrus bayad*	*4.72%*	*Sarotherodon galilaeus*	*5.04%*	*Synodontis nigritta*	*4.98%*
9	*Clarias gariepinus*	*6.10%*	*Petrocephalus bane*	*4.60%*	*Hemichromis faciatus*	*5.03%*	*Oreochromis niloticus*	*3.67%*
10	*Mormyrus rume*	*5.68%*	*Auchenoglanis occidentalis*	*4.23%*	*Bagrus bayad*	*5.02%*	*Schilbe mystus*	*3.55%*
11	*Synodontis budgetti*	*5.11%*	*Mormyrus macrophthalmus*	*4.23%*	*Bagrus decimac*	*5.00%*	*Synodontis membranaceus*	*3.41%*
12	*Synodontis nigritta*	*4.85%*	*Clarias garienpinus*	*4.19%*	*Petrocephalus bovei*	*5.00%*	*Tillapia zilli*	*3.29%*
13	*Clarias angullaris*	*4.82%*	*Marcuseniusa badii*	*4.06%*	*Clarotes laticeps*	*4.99%*	*Protopterus annectens*	*3.11%*
14	*Mercusenius senegalensis*	*4.16%*	*Alestes nurse*	*3.52%*	*Synodontis nigritta*	*4.98%*	*Clarias angullaris*	*2.92%*
15	*Auchenoglanis occidentalis*	*1.84%*	*Synodontis schall*	*2.74%*	*Gymnarchus niloticus*	*4.96%*	*Mormyrops deliciosus*	*2.84%*
16	*Heterotis niloticus*	*1.21%*	*Hyperopisus bebe*	*2.20%*	*Clarias angullaris*	*4.93%*	*Heterotis niloticus*	*2.84%*
17	*Bagrus bayad*	*1.11%*	*Clarotes laticeps*	*2.03%*	*Clarias garienpinus*	*4.90%*	*Synodontis gambiensis*	*2.40%*
18	*Auchenoglanis biscutatus*	*0.97%*	*Synodontis membranaceus*	*1.95%*	*Alestes nurse*	*4.82%*	*Channa Obcura*	*2.32%*
19	*Citharinus citharinus*	*0.62%*	*Alestes baremoze*	*1.74%*	*Synodontis schall*	*4.82%*	*Synodontis schall*	*2.22%*
20	*Sarotherodon galilaeus*	*0.48%*	*Tillapia zilli*	*1.66%*	*Citharinus citharus*	*4.80%*	*Labeo Senegalensis*	*2.00%*

Table 1 highlights 20 most abundant fishes captured during the research in each article reviewed.
The first article[16] conducted its study in River Benue Valley Adamawa State, at five locations namely; Kochiel, Parda, Gongola/Benue Gwakra and Wuro-Bokki. Table1 highlights 20 most abundant fishes captured during the research, *Alestes baremoze, Schilbe intermedius, Hydrocynus forskali, Oreochromis niloticus and Synodontis schal*l were observed to be the five most abundant species respectively. The second study[17] was conducted in the Riverine wetlands of Mayo Ranewo Taraba State, Mayo Ranewo Local government area. In this article, *Synodontis gambiensis, Siluranodon auratus, Mormyrus rume, Schilbe mystus, Labeo senegalensis* had the highest population respectively. The third study[18] was conducted in River Fete Benue state, 20 most abundant species were extracted from the research where by *Clarias garienpinus, Tillapia zilli*, and *Oreochromis niloticus* were observed to be the most abundant species. The fourth article[19] carried out its research in Lower Niger river Idah Kogi state. Table 1 highlights 20 most abundant fishes captured during the research in each article reviewed. *Hyperopisus bebe, Citharinus citharus, Distichodontus rostratus, Clarias garienpinus and Alestes baremoze* were the five most populated fish species.
Note: "+" indicates that the species occurred among the 20 most abundant taxa extracted from the corresponding study; "–" indicates that it was not among those 20 taxa. The table is not intended to represent complete species absence from a study area.

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Synodontis schall has been reported to be able to adapt to many different kinds of food and habitats, increasing the chances of survival (Abu-Gideiri and Nasr, 1973). Clarias gariepinus has only been documented for being the most cultivated fish specie in Nigeria, although it was endemic to Africa, commercial culture of this catfish only started in the early 1970s (Beveridge and Haylor, 1998).

Table 2: 20 most abundant fish species across four articles conducted at Adamawa, Taraba, Benue and Kogi State, respectively.

Class	Order	Family	Species	River Benue Valley Adamawa[16]	Riverine wetlands Mayo Ranewo.	River Fete Benue[18]	Confluence Kogi State[19]
Actinopterygii	*Characiformes*	*Alestidae*	*Alestes baremoze*	+	+	-	+
			Hydrocynus forskali	+	-	-	-
		Characidae	*Alestes nurse*	-	+	+	+
	Siluriformes	*Bagridae*	*Bagrus bayad*	+	+	+	-
			Bagrus docmak	-	-	+	-
		Claridae	*Clarias angullaris*	+	-	+	+
			Clarias gariepinus	+	+	+	+
		Clarotidae	*Auchenoglanis occidentalis*	+	+	-	-
			Auchenoglanis biscutatus	+	-	+	-
			Clarotes laticeps	-	+	+	-
		Mochochidae	*Synodontis budgetti*	+	-	-	-
			Synodontis clarias	-	+	-	-
			Synodontis schall	+	+	+	+
			Synodontis gambiensis	-	+	-	+
			Synodontis membranaceus	-	+	-	+
		Schilbeidae	*Synodontis nigritta*	+	-	+	+
			Schilbe intermedius	+	-	-	-
			Schilbe mystus	+	+	-	+
			Siluranodon auratus	-	+	-	-
	Perciformes	*Centropomidae*	*Lates niloticus*	-	-	-	+
		Cichlidae	*Oreochromis niloticus*	+	-	+	+
	Cichliformes		*Sarotherodon galilaeus*	+	-	+	-
			Tillapia zilli	-	+	+	+
			Tilapia guntheri	-	-	+	-
			Hemichromis faciatus	-	-	+	-
		Gymnarchidae	*Gymnarchus niloticus*	-	-	+	-
		Osteoglossidae	*Heterotis niloticus*	+	-	+	+
	Osteoglossiformes	*Mormyridae*	*Mormyrus rume*	+	+	+	-
			Mercusenius senegalensis	+	-	-	-
			Hyperopisus bebe	-	+	-	+
			Petrocephalus bane	-	+	-	-
			Mormyrus macrothalmus	-	+	-	-
			Marcusenius abadii	-	+	-	-
			Petrocephalus bovei	-	-	+	-
			Mormyrops deliciosus	-	-	+	+
	Cypriniformes	*Cyprinidae*	*Labeo coubie*	+	-	-	-
			Barbus macrops	+	-	-	-
			Labeo senegalensis	-	+	-	+
	Anabantiformes	*Channidae*	*Channa obcura*	-	-	-	+
	Characiformes	*Distichodontidae*	*Distichodontus rostratus*	-	+	-	+
		Citharinidae	*Citharinus citharus*	+	-	+	+
Dipnoi	*Ceratodontiformes*	*Lepidosirenidae*	*Protopterus annectens*	-	-	-	+

Legend:
+ = Dominant specie present - = Dominant specie absent = Dominant in Kogi and 2 of 3 studies at River Benue = Dominant in all 3 studies at river Benue excluding Kogi
= Dominant in all four for articles (river Benue and Kogi)

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The findings of this review align with the report that Clarias gariepinus has all the qualities of an aggressive and successful invasive species. Its high fecundity, flexible phenotype, rapid growth, wide habitat preferences, tolerance to extreme water conditions and the ability to subsist on a wide variety of prey can devastate indigenous fish and aquatic invertebrate populations (Bruton, 1986).

Nine species (Table 2: highlighted in green) were readily available at the confluence in Kogi and two of three articles conducted along River Benue Basin in Nigeria. These species were Alestes baremoze, Schilbe mystus, Alestes nurse, Clarotes laticeps, Synodontis nigritta, Tillapia zilli, Clarias angullaris, Heterotis niloticus and Citharinus citharus. Two fish species namely; *Mormyrus rume* and *Bagrus bayad* as observed in Table 2 (highlighted in yellow) were found to be readily available in all three-article research conducted in the river Benue Basin but were not readily available at the confluence in Kogi.

A study (Guo *et al*., 2018) postulates that, habitat heterogeneity and fragmentation, land use change, climate change, eutrophication and invasive species are the most prevalent driving factors in freshwater biodiversity studies. Fish species (highlighted in Table 2) were observed to be readily available in atleast three of four articles reviewed for this study, signifying that these species have good adaptive, locomotive and reproductive ability to withstand factors influencing biodiversity. These characteristics make them suitable for aquaculture production.

The Order Siluriformes (Catfish) was the most diverse in this study. Families of this order such as Claridae, Clarotidae, Mochochidae and Schilbeidae can be further studied to improve inter- species polyculture in the country.

Discussion

Fish biodiversity in the River Benue basin

The reviewed studies collectively demonstrate that the River Benue basin and its associated rivers support diverse freshwater fish assemblages. However, substantial differences in reported species richness among studies indicate that biodiversity estimates are strongly dependent on sampling design and geographic coverage. The River Taraba study recorded 50 species, while the Adamawa, River Fete, and Idah studies reported 37, 28, and 42 species, respectively. These differences should not be interpreted as evidence that one river section is inherently more biodiverse than another because sampling intensity, sampling duration, fishing gears, habitat types, and seasonal coverage differed among. The occurrence of several taxa across multiple locations is nevertheless noteworthy. Clarias gariepinus, Synodontis schall, Alestes baremoze, Schilbe mystus, Mormyrus rume, Oreochromis niloticus, and Heterotis niloticus were repeatedly represented among the abundant taxa in the reviewed literature. Their repeated occurrence

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suggests that they constitute important components of the fish assemblages of the basin (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

Ecological significance of recurrent species

The recurrence of Clarias gariepinus across all four reviewed studies is particularly relevant. The species is widely distributed in African freshwater systems and is recognized as an important aquaculture species because of its adaptability, growth potential, and tolerance of challenging environmental conditions. However, high abundance in natural waters should not be interpreted solely as evidence of desirable aquaculture characteristics. A species may be abundant because of ecological conditions, fishing selectivity, reproductive strategy, habitat availability, or fishing gear effects. Therefore, aquaculture assessment should incorporate controlled experiments on growth, feed conversion, reproduction, larval survival, disease resistance, stocking density, water-quality tolerance, and production economics (Viveen *et al*., 1985; de Graaf and Janssen, 1996; Brummett *et al*., 2008). Synodontis schall was also represented among the most abundant taxa in all four reviewed studies. Its recurrence indicates ecological importance within the basin and supports further biological investigation. Nevertheless, information on its reproductive biology, hatchery propagation, larval nutrition, growth performance, and commercial culture potential is insufficient to justify immediate promotion as an aquaculture species (Abu-Gideiri and Nasr, 1973).

Implications for aquaculture development

Nigeria's aquaculture sector is strongly associated with freshwater catfish and tilapia production . Reviews of Nigerian aquaculture have identified Clarias and tilapia as major cultured groups, while Heterobranchus and their hybrids are also important (Madu and Aliko, 2004; Brummett *et al*., 2008; FAO, 2022).

The current review suggests that biodiversity conservation and aquaculture development should be considered complementary rather than competing objectives. Several indigenous species occurring in the River Benue basin may represent underutilized aquaculture resources. However, domestication should follow a structured evaluation pathway:

1. taxonomic confirmation and genetic characterization;
2. assessment of broodstock availability;
3. controlled spawning and larval-rearing trials;
4. evaluation of growth and feed conversion;
5. assessment of tolerance to relevant water-quality conditions;
6. disease and parasite screening;
7. evaluation of stocking density and production systems;
8. consumer acceptance and market assessment; and

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9. economic analysis compared with established species.

This approach would prevent the common mistake of equating natural abundance with aquaculture suitability.

Conservation implications

The recurrent presence of commercially valuable species in catches should not be interpreted as evidence that populations are secure. In heavily exploited river systems, species may remain common while experiencing reductions in size structure, recruitment, spawning biomass, or genetic diversity (Arthington *et al*., 2016; Guo *et al*., 2018).

The River Fete study, for example, identified Heterotis niloticus and Barbus occidentalis as species requiring conservation attention (Iber and Ojutiku, 2018). Similarly, the River Taraba study identified fishing pressure, inappropriate mesh sizes, habitat degradation, and other anthropogenic factors as potential contributors to reduced abundance of some taxa (Danba *et al*., 2020). Conservation measures should therefore include enforcement of appropriate fishing gear and mesh sizes, protection of spawning and nursery habitats, maintenance of floodplain connectivity, reduction of pollution, monitoring of fishing effort, and protection of threatened or declining species (Arthington *et al*., 2016; Rodrigues and Cunha, 2017; Guo *et al*., 2018; Iber and Ojutiku, 2018; Danba *et al*., 2020).

Limitations of the available evidence

The principal limitation of this review is the heterogeneity and limited number of studies that could be synthesized. The four selected studies were conducted at different locations and used different sampling designs. Consequently, the relative abundance values reported in one study cannot be directly compared quantitatively with those from another. A second limitation is that the present synthesis used the 20 most abundant taxa reported in each study rather than complete species inventories. Accordingly, the 42 species identified in the comparative analysis represent recurrent or relatively abundant taxa within the extracted datasets and do not represent the total fish diversity of the River Benue basin (Abiodun and John, 2017; Iber and Ojutiku, 2018; Danba *et al*., 2020; Modibbo, 2022).

A third limitation concerns taxonomic consistency. Several of the original publications used inconsistent spellings or nomenclature. For future biodiversity assessments, species identification should be supported by current taxonomic references and, where possible, voucher specimens and molecular confirmation (Arthington *et al*., 2016; Guo *et al*., 2018; Zoua *et al*., 2020).

Finally, the literature search was based primarily on Google Scholar and Bing, and therefore the review cannot be considered an exhaustive systematic review of all available bibliographic databases. Future work should incorporate databases such as Scopus, Web of Science, Dimensions, and CAB

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Abstracts and should follow a fully reproducible systematic-review protocol (Page *et al*., 2021;Truter *et al*., 2023).

Conclusion

The River Benue basin supports a diverse freshwater fish fauna with substantial ecological, fisheries, and socioeconomic importance. The reviewed studies demonstrate considerable variation in species richness among different sections of the basin, while several taxa repeatedly occur among the most abundant species. *Clarias gariepinus* and *Synodontis schall* were represented among the most abundant taxa in all four reviewed study areas, while several other species, including *Alestes baremoze*, *Schilbe mystus*, *Mormyrus rume*, *Oreochromis niloticus*, *Tilapia zillii*, *Heterotis niloticus*, and *Citharinus citharus*, were recurrently reported. These species represent important components of the fish communities of the basin. The findings support further investigation of selected indigenous species for aquaculture diversification, but species abundance or recurrence in capture fisheries should not be regarded as direct evidence of aquaculture suitability. Controlled studies of reproduction, growth, nutrition, disease resistance, environmental tolerance, production efficiency, and market potential are required before domestication programmes are initiated.

At the same time, aquaculture development should not be based on indiscriminate collection of wild broodstocks. Conservation of natural populations and genetic resources should be integrated into any domestication strategy. Standardized long-term biodiversity monitoring, improved taxonomic identification, and coordinated fisheries management are essential for maintaining the ecological integrity and productive capacity of the River Benue basin.

Recommendations

Future research should prioritize:

- standardized fish biodiversity surveys covering dry and wet seasons;
- coordinated sampling across the upper and lower sections of the Benue basin;
- molecular and voucher-based confirmation of problematic fish identifications;
- assessment of population structure and genetic diversity of commercially important species;
- controlled domestication trials for promising indigenous species;
- reproductive and larval-rearing studies;
- growth, feed-utilization, and disease-resistance trials;
- evaluation of environmental tolerance under culture conditions;
- assessment of the economic feasibility and market acceptance of candidate species; and
- establishment of long-term biodiversity monitoring programmes for the River Benue basin.

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