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Research article

Fish abundance and community composition in Bontanga Reservoir in the northern region of Ghana

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Abstract: Bontanga Reservoir is a vital inland water resource in the Northern regio of Ghana, supporting diverse fish communities and sustaining local livelihoods. However, increasing anthropogenic activities, climate change, and ecological disturbances threaten its fish populations and overall ecosystem health. This study investigates fish abundance and community composition in the reservoir to contribute to conservation and sustainable management efforts. A total of 1,176 fish specimens were sampled, with total lengths ranging from 8.0 cm in *Coptodon zillii* and *Brycinus nurse* to 26.6 cm in *Clarias gariepinus*. *Sarotherodon galilaeus* was the most dominant species, with an Index of Relative Importance (IRI) value of 7.757%. In the midstream section, *Synodontis violaceus* (20.50 cm), *Hippopotamyrus pictus* (18.70 cm), and *Synodontis clarias* (17.90 cm) had the highest mean lengths. *Oreochromis niloticus* was present in all three sampling stations, with higher IRI values in upstream and downstream sections. Seasonal variations influenced fish community structure, with certain species displaying seasonal occurrence patterns.

Keywords: Community composition, Reservoir, Ecosystem, ecological health, Human activities

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Introduction

Bontanga Reservoir, located in the Northern region of Ghana, is an important inland water system that plays a crucial role in supporting a wide fish community and promoting livelihoods for local communities (Kwabena et al., 2023). The significance of the reservoir cannot be undermined, as it serves as a lifeline for numerous residents who depend on it for their daily income (Champman et al., 2021). However, the periodic and terminal droughts of the region pose imperative challenges to crop and animal production, threatening the very survival of these communities (Stuart et al., 2019). To manage these problems, the reservoir was constructed for various, such as residential use, animal watering, fisheries, and irrigation for agriculture (Agodzo et al., 2023). The reservoir's ability to serve multiple purposes allows it to support a wide range of activities, making it an imperative resource for the local population(Otis et al., 2013). Over time, the reservoir has developed into a significant fishing ground, attracting fishermen from all over the region (Elis et al., 2015). The two most significant reservoir fish sources in Ghana's northern region are Bontanga and Golinga, Bontanga is 670 hectares in size (Abobi et al., 2021). The reservoir diverse fish population and vast size make it a significant location for commercial and subsistence fishing. Voggu and Bontanga known as the two primary landing sites, serve as bustling hubs of activity, with fishermen selling their daily catch to ready buyers (Abobi et al., 2021).

The Bontanga Reservoir's significance goes far beyond its economic importance, as it also inhabits a rich sequence of aquatic biota(Kwarfo-Apegyah & Ofori-Danson, 2010). The reservoir's wide range of fish community is signification to its ecological health, and efforts must be made to preserve and protect this indispensable resource for future generations (Abobi, 2019).

Bontanga Reservoir, a crucial inland water resource in the northern region of Ghana, is encountering numerous threats to its fish populations and ecosystem health. Human activities, climate change, as well as other ecological environmental factors are affecting the reservoir's complex balance (Miranda et al., 2020). Bontanga reservoir, among other freshwater reservoirs are essential for sustaining healthy fisheries and aquatic ecosystems, aiding crucial ecosystem services and supporting biodiversity (Arlinghaus et al., 2015).

To effectively manage and preserve Bontanga Reservoir, it is important to understand the abundance and community composition of fish populations found in it (Abobi et al., 2023). This study aims to look into the range, distribution, and abundance of fish species with regards to environmental conditions and habitat parameters, providing insight on the delicate dynamics of the reservoir's ecosystem (Sesay et al., 2023).

By examining the interconnected relationships between fish populations and their environment, researchers can identify potential sensitivity and develop targeted conservation strategies.

Freshwater reservoirs are crucial for maintaining biodiversity and providing key ecosystem services, such as water filtration, nutrient cycling, and habitat creation (Guo et al., 2021). However, activities of humans such as pollution, overfishing, and habitat modification imposes significant threats to these ecosystems (Prakash & Verma, 2022). The wide ranged fish community supported by Bontanga Reservoir is essential to the local environment and fisheries, generating a source of income and food security for surrounding communities (Mul et al., 2015). Nevertheless, human interventions and environmental factors alterations could have serious consequences for the fish populations and community composition of the reservoir, potentially disrupting the entire ecosystem (Tesfay Gebrekiros, 2016). It is essential to find solutions to these pressing concerns through sustainable management practices, conservation efforts, and continued monitoring to ensure the long-term health and resilience of Bontanga Reservoir (Abobi, 2019). For numerous reasons, it is essential to explore the fish abundance and community make-up in Bontanga Reservoir. Despite the significance of the reservoir, data regarding the condition of fish populations as well as environmental factors in Bontanga Reservoir at the moment is minimal. To bridge this information gap, this research highlights important details for management and conservation practices. Also, Bontanga Reservoir inhabits a significant variety of aquatic biota, making it an essential freshwater ecosystem. For numerous reasons, it is essential to explore the fish abundance and community make up in Bontanga Reservoir. Despite the significance of the reservoir, data regarding the condition of fish populations as well as environmental factors in Bontanga Reservoir at the moment is minimal. In order to bridge this information gap, this research highlights important details for management and conservation practices. Also, Bontanga Reservoir inhabits a significant variety of aquatic biota, making it an essential freshwater ecosystem.

However, the reservoir’s long-term viability of the fish populations is endangered by human activities such as pollution, overfishing, and habitat deterioration. In addition, the reservoir assists the commercial and subsistence fishing sectors in boosting the local economy. It is important to understand the density of fish populations as well as community makeup to manage these resources responsibly.

This research answers numerous unanswered questions by making enquiries into the fish diversity, distribution, and population characteristics of riverine fishes to determine the full extent of human activities on aquatic biodiversity. These data are vital for effective management and conservation of species, biomonitoring of environmental change, and assessment of the status and viability of riverine fisheries as a resource for human populations and commercial fisheries.

Materials and Methods

Study area

The study was conducted in the Bontanga Reservoir, located in the Northern region of Ghana. Bontanga is situated in Kumbungu District, which was previously part of the Tolon-Kumbungu District. With a total land area of 1.599 km², the district is one of the smallest in the Northern Region. Its borders are to the north with West Mamprugu District and Mongdori District, to the west with Tolon and North Gonja Districts and to the south with Sagnerigu District. The Reservoir is located in a community called Bontanga with a geographical coordinate of 9°33'0"N; 1°11' 12"W. Its surface area is 6.7 km, its mean depth is 5.9 m, and its maximum depth is 9.70 m. The research area is Guinea savanna, and its vegetation is primarily composed of short grasses, shrubs, and trees that are comparatively short. Due to seasonal decline in fish catches, the majority of the local population engages in agriculture, while a smaller proportion participates in fishing. Most people living in the neighborhood are Muslims, although there are also some Christians and Traditionalists. The majority of the people living in the area are Dagombas, with a smaller presence of Mamprusi, Frafras, and other ethnic groups.

Data Collection

Three stations were selected to cover the upper, middle and downstreams of the reservoir. Station 1 (upper stream) was the deepest part of the reservoir. Station 2 (middle stream) was the deep part of the reservoir and station 3 (downstream) was near the shore. The approximate interval between the upper and middle sections was 0.59108km, middle and downstream was 0.76892km. The distances between stations were approximately from the product of the canoeing speed and time of travel between stations.

Fish samples were collected every month from all stations for four months, from March 2024 to June 2024. A small canoe (3m long) was used to access the stations. Sampling for fish was done with a gillnet of different mesh sizes. The different mesh sizes used were 1.857",1.25", 2.75" and 3". All fish caught from each station were stored in labelled polythene bags and kept in an ice chest with ice cubes on them in the field. Samples were transported to the Spanish Laboratory, UDS Nyankpala. In the laboratory, catches from each station were sorted according to species and each species was counted, measured and weighed separately. For each species, length to the nearest 0.1cm, weight to the nearest 0.01g. Species identification was done using protocol described by (Skelton, 1994).

Data Analysis

Simple statistical approaches were employed to examine data manually. Microsoft excel (2019) was used to analyze the study's data, with the results displayed in tables and graphs.

The contribution of the catch of each sampling effort was used to estimate the relative abundance of fish. The relative abundance was assessed using an index of relative importance (IRI). Based on the quantity and weight of individuals in catches as well as their frequency of occurrence, an IRI calculates the species' relative abundance or commonness. Compared to weight, number or frequency alone, IRI provides a more suitable substitute for ecologically significant species.

Index of Relative Abundance of Species = $\frac{(\%Wi+\%Ni)\times\%\text{Fi}}{(\%Wj+Nj)\times\%Fj}\times 100$

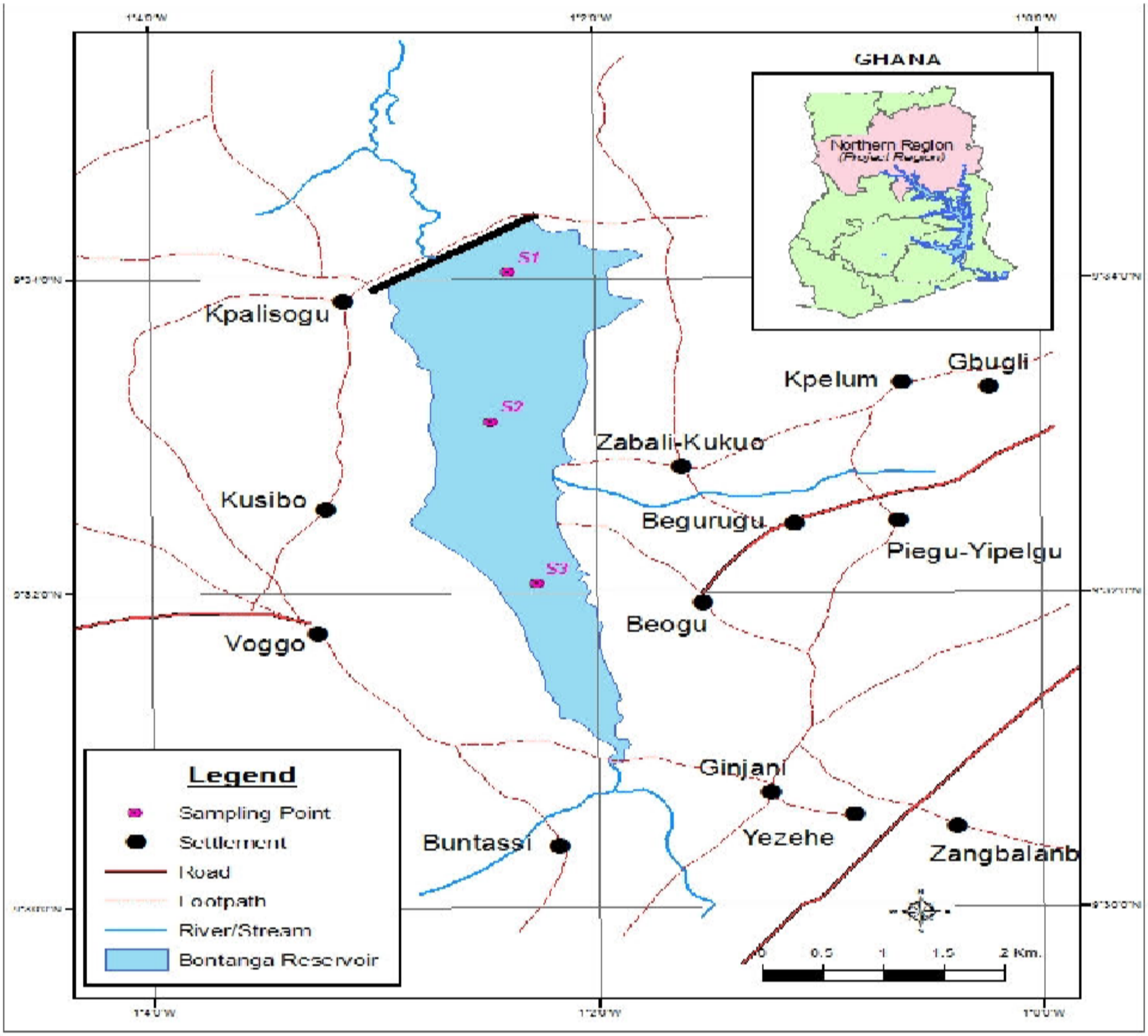

Figure 1. Map of the Bontanga reservoir (Cobbina et al., 2013)

Results

Size range and the model size of the fish species from the reservoir

The size range, mean length and modal class of fish species from the Bontanga reservoir are presented in Table 1. A total of 1,176 fish were sampled, with total lengths ranging from 8.0 cm in *Coptodon zillii* and *Brycinus nurse* to 26.6cm in *Clarias gariepinus*. The model length of the commonest species *Sarotheredon galilaeus,* and *Oreochromis niloticus* were 11.0 and 11.5cm respectively. The weight of the sampled fish ranged from 0.017kg in *Brycinus nurse* to 3.3kg in *Sarotheredon galilaeus.*

Index of *Relative* Importance of the species

The species composition of all the catches from the Bontanga Reservoir were ranked based on the Index of Relative Importance (IRI) for the entire water body (Table 2). *Sarotheredon galilaeus* was the most important fish species in Bontanga with an IRI value of 7.757% followed by *Oreochromis niloticus* which had an IRI value of 1.234%. The remaining species had an IRI percentage of less than 1%.

Table 1. Lengths and weights of fish species in Bontanga reservoir

Species	No.	Standard Length (cm) Range	Total Length (cm) Range	Mean Length (cm)	Modal Class	Weight (g)
Sarotheredon galilaeus	958	7-14.5	9-15.7	16	11	0.04-3.3
Oreochromis niloticus	153	8-11	9.5-14.5	11.3	11.5	0.02-3.1
Coptodon zillii	40	6-11	8-18.1	11.6	12	0.023-0.9
Hippopotamyrus pictus	14	12.7-20	22-12.7	16.4	15	0.031-0.056
Clarias pariepinus	2	19.2-23.5	22.2-26.6	24.4	-	0.081-0.085
Synodontis violaceus	3	13-16.7	16-20.5	17.3	16	0.037-0.88
Hemisynodontis membranaceus	1	0-14	0-17	-	-	0.06
Synodontis clarias	1	0-14.1	0-18	-	-	0.062
Brycinus nurse	4	9.4-9.5	8.1-11.5	9.05	8.1	0.017-0.032

Figure 2. Index of relative importance of fish species in Bontanga Reservoir (%N and %W represent percentage in number and weight of each species in total catch, F represents frequency, %F represents percentage frequency and IRI represents index of relative importance).

Species	No.	%N	W	%W	F	%F	IRI
Sarotheredon galilaeus	958	81.463	39.948	80.119	13.000	27.660	7.757
Oreochromis niloticus	153	13.010	7.400	14.841	12.000	25.532	1.234
Coptodon zillii	40	3.401	1.440	2.888	10.000	21.277	0.232
Hippopotamyrus pictus	14	1.190	0.359	0.720	5.000	10.638	0.035
Clarias pariepinus	2	0.170	0.222	0.445	2.000	4.255	0.005
Synodontis violaceus	3	0.255	0.166	0.333	2.000	4.255	0.004
Hemisynodontis membranaceus	1	0.085	0.060	0.120	1.000	2.128	0.001
Synodontis clarias	1	0.085	0.062	0.124	1.000	2.128	0.001
Brycinus nurse	4	0.340	0.204	0.409	1.000	2.128	0.003
Total	1176	100	49.86	100	47	100	

Species composition of Bontanga reservoir

The most abundant family was Cichlidae (97.85%). It was followed by Mormyridae (0.72%), Mochokidae (0.58%), and Claridae (0.45%). Characidae appeared to be the least with weight percentage of (0.41%). Some of these families were encountered only once throughout the study period (Figure 2).

Mean length of fishes in Bontanga Reservoir

The mean length of fish species from upstream, midstream and downstream of Bontanga Reservoir is indicated in Figure 3. In upstream, *Clarias gariepinus, Hippopotamyus pictus* and *Synodontis violaceus* occurred to be the species with the high mean length representing 22.50cm, 19.67cm and 16.00cm respectively. The remaining species had a mean length of less than 12cm with the exception of *Hemisynodontis membranaceus* and *Synodontis clarias* which were not recorded in the upstream of Bontanga reservoir.

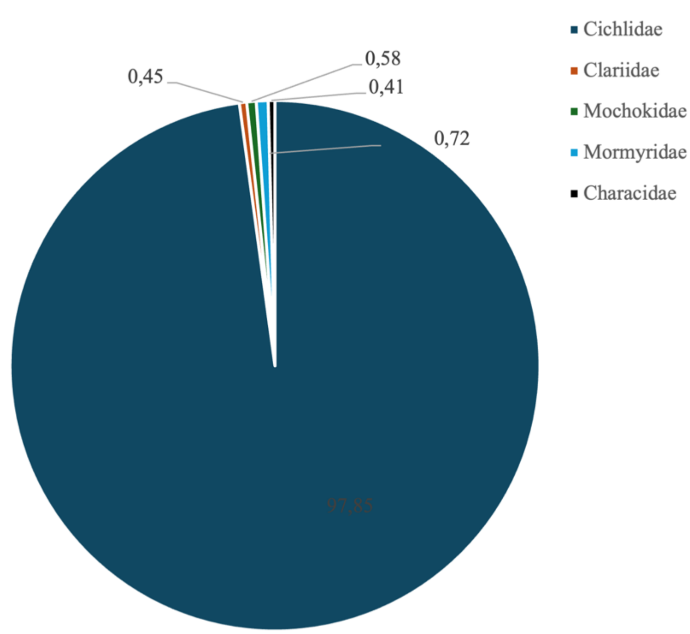

Figure 2. Percentage representation of weights of fish families in Bontanga Reservoir in 2024

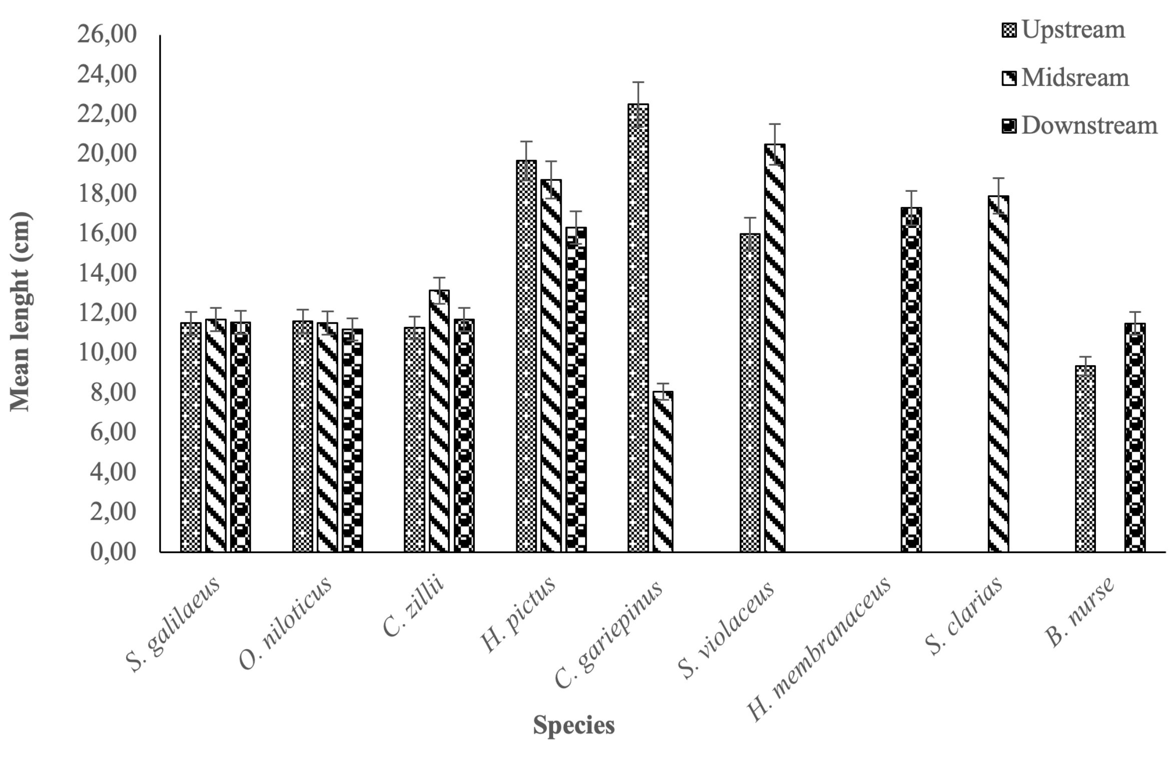

Figure 3. Mean length of fish species in upstream midstream and downstream of Bontanga reservoir

In midstream, *Synodontis violaceus, Hippopotamyus pictus, and Synodontis clarias* were species that had a high mean length representing 20.50cm, 18.70cm and 17.90cm respectively followed by *Captodon Zilli* which had a mean length of 13.15cm, the remaining species had a mean length of less than 12cm. *Hemisynodontis membranaceus* and *Brycinus nurse* were recorded in the midstream of the reservoir.

In the downstream, *Hemisynodontis membranaceus* and *Hippopotamyus Pictus* had the highest mean length of 17.30cm and 16.33cm. The remaining species had a mean length of less than 12cm with exception of *Clarias gariepinus*, *Synodontis violaceus* and *Synodontis clarias* that did not occur in the downstream on Bontanga reservoir.

Index of relative importance of fish abundance in Bontanga reservoir

There was a significant difference in the relative abundance of the species between the three sampling stations (Figure 4). *Sarotheredon galilaeus* occurred to be the species with higher IRI values in upstream (12.1%), midstream (11.6%) and downstream (15.1%). *Oreochromis niloticus* was present in the three stations with higher IRI values in in Upstream and downstream representing 6.4% and 8.5% respectively with low IRI value of 0.5% recorded for *Oreochromis niloticus* from midstream of Bontanga reservoir. The remaining species had low IRI in value for the three stations. While *Synodontis clarias* with IRI value of 1.6% was only present in the midstream and absent in upstream and downstream, *Brycinus nurse* was only present in both upstream and downstream.

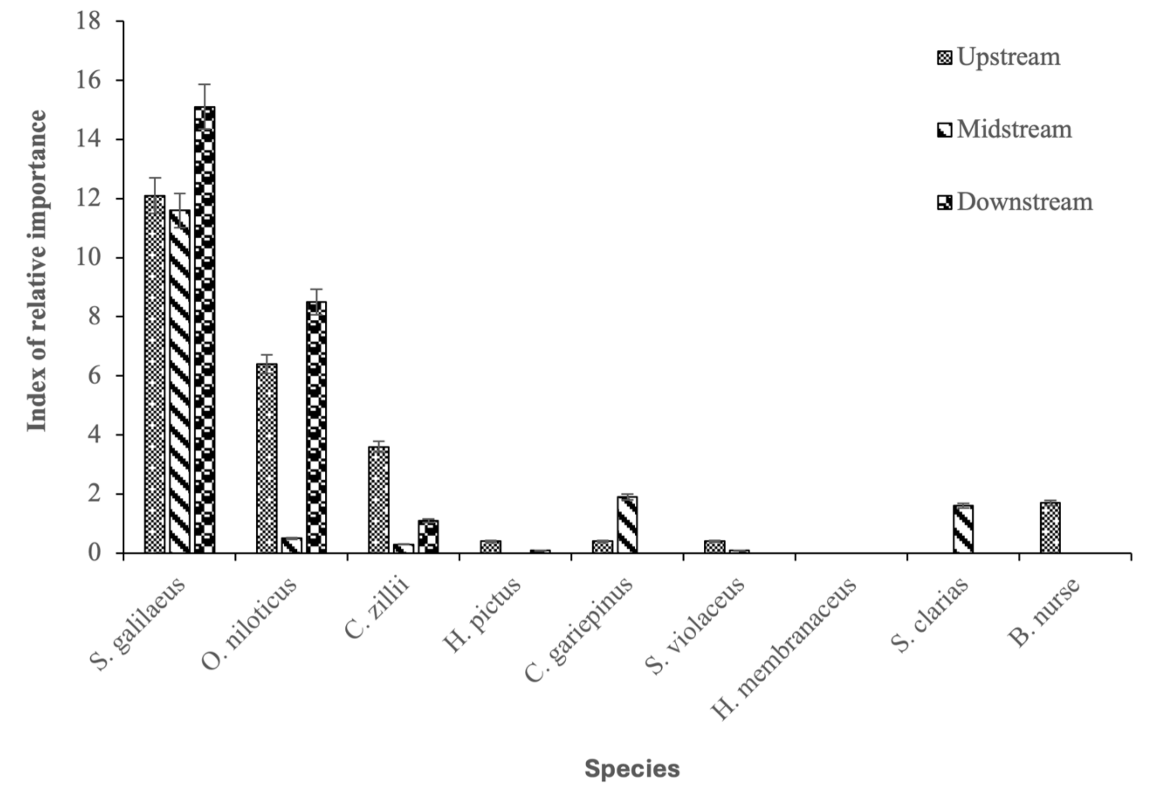

Figure 4. Index of relative abundance of fish species for upstream, midstream and downstream in Bontanga Reservoir

Discussions

Fish Species Composition

The research provided details on fish species composition and relative importance in the Bontanga Reservoir. A total of nine (9) species belonging to five (5) fish families were identified during the period of study from March 2024 to June 2024.

Generally, from the study, the fish family Cichlidae was the most predominant family in the reservoir during the period of the study with *Sarotheredon galilaeus, Oreochromis niloticus* and *Coptodon zillii* being the leading species in terms of number, biomass and frequency of occurrence. The Cichlidae family accounted for 97.85% of the total fish biomass. In contrast, the remaining families Mormyridae (0.72%), Mochokidae (0.85%), Claridae (0.45%), and Characidae (0.41%) contributed only marginally to the total weight.

The reservoir system is known to be rich in fish fauna as recorded by (Alhassan et al., 2014). Abobi & Wolff (2020) who identified twenty-four 24 (twenty-four) fish species from the Bontanga reservoir Ghana while Alhassan et al. (2014) identified eighteen 18 (eighteen) fish species belonging to nine 9 (nine) families. Similarly, a study on the Tono Reservoir in the Northern Region by (Akongyuure & Alhassan, 2021) identified seventeen 17 (seventeen) fish species. Also, (Akongyuure & Alhassan, 2021) classified *Sarotheredon galilaeus, Oreochromis niloticus, Coptodon zillii, Clarias gariepinus* and *Auchenoglanis occidentalis* as the most important fish species in the Tono reservoir.

Studies done by these researchers affirm that the Bontanga reservoir system as well as other inland fisheries in the country are indeed rich in fish fauna and can be a significant contributor to the economies of the region. The reason for a relatively low number of fish species recorded from the Bontanga reservoir in this study in spite of the rich diversity of the reservoir system may be attributed to the climatic condition of the study area. It is important to keep in mind that seasonal changes affect fish community dynamics as some species are seasonal. This study was temporally limited and do not cover the entire year which may be a reason for the relatively low number of fish species compared the research conducted by (Alhassan et al., 2014) on the Bontanga reservoir where 18 species were identified and that of Abobi et al (2020) on Bontanga, Tono and Golinga reservoir where 24 species were identified in the Bontanga reservoir.

It is widely affirmed that species identified in large area of water are higher than that of small area of water as stated by Preston (1962) that large areas tend to contain larger number of species and observationally, the relative numbers seem to follow systematic mathematical relationships.

Index of relative importance of fish species

During the study period, a significant difference in the relative abundance of species among the between the three sampling stations (upstream, midstream and downstream) was observed.

The predominant fish species in all the sampling stations was *Sarotheredon galilaeus* with the highest IRI values. *Oreochromis niloticus* was also found in all the sampling stations but with varying IRI values, indicating variation in its abundance. *Brycinus nurse* was not found in midstream but found in upstream and downstream whereas *Synodontis clarias* was found only in one sampling station (midstream).

Water quality may be a reason for the differences in abundance of fish species in various stations of the reservoir due to low water levels. According to Wang et al. (2020) Biliuhe reservoir as an example. The results showed that the change of water level of Biliuhe reservoir has a significant 13-year periodicity. The unusual water quality changes during the low water level period were as follows: total nitrogen continued to decrease. And iron was lower than its historical level. pH, total phosphorus, and ammonia nitrogen were higher than historical levels and fluctuated seasonally. Permanganate index increased as the water level decreased after initial fluctuations. Dissolved oxygen was characterized by high content in winter and relatively low content in summer. (Wang et al., 2020) It is concluded that the continuous decline of water level has a significant impact on the changes and pollution sources affecting water quality.

Members of the family Cichlidae are generally known for being plankton feeders making the reservoir a conducive environment as plankton is readily available due to the ability of sunlight penetration for photosynthesis to take on.

The reason for *Synodontis clarias* being found in only midstream may be suitability in that sampling station of the reservoir for spawning and nursing of offspring. *Synodontis clarias* prefers rocky or sandy substrates as spawning grounds as they spawn near rocky outcrops, sandy patches or sunken logs with slow or moderate currents and a depth of (0.5–2m). Slow currents and water depth of (0-1m) are required for survival of juvenile. Soft sediments like sand, silt or mud serves as nursery grounds for juveniles as well as cover in harsh situations like predation.similarly, (Říha et al., 2013) stated in a study conducted on post-spawning dispersal of tributary spawning fish species to a reservoir system that, generalists (bream *Abramis brama*, perch *Perca fluviatilis*, *Synodontis clarias* and roach *Rutilus rutilus*) spawn in the tributary as well as at different sites in the main body of the reservoir.

Mean length of fish species

In this study, mean lengths of the fish species from various sampling sites (upstream, midstream and downstream) of the reservoir were recorded. Each fish species captured in the study had a characteristic mean length format in the various sampling sites of the reservoir.

Comparing the mean lengths observed in the various sampling sites, the mean length of *Clarias gariepinus* was seen to be high in upstream and was not found in the downstream. The dominat species in upstream was *Clarias gariepinus, Hippopotamyrus pictus* and *Synodontis clarias* which recorded the highest mean lengths in that section.

Midstream however, had a variation in the mean lengths that were recorded. The species with the highest mean lengths recorded were *Synodontis violaceus, Hippopotamyrus pictus* and *Synodontis clarias. Coptodon zilli* also had a relatively high mean length.

In downstream, *Hemisynodontis membranaceus* and *Hippoptamyrus pictus* were observed to have the highest mean lengths with other species having lower mean lengths in this sampling site.

In each sampling site, majority of the fish species had mean lengths lower than 12cm with the exception of few species recording more than that. Also, the absence of some fish species such as *Brycinus nurse* and *Hemisynodontis membranaceus* was noticed in certain sampling sites (upstream and downstream) respectively.

The mean length pattern observed in this study may be attributed to the fact that different fish species do well in different environmental and ecological conditions such as water temperature as it determines growth rates and metabolism in fish. A similar trend was observed by Wang et al., (2020), who studied the distribution pattern in fishes at different depths in a canyon shaped reservoir. He recorded that fish catches were highest in the upper layer of the water column (upstream). Both juvenile and adult fish preferred the upper part of the reservoir, where a maximum number of species and also the greatest zooplankton were found. Water quality (dissolved oxygen, pH and nutrient levels) which have adverse effects on fish health and growth. Habitat structures including vegetation and substrate influences shelter, feeding and breeding of fish. Another environmental factor is the variation in depth of sampling sites as water depth influences temperature, oxygen levels and light penetration.

Some ecological factors include fish predation pressure where predation is extreme affecting prey abundance and behavior. Fish migration and dispersal, this affects fish population dynamics, distribution as well as gene flow of these fishes.

Ethical Approval

The research was conducted with the approval of the relevant ethics committee, and national and international ethical sensitivities were considered throughout the process.

Conflict of interest

The authors have no conflict of interest.

Funding Statement

The authors don't declare any fund.

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