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Assessment of Fish Composition, Habitat Distribution, Gear Efficiency and Craft Characteristics in Biu Reservoir, Borno State, Nigeria

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Abstract

The study of fish populations highlights the reservoir's importance for food security, economic development, and environmental sustainability. The reservoir's diverse fish species, including tilapia, catfish, and Nile perch, provide essential nutrients and income for local communities. The study's findings on fish composition, distribution, gear efficiency, and craft characteristics provide valuable insights over 18-month from September 2019 to February 2021 for informed decision-making and effective conservation strategies. Data collected from five sampling points. A total of eight species from five families were identified, *Tilapia zillii* from the family *Cichlidae* was the most dominant species, constituting 35.9% of the total catch. Oreochromis niloticus was the second most dominant species, representing 26.3%, followed by *Hemichromis bimaculatus* at 14.7%. The lowest recorded abundance was *Clarias anguillaris,* constituting only 1.5% of the total catch, while accounted for 2.8%. Other species, including Brycinus nurse (7.5%), *Labeo parvus* (6%), and *Petrocephalus bane* (5.3%), were less abundant. The study also highlighted the reliance on different fishing gears, with gill nets being the most commonly used, constituting 44.09% of the total fishing gear. Cast nets followed with 28.00%, while long lines and Malian traps accounted for 11.72% and 9.62%, and the use of Ndurttu was recorded at 6.89% respectively.

Keywords: Species; Reservoir; Gears; Crafts

Introduction

Man-made reservoirs and dams provide numerous benefits across various sectors, including water supply, agriculture, energy production, and recreation. By ensuring a constant water supply, they support domestic, agricultural, and industrial use, particularly during droughts and dry seasons [1]. Additionally, they facilitate irrigation, food security, hydroelectric power generation, and offer opportunities for tourism, fishing, and leisure activities, ultimately mitigating water scarcity risks and contributing to economic development, environmental sustainability, and community well-being. Fish serves as an exceptional source of high-quality protein, crucial for muscle growth, repair, and overall health, particularly in regions where alternative animal protein sources are scarce or unaffordable [2]. Rich in essential nutrients, fish provides omega-3 fatty acids, vitamins A, D, and B_{12}, and minerals like iodine, zinc, and selenium. Notably, omega-3 fatty acids have been linked to reduced cardiovascular disease risk, enhanced brain function, and improved overall well-being [3], making fish a vital component of a balanced diet for optimal health. Globally, fish is a crucial contributor to food security, providing essential protein for billions, especially in developing countries where it is a staple in many diets [4]. Moreover, fishing serves as a primary economic engine for coastal and rural communities, generating income and sustaining local economies [3], underscoring

the importance of fish in ensuring both nutritional and economic well-being. Northern Nigeria's freshwater bodies are home to a diverse array of fish species, including tilapia, catfish, and Nile perch, each contributing uniquely to local fisheries [4]. Notably, the north-eastern region is particularly rich in freshwater fish fauna [5]. The Biu Reservoir, a vital dam impounded for drinking, agriculture, and residential purposes, also presents significant opportunities for fisheries development, providing essential nutrients for human consumption and economic benefits to local communities, highlighting the reservoir's dual importance for both human well-being and environmental sustainability.

The alarming decline of fish diversity due to unchecked overfishing necessitates a critical assessment of the favorability and urgency of conservation efforts. To address this, a preliminary investigation and documentation of Biu Reservoir's fish diversity is crucial, enabling the development of a comprehensive fish diversity information system. This system will integrate bio-informative and geo-referenced databases of fish species and their habitats, providing valuable insights for informed decision-making and effective conservation strategies to safeguard the reservoir's dwindling fish populations. Overfishing, driven by excessive fishing pressure and poor management practices, poses a critical threat to Biu Reservoir's fish populations, potentially leading to stock depletion and reduced numbers [6]. Artisanal fishers rely on various fishing gears and crafts to harvest fish, including gillnets, hand lines, long lines, and traps, which are effective for capturing a range of fish sizes at different depths. Specifically, gill nets and traps are widely used in rivers and lakes, proving particularly effective for catching species like tilapia and catfish [7]. This study assesses the fish composition, distribution, gear efficiency, and craft characteristics in Biu Reservoir, Borno State, Nigeria in view of providing valuable insights into the reservoir's fisheries dynamics.

Materials and Methods

Description of the study area

Biu Reservoir, located in Biu Local Government Area, Borno State, at latitude 10.038'00" N and longitude 12.005'31" E, was initially constructed to provide drinking water to Biu town, the state's second-largest urban center, and irrigate surrounding fertile agricultural land. Although the project was abandoned by successive governments, the reservoir has found alternative uses, with its water now primarily supporting irrigation, fishing, and domestic activities such as washing and animal rearing [8], demonstrating its continued importance to the local community (Figure 1).

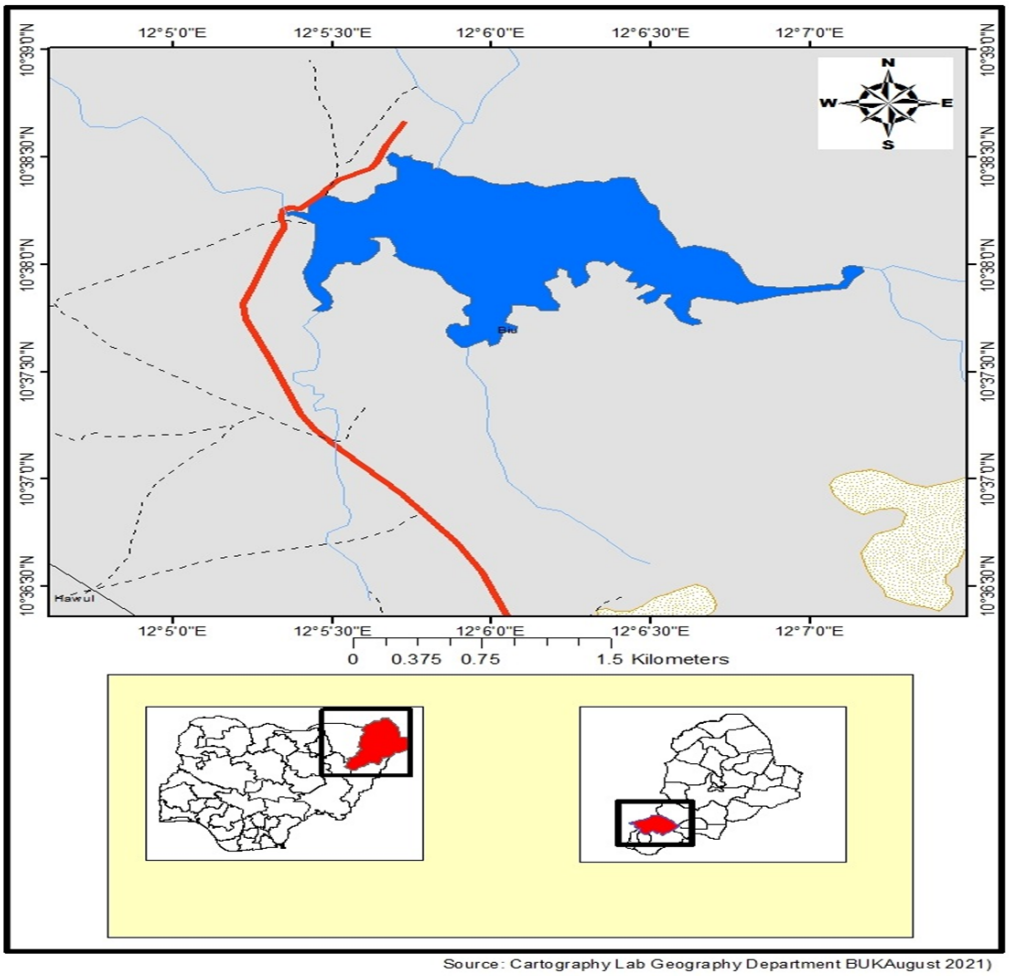

Figure 1: Map of biu reservoir, borno state.

Fish collection, species identification and analysis

Data collection for this study spanned 18 months, from September 2019 to February 2021, covering five sampling sites - A, B, C, D, and E. Researchers assessed, counted, and recorded fishers' catches at each landing site. To ensure accurate fish species identification, local fishermen and the field guide to Nigerian freshwater fisheries by Olaosebikan and Raji were consulted. Additionally, the study documented various fishing gears and crafts used by fishermen in the reservoir, providing valuable insights into the local fishing practices.

Results and Discussions

Fish species composition and abundance

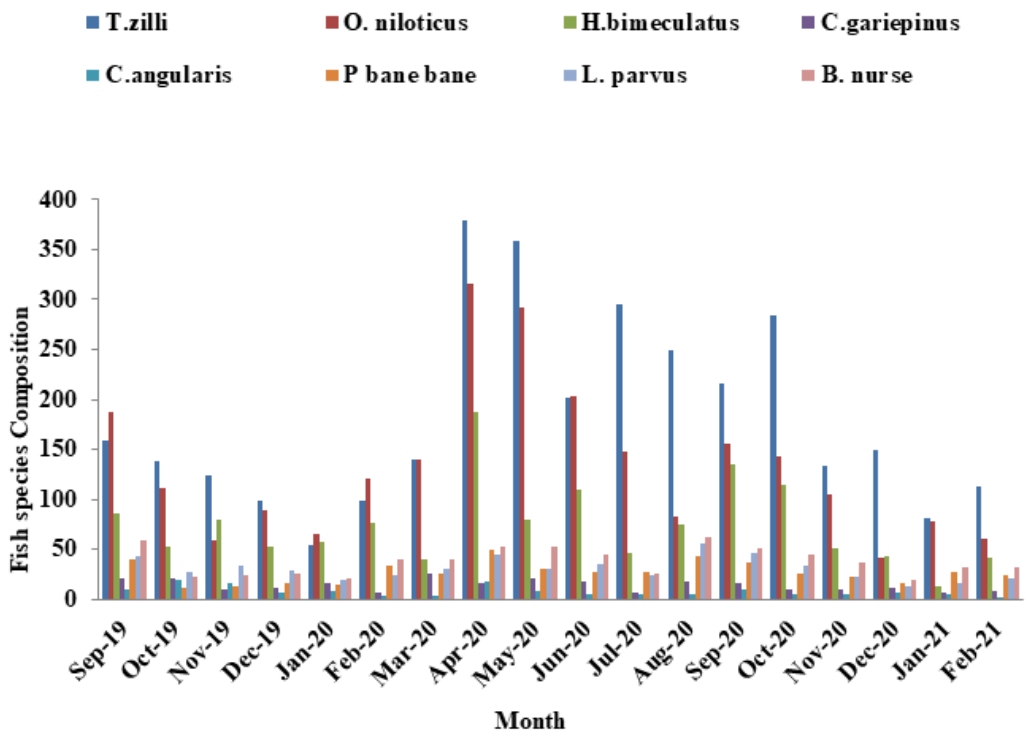

Figure 2: The graphical presentation of monthly mean Composition and abundance of Fish species of Biu reservoir.

Figure 2 and 3 show the species occurrence and their abundance in Biu Reservoir. A total of eight species from five families were recorded in Biu Reservoir during the sampling periods. These include the families *Cichlidae* (with species *Tilapia zilli*, *Oreochromis niloticus*, and *Hemichromis bimaculatus*), Claridae (with species *Clarias gariepinus* and *Clarias anguillaris*), *Alestidae* (with the species *Brycinus nurse*), Mormyridae (with the species *Petrocephalus bane* bane), and *Cyprinidae* (with the species Labeo parvus). The species composition of the fishers' catch remained relatively stable throughout the period of assessment. *Tilapia zillii* from the family *Cichlidae* dominated the catch, contributing 35.9% of the total fish caught during the assessment. The lowest catch was recorded in January 2020, and the highest was in April and May 2020. The minimum mean catch of Oreochromis niloticus was recorded in December 2020, and the maximum was in April 2020. Of all the fish species studied, *Oreochromis niloticus* constituted about 26.3%, making it the second most dominant species (Figure 3). *Hemichromis bimaculatus* represents the third most dominant fish species in Biu Reservoir, constituting about 14.7% of all fish species studied. The lowest was recorded in January 2021, while the highest was recorded in April of the same year. *Clarias gariepinus* from the family *Clariidae* was the second least abundant fish species studied in Biu Reservoir. The lowest catch of *Clarias gariepinus* was recorded in February and July 2020 and January 2021, while the highest was recorded in September 2019 and May 2020 (Figure 2). The percentage catch composition of *Clarias gariepinus* was 2.8% of all the fish species in Biu Reservoir. *Clarias anguillaris* constitutes 1.5% of all the fish species, ranking it the least. It also belongs to the family *Clariidae*. The highest catch was recorded in October 2019, followed by April 2020, while the lowest catch of *Clarias anguillaris* was recorded in January 2021. *Labeo parvus* from the family *Cyprinidae* ranked fifth in abundance of all the fish species caught in Biu Reservoir throughout the period of the study. The species constituted about 6% of the total fish species in Biu Reservoir. The highest monthly mean catch was in August 2020, while the lowest catch abundance was observed in December 2020 at all sites. The monthly mean catch abundance of Brycinus nurse from the family *Alestidae* ranked fourth, with 7.5% of all total fish species in Biu Reservoir. The minimum catch was recorded in January 2020, while the maximum catch was observed in August 2020, followed by September 2020. The mean catch abundance of *Petrocephalus bane* from the family Mormyridae was

recorded as sixth at 5.3%. The minimum catch was recorded from October 2019 through January 2020, while the maximum catch was observed in April 2020, followed by August 2020. In Biu Reservoir, the most commonly used fishing gear is the gill net (44.09%). The lowest usage was recorded in January and November 2020, while the highest usage was recorded in April 2020. The cast net constituted 28.00%, ranking second, with the lowest and highest numbers in September and April 2020, respectively. The long line formed 11.72%, ranking third, with the least usage in September and November 2019, while the highest usage was in May 2020. The Malian trap accounted for 9.62%, and Ndurttu 6.89%, both with the highest usage in April, May, and March 2020, respectively. The lowest numbers were in August and September 2020. The plank canoe recorded a significant usage of 55.36%, a common feature across many Nigerian lakes. However, the significant use of calabash (26.37%) and the simple plot (17.98%) is more unique to Biu Reservoir (Figure 4).

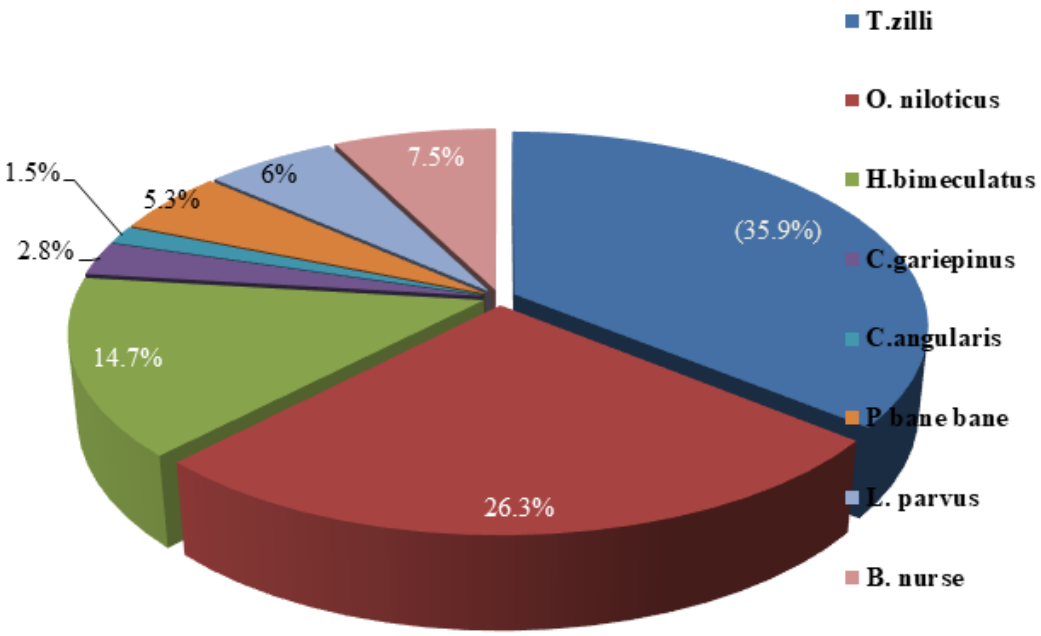

Figure 3: The graphical presentation of monthly percentage composition of fish species of biu reservoir.

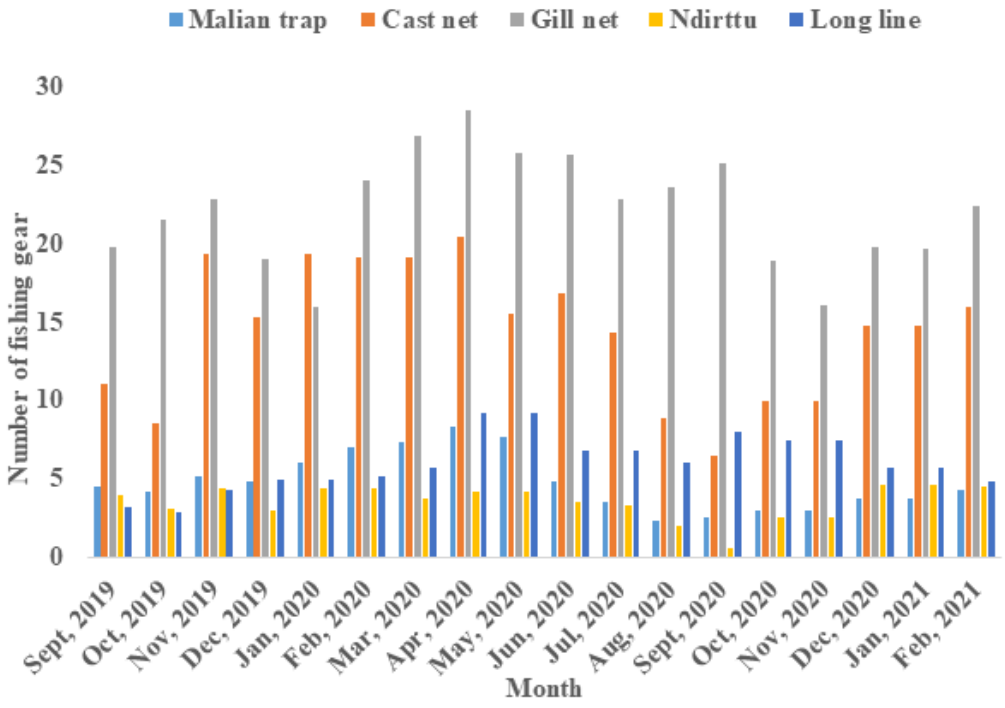

Figure 4: The mean monthly fishing Gears of Biu reservoir.

Discussion

Fish composition

The study of Biu Reservoir presents the first checklist of fish species abundance since damming. The species richness of the stations studied in Biu Reservoir compares favorably with findings by Lamai and Kolo [9], who reported that only four fish families consisting of five species were identified in Dan-Zaria Dam, which is in a comparable ecological zone. The results show that the reservoir is very low in ichthyofauna when compared to most Nigerian inland waters, disagreeing with findings by Ita [10] in other major reservoirs in Nigeria. The fish composition is poor compared to Alau Dam in Borno State, Kiri Dam in Adamawa State, and Dadin Kowa Dam in Gombe State, as well as other northern states. Fishing activities have modified rivers worldwide, affecting species richness and relative abundance. Similar trends are occurring in tropical, subtropical, and arid-zone systems [11,12] (Figure 5). In this study, *Tilapia zillii*, Oreochromis niloticus, and *Hemichromis* were the dominant species. The dominance of the *Cichlidae* family, particularly tilapia, in the study area indicates a habitat conducive to tilapia. This may be due to their prolific reproductive nature and parental care, which allows them to populate water bodies, especially where there are few aggressive and carnivorous species to control their population. The availability of food resources, such as plankton and edible macrophytes, also plays a role. This finding aligns with many studies on Nigerian reservoirs, which report cichlids as the most abundant in terms of number and diversity [13,14]. The family *Clariidae*, though scarce in Biu Reservoir, exemplifies tolerance to adverse water quality parameters, agreeing with findings by Ataguba [14], who noted that the families *Clariidae*, *Cichlidae*, *Characidae*, and Mormyridae are more common in northern Nigeria, especially in the Chad Basin (Figure 6). The low catch abundance may be linked to long-term overexploitation and the tempting market prices for Clarias species compared to other fish species available in Biu Reservoir. The population may not recover quickly enough to replenish the stock through breeding. *Clarias anguillaris*, which was observed as the least abundant, is not native to Biu Reservoir but was recently stocked in 2016, according to local sources. *Brycinus nurse* (family Mormyridae) was the fourth most abundant species in this study. Their emergence may be tied to their relatively small size and ability to feed on a variety of food items. The low catch abundance of other species, such as *Petrocephalus bane* and *Labeo parvus*, may be due to their occasional occurrence, low breeding rates, and changing environmental conditions in the reservoir. These species are considered rare and may require swift conservation measures, as similarly reported by Segun [15]. The use of undesirable fishing gears by fishers, particularly those exploiting fisheries resources as a free gift of nature, is a major contributing factor. Segun [15] and Sogbesan [16] similarly opined that overexploitation leads to the disappearance of fish populations and that poor management of water bodies by relevant government authorities results in low productivity and consequently low catches (Figure 7). A good representation of fishes feeding at all ecological niches in the reservoir was observed. For example, tilapia are primary herbivores, Petrocephalus bane and *Clarias gariepinus* are omnivores, while Brycinus and *Hemichromis* are predatory fishes. Empirically, the trend of abundance and diversity of fish in man-made reservoirs shows that human activities have always affected fish populations. This is similar to previous findings by Shahadat [17], who reported that natural fish populations are partially dependent on environmental variables that always affect competing populations.

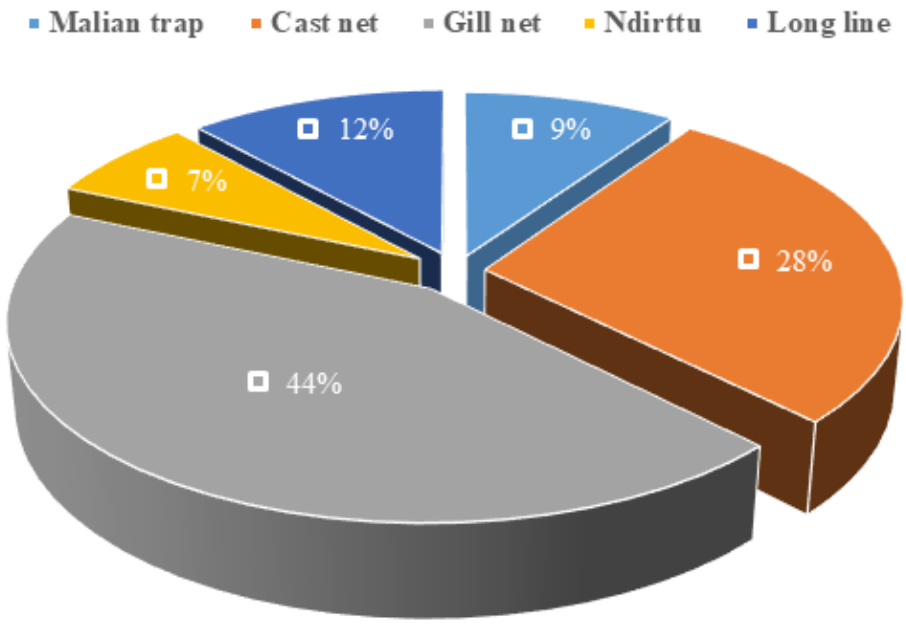

Figure 5: Percentage fishing gear of Biu reservoir.

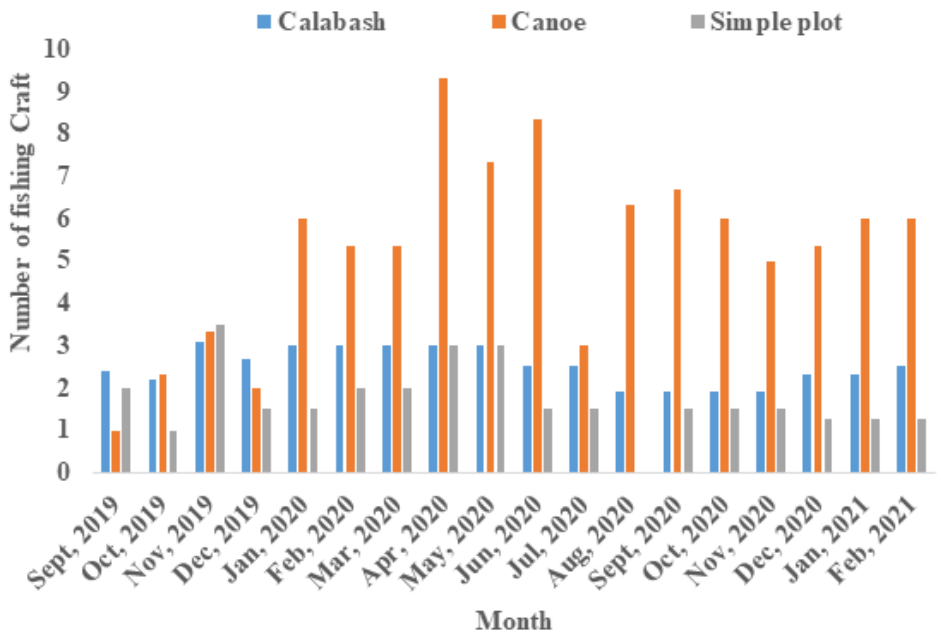

Figure 6: The mean monthly Fishing Craft of Biu reservoir.

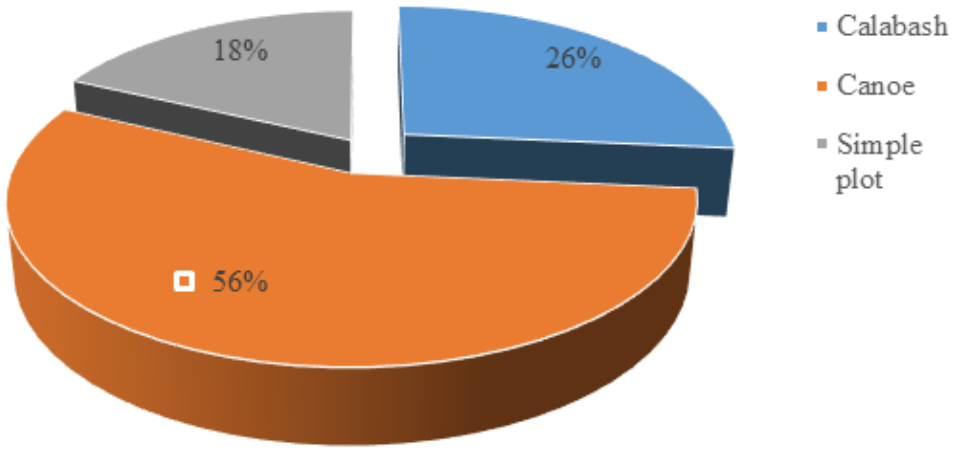

Figure 7: The percentage fishing craft of biu reservoir.

Fishing gears

The array of fishing gears common in Biu Reservoir suggests a preference for passive fishing methods (gill nets) and active methods (cast nets), similar to studies by Mshelia [6] and Adeyemi [18]. The use of traditional methods, such as the Malian trap and Ndurttu, indicates the persistence of local fishing techniques alongside more modern methods [6]. The high percentage of gill net usage (44.09%) in Biu Reservoir is significant, indicating that it is the easiest and cheapest gear, more efficient in catching small fish by fishers whose livelihood depends on it. However, this could lead to indiscriminate fish harvests, where very few fish escape capture [11]. This harvest could exceed the normal rate at which these species can reproduce and replenish themselves [19]. The reservoir is no restricted fishing ground and no fish management programme through restocking of over exploited species can be monitored. If gears with large mesh sizes are introduced and enforced and small mesh gears banned as a rehabilitative measure significant increase in yield can be obtained from Biu fishery. It would be interesting to compare this to other lakes to see if this is a common trend or specific to Biu [20]. One of the most useful and high reliance fishing equipment is Plank boat (canoe). It is locally manufactured non-mechanized and manually operated with oars. Fishing gear such as cast net and long lines may operate through the boat. While, the simple design is locally fabricated by tightening two air tight jerry cans with a little space in-between for the fisher folk to seat on. The canoes are likely a common feature across many Nigerian lakes, but the significant use of calabash and simple plot is more unique to Biu Reservoir. However, this analysis provides a general context

for understanding how fishing practices in Biu Reservoir relate to other Nigerian freshwater bodies. Fishing practices can change over time due to factors like technological advancements, changes in fish populations, and evolving regulations [21,22].

Conclusion

The study of Biu Reservoir reveals that the fish species composition and abundance is low compared to other Nigerian inland waters. A total of eight species from five families were recorded, with *Tilapia zillii*, Oreochromis niloticus, and *Hemichromis bimaculatus* (all from the family *Cichlidae*) being the most dominant. Dominance is likely due to the reproductive advantages and adaptability of *Cichlidae* species in environments with limited predators. However, the low abundance of other species, particularly those from the *Clariidae* family, indicates a potential over-exploitation and environmental stress on the fish population. The *Clariidae* species' scarcity aligns with observations of their vulnerability to adverse conditions, highlighting the need for conservation efforts. The use of a mix of traditional and modern fishing gear, with a significant reliance on gill nets, suggests a fishing strategy that may lead to over-harvesting, further stressing the fish population. The dominance of passive fishing methods may exacerbate the decline in fish abundance, as noted in similar studies across Nigerian reservoirs.

Recommendations

The low abundance of certain species, such as *Clarias gariepinus* and *Clarias anguillaris*, suggests the need for conservation efforts. Implementing measures like restocking and controlled fishing could help restore these populations. The high reliance on gill nets (44.09%) can lead to overharvesting, especially of smaller fish that are crucial for population regeneration. Introducing regulations on mesh size and enforcing restrictions on certain fishing methods would promote sustainability. Given the dominance of certain species like *Tilapia zillii*, which thrive in the absence of predators, it's crucial to manage the habitat to support a balanced ecosystem. This may involve monitoring water quality and preventing activities that degrade the environment. Continuous monitoring and research are needed to track changes in fish populations and the effects of human activities. This will provide data to inform future management decisions and ensure the long-term health of Biu Reservoir.

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