



Research Article

Assessing the Impacts of Artisanal and Abandoned Fishing Gears on Water-Related Activities and Waterbirds in Hadejia Wetland National Park and Hadejia-Nguru Wetland, Jigawa State

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ABSTRACT

Wetlands are globally recognized as critical habitats for biodiversity, particularly waterbirds, yet artisanal and abandoned fishing gears increasingly threaten them through entanglement, injury, and mortality. This study assessed the impacts of these gears on waterbirds at ten locations in Hadejia-Nguru Wetlands and Hadejia Wetland National Park, Jigawa State, Nigeria, a seasonally flooded floodplain system characterized by flooding that generally occurs during the rainy season, with peak inundation around August to October, particularly August and September. Locations that retain water year-round and support continuous artisanal fishing were purposively selected. Each was visited twice monthly for eight months, covering wet and dry seasons to search active fishing grounds for live and dead entangled birds, recorded GPS coordinates of gear, identified species using Borrow and Demey, and interviewed fishermen with structured questionnaires on gear types and past entanglements. Gears encountered included gillnets, cast nets, traps, and longlines. A total of 146 entangled individuals were recorded (79 dead, 67 alive). Herons and egrets (Ardeidae) and kingfishers (Alcedinidae) together accounted for over half of entanglements in both seasons, reflecting vulnerability linked to foraging behavior and habitat use. Garbi recorded the most entangled birds (27), followed by Kwasabar (17), and Tukunzuru, Mabaram, and Malingirin (14 each). Bycatch mortality accounted for most deaths, and resident species showed higher encounter and mortality rates than Intra-African and Afro-Tropical migrants. Entanglement was higher in the wet season, when floodwaters expand feeding habitat and fish availability, attracting birds while intensifying fishing effort.

Keywords: Abandoned fishing gears; Artisanal fisheries; Entanglement; Waterbirds; Wetlands

Citation: Ibrahim, I.B., Muhammad, S.I., & Malam, I. (2026). Assessing the Impacts of Artisanal and Abandoned Fishing Gears on Water-Related Activities and Waterbirds in Hadejia Wetland National Park and Hadejia-Nguru Wetland, Jigawa State. *Sahel Journal of Life Sciences FUDMA*, 4(3): 586-595. DOI: <https://doi.org/10.33003/sajols-2026-0403-61a>

INTRODUCTION

In African inland wetlands, gillnets, cast nets, fish traps, hook lines, and monofilament nets are commonly used by local fishing communities. Research from the Inner Niger Delta in Mali and other

Sahelian floodplains demonstrates that fishing intensity strongly influences waterbird distribution and survival. During seasonal inundation, expanding floodwaters attract both fish and waterbirds into productive feeding habitats, while fishing effort

increases substantially (Zwarts *et al.*, 2009). Within Nigeria, the Hadejia-Nguru Wetlands face a similar pattern, with increasing fishing pressure identified as an emerging threat to the ecological integrity of the wetland ecosystem.

Abandoned or lost fishing gears, often referred to as ghost gears, continue trapping wildlife long after fishing activities have ceased, thereby posing a persistent conservation threat within freshwater ecosystems. In the Hadejia-Nguru Wetlands, indiscriminate disposal of fishing gears, together with habitat fragmentation, has been identified as an emerging threat to the wetland ecosystem and the survival of its bird populations.

Active and abandoned gears frequently entangle birds while they forage, dive, swim, or land on water surfaces, resulting in injuries, drowning, or reduced flight capability (Fayemi *et al.*, 2019; Nalwanga *et al.*, 2022). Studies around Lake Victoria have shown that waterbirds are particularly vulnerable to entanglement in abandoned gillnets during periods of increased fishing effort and seasonal flooding. Nalwanga *et al.* (2022) reported that herons, cormorants, kingfishers, and pelicans frequently interact with fishing gears because they forage close to active fishing grounds and shallow water habitats. Similar observations have been recorded in other East African wetlands, where artisanal fisheries overlap spatially with important bird congregation areas, increasing the risk of bycatch and mortality. In the Sahel, this seasonal overlap between birds and fishing has been identified as a significant driver of accidental mortality among freshwater birds.

Birds are the most studied taxa of all animal species (Gill, 2007). They are easily identified, highly mobile, and diverse, and are found in all habitat types (Sinclair, 2004), including wetlands, which are among the most biologically diverse and productive of all ecosystems. Wetlands serve as home to a wide range of plant and animal life. Birds, waterfowl in particular, depend on wetlands for nesting, breeding, feeding, moulting, and roosting (Kumar and Gupta, 2009). Wetlands provide refuge for resident species and also serve as an important overwintering and staging ground for migratory birds.

Waterbirds are the most threatened of all avian groups globally, and their populations have declined significantly since the 1950s (Paleczny *et al.*, 2015). The greatest drivers of decline are mortality from fisheries bycatch, introduced mammalian predators, and habitat destruction at breeding colonies (Croxall, 2012). The life history and behaviour of waterbirds at

wetlands make them particularly susceptible to these additional threats (Butchart *et al.*, 2004).

The Hadejia-Nguru Wetlands have long been recognised as one of Nigeria's most important bird conservation landscapes. They support internationally significant populations of species such as the Yellow-billed Stork, African Openbill, Black-crowned Crane, Spur-winged Goose, Great White Pelican, and numerous herons, egrets, and kingfishers (Akinsola *et al.*, 2018; Fayemi *et al.*, 2019).

Ramsar sites are wetlands of international importance designated under the Ramsar Convention on Wetlands, an international treaty for the conservation and sustainable use of wetlands. They are recognized for their ecological, hydrological, and biological significance, providing critical habitats for plants, animals, and migratory birds. Ramsar sites also play a vital role in maintaining biodiversity, regulating water flow, and providing ecosystem services such as flood control, water purification, and carbon sequestration (Ramsar Convention on Wetlands Secretariat, 2023).

Despite the international importance of the Hadejia-Nguru Wetlands, there is limited empirical information on the magnitude, spatial distribution, and seasonal pattern of waterbird interactions with artisanal and abandoned fishing gears. Most existing studies in Nigeria have focused on bird diversity, migration, habitat use, and wetland ecology, with little attention to fishing gear-related mortality. This gap limits the development of effective conservation strategies for reducing bycatch and improving sustainable fisheries management within Ramsar-designated freshwater wetlands.

This study therefore provides field-based evidence on waterbird entanglement across selected wetlands within Hadejia Wetland National Park and the Hadejia-Nguru Wetlands. By examining the species affected, seasonal variation, spatial distribution, and causes of mortality, it contributes to understanding how artisanal fishing practices influence freshwater bird conservation in the Afrotropical region.

The aim of the study is to assess the impacts of artisanal and abandoned fishing gears on waterbirds in two Nigerian prominent RAMSAR sites.

MATERIAL AND METHODS

Study Area

The study was conducted at ten wetlands, namely Kudubiya, Auyo, Kwasabar, Jikjik, Tukunzuru, Mabaram, Nguru, Garbi, Dingare and Malingirin, within the Hadejia Wetland National Park and the Hadejia-Nguru Wetlands (HNW) in Jigawa State,

north-eastern Nigeria. The geographic coordinates of each location are given in Table 1, and their positions are shown in Figure 1.

Hadejia Wetland National Park lies about 20 km south-east of Hadejia (Kabir, 2006). It is a Sudano-Sahelian wetland of ponds and seasonally flooded land fed by the annual flooding of the Kafin-Hausa River. It was gazetted in 1985 and covers 101,095 ha. It is especially important for waterbirds such as the Yellow-billed Stork and Knob-billed Goose.

The Hadejia-Nguru Wetlands sit on the southern edge of the Sahel savanna and form a floodplain complex

of seasonally flooded land and dry uplands. They shrank from about 4,125 km² to about 3,500 km² after the 1970s droughts. They hold around 378 bird species, resident and migratory, and serve as breeding, wintering and stopover habitat (BirdLife International, 2023). The complex borders Bauchi, Jigawa and Yobe states and has about 1.5 million people. Parts of it are legally protected, including the Adiani Forest Reserve and the Baturiya Wetland Reserve, which was recently upgraded to National Park status (Ramsar site, 2023).

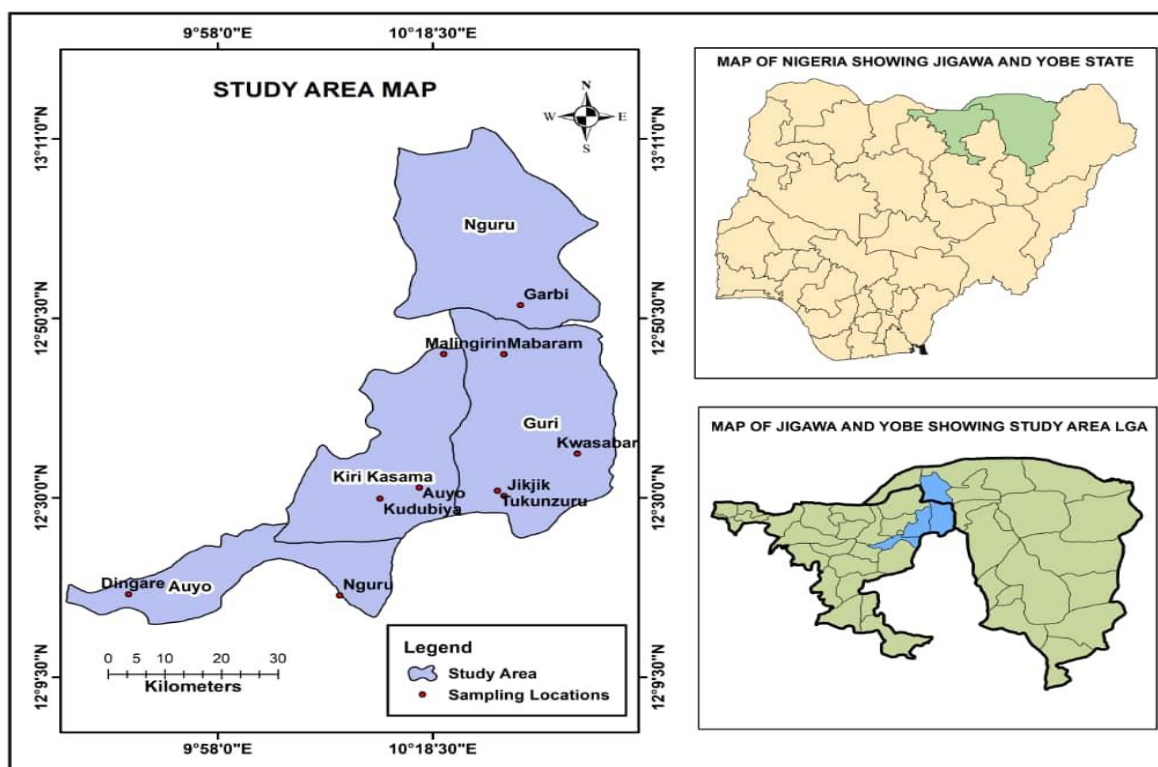


Figure 1: Map of Nigeria showing the Location of the selected 10 wetlands (Source: Federal University, Dutse GIS Laboratory, 2024)

Table1. Location and coordinates of the 10 wetlands location

Location	Latitude	Longitude.
KDBY	12.498265	10.224539
AUY	12.519575	10.286953
JKJK	12.503778	10.421558
MLGRN	12.773784	10.325927
TKZRU	12.513663	10.411244
KWASBR	12.583919	10.537942
MBRM	12.773244	10.421236
GRBI	12.866667	10.447778
NGURU	12.31417	10.160537
DNGRE	12.316521	9.825123

Key: KDBY: Kudubiya, AUY: Auyo, JKJK: Jikjik, MLGRN: Malingirin, TKZRU: Tukunzuru, KWASBR: Kwasabar, MBRM: Mabaram, GRBI: Garbi, Nguru, DNGRE: Dingare

Human Population

The HNW borders three states, Bauchi, Jigawa and Yobe, and has a human population of about 1.5 million. The area is ethnically diverse, with about 60% Hausa-Fulani, 30% Kanuri and 10% other groups such as Yoruba, Igbo and Bade. The Fulani are mostly semi-settled herders, and many also practise some arable farming. Nguru has long been one of Nigeria's major collecting points for gum arabic, groundnut, cotton, meat, hides and skins, which were sent to Lagos by the railway built in the colonial era. A large population in the surrounding villages depends on the wetland's resources for its livelihood through agriculture, fishing and the general harvesting of resources.

Economic Activities around the Wetlands

Communities around the wetlands depend on natural resource-based activities, mainly agriculture, fishing, livestock grazing and fuelwood extraction. Over time the riparian communities have developed a complex system of livelihoods adapted to the variable environment, which also protects them against drought.

Fishing is a year-round activity that peaks as the floods rise and as they recede. Access rights in the fishery are closely tied to the flow of water, and fishing is concentrated in the ponds that form each dry season. Several communities fish throughout the year and rely mainly on fishing for their livelihoods. The fishery is artisanal, operated by small units using simple, hand-operated gear such as hooks, gillnets, traps and baskets, and traditional craft such as dug-out wooden canoes, bamboo rafts and small open fibre-glass boats. In the HNW, fishing is commonly done with traps, set nets, hooks and other artisanal methods (Tagago and Ahmed, 2011; Udolisa *et al.*, 1994). [Add what you observed at the ten sites: the gears most used, whether fishers stay on site or visit daily, and any gear left in the water.]

Because fishers, farmers and livestock keepers share the same wetlands as the birds, fishing gear is set in the shallow feeding areas that waterbirds use. Gear that is lost, damaged or discarded stays in the water as abandoned gear. These overlaps in space and time between fishing and birds are what this study investigates, and they explain why the ten sites were chosen for their year-round water and year-round fishing.

A reconnaissance survey was carried out to identify ten wetland locations that support both waterbirds and year-round fishing activity, for the assessment of artisanal and abandoned fishing gears. Different types of artisanal and abandoned fishing gears present were noted. Potential interaction between

waterbirds and the fishing gears were also assessed. Local expert fishermen and relevant literature where available were consulted for insights.

The historical context of artisanal fishing practices and reasons for gear abandonment and threats posed by the gears such as entanglement were investigated. Spatial data were gathered as waypoints coordinates of the fishing gears-waterbirds interactions were noted to visualize the distribution of fishing gears interactions with waterbirds on a map. Developed structured questionnaires for survey were used as a source for data collection and also field observations, community engagement, and literature review were married together, a well-prepared comprehensive assessment of the interaction between artisanal and abandoned fishing gears and waterbird populations was established using delineate specific research objectives. Scientific and systematic sampling strategy for both on-site observations and interviews were applied to avoid biases.

Finally, a comprehensive data management plan for organizing and analyzing the gathered information were used. This reconnaissance phase served as the foundation for a robust and impactful assessment of the relationship between artisanal and abandoned fishing gears and waterbird populations.

Sampling and Sampling Techniques

Ten wetland locations within the Hadejia Wetland National Park and the Hadejia-Nguru Wetlands (Kudubiya, Auyo, Kwasabar, Jikjik, Tukunzuru, Mabaram, Nguru, Garbi, Dingare and Malingirin) were selected using purposive sampling. The selection criteria were (i) year-round water retention and (ii) continuous artisanal fishing throughout the year. This ensured that both waterbirds and fishing gear were present at every site in both seasons. The criteria were confirmed with local fishermen during the reconnaissance survey.

Each wetland was surveyed twice a month, at the beginning and in the middle of the month, over eight months comprising four months of the wet season and four months of the dry season [state the months sampled]. One day was spent at each wetland per visit, and fieldwork began at 09:00 h. The finishing time depended on the number and size of the wetlands in the complex being visited.

On arrival at each wetland, researchers searched the area for entangled and dead waterbirds, concentrating on active fishing grounds and on places where live (in-use) or abandoned fishing gear was found. Each entangled bird was identified to species using the field guide of Borrow and Demey (2014),

and recorded as live or dead. Dead birds were removed from the gear after recording, to prevent double-counting on later visits. Each carcass was examined to establish the likely cause of death and assigned to one of three categories: **Bycatch mortality:** the bird was found entangled and dead in the fishing gear, **Consumed or decayed:** only remnants of bones or feathers were found in the gear, and **Unknown mortality:** the cause of death could not be established.

Species were also grouped by residency status as Resident, Intra-African migrant (migrating within the African continent), or Afro-tropical migrant (breeding in Europe and wintering in tropical Africa).

The location of every fishing gear and waterbird interaction was recorded as a GPS waypoint. The waypoints were mapped in a GIS to show the spatial distribution of interactions across the ten wetlands. To complement the field observations, structured questionnaires were administered to fishermen, farmers and hunters living around the wetlands. Respondents were selected randomly from those willing to participate. The questionnaire was written in English and translated into the local language, and each interview took about 10 minutes on average. It gathered information on respondent characteristics, waterbird observations, fishing gear use, the abundance and distribution of artisanal and abandoned gear, the effects of gear on waterbirds, and policies and laws. Fishermen were also asked about the types of gear they use and their previous experience with entangled waterbirds.

Sources of Data

The primary source of the data for the study which was the firsthand source of data included surveys, direct observations that provides real-time data, self-administered structured questionnaires to source for information from the resource/wetland users especially the fishermen as well as interviewing the wetland users.

Techniques of Data Collection

Data collection was undertaken and data were gathered through a multidimensional approach that included surveys, structured questionnaires and interviews.

Field data were collected over 8-month period, from July to February, to capture both the dry and wet seasons in the Hadejia-Wetland National Park and the Hadejia-Nguru Wetlands. The sampling period was divided into two seasons of four months each, the wet season (July-October) and the dry season (November-February). This seasonal classification was adopted to evaluate temporal variation in fishing

activities and waterbird entanglement across the study area.

Each wetland was surveyed twice every month at approximately two-week intervals, once during the first half of the month and once during the second half of the month. This produced 16 field visits per wetland over the study period.

Entangled or dead birds were searched on arrival at the wetland; more attention was on areas of fishing. Dead waterbird was collected to avoid double counting and thoroughly checked to assess and established the cause of mortality.

Fishermen were interviewed to get information on their previous experience with trapped waterbird and to ascertain the different types of fishing gears they used. Borrow and Demey (2014) field guide of Western African Birds were used to identify the entangled waterbirds species and to categorized the bird's species into residents, migrants and intra-African migrants. The residence status of bird species was classified as a Resident, Intra-African migrant (birds that migrate within the continental Africa), or Afro-tropical migrants, those that migrate breed in Europe but spend winter in tropical Africa.

The questionnaire was written in English language and then transcribe to Local language. The questionnaires were administered to respondents that are willing to contribute and partake into the study and the targets respondents are the fishermen, farmers, and hunters. Maximum of 10 minutes was allocated on average for each respondent, Entangled or dead birds were searched on arrival at a wetland, bird identification field guide was employed to identify the entangled birds, more attention was on areas of fishing and where live and abandoned fishing gears were found. Dead waterbirds were collected to avoid double-counting and the birds were thoroughly checked to assess and established the cause of the mortality. Subsequently, structured questionnaires were administered randomly to the voluntary respondents at the selected wetlands to provide insights into the respondent's knowledge about the effects of artisanal and abandoned fishing gears on waterbirds.

Structure of the questionnaire

The questionnaire was designed according to the objectives of the study. It consisted of fixed responsive questions which were grouped into five sections: A-E

Section A: Respondents information, Section B: Waterbirds observation, Section C: Fishing gear usage, Section D: Artisanal and abandoned fishing gears abundance and distribution, Section E:

Assessing the impact of fishing gears on waterbirds, Section F: Policies, Laws and Observations

The structured questionnaires were self-administered by random sampling to avoid bias across the ten study locations. It was assumed that uses of different fishing gears and the frequency of the fishing activities within each community around the wetland will determines the frequency of the bycatch.

GIS and Mapping:

GIS and mapping were used to take waypoints as a reference point within the study area of any entangled bird and fishing gear points of interaction for the purpose of navigation.

Technique of Data Analysis

The data were subjected to Shapiro-Wilk normality test that is applied to a sample with a null hypothesis and this indicated that the sample were generated from a normal distribution to determine the type of statistical tool to be used (Parametric or non-parametric).

Number of birds' mortality was the dependent variable and was treated as continuous variables. The PivotTable function in Microsoft excel was used for descriptive analyses and calculated, summarized, sorted, reorganized, grouped, counted, totaled, averaged and analyzed data. Wetlands and seasons were the independent variables and were considered as categorical variables. R statistical programming language (R Development Core Team, 2022) was used to conduct inferential analyses such as t-test, ANOVA, Chi-square test among others.

RESULTS

The study recorded 146 entangled individuals representing 15 bird species from 6 families, demonstrating that entanglement risk is taxonomically widespread. Thirteen (13) species were affected in the dry season and twelve in the wet season (Table 2). Ten species appeared in both seasons. Three species (3) were recorded only in the dry season (African Pygmy Kingfisher, Little Egret and Grey Heron), while two (2) were recorded only in the wet season (Common Moorhen and Malachite Kingfisher). In the dry season, the African Jacana was the most frequently entangled species (10 birds, 14.9%), followed by the Pied Kingfisher (9 birds, 13.4%), and then the Lesser Moorhen and African Pygmy Kingfisher (8 birds each, 11.9%). The Great Egret and Grey Heron were the least affected, with two birds each. In the wet season, the African Jacana, Pied Kingfisher and Squacco Heron shared the top position with nine birds each (11.4%), while the Great

White Pelican and Pink-backed Pelican were the least affected with three birds each.

Ardeidae's susceptibility may be linked to their foraging in shallow waters where artisanal gill nets and traps are deployed, while kingfishers' diving behavior and low-flying foraging strategy bring them into direct contact with fishing lines and nets. The presence of large-bodied species such as the Great White Pelican (*Pelecanus onocrotalus*) and Pink-backed Pelican (*Pelecanus rufescens*) among the victims indicates that artisanal and abandoned gears are non-selective hazards. Pelicans, with their large wingspans and group foraging strategies, may become entangled when pursuing fish near netted areas.

Spatial variation across wetlands

Entanglement was unevenly distributed across sites, with Garbi Wetlands recording the highest number of affected individuals (27), followed by Kwasabar individual (17) while Tukunzuru, Mabaram and Malingirin Wetlands (14 each). This variation may be attributed to differences in fishing intensity, density of abandoned gear, and the ecological significance of each wetland as a foraging ground. Garbi Wetlands may experience higher fishing pressure due to easier access, greater fish abundance, or concentration of artisanal fishing communities. Similar site-specific variations in bycatch risk have been documented in Kenyan and Tanzanian coastal wetlands, where artisanal fishing hotspots coincide with bird congregation zones.

Seasonal Trends in Entanglement

The wet season had a higher number of entangled bird species than the dry season. Seasonal flooding during the wet months expands aquatic habitat, attracting both resident and migratory birds, and intensifying fishing activity to exploit increased fish biomass. The expanded water surface area also increases the likelihood of birds encountering submerged or semi-submerged nets. This trend parallels findings from East African rift valley wetlands, where wet season artisanal fishing effort correlates with peaks in bird entanglement incidents.

Mortality and Bycatch Impacts

Bycatch was the leading cause in both seasons, accounting for 42 birds (62.7%) in the dry season and 39 birds (49.4%) in the wet season. Bycatch mortality was recorded at all ten sites in the dry season and at nine of ten in the wet season, the exception being Auyo, where none was recorded. Garbi had the highest bycatch counts in both seasons. While live individuals may be rescued, many likely suffer from sub-lethal injuries such as feather damage, joint

dislocation, or infections, reducing survival probability post-release. Birds entangled in abandoned gears may drown, starve, or fall victim to predators, making ghost gear a persistent and indiscriminate killer. The mortality observed in this study underscores the urgent need for proactive management of fishing gear use and disposal.

Residency Status and Exposure Risk

Resident birds made up the majority of entangled individuals in both seasons. They accounted for 44 birds (65.7%) in the dry season and 59 birds (74.7%)

in the wet season. Intra-African migrants contributed 15 birds in each season (22.4% and 19.0% respectively), while Afro-tropical migrants were the smallest group, falling from 8 birds (11.9%) in the dry season to 5 birds (6.3%) in the wet season. Garbi had the highest number of resident birds in both seasons (8 in the dry season and 10 in the wet season). The difference in residency composition between seasons was not statistically significant ($\chi^2 = 1.90$, $df = 2$, $p = 0.39$).

Table 2: Number of entangled waterbirds by species and season

Common name	Scientific name	Dry season	Wet season
African Jacana	<i>Actophilornis africanus</i>	10	9
Pied Kingfisher	<i>Ceryle rudis</i>	9	9
Squacco Heron	<i>Ardeola ralloides</i>	4	9
Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	6	8
White-throated Kingfisher	<i>Halcyon smyrnensis</i>	4	8
Lesser Moorhen	<i>Gallinula angulata</i>	8	7
Common Moorhen	<i>Gallinula chloropus</i>	—	7
Reed Cormorant	<i>Microcarbo africanus</i>	5	6
Malachite Kingfisher	<i>Corythornis cristatus</i>	—	6
African Pygmy Kingfisher	<i>Ispidina picta</i>	8	—
Great Egret	<i>Ardea alba</i>	2	4
Great White Pelican	<i>Pelecanus onocrotalus</i>	3	3
Pink-backed Pelican	<i>Pelecanus rufescens</i>	3	3
Little Egret	<i>Egretta garzetta</i>	3	—
Grey Heron	<i>Ardea cinerea</i>	2	—
Total (13 species dry; 12 wet)		67	79

Table 3: Entanglement by bird family and season

Family	Dry (n)	Dry (%)	Wet (n)	Wet (%)
Alcedinidae (kingfishers)	21	31.3	23	29.1
Ardeidae (herons, egrets)	17	25.4	21	26.6
Rallidae (moorhens)	8	11.9	14	17.7
Jacanidae (jacanas)	10	14.9	9	11.4
Pelecanidae (pelicans)	6	9.0	6	7.6
Phalacrocoracidae (cormorants)	5	7.5	6	7.6
Total	67	100	79	100

Table 4: Entangled waterbirds (alive and dead) by site and season

Site	Dry: alive	Dry: dead	Dry: total	Wet: alive	Wet: dead	Wet: total
Kudubiya	2	3	5	5	3	8
Auyo	2	2	4	3	2	5
Kwasabar	4	4	8	4	5	9
Jikjik	4	3	7	4	2	6
Tukunzuru	4	2	6	5	3	8
Mabaram	3	3	6	5	3	8
Garbi	7	5	12	8	7	15
Nguru	3	2	5	5	3	8
Dingare	3	4	7	2	3	5
Malingirin	4	3	7	2	5	7
Total	36	31	67	43	36	79

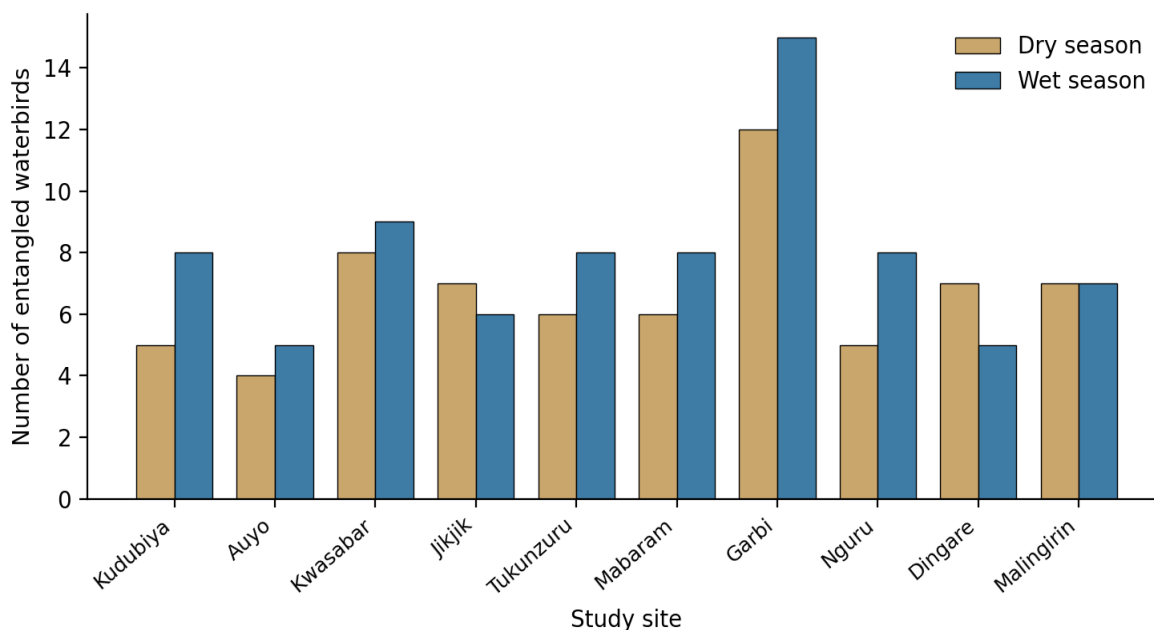


Figure 2: Number of entangled waterbirds recorded at each study site in the dry and wet seasons

Table 5: Cause of mortality of entangled waterbirds by season

Cause	Dry (n)	Dry (%)	Wet (n)	Wet (%)
Bycatch mortality	42	62.7	39	49.4
Consumed by people	13	19.4	27	34.2
Unknown	12	17.9	13	16.5
Total	67	100	79	100

Table 6: Residency status of entangled waterbirds by season

Residency status	Dry (n)	Dry (%)	Wet (n)	Wet (%)
Resident	44	65.7	59	74.7
Intra-African migrant	15	22.4	15	19.0
Afro-tropical migrant	8	11.9	5	6.3
Total	67	100	79	100

However, even short-term exposure during migration can have significant demographic impacts if mortality affects key population segments (BirdLife International, 2018).

Table 7: Levels of Fishing Gear Impact on Waterbirds

Indicator	Evidence	Level
Species richness affected	17 species	High
Mortality rate	40.8%	High
Statistical association ($p < 0.05$)	Yes	High
Spatial consistency	Multiple wetlands	Moderate–High
Seasonal persistence	Both seasons	High

DISCUSSION

This study documented 146 cases of waterbird entanglement in fishing gear across ten wetland sites over an eight-month study period, comprising four wet-season and four dry-season months. Of the recorded birds, 79 (54.1%) were found alive, while 67 (45.9%) were found dead, indicating that

entanglement was associated with substantial observed mortality. However, these figures represent recorded cases rather than estimates of total mortality or population-level effects.

Kingfishers, herons and egrets accounted for a substantial proportion of the entanglement records, with species such as the African Jacana, Pied

Kingfisher and Squacco Heron among those frequently recorded. These findings demonstrate that fishing gear poses a potential threat to diverse waterbird groups in the study wetlands. Nevertheless, differences in recorded entanglement among species should be interpreted cautiously because species abundance, habitat use and survey effort were not used to establish species-specific risk. Spatial variation was evident across the study sites, with Garbi recording the highest number of entanglements in both seasons and Malingirin also recording relatively high numbers. These patterns suggest that local differences in fishing intensity, gear deployment, habitat characteristics and the accumulation of discarded gear may influence exposure. However, these potential explanations require further investigation because the relative contribution of each factor was not directly quantified.

Seasonal comparisons showed slightly more entanglement records during the wet season (79) than during the dry season (67). The difference was not statistically significant according to the reported analysis (chi square= 0.99), (df = 1), (p = 0.32)). Similarly, the proportions of birds found alive and dead were comparable between seasons. These findings suggest that entanglement occurred in both seasons, although the available data do not establish that the underlying risk was constant throughout the year.

Bycatch was the most frequently recorded mortality category in both seasons, accounting for 42 cases (62.7%) in the dry season and 39 (49.4%) in the wet season. Records of birds consumed by people increased from 13 (19.4%) in the dry season to 27 (34.2%) in the wet season, although the overall seasonal difference in mortality categories was not statistically significant (Chi-square=4.09), (df = 2), (p=0.13)). These results indicate that fishing-gear interactions may occur alongside additional human pressures, but the respective contributions of entanglement, bycatch, retrieval practices and subsequent human use require clearer documentation.

The findings are consistent with broader international evidence identifying fishing gear, particularly gillnets and lost or discarded gear, as a source of bird mortality (Manville, 2005; Macfadyen *et al.*, 2009; Žydelis *et al.*, 2013). Research on artisanal fishing in Kenya has also demonstrated that fishing gear can produce substantial ecological impacts, although that study focused on coral reef ecosystems rather than waterbird entanglement (Mangi & Roberts, 2006).

Evidence directly comparable to the present study from Nigerian inland wetlands remains limited, highlighting the value of documenting fishing-gear interactions in African freshwater ecosystems.

CONCLUSION

Overall, the study identifies fishing-gear entanglement as a conservation concern in the surveyed wetlands and supports improved monitoring, responsible gear management and the removal or appropriate disposal of abandoned fishing gear. Further research should distinguish active from abandoned gear, record fishing effort and gear type, and standardise survey effort across sites and seasons. Such measures would strengthen estimates of entanglement risk and help identify targeted interventions to reduce waterbird mortality.

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