QUANTIFYING THE MULTI-FACTOR INFLUENCES OF WATER CONDITIONS AND DIVING BEHAVIOR OF PIED KINGFISHER (*CERYLE RUDIS*)'S FORAGING SUCCESS IN THREE WATER BODIES OF PLATEAU STATE, NIGERIA.

Supported by tetfund
TERTIARY EDUCATION TRUST FUND

Michael Manja Williams[1], Caka Karlsson[1], John Danjuma[2], Mathew Nengel Adendem[3], John Daniel Yiljika[4]
[1]Biota Conservation Hub Foundation (BiotaCHF), Jos, Plateau state, Nigeria
[2]Department of forestry and Wildlife Management, Faculty of Agriculture and Life Sciences, Federal University, Wukari, Taraba State.
[3]Federal University of Lafia, Nasarawa State, Nigeria,
[4]School of Secondary Education, Biology Department, Aminu Saleh College of Education, Azare, Bauchi State.
Corresponding author's email: michaelmangs@gmail.com; Michael.manja@biotachf.org
(ORCID: https://orcid.org/0000-0002-0996-7555) (ORCID: https://orcid.org/0000-0002-8887-6271)

Received: September 14, 2024 Accepted: November 28, 2024

Abstract: Plateau State has been an epicenter of tin mining activities since 1900. As a result, significant portions of its riparian forests have been lost to clearing for mining, cooking, and farming activities. This extensive land use has led to severe environmental degradation, including water pollution and contamination. These environmental changes directly impact organisms such as the Pied Kingfisher (*Ceryle rudis*), which rely on clean water sources for feeding and survival. Pied Kingfishers are renowned for their adeptness in hunting fish across diverse aquatic habitats in tropical Africa. Despite their well-observed hunting behaviors, the factors influencing their feeding success in various water bodies remain understudied. This study investigates the multi-factor influences of water conditions—specifically volume, turbidity, depth—and diving behavior on the foraging success of Pied Kingfishers in central Plateau State, North-central Nigeria. The study was conducted over three years (2018-2020) and spanning dry and rainy seasons, which accounted for seasonal variations. Observations were made across three distinct water bodies, employing depth measurements using weighted lines and turbidity assessments with Secchi disks. Individual kingfishers were observed using binoculars, recording both diving attempts and successful catches to correlate with water volume, turbidity, depth and diving effort. Generalized Linear Models (GLMs) were applied to analyze these factors. Key findings indicate higher hunting success rates during periods of low water volume and clear water conditions. A negative correlation was established between water turbidity and hunting success, highlighting reduced efficiency in murky waters. Moreover, increased diving efforts positively correlated with higher hunting success rates, demonstrating the birds' adaptive behavior in response to varying prey visibility. Importantly, while water volume and turbidity influenced hunting success, water depth did not show significant impact. This research contributes to a broader understanding of Pied Kingfishers' foraging strategies in tropical African ecosystems, emphasizing the critical role of environmental factors in shaping their feeding efficiency. Recommendations include conservation efforts aimed at preserving water clarity and maintaining suitable habitat conditions to support Pied Kingfisher populations amidst environmental changes.

Key words: Pied Kingfisher, Water volume, diving behavior, Feeding success, tropical Africa.

Introduction

Aquatic ecosystems are under increasing pressure from human activities, leading to habitat degradation and water quality decline. These changes can significantly impact aquatic predators, such as the Pied Kingfisher (Ceryle rudis), which rely heavily on fish for sustenance (Reynolds and Hinge, 1996). While previous studies have explored aspects of Pied Kingfisher behavior, including hunting techniques (Corbin and Kirika, 2002) and parental care (Libois and Laudelout, 2004), the complex interplay between water conditions, diving behavior, and foraging success remains poorly understood, particularly in the context of human-impacted environments and advanced anthropogenic activities. It is important to know that, Pied Kingfisher (*Ceryle rudis*), a predominantly black and white bird with a short, bushy crest and a dark bill, Borrow and Demey, (2013), is a proficient hunter found across Africa and Asia (Laudelout, and Libois, 2007).

Pied Kingfisher was commonly observed perched either in pairs or small gatherings and frequently hovers above water when hunting for prey. It resides in diverse waterside environments ranging from lakes to estuaries and mangrove forests. Its vocalizations include sharp notes, as well as dry trills and rattling calls (Yong et al. 2022). Pied Kingfishers (*Ceryle rudis)* rely mostly on fish as their primary food source, Reynolds and Hinge (1996), though some species of the king fishers were found to be eating lizards in addition to the fish (van & Ji 2012). They catch fish either by diving from a hovering position or from perches (Corbin and Kirika, 2002). They catch the fish and eat it within seconds or minutes depending on the size of the prey. Most of the Pied Kingfishers that have nestlings, return to their nests, regurgitate some of the fish pellets to feed their nestlings (Libois and Laudelout, 2004). Their decision on how to fish is affected by where the prey is located and weather conditions, particularly the speed of the wind (Douthwaite, 1976). Though Pied Kingfisher is of least concerned based on the International Union for Conservation of Nature (IUCN), BirdLife International (2017), its unique feeding, creates much admiration and raises more questions on the challenges they face in different water bodies of varied depth and turbidity. They most at times depend on perches and hovering to predate on their prey with swift surprise dives (Bunzel-Drüke, et al. 2023).

Water quality affects hunting success of different predators that depend on aquatic prey (Sweka and Hartman, 2001). For example, turbidity decreases hunting success of predators. This is

because it reduces detectability of the prey by the predator and this in turns, also reduces encounter rate and hunting/feeding success (Sweka and Hartman, 2001; Meager et al. 2005; Beger and Possingham, 2008). Moreso, other environmental factors such as perches or cover, Betts and Betts (1977), density of fishes affects feeding success of kingfishers, though the density of fishes also depends on the environmental factors such as, availability of food (fish concentration), depth of the water, waves, turbidity etc (Sweka and Hartman, 2001; Meager et al., 2005; Beger and Possingham, 2008). Water depth has been found to affect feeding success of Pied kingfisher as they have caught more fishes in shallow water bodies or part of the water that was shallow than in deeper parts of the water, (Vilches et al. 2013). In the same consideration, the question of foraging distance has been raised concerning Kingfishers, however, research shows that, foraging distance of the birds does not affect their feeding success (Renila et al. 2020).

Diving attempts or effort contributes to feeding success among Kingfishers. Though diving and feeding success can also depend on some factors such as water waves or tides Booth et al., (2021), the more kingfishers made efforts, the more they had feeding success. This is compared to those kingfishers making fewer dives (efforts), (Naher and Sarker, 2014; Booth et al. 2021). More so, kingfishers just like any other bird, can be affected by environmental contaminants such as Dichlo-Diphenyl-trychloroethane (DDT) and other chemicals (Evans and Bouwman, 2000). Chemical contaminants are found to have health impact on the kingfishers as they dive and feed from different water bodies (clearer, muddy and even the most polluted). This makes them a great sentinels of our water bodies and also good indicators of the level of pollution of any water body if feathers, food pellets, or drops etc. are obtained for laboratory investigation. Kingfishers are known for its social nature, distinctive vocalizations (Yong et al., 2022), and tendency to perch near water bodies (Corbin and Kirika, 2002). Their hunting behavior, particularly its response to varying water conditions such as turbidity, depth, low or high-water volume, and diving frequency which are all tailored to their hunting or feeding success, remains understudied in Nigeria. The understanding of their foraging strategies, habitat preferences and feeding success contribute directly to assessing their ecological role and responses to environmental changes as they affect its feeding success. This study aims to address this knowledge gap by investigating how water volume, turbidity, and depth, in conjunction with diving effort, influence the hunting success of Pied Kingfishers in central Plateau State, Nigeria.

Aim

The main aim of this research is to investigate the hunting/feeding success rate of Pied Kingfisher in three water bodies of varied depth, volume and turbidity in central Plateau state, North-central Nigeria.

Specific objectives

The objectives of the research were to:

1. Quantify the effect of water volume (high vs. low) on the hunting success rate of Pied kingfishers in Plateau State, Nigeria.

2. Determine the correlation between water turbidity and the hunting success rate of pied kingfishers in Central Plateau State, Nigeria.

3. Investigate the relationship between the number of diving attempts (effort) by pied kingfishers and their hunting success within three water bodies in Plateau State, Nigeria.

4. Evaluate the influence of water depth (categorized) on the hunting success rate of pied kingfishers in Central Plateau State, Nigeria.

Research Questions

1. Does the hunting success of Pied Kingfishers differ significantly between high and low water volumes in Plateau State?

2. Is there a correlation between water turbidity and the hunting success rate of Pied Kingfishers in Central Plateau State, Nigeria? If so, is the correlation positive or negative?

3. Is there a significant relationship between the number of diving attempts (effort) by Pied Kingfishers and their hunting success within three water bodies in Plateau State, Nigeria?

4. How does water depth affect the hunting success rate of Pied Kingfishers in Central Plateau State, Nigeria?

Methodoly

Research Area

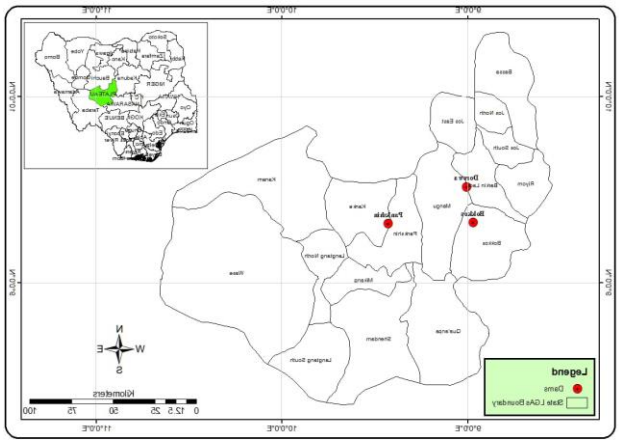

Fig. 1: Map of Plateau state showing the Location of the Studied Water Bodies

The research was conducted in Plateau State, North-Central Nigeria which is located within the Guinea Savanna region of Nigeria. Plateau state has a land mass above 1000m (Hulme, 2007). The central region of the state is made up of mainly scattered bush and grasses, with Rocky outcrops and fragments of Riparian Forest with its bushes cleared for farming and for fuel wood (Hulme, 2007). This diverse landscape encompasses

tropical savannas, grasslands, and patches of montane forests, reflecting its varied topography and climatic gradients. The climate transitions from a tropical savanna at lower elevations to a montane climate at higher altitudes, shaped by the West African Monsoon. Known for its biodiversity, central Plateau State's region supports endemic species adapted to its specific habitats, including diverse bird species, small mammals, and unique plant species. The population driven human activities, such as agriculture, deforestation, logging, and urbanization pose challenges to biodiversity conservation, impacting natural habitats and water resources, which include numerous rivers and streams important for both wildlife and local communities. Most of the water bodies (streams, dams, ponds, and rivers) were a result of tin mining activities. The water bodies became suitable for various agricultural activities, supporting the people whose majority were farmers practicing small scale pastoral and arable farming and depending on the water bodies for dry season irrigation farming.

Three bodies of water from three different Local Governments (LGAs) within the Central Zone of the state were randomly selected. The first dam (Bokkos dam in Butura), located at 9°19'24"N 8°58'24"E, within an area with an elevation of 1,333.01 meters. The water body is surrounded by agricultural fields. The second dam was Dorowa Babuje dam, along Barakin Ladi-Pankshin Road with coordinate's 9°30'56"N 9°00'27"E and an elevation of 1,280.96 meters. The third (Pankshin dam) is located at 9.3176 ^{0} N 9.4302 ^{0} E. This study was conducted over three years (2018-2020). It focused on seasonal variations, with observations made during both the dry season (characterized by low water volume, low turbidity, and reduced depth) and the rainy season (marked by increased water volume, low turbidity, and greater depth due to rainfall). Depth measurements were taken using a weighted line at three representative points (left, right, and middle) across each dam, categorizing depths into low (1-15 meters and high, 16 meters and above). Turbidity was assessed using a Secchi disk, with depths less than 1-2 meters indicating high turbidity and depths greater than 2 meters indicating low turbidity. Using pair of binoculars (Magnification = 10 x 42), individual Pied Kingfishers were observed for 30 minutes, or until a successful fish catch was noted. The number of diving (effort) attempts and successful catches were recorded, with attention given to territorial behavior when multiple kingfishers were present. This focal observation allowed for the correlation of water conditions with kingfisher feeding efficiency. The combined measurement of depth and turbidity, alongside detailed behavioral observations, provided fascinating insights into the feeding success and challenges of the kingfishers.

Method of Data Analysis

R-statistical software (R version 4.2.0, 2022) was used in analyzing the data. To investigate the relationship between all variables simultaneously, considering potential interactions between factors, Generalized Linear Models (GLMs) were used.

Objective 1: Water Volume vs. Hunting Success

A comparative statistical test (two-sample t-test) was used. The test compared the average hunting success rate (number of successful catches) between periods of high and low water volume. The outcome was visualized using a bar chart which showcases the comparison. The x-axis represents water volume (high vs. low), and the y-axis represents the average hunting success rate. Error bars were added to depict the variability within each group.

Objective 2: Turbidity vs. Hunting Success: Pearson's correlation coefficient was used to measure the strength and direction of the relationship between water turbidity levels and hunting success among the Pied Kingfishers. A scatter plot with a regression line was used to indicate the direction of correlation. The x-axis represents water turbidity, and the y-axis represents hunting success rate. The regression line shows the general trend in the data.

Objective 3: Diving Attempts (Effort) vs. Hunting Success: Similar to objective 2, correlation analysis was used appropriately. Pearson's correlation coefficient was used to assess the relationship between the number of diving attempts (effort) and hunting success rate during the hunting/feeding of the Pied Kingfishers. To visualize the result, a scatter plot was also used. The x-axis represents the number of diving attempts, and the y-axis represents the hunting success of the Pied Kingfisher. Regression line was added to show the trend in success rate as the number of dives increases.

Objective 4: Water Depth vs. Hunting Success: The data was categorized into different water depth ranges (lower and higher levels of depth). Then, a two-sample t-test was used to compare the average hunting success rate across these depth categories. Bar chart was used to visualize the feeding success in each of the two categories of depth. Hence, the x-axis represents the water depth categories, and the y-axis represents the average hunting success rate. The bar chart shows the average success for each depth.

RESULTS

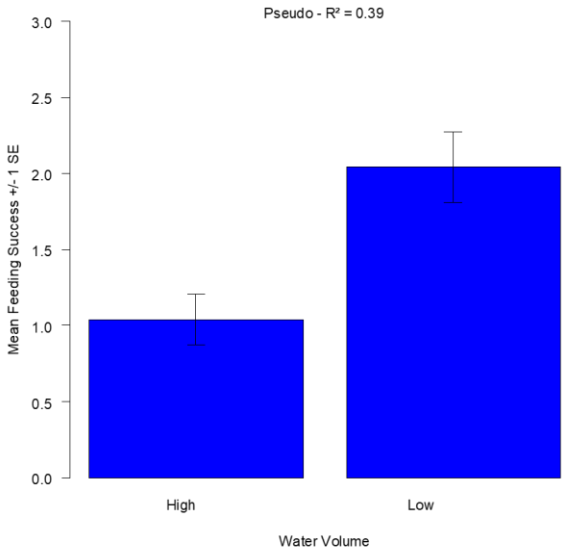

Fig. 2: Pied Kingfisher Had More Feeding Success at Lower, than Higher Water Volume in Central Plateau State, Nigeria

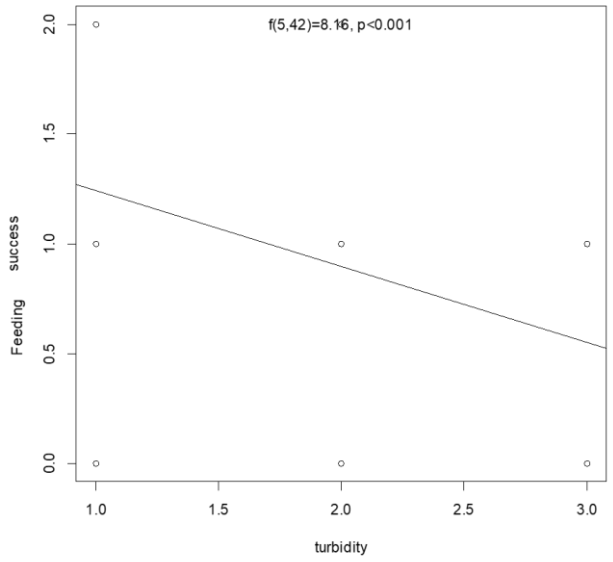

Fig 3: Feeding Success of Pied Kingfishers Reduced with Increasing Turbidity of the Water in Plateau State, Nigeria

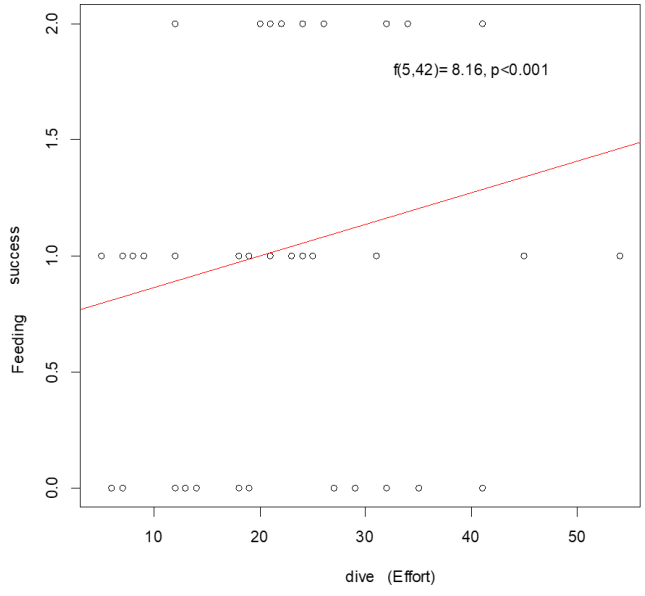

Fig 4: Showing a Relationship in which Increasing Diving Effort of Pied Kingfishers Significantly Increased their Hunting/Feeding Success in the Water Bodies of Plateau State, North-Central Nigeria

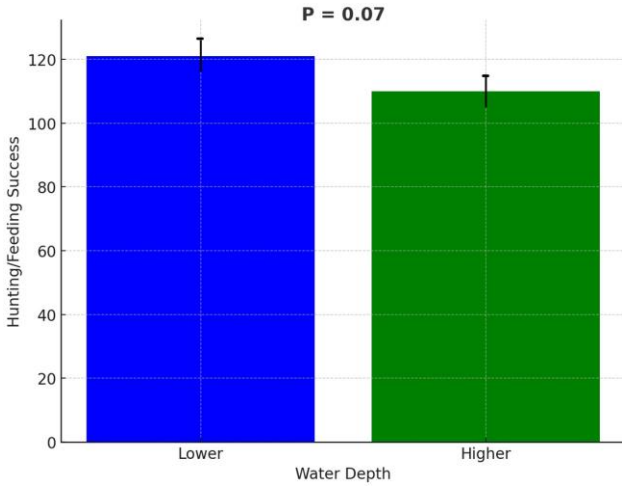

Fig.5: Water Depth has Little Difference on the Hunting/Feeding Success of Pied Kingfisher in Plateau state, North-central Nigeria

Result/Discussion

The study aimed to investigate the feeding success of Pied Kingfishers (*Ceryle rudis*) across three water bodies with varying depth, volume, and turbidity in central Plateau State, Nigeria. The research investigates how environmental changes, driven by both natural processes and human activities such as water pollution and deforestation of riparian forests are impacting the feeding success and survival of the Pied Kingfisher in its ecoregions. These changes, exacerbated by increasing human populations and the necessity for livelihoods, have visibly degraded the environment. Specifically, disturbances like tin mining activities and intensive farming practices have significantly increased water turbidity, directly affecting the ability of Pied Kingfishers to successfully feed and survive in their habitats. Throughout this study, it was also observed that there were many different aquatic animals like crabs, frogs, water snakes, etc. though not in high abundance, but the king fishers were seen feeding only on fish in that eco-region (Reynolds and Hinge, 1996).

Water Volume vs. Hunting Success (Objective 1)

The hunting success of Pied Kingfishers varied significantly between high and low water volumes (Fig. 2). During periods of low water volume, typically during the dry season when depths range from 1 to 15 meters, the average feeding success rate was significantly higher than during periods of high water volume in the rainy season. There was significant difference ($p < 0.05$) in hunting success rates between low and high water volume. Our result aligns with the research of Vilches et al., (2013) who found that Kingfisher made more catches in low water volume (shallow

water). This indicates that, when the water volume is low, kingfishers had more feeding successes than when there was high water volume.

Turbidity vs. Hunting Success (Objective 2)

As is seen in Fig.3 a negative correlation (inverse relationship) was observed between water turbidity and Pied Kingfisher hunting success ($r = -0.62$, $p < 0.01$). As turbidity decreases (water become clearer), feeding success increases. Higher turbidity levels are associated with lower feeding success rates for the Pied Kingfishers. This result aligns with the research outcome of, Sweka and Hartman (2001) who found that turbidity affects encounter rates between brook trout and their prey, and also how turbidity affects brook trout's foraging success. The turbidity reduces the encounter of prey and predator just as the Kingfisher and the fishes in this case. We have seen activities of tin mining which return disturbed water into the water bodies. This demonstrates how anthropogenic activities, such as intensified farming and associated land degradation (tin mining inclusive), contribute to elevated turbidity levels. As farming areas expand, increased sedimentation and runoff contribute to elevated turbidity levels in water bodies, hindering the foraging efficiency of the Pied Kingfisher. The resulting reduced visibility significantly impacts the foraging success of Pied Kingfishers. These results reveal the critical role of water clarity in supporting aquatic ecosystems. It also highlights the cascading effects of human-induced environmental changes on wildlife populations. This also point out the urgent need for sustainable land use practices to mitigate these impacts and conserve biodiversity in vulnerable ecosystems such as the study areas.

Diving Attempts (Effort) vs. Hunting Success (Objective 3)

The study revealed a positive correlation between diving attempts and hunting success among Pied Kingfishers (Fig. 4). Individuals that engaged in more diving attempts during hunting demonstrated higher success rates in capturing fish at specific times. Predominantly using hover-plunge techniques, with occasional perch-plunge strategies, the kingfishers' feeding efficiency notably increased with more diving efforts (Naher and Sarker, 2014; Booth et al., 2021). This finding reveals the adaptability of kingfishers in responding to environmental challenges, such as water waves or tides, which can influence diving and feeding success (Booth et al., 2021). The study's results emphasize the importance of maintaining suitable habitat conditions for Pied Kingfishers, as their feeding behaviors are intricately linked to environmental factors. Conservation efforts should prioritize mitigating disturbances like water pollution and habitat degradation, which could impact diving behaviors and, consequently, the survival of this species in their natural ecosystem.

Water Depth vs. Hunting Success (Objective 4)

As can be seen in Fig. 5, there was no significant difference in hunting success of the kingfishers between regions of high and low depth (t-test = 0.07, $P > 0.05$). The total of 121 hunting successes was observed in regions of low depth, while 110 hunting successes were observed in areas of high depth. This slightly align with the experimental findings of Reyer et al., (1988), who observed Pied and Malachite Kingfishers in an experimental setting and found that depth affected feeding success of the birds. Though statistically, depth and feeding success is not significant, but more catches were made in shallow water regions than in the deeper parts of the water. This outcome aligns with the findings of Vilches et al., (2013) who found that shallow part of water supports more hunting success than the deeper part of the water. In our research, water volume had a significant effect on hunting success, with kingfishers achieving higher success rates in bodies of water with low volume. This result indicates that, unlike water volume, even though there were slightly more catches made by the kingfisher in shallow parts of the water than the deeper parts, variations in water depth may not strongly influence the hunting success of Pied Kingfishers in our study areas. This suggests that factors associated with lower volume, such as clearer water and potentially concentrated prey, might be beneficial for hunting. Water depth, while related to volume, did not show a statistically significant influence on hunting success ($p = 0.07$). It's important to note that while water volume and water depth are related concepts (higher volume often implies greater depth), their impacts on hunting success can vary due to other factors such as prey distribution, habitat complexity, and environmental conditions (Meager et al., 2005; Beger and Possingham, 2008). More so, the depth categories used in this study might not have captured the full range of depths that kingfishers are sensitive to for hunting. Additionally, even within deeper water bodies, shallow areas near the shore might provide more productive hunting grounds due to factors like prey abundance or better visibility. Future studies exploring a wider range of water depths and investigating prey distribution patterns across different depths could provide further insights into this relationship.

Overall, these results reveal the importance of water conditions, including volume, turbidity, and depth, in influencing the feeding success of Pied Kingfishers in central Plateau State, North-central Nigeria. During the dry season with lower water volumes and clearer waters, Pied Kingfishers demonstrated higher hunting success, whereas increased turbidity and deeper waters during the rainy season posed challenges to their foraging efficiency. This study contributes important insights into the intricate relationships between environmental factors and wildlife behavior, emphasizing the importance of integrated approaches to conservation that safeguard both species and their habitats amidst ongoing environmental changes. Preserving riparian vegetation and minimizing agricultural runoff can help mitigate the impacts of turbidity and sedimentation on water quality. These efforts are crucial not only for maintaining biodiversity but also for sustaining ecosystem services provided by aquatic habitats. Future research could further explore how varying depths and seasonal changes in water conditions interact with prey distribution patterns, providing a more comprehensive understanding of the ecological dynamics influencing Pied Kingfisher populations in the region.

Conclusion/Recommendations

The findings of this research shed light on several key aspects influencing the feeding success of Pied Kingfishers (Ceryle rudis) in central Plateau State, Nigeria. Firstly, the study revealed that water depth did not significantly influence hunting success, with similar numbers of successful hunts observed in both shallow and deeper water regions. This suggests that, within the studied

ranges, variations in water depth may not strongly affect the foraging efficiency of Pied Kingfishers. Secondly, the research highlighted the significant impact of water turbidity on hunting success. Clearer waters during periods of lower turbidity, particularly in the dry season, were associated with higher hunting success rates for the kingfishers. This finding reveals how environmental factors such as turbidity, influenced by anthropogenic activities like farming and land use, can affect predator-prey dynamics in aquatic ecosystems. Thirdly, water volume emerged as an important factor influencing feeding success. Pied Kingfishers demonstrated higher success rates in bodies of water with lower volumes, particularly during the dry season when water levels were lower and clearer. This suggests that reduced water volume may concentrate prey and improve visibility, facilitating more efficient hunting for the birds. Lastly, the study examined the correlation between diving efforts and hunting success, revealing a positive relationship. Kingfishers that engaged in more diving attempts during hunting activities tended to achieve higher success rates in catching fish. This highlights the adaptive foraging strategies of the Pied Kingfishers in response to varying environmental conditions and prey availability.

Hence, based on the findings of this study, it is evident that water clarity and habitat conditions play important roles in the foraging success and overall survival of Pied Kingfishers in central Plateau State, Nigeria. We are recommending that, maintaining water clarity and managing water levels are essential for supporting their populations. Efforts should focus on minimizing water pollution and controlling factors that increase turbidity, especially during the rainy season. Conservation strategies should also consider the preservation of shallow water habitats, which provide favorable foraging grounds for these birds. We recommend implementing measures to monitor and manage water quality in key habitats. This includes reducing agricultural runoff and sedimentation that contribute to increased turbidity. Additionally, habitat restoration projects should aim to maintain or create shallow water bodies to support the foraging needs of Pied Kingfishers. Future research should explore the long-term impacts of environmental changes on kingfisher populations and investigate other factors such as wind speed/direction, prey density and sizes, hovering distance, availability of perches, and their distances to water bodies, which could also influence their foraging behavior. By addressing these aspects, we can enhance the conservation efforts for Pied Kingfishers and ensure the sustainability of their populations in central Plateau State or tropical Africa in general.

References

Beger, M., & Possingham, H. P. (2008). Environmental factors that influence the distribution of coral reef fishes: modeling occurrence data for broad-scale conservation and management. Marine Ecology Progress Series, 361, 1-13. Retrieved from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Factors+affecting+distribution+of+fishes&btnG=#d=gs_qabs&t=1721229618051&u=%23p%3Dzlh_V8_PmKgJ

Betts, B. J., & Betts, D. L. (1977). The relation of hunting site changes to hunting success in green herons and green kingfishers. *The Condor*, *79*(2), 269-271. Retrieved from https://www.jstor.org/stable/1367174.

BirdLife International. 2017. *Ceryle rudis* (amended version of 2016 assessment). *The IUCN Red List of Threatened Species* 2017: e.T22683645A110626699. https://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22683645A110626699.en. Accessed on 12 July 2024.

Booth, H., Yruretagoyena, L., Kuruvilla, M., & Slager, D. L. (2021). On the marine feeding behavior and activity budgets of Belted Kingfishers (Megaceryle alcyon) during the post-fledging period. The Wilson Journal of Ornithology, 133(2), 291-295. Retrieved from

Borrow, N., & Demey, R. (2013). Birds of Western Africa. Christopher Helm, Bloomsberry Publishing, London. ISBN: 978-0-7136-6692-2.

Bunzel-Drüke, M., Zimball, O., & Burgert, A. (2023). Wing and tail feather damage in Western Common Kingfishers *Alcedo atthis ispida* in relation to moult. *Ringing & Migration*, *38*(1–2), 9–24. https://doi.org/10.1080/03078698.2023.2284687

Corbin, C. E., & Kirika, M. J. (2002). Foraging behaviour of brown-hooded kingfishers (*Halcyon albiventris*) in the East UsambaraMountains, Tanzania. *African Zoology*, *37*(1), 47–54. https://doi.org/10.1080/15627020.2002.11657154

Douthwaite, R. J. (1976). FISHING TECHNIQUES AND FOODS OF THE PIED KINGFISHER ON LAKE VICTORIA IN UGANDA. *Ostrich*, *47*(4), 153–160. https://doi.org/10.1080/00306525.1976.9639555. Retrived from https://www.tandfonline.com/doi/pdf/10.1080/00306525.1976.9639555.

Evans, S. W., & Bouwman, H. (2000). The geographic variation and potential risk of DDT in the blood of Pied Kingfishers from northern KwaZulu-Natal, South Africa. *Ostrich*, *71*(1–2), 351–354. https://doi.org/10.1080/00306525.2000.9639957

Hulme, M. F. (2007). *The density and diversity of birds on farmland in West Africa* (Doctoral dissertation, University of St Andrews). Retrieved from https://research-repository.st-andrews.ac.uk/handle/10023/424.

Laudelout, Arnaud & Libois, Roland. (2007). On the Feeding Ecology of the Pied Kingfisher, Ceryle rudis at Lake Nokoué, Benin. is there Competition with Fishermen?. 10.1002/9780470995372.ch12. retrieved from https://www.researchgate.net/publication/230364316_On_the_Feeding_Ecology_of_the_Pied_Kingfisher_Ceryle_rudis_at_Lake_Nokoue_Benin_is_there_Competition_with_Fishermen

Libois, R., & Laudelout, A. (2004). Food niche segregation between the Malachite Kingfisher, *Alcedo cristata*, and the Pied Kingfisher, *Ceryle rudis*, at Lake Nokoué,

Bénin. *Ostrich*, *75*(1–2), 32–38. https://doi.org/10.2989/00306520409485409

Meager, J. J., Williamson, I., & King, C. R. (2005). Factors affecting the distribution, abundance and diversity of fishes of small, soft-substrata tidal pools within Moreton Bay, Australia. Hydrobiologia, 537, 71-80. Retrieved from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Factors+affecting+distribution+of+fishes&btnG=#d=gs_qabs&t=1721229200976&u=%23p%3Da_3Ta2vUlowJ

Naher, H., & Sarker, N. J. (2014). Food and feeding habits of white-throated kingfisher (Halcyon smyrnensis) in Bangladesh. Bangladesh Journal of Zoology, 42(2), 237-249.

Renila, R., Bobika, V.K., Nefla, A., Manjusha, K. and Aarif, K.M., (2020)., December. Hunting behavior and feeding success of three sympatric kingfishers' species in two adjacent wetlands in Southwestern India. In Proceedings of the Zoological Society (Vol. 73, pp. 392-399). Springer India. Retrieved from https://link.springer.com/article/10.1007/s12595-020-00344-4.

Reyer, H. U., Migongo-Bake, W., & Schmidt, L. (1988). Field studies and experiments on distribution and foraging of Pied and Malachite Kingfishers at Lake Nakuru (Kenya). The Journal of Animal Ecology, 595-610. Retrieved from https://www.jstor.org/stable/4927

Reynolds, S. J., & Hinge, M. D. C. (1996). Foods brought to the nest by breeding Kingfishers *Alcedo atthis* in the New Forest of southern England. *Bird Study*, *43*(1), 96–102. https://doi.org/10.1080/00063659609460999

Sweka, John & Hartman, Kyle. (2001). Influence of Turbidity on Brook Trout Reactive Distance and Foraging Success. Transactions of the American Fisheries Society - TRANS AMER FISH SOC. 130. 138-146. 10.1577/1548-8659(2001)130<0138:IOTOBT>2.0.CO;2. Reyrieved from https://www.researchgate.net/publication/250019685_Influence_of_Turbidity_on_Brook_Trout_Reactive_Distance_and_Foraging_Success

van Winkel, D., & Ji, W. (2012). Evidence of lizard predation by New Zealand kingfishers (*Todiramphus sanctus vagans*) and potential implications for threatened species translocations. *New Zealand Journal of Zoology*, *39*(3), 201–208. https://doi.org/10.1080/03014223.2011.638309

Vilches, A., Arizaga, J., Salvo, I., & Miranda, R. (2013). An experimental evaluation of the influence of water depth and bottom color on the common kingfisher's foraging performance. *Behavioural processes*, *98*, 25-30.

Yong Chee Keita Sin, James A Eaton, Robert O Hutchinson & Frank E Rheindt. (2022). Re-assessing species limits in a morphologically cryptic Australasian kingfisher lineage (Coraciiformes: Halcyonidae) using bioacoustic data. *Biological Journal of the Linnean Society* 136:4, pages 489-505.