JFB
Research Article

Journal of Fauna Biodiversity
pISSN: 3007-5041

eISSN: 3007-6102

V. 3, N. 1:50-62, 2026

https://doi.org/10.70206/jfb.v3i1.18220

Plant reproductive stage shapes bird-plant interactions in urban residential landscapes of Jos, Nigeria

Ezekiel S.M.*, Ogunleye C. O., Onah J.A., Egwu L.S., Talatu T., Chaksda A.A., Dami F.D.

A.P. Leventis Ornithological Research Institute, Centre of Excellence.

*Corresponding author: ezekielstv@gmail.com

Received 18 March 2026 | Accepted 25 May 2026 | Published 04 June 2026

Abstract

Urban vegetation supports bird communities by providing food resources, shelter, and perching sites. However, how plant reproductive stages influence bird visitation patterns in African urban environments remains poorly understood. This study examined bird–plant interactions in residential areas of Jos, North-central Nigeria, focusing on the influence of plant species identity and reproductive stage on visitation frequency and behavior. Field observations were conducted at 40 systematic point count locations across Jos North and Jos South metropolitan areas. Bird–plant interactions feeding, perching, and nesting were recorded on selected urban plants. A total of 171 interaction records were documented involving 50 bird species and 18 plant species. Urban-adapted generalist species, particularly village weavers, doves, sunbirds, and sparrows, accounted for most interactions. Visitation frequency varied significantly among plant species; *Tithonia diversifolia*, *Borassus aethiopum*, and *Elaeis guineensis* recorded the highest levels. Generalized linear models with overdispersion assessment showed that flowering plants received significantly higher visitation frequencies than fruiting or non-reproductive plants. Feeding interactions were predominantly associated with flowering and fruiting plants, while perching occurred across all reproductive stages. These findings indicate that plant reproductive stage shapes bird visitation patterns in urban residential landscapes. Retaining and incorporating flowering and fruit-bearing species within urban green spaces may support bird habitat use and ecological interactions in rapidly urbanizing tropical cities.

keywords: Urban ecology, bird–plant interactions, reproductive phenology, bird visitation, flowering plants, Nigeria

1. Introduction

Urbanization is one of the most pervasive forms of land-use change globally, reshaping natural habitats and altering species interactions (Moreno-García et al., 2025; Theodorou, 2022). As cities expand, native vegetation is often replaced or modified, leading to changes in the availability of food, shelter, and breeding resources for wildlife (Meillère, 2015). Birds are among the most conspicuous and well-studied components of urban biodiversity, making them useful indicators of how urban ecosystems function and respond to environmental changes (Morelli et al., 2021). In urban environments, interactions between birds and plants are particularly important, as vegetation provides critical resources that influence bird occurrence behavior, and community structure (Abdul et al., 2025).

Bird–plant interactions, such as feeding, perching, and nesting, support key ecological processes including pollination, seed dispersal, and habitat structuring (Whelan et al., 2008; Garcia, 2016). The strength and frequency of these interactions are often mediated by plant functional traits, especially reproductive characteristics such as flowering and fruiting (Garcia, 2016). Flowering plants can provide nectar, while fruiting plants offer direct food resources and play an important role in seed dispersal (Valdovinos et al., 2022). In natural and semi-natural ecosystems, plant traits are known to strongly influence bird visitation patterns (Söderström et al., 2001); however, in urban settings, these relationships may be altered by habitat fragmentation, exotic plant species, and human management of vegetation (Parejo-Farnés et al., 2020).

Most existing studies on bird–plant interactions and trait-mediated processes have been conducted in temperate regions, with comparatively little attention given to rapidly urbanizing cities in sub-Saharan Africa (Gelmi-Candusso & Hämäläinen, 2017; Muñoz-Pacheco & Villaseñor, 2021). African cities vary greatly in vegetation composition, urban form, and socio-ecological dynamics due to differences in climate, land-use history and levels of urban development. These factors shape the diversity of plant species present in cities, including the balance between native and exotic species, vegetation structure, and the availability of food and nesting materials for birds. Despite this ecological complexity, empirical evidence on how urban plant traits influence bird interactions remains scarce (Awoyemi & Ibáñez-Álamo, 2023; Kumdet et al., 2021). This knowledge gap limits our ability to develop evidence-based urban greening strategies that support biodiversity conservation and ecosystem functioning, especially in regions with high human populations.

Understanding which plant species and characteristics attract birds in residential areas is particularly relevant, as such areas often dominate urban landscapes and represent important habitats for urban-adapted bird species (Melles et al., 2003; Shoffner et al., 2018). Trait-based approaches offer a robust framework for linking plant characteristics to bird behavior and interaction frequency, providing insights that extend beyond simple species lists (Green et al., 2022).

To address this gap, in this study, we investigate bird–plant interactions in residential areas of Jos, North-central Nigeria, with a focus on how plant species identity and reproductive traits influence bird visitation and activity. Specifically, we assess patterns of bird visitation across plant species, document the diversity of bird species involved, and examine the role of plant reproductive stage in shaping interaction frequency and behavior. By adopting a trait-based perspective, this study aims to contribute to a better understanding of urban ecological processes in African cities and to inform urban vegetation management strategies that enhance avian biodiversity and ecological functions.

2. Materials and methods

Study area

The study was conducted in residential areas of Jos North and Jos South Local Government Areas, Plateau State, North-central Nigeria, between June and August 2024. This period coincides with the early wet season, when vegetation productivity, flowering, and bird activity are relatively high in the region.

Jos is located on the Jos Plateau between approximately 9°50′–10°00′ N and 8°50′–9°00′ E, at an average elevation of about 1,200–1,400 m above sea level. The city experiences a tropical highland climate characterized by relatively cooler temperatures compared to much of Nigeria, with mean annual temperatures ranging between 18°C and 25°C. Annual rainfall averages between 1,200 and 1,500 mm, occurring mainly between April and October, with peak rainfall typically recorded between July and August.

The study area is characterized by a rapidly urbanizing landscape composed of residential buildings, roads, gardens, cultivated plots, ornamental vegetation, and remnant patches of natural and semi-natural vegetation. Urban vegetation within the residential areas includes a mixture of native and exotic plant species, such as flowering ornamentals, fruit trees, shrubs, grasses, and scattered mature trees. These vegetation types provide important ecological resources for urban birds, including food sources, nesting materials, shelter, and perching sites.

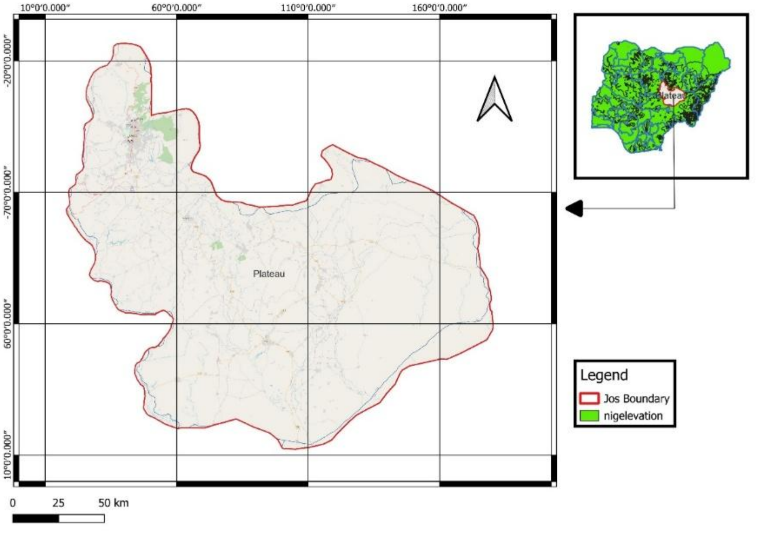

Figure 1. Map of study area

Study Site and Sampling Design

Field surveys were conducted during the wet season between May and July 2025 in residential areas of Jos North and Jos South metropolitan areas, Plateau State, Nigeria. Bird observations were carried out during peak periods of avian activity in the early morning between 06:30 h and 11:00 h under suitable weather conditions, avoiding periods of heavy rainfall or strong winds that could influence bird activity and detectability

To quantify bird–plant interactions, 40 systematic point count stations were established, with 20 sampling points distributed within each metropolis. Each sampling point was separated by a minimum distance of 100 m, extending up to 400 m where necessary due to terrain and accessibility, in order to minimize pseudo-replication and maintain independence among bird records.

Each point was visited twice during the study period, resulting in a total of 80 observation sessions. During each visit, birds were observed for 10 minutes within a 50 m radius using binoculars. All bird species interacting with plants through feeding, perching, or nesting activities were recorded.

At each sampling point, at least five actively utilized plant individuals were selected for monitoring based on visible evidence of bird activity, including feeding visits, perching frequency, or nesting behavior. In total, over 200 plant individuals representing flowering, fruiting, and non-reproductive stages were monitored throughout the study. Plant species identity and reproductive stage were recorded during each observation session.

Bird Observations and Interaction Monitoring

At each designated sampling point, bird surveys were conducted using the standard fixed-radius point count method following Bird Census Techniques (Bibby et al., 2000). All bird species detected within a 50 m radius were recorded during a standardized 10-minute observation period using binoculars. Simultaneously, plant species exhibiting noticeable bird activity were monitored to document bird–plant interactions.

A bird–plant interaction was defined as any direct and observable association between a bird and a plant individual, including feeding, perching, or nesting activity. Each discrete landing or activity event by an individual bird on a plant was counted as a single interaction. Repeated visits by the same bird species were recorded as separate interactions only when the individual left the plant and subsequently returned after a clear interruption in activity.

At least five actively utilized plant individuals were monitored per sampling point. For every interaction observed, the following information was recorded:

1. Taxonomic identity of both the bird and plant species involved;
2. Visit frequency, defined as the total number of discrete interaction events recorded per plant individual; and
3. Behavioral category, classified as feeding, perching, or nesting.

Feeding interactions included nectar feeding, fruit consumption, seed feeding, or insect foraging associated with the plant. Perching behavior referred to birds temporarily resting or using the plant as a lookout site without evidence of feeding. Nesting observations were comparatively rare and included active nest construction, nest occupancy, or the use of plant material for nesting purposes.

Plant Trait Assessment and Phenology

A comprehensive vegetation survey was conducted at each sampling point to evaluate the functional characteristics of the local flora. We assessed specific traits hypothesized to influence avian choice, including Morphological Traits: Plant height, foliage structure, and fruit type.

Additionally, Plants were classified by their reproductive stage at the time of sampling (flowering vs. fruiting).

Interaction frequency served as a quantitative proxy for "plant attractiveness," allowing for a statistical comparison between different plant traits and their respective bird assemblages.

Data Preparation

The raw data were first organized into a tabular format and then analyzed using R statistical software (RStudio version 2023.06.0). To maintain consistency across the dataset, plant-level variables—including observation point, plant ID, and reproductive stage were forward-filled across all corresponding interaction records. To ensure the high fidelity of the results, any records with missing values or incomplete behavioral data were excluded from the final analytical model.

Statistical Analysis

All statistical analyses were conducted in R statistical software (RStudio version 2023.06.0) using the tidyverse and MASS packages. Descriptive analyses were first performed to summarize bird–plant interaction patterns, quantify visitation frequencies across plant species, and identify bird species most frequently involved in interactions. Total visitation frequency for each plant and bird species was calculated by summing the number of discrete interaction events recorded during field observations.

To examine factors influencing bird visitation patterns, generalized linear models (GLMs) were used with bird visitation frequency as the response variable. Bird visitation frequency was defined as the total number of discrete bird visits recorded per plant individual. Predictor variables included plant species identity and plant reproductive stage (flowering, fruiting, and non-reproductive stages), both treated as categorical variables.

Model 1:

Bird visitation frequency ~ Plant species identity

Model 2:

Bird visitation frequency ~ Plant reproductive stage

Following model evaluation, the GLM framework was retained and outputs were interpreted accordingly. Reference categories for categorical predictors were specified during model fitting to facilitate interpretation of coefficient estimates.

Associations between plant reproductive stage and bird behavioral categories were examined using contingency tables and Pearson’s chi-square tests. Bird behaviors recorded during the study included feeding, perching, and nesting activities. Differences in visitation frequencies among reproductive stages were visualized using boxplots, while patterns of bird behavior across plant stages were illustrated using stacked bar charts.

All statistical tests were conducted at a significance level of $\alpha = 0.05$.

3. Results

A total of 50 bird species belonging to 24 families were recorded during the survey, comprising 415 individual observations (Table 1). The assemblage was dominated by granivorous species, particularly members of the family Ploceidae and Columbidae.

The most abundant species was the Village Weaver (n = 111), accounting for 27.0% of total observations. This was followed by the Laughing Dove (n = 60) and the Variable Sunbird (n = 31). Together, these three species contributed approximately 49% of all records, indicating a community strongly dominated by a few highly abundant taxa.

Granivores constituted the most represented feeding guild (n = 268 individuals; 65.2%), followed by insectivores (n = 65; 15.8%), nectarivores (n = 47; 11.4%), frugivores (n = 29; 7.1%), omnivores (n = 15; 3.6%), and carnivores (n = 3; 0.7%).

Table 1. Checklist of bird species recorded interacting with urban plants in residential areas of Jos, Nigeria, showing feeding guilds and number of observations.

S/N	Bird species	Feeding guild	Number of observations
1	Village weaver (*Ploceus cucullatus*)	Granivore	111
2	Laughing dove (*Spilopelia senegalensis*)	Granivore	60
3	Variable sunbird (*Cinnyris venustus*)	Nectarivore	31
4	Red-cheeked cordon-bleu (*Uraeginthus bengalus*)	Granivore	26
5	Northern grey-headed sparrow (*Passer griseus*)	Granivore	23
6	Speckled mousebird (*Colius striatus*)	Frugivore	12
7	Scarlet-chested sunbird (*Chalcomitra senegalensis*)	Nectarivore	12
8	Heuglin's masked weaver (*Ploceus heuglini*)	Granivore	11
9	Red-billed firefinch (*Lagonosticta senegala*)	Granivore	10
10	Singing cisticola (*Cisticola cantans*)	Insectivore	9
11	Adamawa turtle dove (*Streptopelia hypopyrrha*)	Granivore	8
12	Western grey plantain-eater (*Crinifer piscator*)	Frugivore	7
13	Green wood-hoopoe (*Phoeniculus purpureus*)	Insectivore	7
14	Snowy-crowned robin-chat (*Cossypha niveicapilla*)	Insectivore	7
15	White-rumped seedeater (*Crithagra leucopygia*)	Granivore	7
16	Yellow-crowned gonolek (*Laniarius barbarus*)	Insectivore	7
17	Common bulbul (*Pycnonotus barbatus*)	Omnivore	6
18	Black flycatcher (*Melaenornis edolioides*)	Insectivore	5
19	African thrush (*Turdus pelios*)	Omnivore	4
20	Grey-backed camaroptera (*Camaroptera brachyura*)	Insectivore	4
21	Long-tailed starling (*Lamprotornis caudatus*)	Omnivore	4
22	Speckled pigeon (*Columba guinea*)	Granivore	4
23	Senegal coucal (*Centropus senegalensis*)	Insectivore	3
24	African paradise flycatcher (*Terpsiphone viridis*)	Insectivore	3
25	Black-billed wood dove (*Turtur abyssinicus*)	Granivore	3
26	Bruce's green pigeon (*Treron waalia*)	Frugivore	2
27	Green-headed sunbird (*Cyanomitra verticalis*)	Nectarivore	2
28	Lavender waxbill (*Estrilda caerulescens*)	Granivore	2
29	Senegal parrot (*Poicephalus senegalus*)	Frugivore	2
30	Yellow white-eye (*Zosterops senegalensis*)	Nectarivore	2
31	Yellow-fronted tinkerbird (*Pogoniulus chrysoconus*)	Frugivore	2
32	Common kestrel (*Falco tinnunculus*)	Carnivore	1
33	Fox kestrel (*Falco alopex*)	Carnivore	1
34	Bearded barbet (*Lybius dubius*)	Frugivore	1
35	Vieillot's barbet (*Lybius vieilloti*)	Frugivore	1
36	Familiar chat (*Oenanthe familiaris*)	Insectivore	1

37	Sulphur-breasted bush-shrike (*Telophorus sulfureopectus*)	Insectivore	1
38	Short-winged cisticola (*Cisticola brachypterus*)	Insectivore	1
39	Senegal batis (*Batis senegalensis*)	Insectivore	1
40	Blue-breasted kingfisher (*Halcyon malimbica*)	Carnivore	1
41	African cuckoo (*Cuculus gularis*)	Insectivore	1
42	Klaas's cuckoo (*Chrysococcyx klaas*)	Insectivore	1
43	Levaillant's cuckoo (*Clamator levaillantii*)	Insectivore	1
44	Little greenbul (*Eurillas virens*)	Omnivore	1
45	Mocking cliff-chat (*Thamnolaea cinnamomeiventris*)	Insectivore	1
46	Northern crombec (*Sylvietta brachyura*)	Insectivore	1
47	Northern red bishop (*Euplectes franciscanus*)	Granivore	1
48	Pin-tailed whydah (*Vidua macroura*)	Granivore	1
49	Red-eyed dove (*Streptopelia semitorquata*)	Granivore	1
50	Senegal eremomela (*Eremomela pusilla*)	Insectivore	1

Plant Species Most Attractive to Birds in Urban Jos, Plateau State

Tithonia diversifolia (Mexican sunflower) attracted significantly more bird visits than any other plant species (3.625 ± 0.835. Figure 2), followed by *Borassus aethiopum* (African fan palm; 3.125 ± 0.835) and *Elaeis guineensis* (Oil palm; 2.625 ± 0.975). No other plant species differed significantly in bird attraction from the intercept (Table 2, Figure 2).

Table 2. Generalised Linear Model (GLM) output showing variation in bird visitation frequency across plant species in urban Jos.

Variable	Estimate	SE	t-value	p-value
(Intercept)	1.375	0.666	2.064	**0.041***
Anacardium occidentale (Cashew)	1.009	0.847	1.192	0.235
Annona muricata (Soursop)	0.025	1.074	0.023	0.981
Azadirachta indica (Neem)	0.054	0.975	0.055	0.956
Borassus aethiopum (African fan palm)	3.125	0.835	3.741	**<0.001***
Butea monosperma (Flame of the forest)	0.958	0.916	1.046	0.297
Carica papaya (Pawpaw)	0.125	1.018	0.123	0.902
Citrus sinensis (Orange)	0.825	1.074	0.768	0.443
Dacryodes edulis (African pear)	0.375	0.942	0.398	0.691

Variable	Estimate	SE	t-value	p-value
Elaeis guineensis (Oil palm)	2.625	0.975	2.691	**0.007***
Eucalyptus camaldulensis (Eucalyptus)	−0.175	1.074	−0.163	0.871
Gmelina arborea (Gmelina)	−0.232	0.975	−0.238	0.812
Tithonia diversifolia (Mexican sunflower)	3.625	0.835	4.340	**<0.001***
Mangifera indica (Mango)	0.558	0.825	0.677	0.499
Moringa oleifera (Moringa)	0.500	0.942	0.531	0.596
Parkia biglobosa (Locust bean)	0.425	1.074	0.396	0.693
Persea americana (Avocado)	0.572	0.794	0.721	0.472
Psidium guajava (Guava)	0.196	0.975	0.201	0.841
Terminalia mantaly (Umbrella tree)	1.534	0.876	1.752	0.082

Note. Estimates are relative to the intercept (Cashew omitted as reference). SE = standard error. $^*p < 0.05$*. Adjusted* $R^2 = 0.22$*, overall* $p < 0.001$*. Species names corrected: Elaeis guineensis (from 'guneensis'); Tithonia diversifolia (spacing); Gmelina arborea (from 'aborea'); Psidium guajava (from 'gujava').*

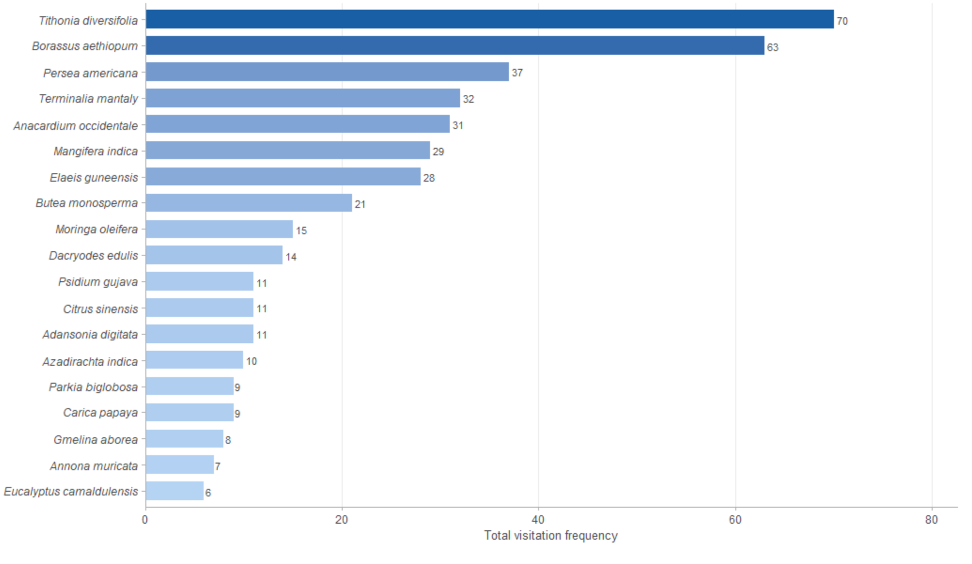

Figure. 2. Total visitation frequency of birds across plant species recorded in urban residential areas of Jos, Plateau State, Nigeria.

Plant Reproductive Stage and Bird Visitation

Flowering plants showed a strong, significant positive association with bird visitation ($\beta = 3.419 \pm 0.377$ SE, $t = 9.062$, $p < 0.001$). By contrast, fruiting plants ($\beta = -1.169 \pm 0.592$ SE, $t = -2.209$, $p = 0.029$) and non-reproductive plants with leaves only ($\beta = -1.201 \pm 0.427$ SE, $t = -2.812$, $p = 0.006$) were associated with significantly fewer bird visits relative to the flowering reference category.

Although flowering status was the strongest predictor of bird visitation at the plant level, the overall model explained only a modest proportion of variance (Adjusted $R^2 = 0.03$, $p = 0.108$), indicating that additional environmental or structural factors contribute to bird attraction patterns in the urban landscape.

Table 3. Generalised Linear Model (GLM) output showing the influence of plant reproductive stage on bird visitation frequency.

Plant Reproductive Stage	Estimate (β)	SE	t-value	p-value
Flowering	3.419	0.377	9.062	**<0.001***
Fruiting	−1.169	0.592	−2.209	**0.029***
Non-reproductive (leaves only)	−1.201	0.427	−2.812	**0.006***

*Note. Reference category = flowering plants. SE = standard error. * $p < 0.05$. Adjusted $R^2 = 0.03$, overall $p = 0.108$.*

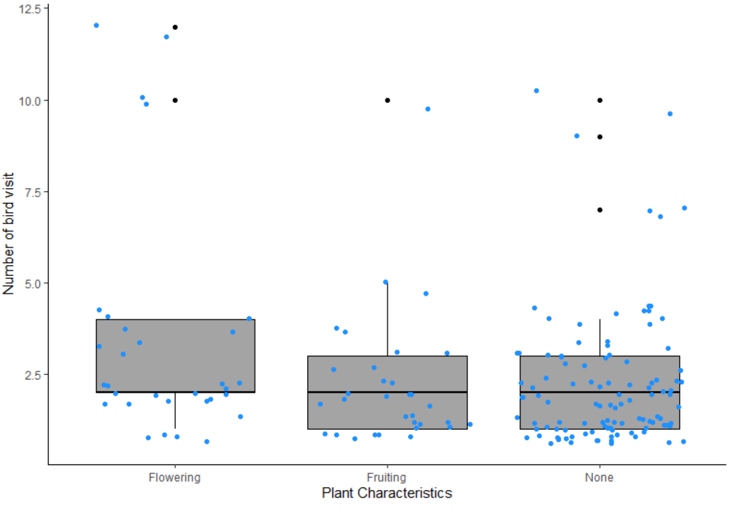

Figure 3. Boxplot showing the plant characteristics attracted to by birds in the Jos Urban area

4. Discussion

Bird–plant interactions in urban environments are strongly influenced by the composition and phenological condition of vegetation within the landscape (Garcia, 2016; Valdovinos et al., 2022). In this study, bird visitation was unevenly distributed across plant species, with *Tithonia diversifolia*, *Borassus aethiopum*, and *Elaeis guineensis* recording the highest frequencies of interaction. These findings suggest that some urban plant species may provide more favorable ecological resources or structural conditions for urban-adapted birds in residential landscapes of Jos. Similar studies have shown that vegetation characteristics can strongly influence urban bird occurrence, habitat use, and ecological interactions (Melles et al., 2003; Shoffner et al., 2018; Morelli et al., 2021).

The dominance of generalist and urban-adapted bird species such as village weavers, doves, sunbirds, and sparrows observed in this study is consistent with ecological patterns reported from urban ecosystems globally, where species capable of exploiting modified habitats often dominate urban bird assemblages (Stofberg, 2023; Meillère, 2015; Morelli et al., 2021). Granivorous birds, particularly members of the family Ploceidae and Columbidae, accounted for a large proportion of the recorded interactions, reflecting the suitability of residential landscapes for species that can utilize ornamental vegetation, cultivated plants, and anthropogenic food resources.

Tithonia diversifolia recorded the highest bird visitation frequency among all monitored plant species. This pattern may be associated with its conspicuous flowering display during the sampling period, which likely increased its attractiveness to birds, particularly nectarivorous and opportunistic species. Flowering plants are known to provide important seasonal resources for birds through nectar production and associated arthropod activity (Garcia, 2016; Wang et al., 2023). Previous studies have similarly reported increased bird activity around flowering vegetation in urban and tropical ecosystems (Belcher et al., 2019; Silva 2018). However, because nectar availability and insect abundance were not directly quantified in the present study, these explanations should be interpreted cautiously.

Borassus aethiopum and *Elaeis guineensis* also recorded relatively high visitation frequencies. These plant species were frequently used as feeding and perching sites by several bird species observed during the study. Fruiting palms are recognized as important ecological resources for many tropical birds because they may provide food, shelter, and structural support within modified landscapes (Azhar et al., 2013). In urban systems, structurally complex vegetation has been associated with increased bird activity and habitat use (Söderström et al., 2001; Shoffner et al., 2018). Nonetheless, structural variables such as canopy density, fruit abundance, and foliage complexity were not quantified in this study and therefore remain potential areas for future investigation.

Plant reproductive stage emerged as an important predictor of bird visitation patterns in the present study. Flowering plants received significantly higher visitation frequencies than fruiting and non-reproductive plants. This finding suggests that reproductive phenology may influence temporal resource availability and consequently shape bird activity within urban residential environments. Similar relationships between plant phenology and bird visitation have been documented in both natural and urban ecosystems, where flowering and fruiting events influence foraging opportunities and movement patterns of birds (Garcia, 2016; Valdovinos et al., 2022; Wang et al., 2023).

Behavioral observations further indicated that feeding interactions occurred more frequently on flowering and fruiting plants, whereas perching behavior was distributed across all reproductive stages. These findings support the idea that urban vegetation performs multiple ecological functions for birds, including food provision, temporary refuge, and habitat structure (Whelan et al., 2008; Schleuning et al., 2015). Nesting interactions were comparatively rare during the observation period, possibly reflecting seasonal breeding patterns or limitations associated with short-term observational surveys.

Although the study initially aimed to examine broader plant functional traits, incomplete and inconsistent measurements of additional traits such as canopy architecture, flower morphology, nectar volume, and fruit size limited their inclusion in the final analyses. Consequently, the study focused primarily on plant reproductive stage and species identity as the main ecological variables influencing bird visitation. This limitation should be acknowledged when interpreting the findings, as other unmeasured environmental and vegetation characteristics may also contribute to observed bird–plant interaction patterns (Green et al., 2022; Peña et al., 2022).

The relatively low explanatory power of some statistical models suggests that additional ecological factors beyond reproductive stage may influence bird visitation within urban residential landscapes. Variables such as vegetation complexity, surrounding land-use intensity, human disturbance, seasonal resource availability, and microhabitat structure may all contribute to shaping urban bird interactions (Parejo-Farnés et al., 2020; Kumdet et al., 2021; Awoyemi & Ibáñez-Álamo, 2023).

Overall, the findings highlight the ecological importance of flowering and fruit-bearing vegetation within residential urban environments. Maintaining diverse urban vegetation with varying reproductive stages throughout the year may help support bird visitation and ecological interactions in rapidly urbanizing tropical cities such as Jos, Nigeria. These findings contribute to the growing body of research emphasizing the role of urban vegetation management in supporting urban biodiversity conservation and ecological functioning (Theodorou, 2022; Monniez et al., 2022).

5. Conclusion

This study demonstrates that plant reproductive stage influences bird–plant interactions within residential urban landscapes of Jos, Nigeria. Flowering plants received higher bird visitation frequencies than fruiting and non-reproductive plants, indicating that reproductive phenology may shape patterns of bird activity and habitat use in urban environments. In addition, visitation frequency varied among plant species, with Tithonia diversifolia, Borassus aethiopum, and Elaeis guineensis recording the highest levels of bird interaction.

The findings further show that urban vegetation serves multiple ecological functions for birds, including feeding and perching opportunities. However, because additional vegetation characteristics such as canopy structure, nectar availability, and fruit abundance were not directly measured, the mechanisms underlying these interaction patterns require further investigation.

Overall, the study suggests that the presence of flowering and fruit-bearing plants within residential urban landscapes may support bird visitation and ecological interactions in rapidly urbanizing tropical cities. Future studies incorporating broader plant functional traits and seasonal variation would provide a more comprehensive understanding of bird–plant interactions in African urban ecosystems.

Acknowledgements

Conflict of interest
The authors declare that they have no competing interests.

References
Abdul, I. D., Muhammad, S. I., Balogun, J. B., Abdullahi, H. A., & Mustapha, T. (2025). Impacts of plant functional traits and bird visitation on the abundance and diversity of birds in Zandama hill, Jigawa state, Nigeria. Journal of Fauna Biodiversity, 2(3), 52-60.

Awoyemi, A. O., & Ibáñez-Álamo, J. D. (2023). Urban bird ecology in sub-Saharan Africa: Emerging patterns and conservation implications. African Journal of Ecology, 61(2).

Azhar, B., Lindenmayer, D. B., Wood, J., Fischer, J., Manning, A., Mcelhinny, C., & Zakaria, M. (2013). The influence of agricultural system, stand structural complexity and landscape context on foraging birds in oil palm landscapes. Ibis, 155(2), 297-312.

Belcher, R. N., Sadanandan, K. R., Goh, E. R., Chan, J. Y., Menz, S., & Schroepfer, T. (2019). Vegetation on and around large-scale buildings positively influences native tropical bird abundance and bird species richness. Urban Ecosystems, 22(2), 213-225.

Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. (2000). Bird census techniques (2nd ed.). Academic Press.

Franklin, J., Roberts, D., & Martinez, L. (2021). Nectar availability and bird visitation patterns in tropical flowering plants. Journal of Tropical Ecology, 37(4),

Garcia, D. (2016). Plant traits and seed dispersal effectiveness in bird-mediated interactions. Functional Ecology, 30(4), 507–518.

Gelmi-Candusso, T. A., & Hämäläinen, A. (2019). Urbanization and ecological interactions: A global perspective. Trends in Ecology & Evolution, 34(10), 913–924.

Gelmi-Candusso, T. A., Hämäläinen, A., Hurskainen, S., & Tomppo, E. (2017). Effects of forest biodiversity on bird and bat insectivory. Ecology and Evolution, 7(20), 8298–8308.

Green, S. J., Brookson, C. B., Hardy, N. A., & Crowder, L. B. (2022). Trait-based approaches to global change ecology: moving from description to prediction. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1971).

Kumdet, C., et al. (2021). Socio-ecological drivers of urban biodiversity in African cities. Landscape and Urban Planning, 214, 104172.

Meillère, A. (2015). Impacts of urbanization on avian communities. Landscape Ecology, 30(6), 987–1001.

Melles, S., Glenn, S., & Martin, K. (2003). Urban bird diversity and landscape structure. Landscape and Urban Planning, 65(3), 149–162.

Miller, R. J., Thompson, J., & Clark, P. (2015). Insect abundance and avian insectivory in tropical ecosystems. Biotropica, 47(5),

Monniez, P., et al. (2022). Habitat modification and ecological networks in cities. Urban Ecosystems, 25(4), 1015–1028.

Morelli, F., Benedetti, Y., Ibáñez-Álamo, J. D., Jokimäki, J., Mänd, R., Tryjanowski, P., & Møller, A. P. (2021). Evidence of evolutionary homogenization of bird communities in urban environments. Nature Communications, 12, 1175.

Morelli, F., Benedetti, Y., Ibáñez-Álamo, J. D., Jokimäki, J., Mänd, R., Tryjanowski, P., & Møller, A. P. (2021). Evidence of evolutionary homogenization of bird communities in urban environments. Nature Communications, 12, 1175.

Moreno-García, P., Savage, A., Salgado, A. L., Tartaglia, E. S., Cocciardi, J. M., Aronson, M. F. J., Jarzyna, M. A., Alberti, M., & Li, D. (2025). The effects of urbanization on species interactions. Nature Cities, 2(8), 693–702. https://doi.org/10.1038/s44284-025-00288-w

Muñoz-Pacheco, C. B., & Villaseñor, N. R. (2022). Avian species richness in cities: A review of the Spanish-language literature from the Southern Cone of South America. Urban Ecosystems, 25(2), 601-616.

Muñoz-Pacheco, R., & Villaseñor, J. L. (2021). Urban flora and its ecological implications in tropical cities. Biological Conservation, 260, 109201.

Parejo-Farnés, C., et al. (2020). Effects of exotic vegetation on bird–plant interactions in urban landscapes. Urban Forestry & Urban Greening, 48, 126561.

Peña, E., et al. (2022). Functional traits and interaction networks in changing environments. Ecology Letters, 25(3), 567–579.

Schleuning, M., Fründ, J., & García, D. (2015). Predicting ecosystem functions from biodiversity and mutualistic networks: an extension of trait-based concepts to plant–animal interactions. *Ecography*, *38*(4), 380-392.

Shoffner, A., et al. (2018). Residential landscapes as habitats for urban birds. Urban Ecosystems, 21(6), 1117–1129.

Silva, P. A. (2018). Bird-flower interactions in an urban area: Ceiba pubiflora provides nectar and promotes biodiversity in the city. Urban Forestry & Urban Greening, 36, 42-49.

Söderström, B. O., Svensson, B., Vessby, K., & Glimskär, A. (2001). Plants, insects and birds in semi-natural pastures in relation to local habitat and landscape factors. Biodiversity & Conservation, 10(11), 1839-1863.

Söderström, B., et al. (2001). The influence of habitat structure on bird communities. Ecography, 24(6), 603–612.

Stofberg, M. (2023). The influence of anthropogenic food on bird behaviour and community structure in urban environments.

Theodorou, P. (2022). The effects of urbanisation on ecological interactions. Current Opinion in Insect Science, 52, 100922.

Thompson, K., & Mabey, R. (2018). The ecological importance of palms in tropical ecosystems. Oxford University Press.

Valdovinos, F. S., et al. (2022). Mutualistic networks and ecosystem functioning. Annual Review of Ecology, Evolution, and Systematics, 53, 147–170.

Wang, X., et al. (2023). Reproductive traits and animal visitation in plant communities. Functional Ecology, 37(2), 456–468.

Whelan, C. J., Wenny, D. G., & Marquis, R. J. (2008). Ecosystem services provided by birds. Annals of the New York Academy of Sciences, 1134, 25–60.