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***Research Article***

# Avian Encounter Rates and Interaction Network with Trees in an Urban Setting

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**ABSTRACT**

The interactions of birds with trees facilitate the provision of ecosystem services that are crucial for maintaining ecosystems. Knowledge of these interactions can be beneficial to conservation actions. The study assessed bird-tree interaction network and encounter rates within the Akoka campus of the University of Lagos. Focal observations of avian visits were made for 15 minutes on a total of 50 randomly selected trees spaced 200 m apart. Each selected tree was visited repeatedly from February to June 2022. A total of 14 bird species belonging to 13 families were recorded while 21 different tree species constituted the focal trees; the top three being *Albizia lebbeck* (n=7, 15%), *Delonix regia* (n=7, 15%), and *Milletia thonningii* (n=6, 13%). The most abundant bird species were African Thrush *Turdus pelios*, Common bulbul *Pycnonotus barbatus*, and Laughing dove *Spilopelia senegalensis*. Bird species encounter rates among focal trees did not significantly differ, nor did they correlate with fruiting and flowering status or diameter at breast height, but a positive correlation existed with canopy cover ($p<0.05$). Network analysis revealed varying bird interactions with different tree species, with some birds interacting with multiple species and others with only one. Notably, *Albizia lebbeck*, *Delonix regia*, and *Milletia thonningii* were highly interacted with multiple bird species. We conclude that bird conservation on the campus will benefit from the preservation of these tree species among others.

**Keywords:** Bird-tree interaction, Encounter rate, Focal trees, Interaction network

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## INTRODUCTION

Birds interact with tree species via processes such as herbivory, seed dispersal, and pollination and thus contributing to the maintenance of ecosystems throughout the world (Whelan *et al*., 2010). Seed dispersal, for example, is crucial for gene flow between fragmented habitats and the restoration of degraded habitats or colonization of new habitats (Jordano, 2017). The magnitude of seed dispersal in an area is however influenced by the abundance and diversity of dispersal agents present e.g. birds (Pejchar *et al.,* 2008). Generally, birds visit trees to take advantage of the various resources available, and these range from feeding and roosting to nesting opportunities that different tree species offer at different times of the year. Tree species may also receive different avifauna visitation rates at different seasons owing to their phenological stage (Khamcha *et al*., 2012); a tree is more likely to receive more avian visitors when fruiting or flowering as compared to when it is not. Thus, differential resource availability between seasons will contribute to a difference in the avian composition recorded on an individual tree monitored over different seasons. In addition, the characteristics of tree species vary between seasons. For example, canopy cover of tree species can vary between the rainy and dry seasons and thus contribute to seasonal patterns of avifauna visitation. An increase in vegetation canopy cover has been linked to improved insect prey abundance (Blaise *et al*., 2022) while differences in tree branch density between species can result in differential opportunities for nesting or perching for bird species (Batisteli *et al*., 2018).

Different tree species host varieties of insects and fruits that serve as food for birds, and the birds, in turn, are significantly responsible for seedling recruitment, forest regeneration, and nutrient cycling (Wenny *et al*., 2011; Buba and Jaafar, 2021). Some bird species are found solely or preferentially in the forest interior, implying that tree size and density are strongly related to their performance (Buba and Jaafar, 2021). The attractiveness of various tree species is determined by qualities such as crown size and branch density, which birds use as perching and breeding locations. Which consequently influences the abundance and distribution of several bird groups (Wydhayagarn *et al.,* 2009; Zwarts and Bijlsma, 2015; Buba and Jaafar, 2021).

Bird species are particularly susceptible to environmental changes brought on by factors like urbanization (Plein *et al*., 2013). This is because, as the landscape and vegetation structure is altered, tree species on which birds are largely dependent may become lost resulting in changes in avian species composition (Mckinney, 2008; Sol *et al*., 2014) and consequently impairing critical ecosystem services like avian-mediated seed dispersal, pest control, and pollination (Mukhopadhyay and Mazumdar, 2019).

Knowledge of bird-tree interaction networks in urban ecosystems is crucial particularly in Africa as more natural habitats are at risk of being transformed into cities (OECD/SWAC, 2020), and green areas increasingly become the centre of conservation in urban areas. Avifauna-tree interaction networks can therefore guide tree removal decisions in land-use alternatives. Furthermore, only a few studies have investigated avian-tree interaction networks in Nigeria (Nsor *et al*., 2017 and 2019). This study therefore seeks to investigate how avifauna species interact with selected tree species within the University of Lagos, Nigeria.

## MATERIALS AND METHODS

### Study Area

The study was carried out at the University of Lagos campus in Akoka Yaba, Lagos, South-western Nigeria (Latitudes 6°31’30’’ to 6°31’10’’N and Longitudes 3°23’0’’ and 3°24’30’’E, Figure 1) from February to June 2022. The study area covers approximately 802 acres (3.25 $km^2$) of land area and is surrounded by the Lagos Lagoon on three sides. The study area is characterised by wetlands and creeks adjoining the Lagos lagoon and fragments of the mangrove forest vegetation characteristic of coastal Nigeria as well as built-up areas. The campus supports a rich diversity of resident and migratory bird species (Iwajomo *et al*., 2018).

### Tree Mapping

A point transect method was used to select 50 tree species systematically spaced at 200 m apart and on alternate sides of the transects. The distance between individual focal trees was measured using a Garmin global positioning system (GPS MAP® 60). The selected trees were both tagged and identified at first level using the PlantsSnap® plant identification app. Thereafter the identity of each tree was confirmed with the help of a taxonomist at the University of Lagos herbarium.. Measurements such as tree height, canopy cover and tree circumference to compute the diameter at breast height (DBH) were taken on the selected trees. Tree circumference was measured using meter rule and thereafter the diameter at breast height (DBH) was computed by dividing tree circumference by 3.142.

### Bird Survey

The survey was conducted in the morning, between 6:30 a.m. and 10:30 a.m., when bird activity was at its peak. At each of the focal trees, all birds perched and foraging or resting were recorded within 15 minutes of observation. Bird species were identified using a pair of binoculars (Lotus® 8 x 42) and based on features described in the Helm field guides for Birds of Western Africa (Borrow and Demey 2014). Each focal tree was visited 10 times.. Care was taken to ensure that only birds utilising the focal tree were recorded. When a bird was heard calling from the tree, a careful search was done to confirm that the bird was on the tree before it was recorded All birds flying over the focal tree were not recorded.

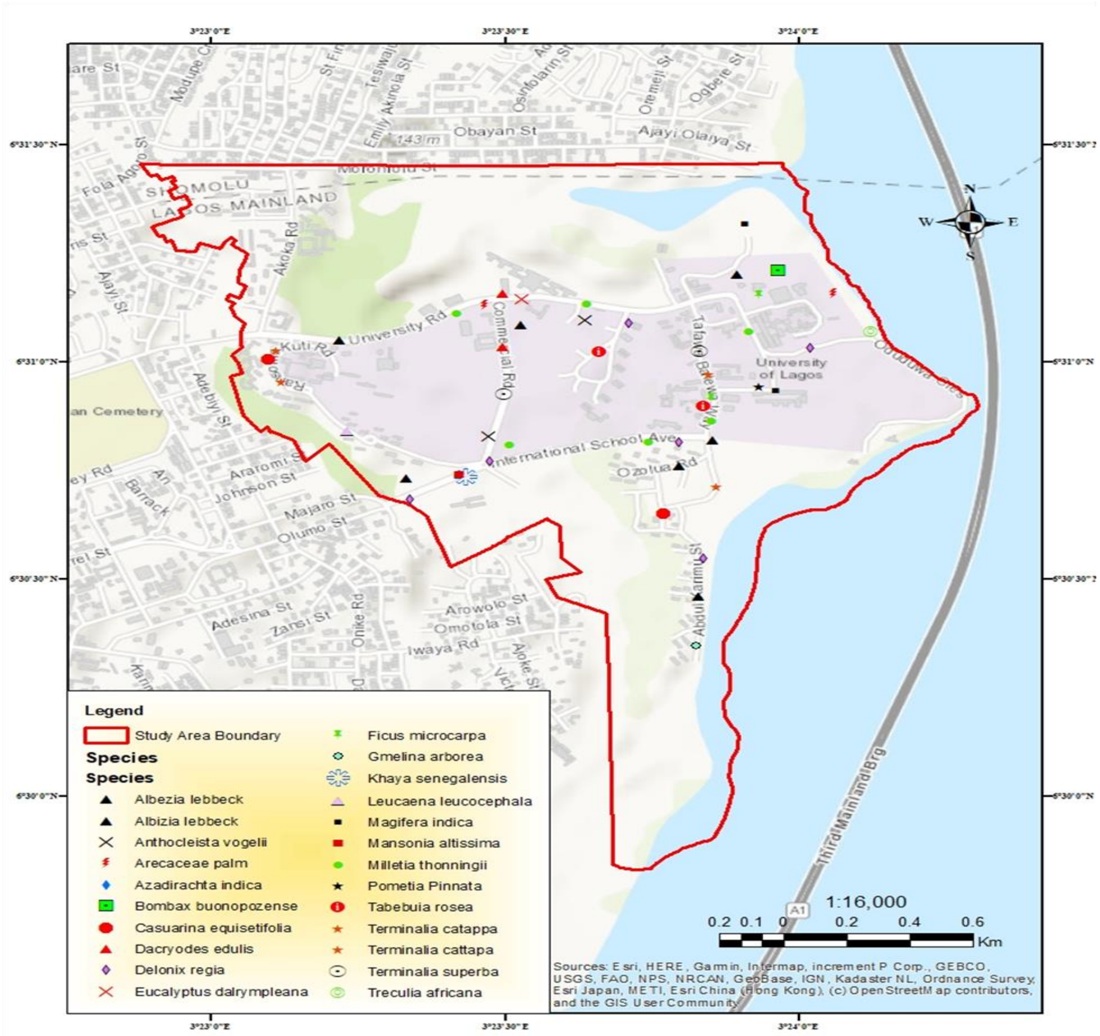


**Figure 1: Map of study area showing distribution of focal trees**

**Data Analysis**

Data were analysed using R statistical software, version 4.1.2 (R Core Team, 2021). The effect of phenological events such as flowering and fruiting on the mean bird species encounter rate on focal trees was tested using the Wilcoxon rank-sum test. This was performed specifically for tree species for which encounter rate data for flowering vs non-flowering (n=9) fruiting vs non-fruiting individuals (n=6) was available. In addition, we tested whether bird encounter rates correlated with DBH and canopy cover of focal trees. The interactions between birds and selected tree species were analysed using the *plotweb* and *visweb* functions in the bipartite package (Dormann *et al*., 2008).

**RESULTS**

A total of 14 bird species of 13 families were recorded in this study. Out of the total birds recorded, only 5 (36%) species are frugivores while 9 (64%) are either insectivores or omnivores. The top three most abundant species recorded were the African Thrush *Turdus pelios*, Common bulbul *Pycnonotus barbatus,* and Laughing dove *Spilopelia senegalensis* with a total abundance of 183, 74 and 54 individuals respectively (Table 1) accounting for 41%, 15% and 13% respectively of all the birds recorded. A total of 21 different tree species made up the 50 focal trees and the top three most abundant species were *Albizia lebbeck* (n=7, 15%), *Delonix regia* (n=7, 15%) and *Milletia thonningii* (n=6, 13%) (Table 1).

Mean bird species encounter rate did not differ significantly between focal trees (ANOVA: $F_{(19,}$

186)=0.74, p =0.778, Figure 2). In addition, mean bird species encounter rate did not depend on whether the focal trees species were fruiting or not (Wilcox test: W=51.5, p=0.335) neither did it depend on whether the focal trees where fruiting or not (Wilcox test: W=30.5, p=0.433). Bird encounter rate did not correlate significantly with the diameter at breast height of focal trees (p=0.667) but there was a positive correlation with canopy cover of focal trees (r=0.56, p<0.001, Figure 3).

**Table 1: List of bird species recorded and focal tree species surveyed**

| Family | Common Name | Scientific Name | Number Observed/ Surveyed |
|---|---|---|---|
| **Bird Species** | | | |
| Turdidae | African Thrush | *Turdus pelios* | 183 |
| Coraciidae | Broad-billed Roller | *Eurystomus glaucurus* | 1 |
| Ardeidae | Cattle Egret | *Bubulcus ibis* | 4 |
| Pycnonotidae | Common Bulbul | *Pycnonotus barbatus* | 74 |
| Columbidae | Laughing Dove | *Spilopelia senegalensis* | 54 |
| Columbidae | Red-eyed Dove | *Streptopelia semitorquata* | 14 |
| Psittaculidae | Rose-ringed Parakeet | *Psittacula krameri* | 11 |
| Nectariniidae | Variable Sunbird | *Cinnyris venustus* | 8 |
| Musophagidae | Western Grey Plantain-eater | *Crinifer piscator* | 36 |
| Alcedinidae | Woodland Kingfisher | *Halcyon senegalensis* | 10 |
| Sturnidae | Splendid Starling | *Lamprotornis splendidus* | 25 |
| Phoeniculidae | Green Wood-hoopoe | *Phoeniculus purpureus* | 4 |
| Corvidae | Pied Crow | *Corvus albus* | 6 |
| Picidae | African grey woodpecker | *Dendropicos goertae* | 3 |
| **Focal Tree species** | | | |
| Anacardiaceae | Mango | *Mangifera indica* | 2 |
| Aracaceae | Acia | *Arecaceae palm* | 2 |
| Bignoniaceae | Pink trumpet | *Tabebuia rosea* | 2 |
| Burseraceae | Native pear | *Dacryodes edulis* | 2 |
| Casuarinaceae | Coastal She-oak or Horsetail She-oak | *Casuarina equisetifolia* | 2 |
| Combretaceae | Shinglewood | *Terminalia superba* | 2 |
| Combretaceae | Tropical almond | *Terminalia catappa* | 5 |
| Fabaceae | Turburku Fruit | *Milletia thonningii* | 6 |
| Fabaceae | Flamboyant, Flame-of-the-forest | *Delonix regia* | 7 |
| Fabaceae | Sirisa, frywood | *Albizia lebbeck* | 7 |
| Fabaceae | Jumbay, pearl wattle | *Leucaena leucocephala* | 1 |
| Gentianaceae | Murderer’s Mat | *Anthocleista vogelii* | 2 |
| Lamiaceae | Beechwood | *Gmelina arborea* | 1 |
| Malvaceae | Gold Coast bombax | *Bombax buonopozense* | 1 |
| Meliaceae | African mahogany | *Khaya senegalensis* | 1 |
| Meliaceae | Neem | *Azadirachta indica* | 1 |
| Meliaceae | African walnut | *Mansonia altissima* | 1 |
| Moraceae | African breadfruit | *Treculia Africana* | 1 |
| Moraceae | Curtain fig | *Ficus microcarpa* | 2 |
| Myrtaceae | Mountain gum | *Eucalyptus dalrympleana* | 1 |
| Sapindaceae | Island lychee, Pacific lychee | *Pometia Pinnata* | 1 |

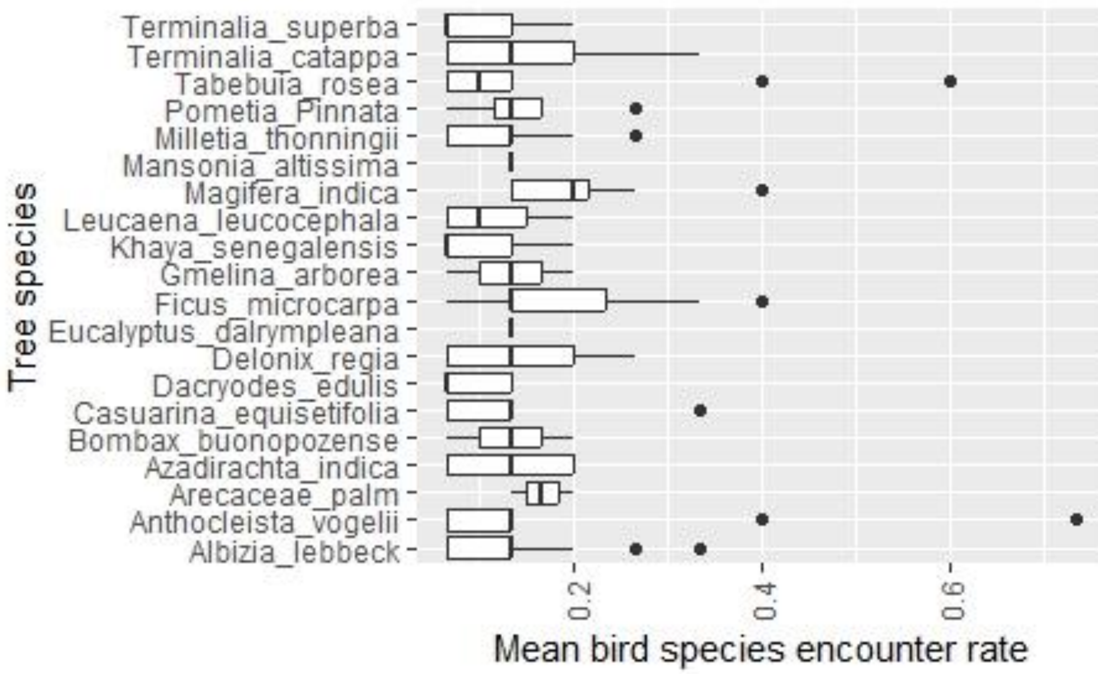


**Figure 2: Mean bird species encounter rate per focal tree species**

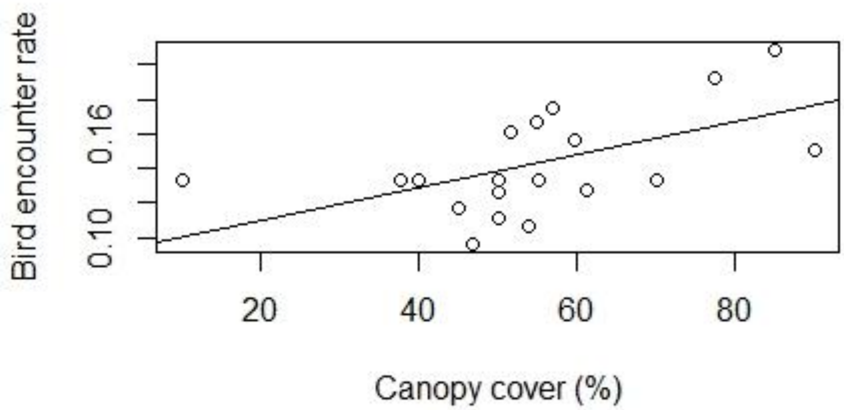


**Figure 3: Relationship between bird encounter rate and canopy cover of focal trees.**

The network analyses of data from this study revealed that the focal tree species received varying number of visits by different bird species. The results showed that birds species like the African thrush and Common bulbul interacted with 19 and 12 different tree species respectively within the study period whereas species like the Broad-billed roller (*Eurystomus glaucurus*), African Grey woodpecker (*Dendropicos goertae*) and Green wood-hoopoe (*Phoeniculus purpureus*) interacted with only one tree species each (Figure 4). The tree species most interacted with by bird species are *Albizia_lebbeck (*10 bird species)*,* *Delonix_regia* (9 bird species), *Milletia_thonningii* (8 bird species), *Mangifera indica* (7 bird species) *and Terminalia catappa* (7 bird species) (Figure 4).

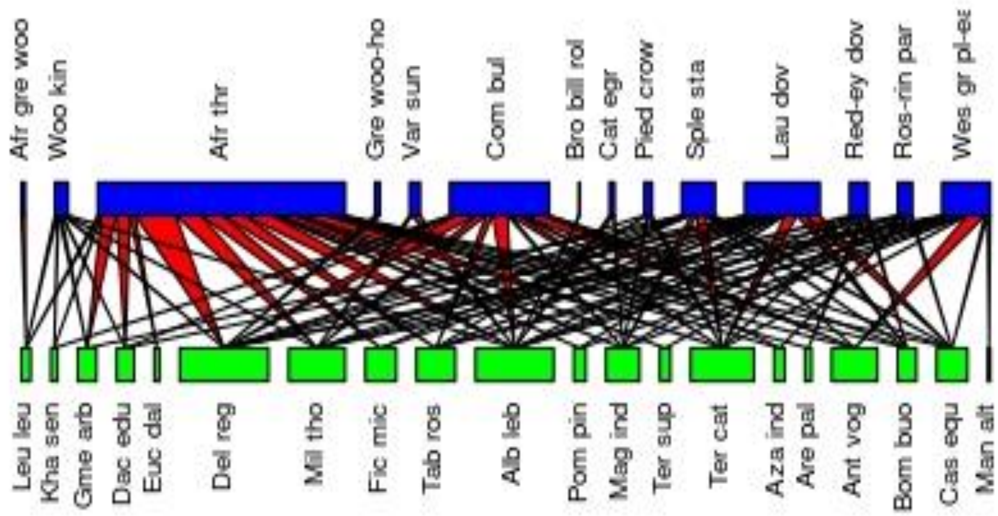


Figure 4: Bird-tree species interaction network. Bird species: Afr gre woo = African grey woodpecker; Afr thr = African thrush; Bro bill rol = Broad-billed roller; Cat egr = Cattle egret; Com bul = Common bulbul; Gre woo-ho = Green woodhoopoe; Lau dov = Laughing dove; Red-ey dov = Red-eyed dove; Ros-rin par = Rose-ringed parakeet; Sple sta = splendid starling; Wes gr ple-eat = Western grey plantain-eater; Woo kin =Woodland kingfisher. Tree species: Alb leb = *Albizia lebbeck;* Ant vog =*Anthocleista vogelii;* Are pa =*Arecaceae palm*; Aza ind = *Azadirachta indica*; Bom buo = *Bombax buonopozense*; Cas equ = *Casuarina equisetifolia*; Dac edu = *Dacryodes edulis*; Del reg = *Delonix regia*; Euc dal = *Eucalyptus dalrympleana*; Fic mic = *Ficus microcarpa*; Gme arb = *Gmelina arborea*; Kha sen = *Khaya senegalensis*; Leu leu = *Leucaena leucocephala; Mag ind = Magifera indica; Man alt = Mansonia altissima; Mil tho = Milletia thonningii*; Pom pin = *Pometia pinnata*; Tab ros = *Tabebuia rosea*; Ter cat = *Terminalia catappa*; Ter sup = *Terminalia superba*

**DISCUSSION**

This study reveals the interaction between 14 bird species from 13 families with 21 tree species from 14 families. The majority of encountered bird species are insectivores or omnivores, comprising 64% of the total, while only 36% are frugivores. This suggests that vegetation composition of the University of Lagos, Nigeria can support diverse groups of bird species. A significant portion of bird species recorded on focal trees consisted of the African Thrush, Common Bulbul, and Laughing Dove. Furthermore, the African Thrush is an insectivorous species that forages mostly by hopping on the ground or probing into leaf litter and soil for invertebrates, the species is also known to search for insects on trees in addition to supplementing its diet with fruits and berries (Collar, 2020). The Common bulbul on the other hand can be described as an omnivorous species, feeding mostly on fruits, insects and sometimes nectar (Fishpool and Tobias, 2020). The Laughing dove, although primarily a granivorous bird that forages on the ground, also opportunistically feeds on fruits, nectar and insects (Baptista *et al*., 2022). This therefore underscores the ecological importance and potential roles of species like the African Thrush and Common bulbul as key seed dispersers and insect controllers within the study area.

In this study, bird encounter rate did not differ significantly between tree species. This is likely due to attributes of the tree species such as height. Many of the focal trees were not completely isolated from other vegetation. Hence it is possible that the individual effect of the focal trees on bird encounter rate may have been masked by the presence of nearby shrubs and bushes that serve as potential foraging locations or cover for bird species.

Phenological events such as fruiting and flowering have been shown to influence bird-tree interactions via resource availability (Gonzalez and Loiselle, 2016). In this study there was no significant differences in the mean bird encounter rates based on flowering or fruiting phenology. This may be attributed to the fact that the composition of birds species recorded are species with a varied foraging habit and so are not solely reliant on flowering or fruiting trees.

Further, vegetation structure indices have been documented to influence bird assemblages (Basile *et al*., 2021). In this study there was a significant correlation between bird encounter rates and canopy cover of focal tree species. This is likely because trees with large canopy cover provide enhanced foraging opportunities via the large surface area of foliage over which bird species can feed on insects. In addition, a large canopy cover is likely to support the nesting and roosting activities of many bird species.

The network analysis revealed that a varying number of bird species interacted with the focal tree species. Also, the observed interactions with multiple tree species, generalist species like the Common bulbul and African thrush utilize a variety of resources that these trees provide. This is not surprising as the bird species are well adapted to urban settlements. On the other hand, the exclusive interaction with a single tree species, by species such as the African Grey woodpecker, the Green Wood-hoopoe, and the Broad-billed roller, may be attributable to their feeding habits or habitat preferences and so highlighting the significance of particular tree species in their ecology. Furthermore, several tree species—like *Terminalia catappa*, *Delonix regia, Milletia thonningii, Mangifera indica* and *Albizia lebbeck* are centers for bird interactions, emphasizing the importance of these species as essential elements of the ecosystem.

## CONCLUSION

This study highlights the influence of the studied tree species on avifaunal encounter rates and interaction network that these trees support. The interactions have implications on seed dispersal and insect pest control in the study area.. Therefore, the revealed interaction between bird species and tree species can help guide conservation initiatives by enabling focused actions to protect important habitat components that are essential for preserving avian diversity and ecosystem health.

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