



Birds Feeding on Cebu Mistletoe *Lepeostegeres cebuensis* (Loranthaceae) in Nug-as Forest, Alcoy, Cebu, Central Philippines

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Abstract: We studied the birds visiting and feeding on Cebu mistletoe (*Lepeostegeres cebuensis*) to understand the dynamics between the birds and the mistletoe. All birds feeding on and visiting the mistletoe from 6:00 AM to 6:00 PM were recorded using the modified listing and timed species count method over 108 observer-hours, divided into three replications. Eleven species in 7 families of birds were recorded, including 7 species feeding on the mistletoe and 4 plain visitors. *Aethopyga bella*, Tweeddale 1877, *A. magnifica*, Sharpe, 1876, *Dicaeum pygmaeum*, Kittlitz 1833, *Zosterops everetti*, Tweeddale 1878, and *Parus elegans*, Lesson 1831, fed only on nectar, while *Cinnyris jugularis*, Linnaeus 1766, and *D. australe*, Hermann 1783, fed on both nectar and fruits. *Dicaeum australe* was observed as the main agent of dispersal of *L. cebuensis* by removing ripe fruit, carrying it in flight, and rubbing its bill on a tree branch where the seed sticks. Significant differences were detected in the numbers of species and individuals visiting, as well as in the numbers of individuals feeding on nectar and fruits at different times of day. Birds prefer to feed in the morning, with sunbirds (*C. jugularis*, *A. bella*, and *A. magnifica*) generally feeding on nectar of flowers and the flowerpecker (*D. australe*) generally feeding on fruits.

Keywords: Cebu mistletoe; flowerpeckers; *Lepeostegeres cebuensis*, Nug-as forest; sunbirds

1. Introduction

Mistletoes (Loranthaceae and Viscaceae) are hemiparasitic plants that depend on host trees for water and nutrients but produce abundant flowers and fleshy fruits that serve as critical food resources for birds. This dual role positions mistletoes as keystone species in many ecosystems, sustaining avian diversity and ecosystem resilience [1–3]. Birds, in turn, act as pollinators and seed dispersers, facilitating mistletoe reproduction and spatial distribution [4–6]. Avian visitation to mistletoe flowers is often dominated by nectarivorous species such as sunbirds, honeyeaters, and hummingbirds, which maximize sugar intake during the morning peak of nectar secretion [5–7]. Frugivorous birds, particularly flowerpeckers and bulbuls, are specialized dispersers of mistletoe seeds, consuming fruits and depositing sticky, viscin-coated seeds onto host branches, where germination occurs [8–13]. The sticky viscin coating of mistletoe seeds enhances adhesion to host twigs, a trait that has co-evolved with bird dispersal behavior [14].

Recent studies demonstrate that mistletoe-bearing trees significantly influence bird foraging patterns, increasing avian diversity in both natural and urban landscapes [15]. Spatial distribution analyses further reveal that host tree properties and forest heterogeneity shape mistletoe abundance and bird visitation rates [8, 10]. In tropical Asia, mistletoe–bird interactions have been shown to sustain endemic species in fragmented habitats, underscoring their conservation importance [16, 17]. Beyond their immediate mutualism, mistletoe–bird relationships contribute to forest dynamics by influencing nutrient cycling, canopy structure, and habitat heterogeneity [1, 2, 18]. Mistletoes also enrich forest ecosystems by providing food and nesting sites, thereby supporting birds and indirectly benefiting other taxa such as insects and mammals [7, 19]. In the context of climate change and habitat fragmentation, these interactions are increasingly recognized as vital for maintaining ecological connectivity and resilience [20]. This study investigates the ecological role of birds feeding on *Lepeostegeres cebuensis* and dispersing its seeds in Cebu’s Nug-as forest. Specifically, we examine species composition, temporal visitation patterns, and feeding specialization to understand how mistletoe–bird interactions sustain avian diversity and ecosystem resilience.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Nug-as forest. The Nug-as forest is mainly found in the town of Alcoy, although it extends into the neighboring town of Boljoon. It faces Bohol in the southeast of Cebu (Figure. 1). The Nug-as forest is the largest remaining forest fragment in Cebu, with an estimated area of 800-1000 ha [21], although a recent estimate is 1200 ha [22]. Its elevation ranges from 300 to over 800masl. The area is primarily a limestone forest, with vegetation mainly covering the middle to the mountain ridges. The area has plenty of caves and sinkholes, which may host various bat species, especially insectivorous ones. The Nug-as forest is located at coordinates 51P 0549264 N 1074836 E. Malakopa *Buchanania arborescens*, Blume 1850, Bakauan gubat *Carallia brachiata* (Loureiro) Merrill 1920, and Hambabalud *Neonauclea* sp. are among the trees growing in the lower elevations, while Mountain agohe *Casuarina* sp. and *Ficus* are among the tree species growing at high elevations.

The Nug-as forest is also considered an Important Bird Area (IBA) together with Mt. Lantoy in Argao [23]. Nug-as is known for its largest forest patch on Cebu Island, which harbors 15 taxa endemic to the Philippines, including four threatened species [24] and the largest number of the threatened black shama (*Kittacincla cebuensis*) [25]. Although Nug-as is popularly known for its shama, the forest also hosts most of Cebu’s remaining biodiversity, including the other three endemic birds of the island: Cebu Hawk Owl (*Ninox rumseyi*), Cebu Flower Pecker (*Dicaeum quadricolor*), and Cebu Brown Dove (*Papitreron frontalis*). These and other birds in the area made Nug-as one of the 11 bird-watching sites of the Philippines [26]. Moreover, the highest remaining population of Cebu Cinnamon *Cinnamomum cebuense*, Kost. 1986, an endemic tree of Cebu is also in the Nug-as forest. Its floral diversity remains understudied and constitutes a significant plant resource in limestone.

2.2 Search and selection of *Lepeostegeres cebuensis*

Lepeostegeres cebuensis were searched purposively in the Nug-as forest. Plants selected for observations were flowering, fruiting, or both. The mistletoe was attached to the host plant within 10 meters, providing a relatively good vantage point for observing visiting birds.

2.3 Bird observation and identification

We used a modified listing and timed species count method [27]. We positioned ourselves at chosen vantage points where birds visiting the mistletoe can be seen. When the distance was within 10 meters, we made observations with what we could see with the naked eye; however, 10x40 Kenko binoculars were occasionally used for verification. The observation period was made from 6:00 AM to 6:00 PM. Time was noted for every bird that visited the mistletoe. However, the total number of individuals listed as visiting or feeding does not necessarily indicate different individuals, as each may revisit the mistletoe at any time of day during the observation period. The frequencies were used only to analyze whether birds visiting and feeding on the mistletoe exhibited a pattern. A bird was classified as “feeding” when it made direct contact with flowers or fruits through probing, bill contact, or swallowing; birds that perched on or near the mistletoe without any

feeding action were classified as “visitors.” Three observers were deployed simultaneously during each replicate, each stationed at a designated vantage point covering the same mistletoe plant(s). A total of 36 observer-hours were spent per replicate, and the experiment was replicated three times. Overall, 108 observer-hours were spent, equivalent to observing the mistletoe for nine days. The feeding behavior of birds eating flowers or fruits was noted and described to aid in the discussion of the results. Birds were identified using a field guide [28].

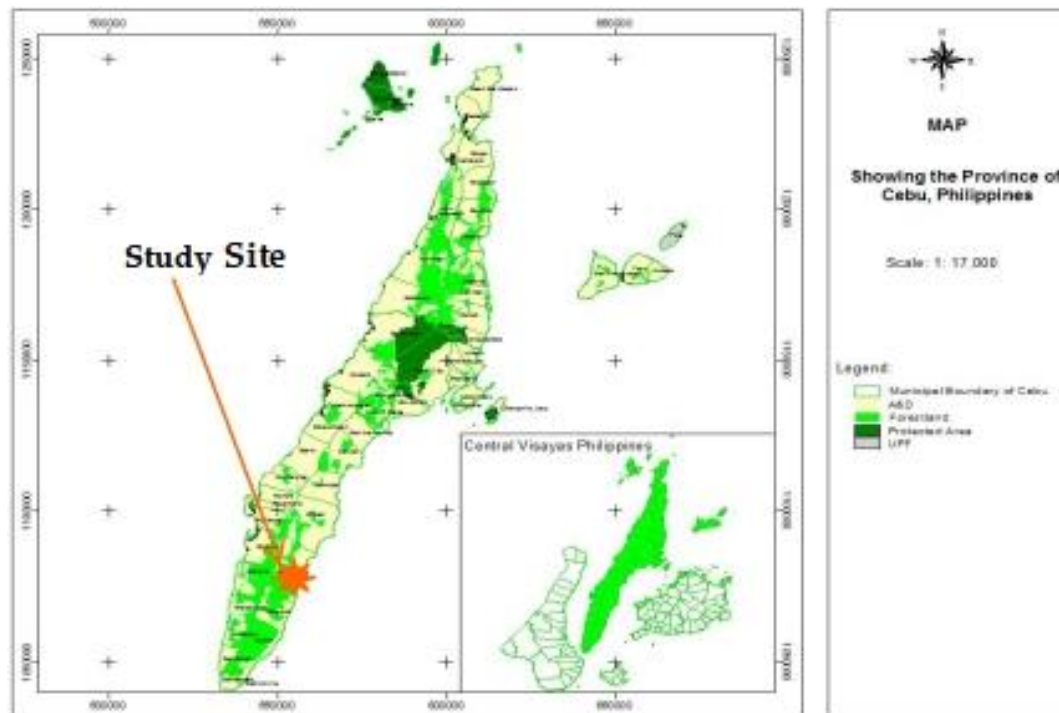


Figure 1. Location map of the Nug-as forest in the municipality of Alcoy, southeastern Cebu, Central Philippines, the study site for observations of birds feeding on *Lepeostegeres cebuensis*.

2.4 Analysis of Data

We grouped the birds visiting the mistletoe at every hour of observation i.e. 6-7 AM, 7-8 AM, 8-9 AM, 9-10 AM, 10-11 AM, 11-12 NN, 12-1 PM, 1-2 PM, 2-3 PM, 3-4 PM, 4-5 PM, and 5-6 PM while feeding time was grouped into four namely 6-9 AM (early morning), 9-12 AM (late morning to noon time), 12-3 PM (noon to early afternoon), and 3-6 PM (late afternoon). Data were analyzed using descriptive statistics based on actual field observations. The species of birds and the total number of individuals across species visiting and feeding on *L. cebuensis* were analyzed using ANOVA, and means were analyzed using LSD. Significance was determined at a 5% level.

3. Results and Discussion

3.1 Birds Visiting and Feeding on *Lepeostegeres cebuensis*

The results of bird visitation and feeding on *Lepeostegeres cebuensis* highlight its role as a keystone resource in the Nug-as forest ecosystem. Eleven bird species from seven families were observed, including six Philippine endemics (Table 1).

Table 1. Birds visiting and feeding on *L. cebuensis*.

Common Name	Scientific Name	Family Name	Remarks
Handsome sunbird	<i>Aethopyga bella</i> Tweeddale 1877*	Nyctariniidae	feeds on flower
Magnificent sunbird	<i>Aethopyga magnifica</i> Sharpe 1876*	Nyctariniidae	feeds on flower
Olive-backed sunbird	<i>Cinnyris jugularis</i> Hermann 1783	Nyctariniidae	feeds on flowers and fruit
Pygmy flower pecker	<i>Dicaeum pygmaeum</i> Kittlitz 1833*	Dicaeidae	feeds on flower
Orange-bellied flower pecker	<i>Dicaeum trigonostigma</i> Scopoli 1786	Dicaeidae	visit only
Red-striped flower pecker	<i>Dicaeum australe</i> Hermann 1783*	Dicaeidae	feeds on flowers and fruit
Arctic warbler	<i>Phylloscopus borealis</i> Blasius 1858	Phylloscopidae	visit only
Everett's white-eye	<i>Zosterops everetti</i> Tweeddale 1878	Zosteropidae	feeds on flower
Elegant tit	<i>Parus elegans</i> Lesson 1831*	Paridae	feeds on flower
Philippine bulbul	<i>Hypsipetes philippinus</i> Forster 1795*	Pycnonotidae	visit only
Black-naped monarch	<i>Hypothymis azurea</i> Boddaert 1783	Monarchidae	visit only

Legend: * = Philippine Endemic

The olive-backed sunbird (*Cinnyris jugularis*) and red-striped flowerpecker (*Dicaeum australe*) were the most frequent visitors, reflecting the reliance of nectarivorous and frugivorous birds on mistletoe flowers and fruits [1, 2, 29]. Endemics such as *Aethopyga bella*, *A. magnifica*, *D. pygmaeum*, and *Parus elegans* underscore the conservation importance of mistletoe–bird interactions [16, 29]. Host tree properties and mistletoe distribution further shape visitation [8, 10], while mistletoe-bearing trees enhance bird foraging even in urban environments [15].

3.2 Temporal Patterns of Visitation

Species richness peaked between 10–11 AM, with nine species recorded (mean = 5.67), while the lowest visitation occurred late in the afternoon (5–6 PM, three species, mean = 1.67) (Figure 2). Individual visitation peaked earlier, between 7–8 AM, with 86 individuals recorded (mean = 28.67), followed by a smaller secondary peak at 3–4 PM (40 individuals, mean = 16.67). Activity declined steadily through midday and into the late afternoon, reaching its lowest level at 5–6 PM (6 individuals; mean = 5.00) (Figure 3). These temporal patterns correspond to nectar secretion rhythms, which peak in the morning and enable nectarivorous birds to maximize sugar intake [5, 6, 7]. Similar declines have been documented in mistletoe systems in Asia and Latin America, where visitation drops after morning peaks due to resource depletion and abiotic stress [8, 10]. The afternoon decline reflects broader ecological trends in tropical forests, where high temperatures reduce nectar production and limit bird activity [1].



Figure 2. Species richness of birds visiting *Lepeostegeres cebuensis* across hourly intervals from 6:00 AM to 6:00 PM in the Nug-as forest, Alcoy, Cebu. Richness peaked between 10–11 AM (nine species) and was lowest between 5–6 PM (Three species).

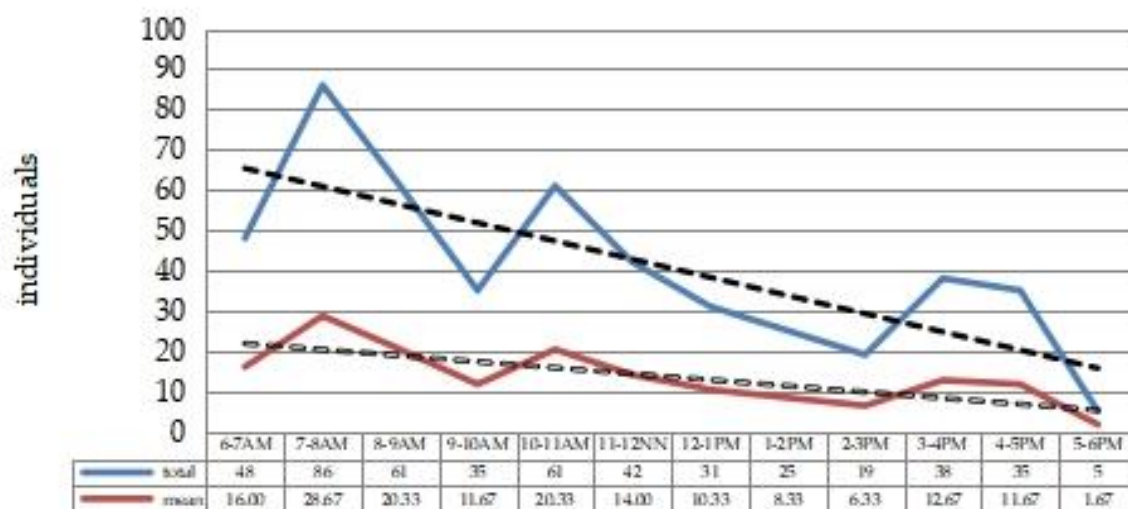


Figure 3. Number of individual birds visiting *Lepeostegeres cebuensis* across hourly intervals from 6:00 AM to 6:00 PM in the Nug-as forest, Alcoy, Cebu. Visitation peaked between 7–8 AM (86 individuals), with a smaller secondary peak at 3–4 PM (40 individuals), and declined to a low of 6 individuals between 5–6 PM.

3.3 Feeding Behavior

Nectar feeding was highest in the early morning (73 individuals, 6–9 AM) and declined to 20 individuals by late afternoon. Fruit feeding was concentrated in the morning (16 individuals, 6–9 AM; 14 individuals, 9–12 NN) and nearly absent by late afternoon (Figure 4).

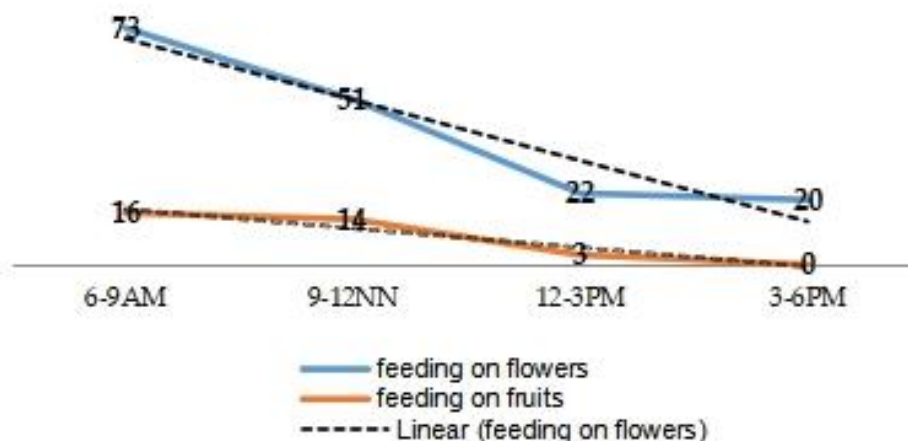


Figure 4. Number of birds feeding on nectar versus fruit of *Lepeostegeres cebuensis* across four time periods (6–9 AM, 9–12 NN, 12–3 PM, 3–6 PM) in the Nug-as forest, Alcoy, Cebu. Nectar feeding peaked in the early morning (73 individuals, 6–9 AM) and declined to 20 individuals by late afternoon, while fruit feeding was concentrated in the morning (16 individuals, 6–9 AM; 14 individuals, 9–12 NN) and was nearly absent by late afternoon.

Functional specialization was evident, with sunbirds (*C. jugularis*, *A. bella*, *A. magnifica*) dominating nectar feeding and flowerpeckers (*D. australe*) specializing in fruit feeding. Such resource partitioning enhances ecosystem resilience by diversifying foraging strategies [30–33]. The prominence of *D. australe* in fruit feeding underscores its role as a key seed disperser, facilitating mistletoe reproduction and forest regeneration [16]. The sharp decline in fruit feeding after midday suggests resource depletion or shifts in

foraging behavior, consistent with mistletoe systems in Latin America and Asia [1, 8]. Notably, the Cebu Flowerpecker (*Dicaeum quadricolor*), a Critically Endangered endemic functionally central to mistletoe seed dispersal, was not observed interacting with *L. cebuensis* during this study. Its absence from the observed feeding guild warrants further investigation, particularly given the conservation significance of this species within Nug-as forest [34]. In summary, our data collectively demonstrate that mistletoes act as keystone resources, structuring bird activity rhythms and sustaining both nectarivorous and frugivorous guilds [1]. The presence of Philippine endemics further emphasizes the conservation value of mistletoe–bird interactions, with direct implications for biodiversity management in fragmented tropical habitats. Protecting mistletoe-bearing host trees is therefore critical for conserving avian diversity, maintaining ecological connectivity, and strengthening ecosystem resilience [15].

4. Conclusions

Our findings confirm that *Lepeostegeres cebuensis* functions as a keystone resource in Cebu's Nug-as forest, sustaining diverse bird communities through its flowers and fruits. Eleven bird species, including six Philippine endemics, were recorded, with sunbirds specializing on nectar and flowerpeckers, particularly *Dicaeum australe*, serving as the primary fruit dispersers. Temporal patterns of visitation revealed a morning peak coinciding with maximum nectar secretion and a secondary peak in the afternoon, while feeding declined sharply by late day. These results highlight the importance of mistletoe resources in structuring avian foraging rhythms and maintaining functional diversity among nectarivorous and frugivorous guilds. By aligning species composition, temporal activity, and feeding specialization, this study demonstrates that mistletoe–bird mutualisms are central to ecological connectivity and resilience in fragmented tropical habitats. Protecting mistletoe-bearing host trees is therefore essential not only for sustaining endemic bird populations but also for reinforcing biodiversity management strategies across both natural and human-modified landscapes.

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