

Variation in Avian Visits on Two Host Plants of the Mistletoe *Tapinanthus sesselifolius* Depended on Habitat Type and Presence of Matured Flowers

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Abstract

This study investigated avian foraging behaviour on the Mistletoe, *Tapinanthus sesselifolius* with a view to determine whether avian visits to the stem parasitic plant significantly differ between its two common host plant species in the Amurum Forest Reserve, Nigeria namely; *Dichrostachys cinerea* and *Ochna afzelii*. Also the study determined whether habitat type and abundance of the three flower developmental stages of *T. sesselifolius* (i.e. closed unripe, closed ripe and open flowers) influenced avian visits to *T. sesselifolius*. Data was obtained using focal observations; 22 individuals of each of the two plant species hosting the Mistletoe *T. sesselifolius* were selected through stratified sampling. Focal observations to determine avian visits were conducted over a period of 1-hour per individual plant. Flower developmental stages were sampled through direct counts on three randomly selected branches of the parasitic plant. A significant difference was observed in avian visits to *T. sesselifolius* on the two study host plants with higher mean visits per hour to *T. sesselifolius* on *D. Cinerea*. While *T. sesselifolius* around the gallery forest habitat received significantly more avian visitors than those located in the savannah scrub and rocky outcrop. Also closed ripe flowers had significant effect on avian visits with avian visits increasing significantly to *T. sesselifolius* having higher numbers of closed ripe flowers. The complex structure of *D. cinerea* and the dense vegetation structure of the gallery forest could act as buffer against birds of prey and may have encouraged more visits to *T. sesselifolius* based on these factors. Also, the tamper proof nature of ripe flowers and its high nectar content as observed in previous studies is speculated as reasons for its significant positive effect on avian visits in the study. These observations may have implications on the reproductive potential of the stem parasitic plant since reduced pollinator visits is known to limit pollen deposition and eventual fruit set in plants.

Keywords: avian visits, *Tapinanthus sesselifolius*, host plant, habitat type

DOI: 10.7176/JNSR/12-8-01

Publication date: April 30th 2021

1. Introduction

The fitness of ornithophilous (i.e. bird pollinated) plants, is established to increase with avian visits and duration of foraging this is because this variables increases chances of pollen deposition at stigma of flowers and consequently enhanced seed/fruit set (Klinkhamer and De Jong, 1990; Ågren, 1996; Ladley *et al.*, 1997; Kwak *et al.*, 1998; Bosch & Waser, 1999; Ashmann *et al.*, 2004).

Among several plant flowers visited and pollinated by birds, are those of the xylem-parasitic Mistletoe family, Loranthaceae (Barlow, 1983; Ladley *et al.* 1997; Norton *et al.*, 1997). Mistletoes grow on the branches of several host trees and shrubs which includes *Parkia biglobosa*, *Acacia seyal* (Mimosoideae), *Anogeissus leiocarpus* (Combretaceae) (Barlow, 1983; Boussim *et al.*, 2004) absorbing water, water-conducted nutrients and organic solutes from the host's xylem but photosynthesise on its own using its leaves (Ladley and Kelly, 1996; Vaknin *et al.*, 1996). Most of the plants possess obligate explosive flowers where only ripe flowers (often with dark terminal bud) open up upon tweaking by birds or strong mandibled insects (Ladley *et al.*, 1997; Watson, 2001). During this process, pollen accumulated on the fore-crown of birds can get to a flower's stigma when it makes contact with the bird's head during foraging for nectar (Ladley and Kelly, 1995).

The effect of floral characteristics such as nectar quantity and quality as well as floral density and size in regulating avian visitors have been previously widely considered (Klinkhamer and de Jong 1990; Ladley *et al.*, 1997; Johnson *et al.*, 2006; Chaskda *et al.* 2013). However, in the case of the African endemic Loranthaceae Mistletoes, specifically the species *Tapinanthus sesselifolius* previous studies have not fully exploited the above aspects particularly how avian visits relates with the various host plant species of the parasitic plant and the habitat types in which individuals are located. This is important considering that pollinator birds have been shown to adjust foraging behaviour in favour of such patches that gives maximum energetic reward with negative implications in terms of reduced fitness for the avoided plant (Gill and Wolf 1975). Therefore, this study aims at determining whether avian visit rates to *T. sesselifolius* differed between its two dominant host plant species *Dicrostachys cinerea* and *Ochnia afzelii* based on a previous survey in the Amurum Forest Reserve

and whether such differences if any depends on the habitat type in which the host plant is located and the abundance of the different flower developmental stages on the plant (Chaskda *et al.*, 2013).

2. Materials and methods

2.1 Study area

This Research was carried out within the Amurum Forest Reserve ($9^{\circ} 53' N$, $8^{\circ} 59' E$) located 15 km, northeast of Jos, Plateau State, North-Central Nigeria. The area spans 300 ha and is characterized by various habitat types which include patches of gallery forest, scrub savannah rocky out crops and grassland (Ezealor, 2002) (Fig. 1). These habitat types host several plant species some of which are hosts to the parasitic mistletoes, such as *T. sesselifolius*, *T. dondrofolius* and few others (Chaskda, 2005). The forest has been identified as an Important Bird Area (Ezealor, 2002) and hosts a number of nectar feeding birds such as the scarlet-chested sunbird (*Chalcomitra senegalensis*) and the Green-headed sunbird (*Cyanomitra verticalis*). These characteristics of the Amurum forest Reserve influenced its choice as a study area.

2.2 Data collection

Data collection was conducted during the wet season of 2012 starting from first week of August to the last week of September. Two of the top five plant species earlier reported as major hosts of the mistletoes *T. sesselifolius* (Chaskda, 2005) that is *D. cinerea* and *O. afzelii* were chosen for this study. Their choice was also based on their distribution within the reserve. 22 parasitized individuals of each host plant species were observed using Focal Observation Technique (*cf.* Ladley *et al.*, 1997). None of the selected candidate study plant species were less than 1.0 m in height and were selected using stratified random sampling such that no two individuals were less than 30 m from each other to achieve wider spread of sampling points across the reserve. The 22 individual plants selected for the two host plant species were observed each for a period of one hour using a binocular (Trekka, 10 x 45 field of view) at the rate of minimum of three individual plants per day. Observations were conducted at a minimum distance of 10 m away from focal plant to avoid distracting avian behaviours. All observations were conducted between 0630 hrs to 1130 hrs. During the observations, the following variables were recorded:

- i. Frequency of visits by each bird species visiting *T. sesselifolius* on the study host plants.
- ii. The particular *T. sesselifolius* host plant species being sampled.
- iii. The habitat type where each individual of the study host plant species was located.
- iv. Mean number of the various flower developmental stages of *T. sesselifolius* per branch namely; closed-unripe (early flower developmental stage characterised by pink to yellow terminal bud), closed ripe (has dark-brown terminal bud and has matured stigma and pollen ready for pollination) and open flowers (often opened by the activity of birds and strong mandibled insects that have probed for nectar) (Ladley *et al.*, 1997; Watson, 2001; Chaskda *et al.*, 2013). Each flower type was sampled on three branches of the parasitic plant and averages taken.

Individuals belonging to each bird species were not distinguished throughout the study because not all birds in the area were ringed or colour banded. Thus, comparisons between birds were based on species differences.

2.3 Data analysis

Data was analysed using the SPSS Statistical package, version 17.0 (www.spss.com). The Independent sample t-test was used to test the significance of the differences in mean number of visits between the bird species recorded on *T. sesselifolius* during the study. Using number of avian visits as dependent variable, the General Linear Model (GLM) was used to determine the significant predictors of avian visits to *T. sesselifolius* the backward deletion technique of the most non-significant predictors was used until the minimum model containing significant predictors of avian visits was achieved. Predictors tested include: host plant species, habitat type, number of unripe flowers, number of ripe flowers, number of open flowers and the interactions between host plants and the different flower developmental stages.

3. Results

3.1 Avian visitors to *T. Sesselifolius*

Two bird species; the variable sunbird, *Cinnyris venustus* and the scarlet-chested sunbird, *Chalcomitra senegalensis* were recorded foraging on *T. sesselifolius* during the study. Variable sunbird had a total of 80 visits (representing 62.5 % of 128 visits) while scarlet-chested sunbird had 48 visits (37.5 %); the visits by the two bird species differed significantly (Independent Sample t-test, $t = 2.787$, $P = 0.007$); variable sunbird had 40 visits (45.46 %) to *T. sesselifolius* on *D. cinerea* and all the 40 visits to *O. afzelii* (100 %) while the scarlet-chested sunbird had 48 visits (54.55 %) to the parasitic plant on *D. cinerea* and none to *O. afzelii* (0 %).

3.2 Differences in avian visits across host plants, habitat type and flower abundance

Avian visits to *T. sesselifolius*, differed significantly between the two host plants *D. cinerea* and *O. afzelii* (Table 1, Fig. 2). Also, avian visits to *T. sesselifolius* on the two host plant species depended significantly on the habitat type in which the individual host plant was located. For example the highest mean visits to *T. sesselifolius* on both *D. cinerea* and *O. afzelii* occurred in the gallery forest as compared to the other habitat types (Table 1, Fig. 2). Also, mean avian visits related positively with the number of ripe flowers on *T. sesselifolius* (Table 1, Fig. 3) irrespective of the host plant species on which the parasitic plant is growing (GLM, $F_{1, 166}=3.274$, $P=0.072$).

Table 1. Significant predictors of avian visits to *T. sesselifolius*

Dependent model: number of avian visits per hour

Variable	df	F	P
Host plant species	1, 171	139.72	<0.001
Habitat type	2, 171	14.82	<0.001
Number of mature ripe flowers per branch	1, 171	10.49	0.001

*all significant values are at 0.05 level

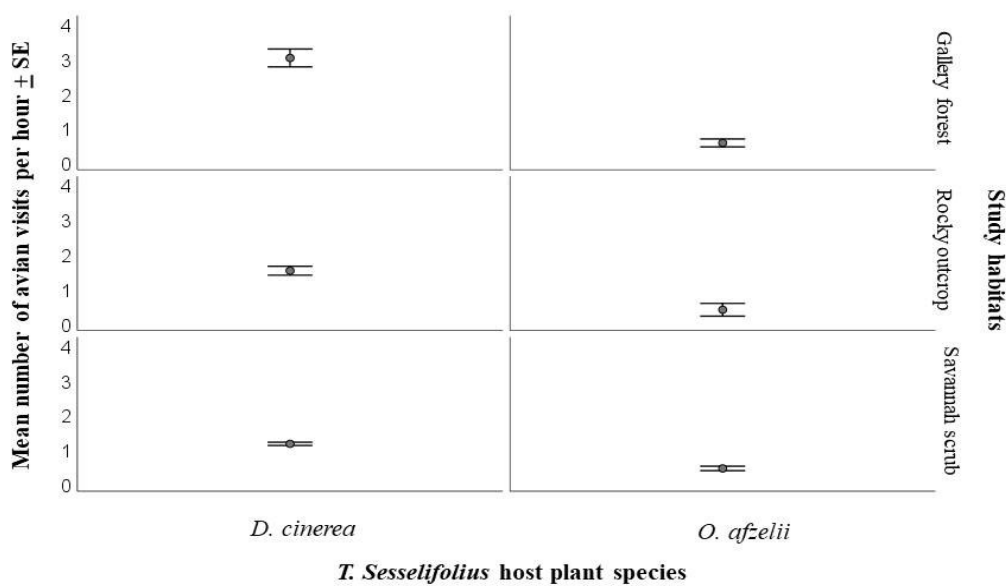


Figure 2. Avian visit rate between study host plant species and habitat type in the Amurum Forest Reserve

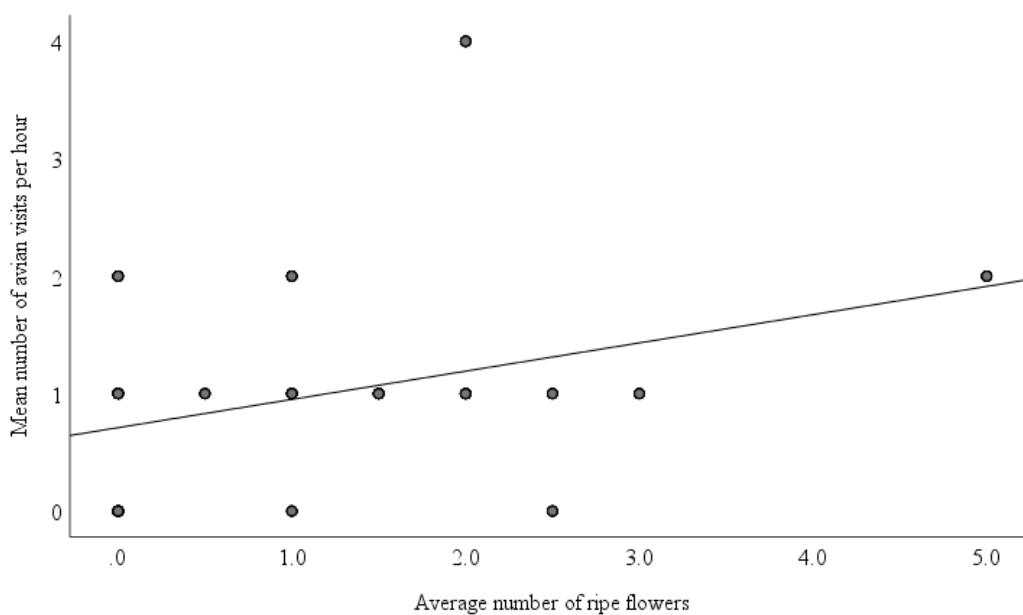


Figure 3. Avian visit rate per hour and average number of ripe flowers

4. Discussion

The results of these study showed that the variable sunbird and the scarlet-chested sunbird are avian pollinators of the mistletoe *T. sesselifolius* in the Amurum Forest Reserve. However, the variable sunbird seems to be more versatile as it appears to be the dominant forager on the two host plant species of the parasitic plant with the scarlet-chested sunbird never recorded throughout the study on *O. afzelii*.

Higher visits by avian visitors to *T. sesselifolius* on the host plant *D. cinerea* can be attributed to several factors. Among these is the nature of the host plant *D. cinerea* which poses complex structure comprising of thorns, which looked obstructive with the potential of reducing foraging efficiency of predatory birds as speculated in previous studies (Chaskda, 2005) thus, if pollinator birds recognize this protective effect, it may influence their preference to forage on the host plant. However, nectar quantity and quality have also been previously reported to have positive effects on avian visits (Ladley *et al.*, 1997). Other plant features known to have effects on avian visits include plant size, floral size and density of flowers on a plant (Klinkhamer and de Jong, 1990; Ladley *et al.*, 1997; Ashmann *et al.*, 2004).

Similarly, more visits to *T. sesselifolius* in the gallery forest habitat as against other habitat types considered in this study, could still be tied to the predator hypothesis as the gallery forest has more dense vegetation that could provide cover against predators compared to the more open savannah scrub with scattered shrubs and degraded areas or the more open rocky outcrop with rocky surfaces limiting efficient plant growth.

On the other hand, effects of closed ripe flowers on avian visits may not be unconnected with its nectar content. Such flowers have been demonstrated in the past to have high nectar quantity and their sealed nature is suspected to provide an assuring reward for foraging birds. These are likely to be energetically more rewarding than re-visiting already opened flowers or the closed unripe flowers that do not contain nectar (Ladley *et al.* 1997). As a result, larger sunbirds feed mainly on unopened buds (Gill and Wolf 1975).

Thus, the pattern of foraging behaviour by avian visitors as observed in this study may have huge implications on the reproductive potential of *T. sesselifolius*. This is because increased avian visits and duration of foraging is known to have high implications on the pollination potential of a plant; the higher the visits and duration of foraging, the higher the tendency of flowers getting pollinated and consequently, the higher the fruit set on the plant (Ågren, 1996; Roll *et al.*, 1997; Kwak *et al.*, 1998). Thus, observations from this study may have reproductive implications for *T. sesselifolius* depending on the host plant species, habitat type and abundance of matured flowers on the plant.

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