Acta Scientific Biotechnology (ASBT)

Volume 1 Issue 8 August 2020

Research Article

Species Composition and Abundance of Sunbirds Foraging on *Tapinanthus globiferus* Parasitizing *Citrus sinensis* in Permanent Site of Federal University of Lafia, Nasarawa State, Nigeria

Ombugadu A[1]*, Benson RF[1], Ahmed HO[1], Ombugadu EO[2], Pam VA[1], Audu EA[1], Adamu S[3], Njila HL[4], Echor BO[4], Deme GG[5], Abbas AA[6], Aimankhu OS[1], Terna TP[7], Ayuba SO[1], Dogo KS[1], Angbalaga GA[6], Attah AS[1], Adejoh VA[1], Micah EM[1], Samuel MD[1], Anyim JO[1], Nkup CD[8], Maro SA[1], Polycarp IA[1], Simon ME[1] and Uzoigwe NR[1]

[1]*Department of Zoology, Faculty of Science, Federal University of Lafia, Nasarawa State, Nigeria*

[2]*Plant Pathology Unit, Department of Crop Production, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria*

[3]*Department of Science Laboratory Technology, Federal Polytechnic Nasarawa, Nasarawa LGA, Nasarawa State, Nigeria*

[4]*Department of Science Laboratory Technology, Faculty of Natural Sciences, University of Jos, Plateau State, Nigeria*

[5]*State Key Laboratory of Ecology and Conservation, Institute of Zoology, Chinese Academy of Science, Beijing, PR, China*

[6]*Department of Microbiology, Faculty of Science, Federal University of Lafia, Nasarawa State, Nigeria*

[7]*Department of Botany, Faculty of Science, Federal University of Lafia, Nasarawa State, Nigeria*

[8]*Department of Biology, College of Arts, Science and Technology, Kurgwi, Qua'an LGA, Plateau State, Nigeria*

***Corresponding Author:** Ombugadu A, Department of Zoology, Faculty of Science, Federal University of Lafia, Nasarawa State, Nigeria. **Email:** akwash24@gmail.com

Received: June 15, 2020

Published: July 21, 2020

Abstract

The foraging strategies of animals is often shaped by the distribution and availability of resources. Ornithophilous plants greatly rely on avian foraging preference which is measured based on the frequency of avian visit and duration of foraging. To this end, the study on species composition and abundance of sunbirds foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in Permanent Site of Federal University of Lafia, Nasarawa State, Nigeria was carried out from January to July 2017. Focal observation with the aid of a pair of binoculars on visiting sunbirds was carried out thrice weekly in the morning and evening sessions on twelve randomly selected *C. sinensis* trees parasitized by *T. globiferus*. A total of 376 sunbirds were sighted which spread across *Chalcomitra senegalensis* (scarlet–chested sunbird) 181 (48.13%), *Cinnyris venustus* (variable sunbird) 134 (35.63%), *Cinnyris pulchellus* (beautiful sunbird) 43 (11.17%) and *Cyanomitra verticalis* (green-headed sunbird) 19 (5.05%). Thus, there was a very high significant difference (F_{180} = 8.129, Adjusted R^2 = 0.1046, P < 0.001) in relation to the abundance of sunbird species foraging on *T. globiferus*. The abundance of sunbirds foraging on *T. globiferus* between months and as well as in relation to seasons showed a very high significant difference (months: F_{655} = 9.216, Adjusted R^2 = 0.0586, P < 0.001; seasons: t = -5.8684, df = 589.02, P < 0.001). Also, abundance of sunbirds foraging on mistletoe showed a very high significant difference (t = 8.5947, df = 472.33, P < 0.001) in relation to time of day. On the average, *Cinnyris pulchellus* (beautiful sunbird) spent the highest foraging time (20.0 ± 2.0 seconds) on *T. globiferus*. However, there was no significant difference (F_{180} = 0.3172, Adjusted R^2 = -0.01132, P = 0.8129) in foraging duration between sunbird species. This is the first study on sunbirds in the University Permanent Site which clearly shows that the *Citrus* orchard is a potential conservation site that will be of great benefit to sunbirds and other organisms, hence, it should not be cleared for building construction in the near future but allocated as a part of the Institution's zoological garden. Trees parasitized by mistletoe in the area should be protected.

Keywords: Sunbirds; *Tapinanthus globiferus*; *Citrus sinensis*; Months; Seasons; Time of Day; Foraging Duration

Introduction

The distribution and availability of resources often shape the foraging strategies of animals [1,2]. The behaviour of animals may influence the ecology and evolution of their resources at the same time [3]. Inter-specific interactions such as between plants and animals are the central point of many population interactions in the ecosystem [4]. About 90% of plants in the tropics rely on animal mutualists for a range of services including pollination [5,6]. The ability to fly and the need to obtain energy has resulted in birds accessing different habitat types and a variety of plants, thereby, becoming good pollination agents [7,8]. Consequently, about 50 bird families are reported as flower visitors [8].

Among several plant flowers visited and pollinated by birds is *Tapinanthus globiferus* which belongs to the xylem-parasitic mistletoe family, Loranthaceae [9,10]. *Tapinanthus globiferus* was first described by Rich, A. in 1895 [11]. Like other Loranthaceae, mistletoe is a stem hemiparasite and grows on the branches of several host trees and shrubs absorbing water, water-conducted nutrients and organic solutes from the host's xylem. However, it produces its own sugar using its leaves [12,13]. Birds chiefly regulate the reproductive success of the plant [11]. *T. globiferus* is endemic to Africa, with a geographic spread ranging from the dry country of Mauritania to Ethiopia, extending south in West Africa which includes Nigeria to the Gulf of Guinea. The plant is found on plateaux, lowland forests, mangroves and extending into forested areas of Southern Ethiopia. Mistletoe with the common names - bird lime, all heal, devil's fuge, Iscador, etc. is a general term for woody shoot parasites in several plant families especially Loranthaceae and Viscaceae [14-16] and most genera of African mistletoes belong to the family Loranthaceae [16]. Seven genera of the Loranthaceae - *Helixanthera, Berhautia, Englerina, Globimetula, Agelanthus, Tapinanthus* and *Phragmanthera* - with about five dozens or more species are recognized in West Africa [14] and the group term mistletoe is used for all these species.

In West Africa, mistletoes are found on many tree crops of economic importance including the *Vitellaria paradoxa Gaertn. f.* (shear butter tree), *Azadirachta indica L.* (neem tree), *Citrus sinensis L.* (orange tree) and *Citrus paradisi L*. (grape), *Theobroma cacao L.* (cocoa) [17,18]. Economically-valuable fruit trees in wild forests, gardens or orchards are lost due to the impact of parasitic mistletoes [17,19-21]. These hemi-parasitic plants have caused the host plants many biological effects, chief among which is salt imbalance. A formulated hypothesis is that these hemi-parasites (Loranthaceae) would contribute to decrease the salt content in parasitized host boughs particularly those bearing fruits [22].

Birds association with mistletoe plant have been found to be very strong. Watson [23] reported that birds show preference for living where mistletoe is common. The study pointed out that woodlands where mistletoes have been left intact, had 17% more total birds than woodlands where mistletoe have been removed and of all 44 bird species recorded during the study, 70% were seen regularly within areas with mistletoes. Other ecological benefits of the plant have been reviewed by Watson [23] and Grund [24] some of which include: serving as a food resource to about 66 families of birds and 30 families of mammals through its flowers, fruits and leaves; a suitable nesting and roosting site to about 43 families of birds and 7 families of mammals; and it controls the success of introduced plant species.

Krebs and Davies [25] stated that the importance of feeding is to provide the raw material for growth, self-maintenance, and reproduction. Birds, like any other foraging animal, are faced with two kinds of currencies: rate of food intake and efficiency. Therefore, choosing a variable foraging option may minimize the risk of starvation. This is especially likely to be important when the animal lives in an environment that is unpredictable and the exact amount of food the animal will obtain is uncertain [4]. Sunbirds have high energetic lifestyle and high metabolic rates [26] and they are wide in distribution on the African continent in almost all habitat types [27]. They patronize nectar of most flowering plants and several of them are insectivores thereby aiding in checking insects' population explosion that could assume pest status [28].

The abundance of sunbirds decrease with increasing temperature but increases with vegetation diversity and monthly rainfall [29]. In sunbirds, territoriality occurs mainly when food resources are scarce and the size of the territory decreases as the density of resources increases [30-32]. When resources are abundant, no benefit accrues from aggressiveness and the sunbirds relax their territoriality [30,33]. Carpenter and Hixon [34] found that when feeding by nectarivorous birds is interrupted by harsh weather conditions such as rain, they are bound to respond. In the Rufous Hummingbirds (*Selasphorus rufus*) for example, days of rain results in drastic weight loss which is reversed when they recommence feeding upon the return of good weather.

Pollination is achieved when sunbirds probe and/or open up ripe flowers for nectar [16] during which their fore-head (crown) picks up pollen grains and comes in contact with the stigma of another flower of the same plant species when it is visited by the sunbird thereby effecting pollination and increasing the chances of cross pollination which in turn increases the plant's fitness, reproductive success and vigor [35].

Close observation may reveal circadian fluctuations in feeding rate of sunbirds on *T. globiferus*, however, even under constant conditions, particularly in the early morning and evening. Studies found that nectar volume was highest at the beginning of the day and decreased as the day progressed [36] which accounts for more sunbirds visitors in the morning hours than any other time of day.

Seasonality plays a major role in determining the abundance and distribution of birds. Seasonality affects food and cover availability of bird population, which in turn affects breeding success and ultimately survival of the bird species [37]. The seasonal variation in the amount of rainfall and temperature and spatial and temporal microhabitat conditions are known to affect the availability of various food items for birds [38]. Based on species sensitivity to the type of habitat, these could alter the diversity, abundance, and distribution of birds in an area [39].

There is no baseline information on foraging activities of sunbird species on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in the Permanent Site of Federal University of Lafia (FULafia), Nasarawa State, Nigeria in relation to months, seasons, time of day (constant weather conditions: the early morning and evening hours), and foraging duration (time spent in feeding). Against this backdrop, the study on species composition and abundance of foraging sunbirds on *Tapinanthus globiferus* parasitizing *Citrus sinensis* was investigated at the University Permanent Site.

Materials and Methods

Study site

The study was carried out in the Permanent Site of Federal University of Lafia, Nasarawa State, Central Nigeria located on latitude 8˚28´N and longitude 8˚32´E (Figure 1). Lafia have an elevation of 179 meters above sea level with average temperature of 27.5°C and an annual rainfall of 1316 mm or 51.8 inch [40]. The University Permanent Site is characterized by grassland savannah, scrub woodland and interspersed by gallery forest. Also, there is a *Citrus* orchard in the site whose trees are parasitized by mistletoe plant.

Sampling

Twelve trees of *Citrus sinensis* that were parasitized by flowering *Tapinanthus globiferus* were randomly selected for focal observation using a pair of binoculars between January and July 2017. The selected *Citrus* trees were marked using a Geographical Positioning Satellite System (GPS) Machine (Garmin etrex 10 model 16Q823121) and a ribbon was tied around the selected trees for easy identification during repeat visits.

A well designed data sheet was used to record focal observation variables. Focal observation on the twelve selected trees was carried out with the aid of a pair of binoculars between 07:00 to 10:00 hours for morning session and 15:00 to 18:00 hours for evening session for a period of three days in each week of the survey for a ten minutes duration on each tree stand. Within the 10 minutes of focal observation, sunbirds sighted on the mistletoe were identified using bird field guide by Burrow and Demey [41] and a stop watch was used to take note of the time spent foraging. Mistletoe that eventually phased out flowers were replaced with those flowering.

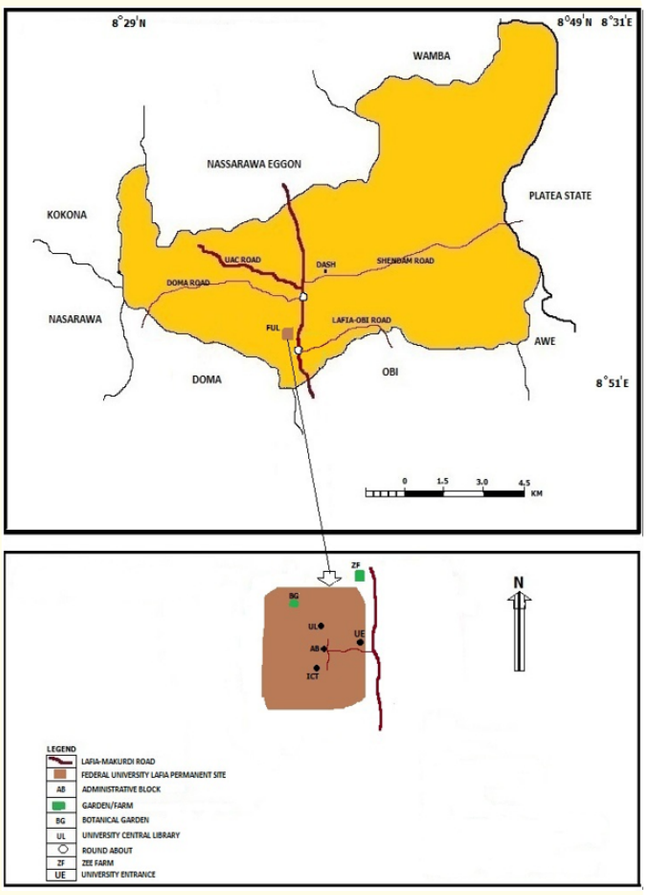

Figure 1: Map of Lafia LGA of Nasarawa State, Nigeria showing Permanent Site of Federal University of Lafia, and map of the Permanent Site of the University showing the *Citrus* orchard denoted by ZF above the green colour patch.

Statistical analysis

Data obtained was analyzed using R Console software version 3.2.2. One way analysis of variance (ANOVA) was used to compare the mean abundance of sunbirds in relation to species, months and as well as time spent foraging across sunbird species. Welch two sample t-test was used to compare the abundance of sunbirds in relation to seasons and as well as time of day. The P-values < 0.05 were considered statistically significant.

Results

Composition of sunbirds foraging on *Tapinanthus globiferus*

A total of 376 sunbirds were sighted which spread across 4 sunbird species in which scarlet-chested sunbird was the most abundant 181 (48.13%) forager on *T. globiferus* followed by variable sunbirds 134 (35.63%) then beautiful sunbird 43 (11.17%) and green-headed sunbird was the least 19 (5.05%) (Table 1). There-

fore, there was a very high significant difference (F_{180} = 8.129, Adjusted R^2 = 0.1046, P < 0.001, Figure 2) in the mean abundance between sunbird species foraging on *T. globiferus*.

Abundance of sunbirds foraging on *Tapinanthus globiferus* in relation to months

The abundance of sunbirds foraging on *T. globiferus* in relation to months was highest in June 142 (37.76%) followed by May 121 (32.18%) and was least in July 21 (5.58%). Therefore, there was a very high significant difference (F_{655} = 9.216, Adjusted R^2 = 0.0586, P < 0.001, Figure 3) in the mean abundance of sunbirds foraging on *T. globiferus* in relation to months.

Table 1: Checklist of sunbird species foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in the permanent site of Federal University of Lafia, Nasarawa State, Nigeria between January and July 2017.

Species	Seasons/Months						
	Dry season (%)			Wet season (%)			
	January	February	March	May	June	July	Total (%)
Beautiful sunbird	2 (4.76)	0 (0.00)	2 (4.76)	4 (9.52)	28 (66.67)	6 (14.28)	**42 (11.17)**
Scarlet-chested sunbird	28 (15.46)	23 (12.70)	12 (6.62)	59 (32.60)	56 (30.93)	3 (1.65)	**181 (48.13)**
Variable sunbird	3 (2.23)	10 (7.46)	12 (8.95)	57 (42.53)	47 (35.07)	5 (3.73)	**134 (35.63)**
Green-headed sunbird	0 (0.00)	0 (0.00)	0 (0.00)	1 (5.26)	11 (57.89)	7 (36.84)	**19 (5.05)**
Total (%)	**33 (8.77)**	**33 (8.77)**	**26 (6.91)**	**121 (32.18)**	**142 (37.76)**	**21 (5.58)**	**376**

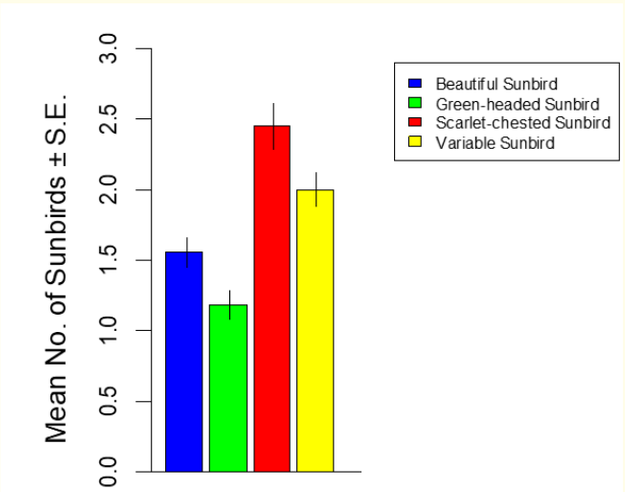

Figure 2: The mean number of sunbird species foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in the Permanent Site of Federal University of Lafia, Nasarawa State, Nigeria between January and July 2017.

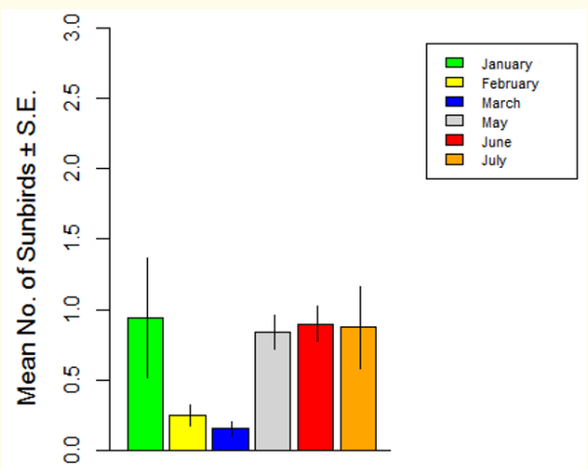

Figure 3: The mean number of sunbirds foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in relation to months.

Abundance of sunbirds foraging on *Tapinanthus globiferus* in relation to seasons

The abundance of sunbirds foraging on *T. globiferus* in wet season was high with a population of 284 (75.5%) than the dry season 92 (24.5%). Therefore, the mean abundance of sunbirds foraging on mistletoe showed a very high significant difference (t = -5.8684, df = 589.02, P < 0.001, Figure 4) in relation to seasons.

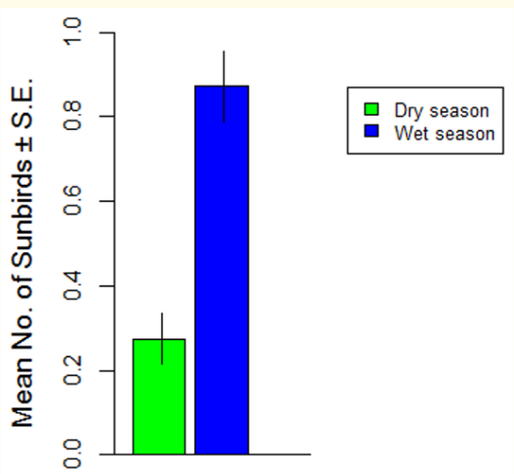

Figure 4: The mean number of sunbirds foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in relation to seasons.

Abundance of sunbirds foraging on *Tapinanthus globiferus* in relation to time of day

The abundance of sunbirds foraging on *T. globiferus* was higher in the morning session 336 (89.40%) than evening session 40 (10.60%). Therefore, the mean abundance of sunbirds foraging on mistletoe showed a very high significant difference (t = 8.5947, df = 472.33, P < 0.001, Figure 5) in relation to time of day.

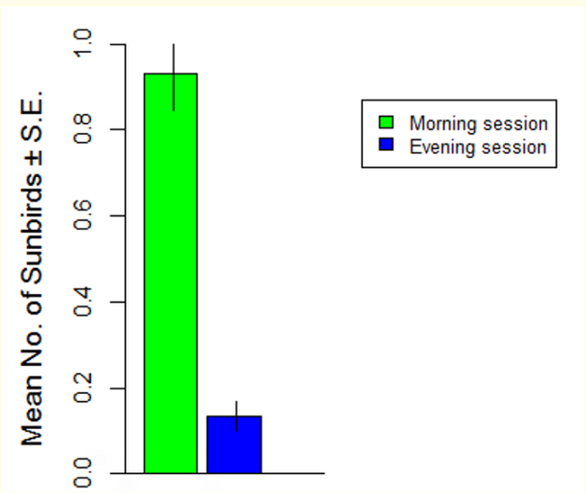

Figure 5: The mean number of sunbirds foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in relation to sessions.

Time spent in foraging on *Tapinanthus globiferus* in relation to sunbird species

On the average, beautiful sunbird spent the highest mean time (20.0 ± 2.0 seconds) foraging on mistletoe followed by scarlet-chested sunbird (18.7 ± 1.2 seconds) then green-headed sunbird (18.5 ± 2.5 seconds) and the least foraging time was observed in variable sunbird (17.8 ± 1.2 seconds). However, there was no significant difference (F_{180} = 0.3172, Adjusted R^2 = -0.01132, P = 0.8129, Figure 6) in the mean time spent foraging on *T. globiferus* across sunbird species.

Discussion

Composition of sunbirds foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis*

The four sunbird species foraging on the flowers of *Tapinanthus globiferus* parasitizing *Citrus sinensis* in FULafia Permanent Site possibly suggests that *T. globiferus* flower obviously has rich nectar content that provides the raw material needed for sunbirds growth, self-maintenance, and reproduction. This stands in line with Watson [23] who reported that birds show preference for living where mistletoe is common. Also, Klinkhamer and de Jong [42] showed that highly dense flowering plant could be an area of food abundance providing more reward for foraging efforts by birds.

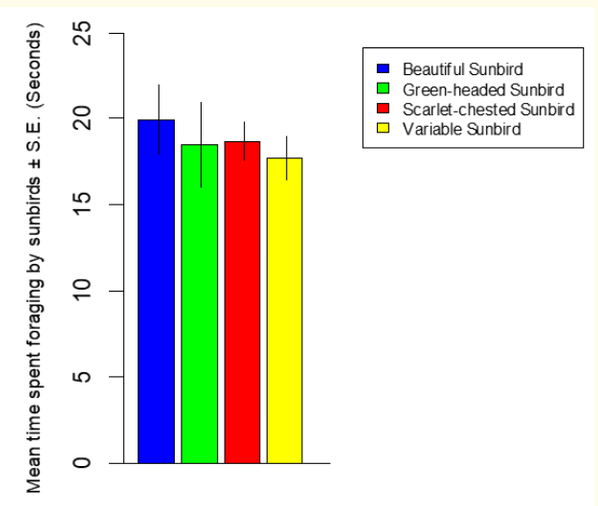

Figure 6: The mean time spent foraging on *Tapinanthus globiferus* parasitizing *Citrus sinensis* in relation to sunbird species.

The high number of sunbirds recorded in this study suggests their preference to forage in a homogenous patch such as the *Citrus* orchard. This agrees with optimization of foraging in a single site in which birds stay longer with more food with less predation risk and energy expenditure [43].

Variability in the abundance of sunbird species on T*apinanthus globiferus*

The variation in abundance of sunbirds on *Tapinanthus globiferus* between species may be due to high survival strategy exhibited by beautiful sunbird who are the species to first open up ripe mistletoe. However, Anthony [44] in a study on seasonal changes in nectar-feeding by birds at Zaria, Nigeria reported that scarlet-chested sunbird was the predominant visitor on ornithophilous plants whereas others were very rare resident birds.

Sunbirds foraging on *Tapinanthus globiferus* in relation to months

The observed difference in the abundance of sunbirds across the months possibly suggests the month of June as the most favourable period due to the very high number of ripe *T. globiferus* flowers observed which translates into a more readily available nectar content that will attract very high number of sunbirds visitors. This agrees with the study in Central Namibia on White-bellied sunbirds which were highest in the month of June but sparsely recorded during July of 2002 [45]. Also, sunbirds abundance have been shown to increase with vegetation diversity and monthly rainfall [29].

Sunbirds visiting *Tapinanthus globiferus* in relation to seasons

The higher number of sunbird visitors on *Tapinanthus globiferus* in wet season over the dry season period possibly implies that

the wet season accelerates flowering rate and quick ripening of the flowers thereby providing sufficient nectar for the sunbirds in very high concentration. This is in agreement with the findings of Mengesha and Bekele [37] who found that seasonality affects food availability of bird population, which in turn affects breeding success and ultimately survival of the bird species. Also, Rebelo [29] and Mengesha *et al.* [38] recorded that rainfall influence the availability of food items which thereby increases sunbirds abundance. On the contrary, Carpenter and Hixon [34] asserted that rainfall interrupted foraging activity of nectarivorous birds in which the number of individuals sighted was low.

Association between sunbirds visits on flowers and time of the day

The variance in the abundance of sunbirds on *Tapinanthus globiferus* across time of day possibly suggests that the morning session yields higher nectar content. This agrees with Adhola and Permain [36] and Quintana-Rodríguez [46] who reported that nectar volume correlate with time of day. Nectar concentration and nectar volume are inversely related where an increase in one leads to a decrease in the other. Plant species build up nectar over night when the activity of nectar feeders is expected to be low [46]. This activity could possibly result in a high nectar volume in the early morning [47] before sunbird activity starts hence the low nectar concentration. Furthermore, physical environmental factors such as humidity, wind, temperature could cause changes in sunbirds abundance and foraging behaviour [48]. On the contrary, the number of visit over time periods during the day by sunbirds in Kibale National park, in Western Uganda showed no variation [49].

Time spent foraging by sunbirds

The evenness in the time spent foraging by sunbird species on *Tapinanthus globiferus* suggests that they have same adaptive behaviour in sourcing for energy and are predispose to similar bird of prey. Similarly, Wolf *et al.* [32] found that the actual foraging efficiency of these nectar-feeding birds is an increasing function of energy available per flower. Sunbirds foraging efficiency or profitability is directly related to foraging time which is linked to predation risk [32].

Conclusion

The abundant and diverse sunbirds recorded on *T. globiferus* parasitizing *Citrus sinensis* signifies that the hemiparasite is highly beneficial and complements food resource required for sunbirds survival and breeding success since it grows all year round. The abundance obtained between sunbird species in the area was the same. Also, sunbirds were more abundant in wet season and most especially in the month of June. The higher abundance of sunbirds recorded in the morning session over the evening session clearly shows that time of day regulates the physiological activity of sunbirds. All the sunbirds recorded spent the same foraging time in order to escape birds of prey in the area. This study shows that the parasitized *Citrus* orchard in FULafia Permanent Site is a potential conservation site that is of immense benefit to sunbirds and other animals too such as the bronze mannakin and African paradise flycatcher that were sighted on the plant during the survey. Hence, the orchard should not be cleared in the near future for the purpose of building structures but be reserved as a part of the Institution's zoological garden.

Bibliography

1. Sulikowski D and Burke D. "Win-shift and win-stay learning in the rainbow lorikeet (*Trichoglossus haematodus*)". *Journal of Comparative Psychology* 125 (2011): 143-149.

2. Beerens JM., *et al.* "Linking dynamic habitat selection with wading bird foraging distributions across resource gradients". *Plos One* 10 (2015): 1-26.

3. Stiles FG. "Geographical aspects of bird-flower coevolution, with particular reference to Central America". *Annals of the Missouri Botanical Garden* 68 (1981): 323 -351.

4. Krebs JR and Davies NB. "An introduction to behavioural ecology, Third edition". Blackwell Science, London. (1993).

5. Kelly D., *et al.* "Is dispersal easier than pollination? Two tests in New Zealand Loranthaceae". *New Zealand Journal of Botany* 42 (2004): 89-103.

6. Voigt FA., *et al.* "Low fruit set in dioecious tree. Pollination ecology of *Commiphora harveyi* South African". *Journal of Tropical Ecology* 21 (2005): 179-188.

7. Segun AO. "Tropical Zoology (2nd Edition)". University Press PLC (1998): 228.

8. Valido A., *et al.* "Bird flower interactions in the macaronesian islands". *Journal of Biogeography* 31 (2004): 1945-1953.

9. Ladley JJ., *et al.* "Explosive flowering, nectar production, breeding systems and pollinators of New Zealand mistletoes (Loranthaceae)". *New Zealand Journal of Botany* 35 (1997): 345-360.

10. Norton DA., *et al.* "Distribution and population structure of Loranthaceous mistletoes *Alepis flavida, Peraxilla colensoi* and *Peraxilla tetrapetala* within two New Zealand nothofagus forests". *New Zealand Journal of Botany* 35 (1997): 323-336.

11. Barlow BA. "Biogeography of loranthaceae and viscaceae". Sydney, Aust: Academic. (1983): 348.

12. Ladley JJ and Kelly D. "Dispersal, germination and survival of New Zealand mistletoes (Loranthaceae): dependence on birds". *New Zealand Journal of Ecology* 20.1 (1996): 69-79.

13. Vaknin Y., *et al.* "Flowering seasonality and flower characteristics of *Loranthus acaciae* Zucc. (Loranthaceae): implications for advertisement and bird pollination". *Sex Plant Reproduction* 9 (1996): 279-285.

14. Burkill HM. "The useful Plants of West Tropical Africa". 3 (families J-L) Royal Botanical Gardens, Kew. (1985): 548-560.

15. Parker C and Riches CR. "Biology and Control". Wallingford: CAB International. Parasitic weeds of the World. (1993): 332.

16. Polhill R and Wiens D. "Mistletoe of Africa". The Royal Botanic Garden, Kew, U.K. (1998): 370.

17. Bright EO and Okusanya BA. "Infestation of economic plants in Badeggi by *Tapinanthus dodoneifolius* (DC) Danser and *Tapinanthus globiferus* (A. Rich) Van Tiegh". *Nigerian J of Weed Science* 11 (1998): 51-56.

18. Gill LS and Onyibe HI. "Mistletoes on rubber trees in Nigeria". *Haustorium* 23 (1990): 1-2.

19. Sridhar TS and Rao VR. "*Dendrophthoe falcata*, a menace to fruit orchards". *Current Science* 38 (1978): 908.

20. Zewdie K and Eshetu T. "Proceedings of the 7 Annual Conference of the Ethiopian Weed Science Committee, Rezene Fesehale (IAR, (Ethiopia) EWSC. Preliminary observation on feasibility of mechanical control of parasitic plants on trees". (1993): 41-42.

21. Jiofack RT., *et al.* "The Loranthaceae of the Bafou area in Cameroon; identification, distribution, biology and eradication strategies". In: Burgt X van der, Maesen, J. van der, Onana, J. M., editors. Systematic and Conservation of African Plants; Proceedings of the 18th AETFAT Congress, Yaounde, Cameroon (2010): 229-235.

22. Dibong SD., *et al.* "The study of sodium and potassium distribution in five host species of *Phragmanthera capitata* (Sprengel) S. Balle in the littoral region of Cameroon". *Journal of Applied Bioscience* 30 (2010): 1839-1844.

23. Watson DM. "Mistletoe - a key stone resource in forests and woodlands worldwide". *Annual Review of ecological Systems* 32 (2001): 219-249.

24. Grund R. South Australian butterflies data sheet: mistletoe. www.Chariot.net.au/~rbg/mistletoe-ds.htm (2002).

25. Krebs JR and Davies NB. "Behavioural ecology". Blackwell Oxford (1997).

26. Nicolson SW and Fleming PA. "Nectar as food for birds: the physiological consequences of drinking dilute sugar solutions". *Plant Systematics and Evolution* 238 (2003): 139-153.

27. Larsson C and Hemborg AM. "Sunbirds (*Nectarinia*) Prefer to Forage in Dense Vegetation". *Journal of Avian Biology* 26.1 (1995): 85-87.

28. Akosim C., *et al.* "Species Obsolute population density and diversity of water bird in wetland areas of Yankari National park, Bauchi state, Nigeria". *Journal of Environment Research* 2.1 (2008): 28-32.

29. Rebelo AG. "Community organization of sunbirds in the Afrotropical region". Proc. XX Int. Orn. Cong. (1990): 1180-1187.

30. Gill FB and Wolf LL. "Economics of feeding territoriality in the golden-winged sunbird". *Ecology* 56 (1975): 333-345.

31. Carpenter FL and MacMillen RJ. "Threshold Model of feeding territoriality and test with a Hawaiian Honey Creeper". *Science* 194 (1976): 639-642.

32. Wolf LL., *et al.* "Foraging Efficiency and Time Budgets in Nectar-feeding Bird". *Ecology* 65 (1975): 117-128.

33. Carpenter FL. "Concluding remarks: social patterns in nectarivorous birds". Proceedings XX Int. Orn. Congr. 1188-1191. In: Larsson, C. and Hemborg, A.M. (1995). Sunbirds (*Nectarinia*) Prefer to Forage in Dense Vegetation. *Journal of Avian Biology,* 26.1 (1990): 85-87.

34. Carpenter FL and Hixion MA. "Distinguishing energy maximizers from time minimizers: a comparative study of two hummingbird species". *Integrative and Comparative Biology* 28 (1988): 913:925.

35. Aluri RJS. "Pollination Biology of *Decalepis Hamiltonni* and *Shorea Tumbuggaia*". (2005).

36. Adhola T and Permain E. "Foraging behaviour of the Nectariniidae in Kirindy forest, using *Chadsia irondoensis* as the focal plant species". (A Tropical Biology Association field course project) (2004).

37. Mengesha G and Bekele A. "Diversity and relative abundance of birds of Alatish National Park". *International Journal of Ecology and Environmental Sciences* 34 (2008): 215-222.

38. Mengesha G., *et al*. "A comparison of terrestrial bird community structure in the undisturbed and disturbed areas of the Abijata Shalla lakes national park, Ethiopia". *International Journal of Biodiversity and Conservation* 3 (2011): 389-404.

39. Newton I. "The Migration Ecology of Birds". Academic Press, San Diego (2008).

40. www.climate-Data.org/AMOP/OpenStreetMapcontributors

41. Burrow N and Demey R. "Field Guide to the birds of Western Africa". Christopher Helm London, Imprint of A & c Black Publishers Ltd (2008): 512.

42. Klinkhamer PGL and de Jong TJ. "Effects of plant size, plant-density and sex differential nectar reward on pollinator visitation in the protandrous *Eschium vulgare* (Boranginaceae)". *Oikos* 57 (1990): 399-405.

43. Smith RL and Smith TM. "Elements of ecology (4th Edition)". Addison Wesley Longman, Inc (2000): 545.

44. Anthony P. "Seasonal changes in Nectar feeding by Birds at Zaria, Nigeria". *IBIS* 119.3 (1977): 291-308.

45. Wessel S. "Seasonal movements and distribution of the White-bellied sunbird in Western and Central Namibia". *Bird Numbers* 13.1 (2004): 31-34.

46. Quintana-Rodríguez E., *et al.* "Biochemical Traits in the Flower Lifetime of a Mexican Mistletoe Parasitizing Mesquite Biomass". *Frontiers in Plant Science* 9 (2018): 1031.

47. Gryj E.*, et al.* "Avian pollination and nectar use in *Combretum fruticosum* (Loefl.) stuntz". *Biotropica* 22 (1990): 266-271.

48. Ramsey M. "Causes and Consequences of Seasonal Variation in Pollen Limitation of Seed Production in *Blandfordia grandiflora* (Liliaceae)". *Oikos* 73 (1995): 49-58.

49. Desta HT.*, et al.* "Patterns of sunbird visitation to four sympatric plant species in Kibale National Park, Uganda". *International Journal of Molecular Evolution and Biodiversity* 6.3 (2016): 1-8.