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Avian Utilization of the Fruits of *Carissa Edulis* Vahl and *Jasminum Dichotomum* Vahl in A Central Nigerian Reserve

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Abstract
This study determined the avian fruit utilizers of the plants *Carissa edulis* and *Jasminium dichotomum* both related in the colour and size of their fruits. Furthermore, the study also compared the two plant species in terms of the diversity of avian fruit utilizers, their frequency and duration of visits and activities performed during visits to the plant species. Data was collected in the Amurum Forest Reserve, north central Nigeria, between June and July 2011 through focal observations. A total of 107 individual birds comprising 22 species were recorded during the study. *C. edulis* had the highest diversity and abundance of bird species as compared to *J. dichotomum*. Seven bird species were exclusively found on *C. edulis* while 5 bird species were exclusive to *J. dichotomum*. The Common bulbul (*Pycnonotus barbatus*) and Speckled mousebird (*Colius stratus*) were the most common bird species observed on the two plants. Mean time spent foraging differed significantly across bird species foraging on *C. edulis* but not on *J. dichotomum* with the Western grey plantain-eater (*Crinifer piscator*) spending the highest time foraging on the former. Activities performed by bird species on the two study plants include foraging and perching which did not differ significantly between plants. These observations highlights the ecological importance of the two plants within the reserve particularly in enhancing the survival of other animal groups within the reserve.
Keywords: *Carissa edulis, Jasminum dichotomum*, Bird species, Fruit, Frugivores.

1. Introduction

Plants are the primary food source for majority of tropical animals, which in turn are major dispersal vectors for the plant species. Dispersal of fruits and seeds determines where plant species are found in a given habitat. The types and sizes of fruits and seeds produced by plants provide information about what food may be available for animal species within a given habitat (Lundberg and Moberg 2003; Mayfield *et al*., 2006). Birds contribute to ecosystem services through their foraging behaviour (Whelan *et al.*, 2008). Some birds visit plants for their fruits thus serving as dispersers of such plant seeds (Krebs, 2001).

The outcome of mutualistic interactions of plants and animals depend on the complex structures of the plants such as flowers and fruits (Herrera *et al*., 2002). Complex anatomical structures of fleshy fruits consist of phenotypically and functionally complex organs resulting from various combinations of visual, nutritional and morphological traits. These combinations of traits interact with the visual, tactile and gustatory senses of frugivorous animals (Jordano, 2000). Animals therefore, select fruits differentially based on their different sensory ecology (Lomascolo *et al*., 2010) which potentially leads to different phenotypic interactions. The fruit colour attracts frugivores from a distance. The fruit morphology interacts with the tactile senses as the animal picks the fruits, while fruit chemistry interacts with taste and digestion when the fruit is eaten (Valido *et al*., 2011). Colour is an important mediator in plant-animal communication. Frugivorous animals use visual stimuli as indicators of nutritional rewards. Therefore, fruit selection by frugivorous animals is mediated by the colour of the fruits (Lomascolo, 2010).

Carissa is a genus of plants belonging to the family Apocynaceae. It is commonly referred to as simple-spined Carissa and *lemun tsuntsu* in Hausa language in northern part of Nigeria. It's been described by Orwa *et al.* (2009) as a shrub, with spines up to 5 m. Leaves are ovate, opposite, leathery, dark green above and paler green below. Flowers are white tinged with purple, up to 1.8 cm long, about 2 cm in diameter, slender and tubular, it is sweetly scented, in terminal heads about 4 cm in diameter. Flowering occurs from September to December and fruiting from November of a year to January of another year. Insects pollinate the bisexual flowers. Fruits are ovoid in shape, up to 1.1 cm in diameter, red-black in colour to purplish black when fully ripe, containing 2-4 flat seeds.

Jasminum dichotomum belongs to the family Oleaceae. The plant is commonly referred to as Jasmine or Gold coast Jasmine. Jasmine has been described by Long and Lakela (1971) as an evergreen woody climber, 8m tall with glabrous stem. Leaves are unifoliate, simple, roundish oblong, glossy, leathery, 5-7cm long with pointed tips. Flowers are white in colour which open at night and quite fragrant, they occur in clusters at leaf axils, petals are fused into a narrow tube of 2.5 cm long, with 5-9 terminal lobes about 1.3 cm long. The fruit is a small fleshy berry, 2-lobed, roundish and black in colour. Flowering occurs all year round. However, personal

observations showed flowering as lasting only between September to December in the Amurum forest Reserve, Nigeria while fruiting was observed from January to August.

Carissa edulis and *Jasminum dichotomum* have similar flower colour and fruit size and they both flower and fruit at almost the same time usually at the onset of the rainy season in the reserve. Thus, it is important to determine whether these similarities also influences the type and behaviour of animal visitors to the two plants particularly frugivorous birds which have the potential of exploiting the fruits presented by the two plants. Notwithstanding, avian utilizers of these plants fruits in the Amurum Forest Reserve are yet to be established through detailed scientific studies. Thus, the aim of this research was to find out how *Carissa edulis* and *Jasminum dichotomum* are utilized by birds in Amurum Forest Reserve.

2. Materials and Methods

2.1 Study site

This research was carried out in Amurum Forest Reserve (9º53'N, 8º 59'E). It is located in Laminga village, 15 km northeast of Jos, Plateau state, North-Central Nigeria. It covers an area of about 300 ha and a mean annual rainfall of 1375 mm-1750 mm per annum with a mean temperature of 10-13 ºC. Habitat types in the area include rocky outcrops, dry scrub savannah with gallery forests and patches of grassland (Fig. 1). The most unique species of biological significance are the avifauna population; the reserve holds about 300 species of birds which includes the nationally endemic *Lagonosticta sanquinodorsalis* and its brood-parasite *Vidua maryae*. The common tree species in the reserve include *Khaya senegalensis, Daniella oliveri, Parkia biglobosa, Lophira lanceolata, Ficus spp* (Ezealor, 2002).

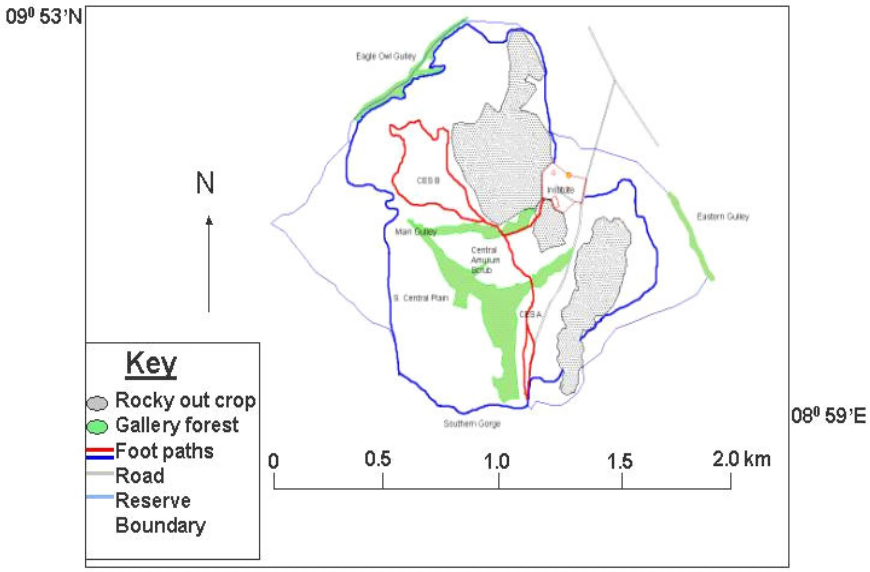

Figure 1: Map of Amurum Forest Reserve

2.2 Focal observation

Twenty individual plants of each species were selected using stratified random sampling such that no two individual plants of same species were less than 50 m from each other. The focal observation was carried out in three sessions viz: morning session: 6.30 am to 8.30 am, afternoon session: 12.00 am to 2.00 pm and evening session: 4.00 pm to 6.00 pm. Each session was observed five times a week, for two months.

During each observation session, one focal plant of each species was observed for a period of 1 hour each. Birds and other animal species that visited each plant were identified and recorded. The arrival time, departure time, and activity carried out by the birds and other animals observed on the focal plant were also recorded. A pair of binoculars (Olivon 10 x 42 field of view) and bird guide (Borrow and Demey, 2004) was used to confirm identification of bird species.

2.3 Data analysis

Data analysis was carried out using R statistical package (2.9.0).

The normal Q-Q plot was used to test for normality of the response variables. Diversity of visiting bird species on each plant species was determined using Shannon Weiner diversity index:

$$H = \frac{n \log n - \sum fi \log fi}{n} \qquad (1)$$

where: fi = number of observations in category i, n = sample size.
One-way ANOVA and independent sampled t-test was used in statistical analyses of the normally distributed variables. Kruskal-Wallis test and Mann-Whitney u test were used in statistical analyses involving non-normally distributed variables.

3.0. Results

3.1 Bird Species diversity

A total of 107 individual birds comprising 22 species belonging to 14 families were observed on both *Jasminum dichotomum* (Jasmine) and *Carissa edulis* (Carissa). Fifty eight of 107 (54.21%) individuals making up 16 species were observed on Carissa and 49 of 107 (45.79%) individuals comprising 14 species were observed on Jasmine. 9 bird species visited both Jasmine and Carissa while 5 bird species were exclusive visitors of Jasmine and 7 species were recorded exclusively on Carissa (Table 1). Bird species observed includes frugivores (65%), insectivores (19%) and granivores (16%). Bird diversity was higher on Carissa (0.225) than Jasmine (0.176). There was no significant difference in the diversity of bird species that visited Jasmine and Carissa (Mann-Whitney u test: W = 100, p = 0.67).

3.2 Mean number of visits by Bird Species

A total of 49 visits were recorded on Jasmine. Thirteen of 49 (26.53%) were Common Bulbuls and 7 of 49 were Village Weavers. Yellow-mantled Widowbird, Speckle-fronted Weaver and Yellow-fronted Tinkerbird visited once thus making 2.04% per visit (table 1). The avian visitors varied significantly in their mean number of visits per hour on Jasmine (Kruskal-Wallis test, $X^2 = 66.00$, df = 14, $p < 0.001$; table 1).

Also, of the total 58 visits recorded on Carissa; thirteen of 58 (22.41%) visits were by the Speckled Mousebird, 8 (13.79%) visits each by African Thrush and Common Bulbul and 1(1.72%) visit each by Purple- Glossy Starling, Northern Red Bishop, Western Grey Plantain-eater, Pin-tailed Whydah, Senegal Eremomela and Scarlet-chested Sunbird. Kruskal-Wallis test showed a high significant difference in the hourly visits by bird species observed on Carissa (Kruskal-Wallis test, $X^2 = 66.53$, df = 16, $p < 0.001$; table 1). However, mean number of visits by bird species did not vary significantly between Carissa and Jasmine
(Mann-Whitney u test: W = 2941, p = 0.13).

Table 1: Checklist showing bird species visits on Carissa and Jasmine

English name	Scientific name	No. on Jasmine (N=20)	No. on Carissa (N=14)
African Thrush	*Turdus pelios*	_	0.40 ± 1.76
Black- crowned Tchagra	*Tchagra senegalus*	0.10 ± 0.57	_
Bronze Mannikin	*Spermestes cucullatus*	_	0.15 ± 0.75
Common Bulbul	*Pycnonotus barbatus*	0.65 ± 2.82	0.40 ± 1.81*
Grey-backed Camaroptera	*Camaroptera brachyura*	0.10 ± 0.49	0.15 ± 0.86
Northern Crombec	*Sylvietta bracchyura*	_	0.05 ± 0.29
Northern Red Bishop	*Euplectus fransiscanus*	0.15 ± 0.86	0.10 ± 0.57
Purple Glossy Starling	*Lamprotonis purpureus*	0.15 ± 0.86	0.05 ± 0.29
Pin-tailed Whydah	*Vidua macroura*	_	0.05 ± 0.29
Red-billed Firefinch	*Lagonosticta senegala*	0.10 ± 0.57	_
Red-cheeked Cordon-blue	*Uraegintus bengalus*	0.15 ± 0.86	_
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	_	0.05 ± 0.29
Senegal Eremomela	*Eremomela pusilla*	_	0.05 ± 0.29
Speckle-fronted Weaver	*Sporopipes frontalis*	0.05 ± 0.29	_
Speckled-Mousebird	*Colius stratus*	0.20 ± 0.93	0.65 ± 2.80
Village Weaver	*Ploceus cucullatus*	0.35 ± 1.66	0.10 ± 0.57
Variable Sunbird	*Cynnirus venustus*	0.25 ± 1.19	0.35 ± 0.57
W.grey Plantain-eater	*Crinifer piscator*	_	0.05 ± 0.29
Yellow-crowned Gonolek	*Laniarus barbarus*	0.10 ± 0.57	0.10 ± 0.57
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	0.05 ± 0.29	0.20 ± 1.02
Yellow-mantled Widowbird	*Euplectus macrouca*	0.05 ± 0.29	_

3.3 Mean time spent by Bird Species

There was a significant difference in the mean time spent by bird species between Jasmine and Carissa (Independent- sampled t test: t = 5.2538, df = 73.585, $p < 0.001$; table 2). There was no significant difference in the mean time spent by bird species on Jasmine (One-way ANOVA: $F_{13, 19} = 1.479$, $R^2 = 0.16$, p = 0.21). However, mean time spent was significantly different among bird species observed on Carissa (Kruskal-Wallis test, $X^2 = 25.52$, df = 15, p = 0.04).

Table 2: Mean time spent by bird species on Carissa and Jasmine

Plant species	Mean time spent (Seconds) ± S.E
Carissa	0.0128 ± 0.0023
Jasmine	0.0004 ± 0.0001

3.4 Activity carried out by Bird Species on Plants

Activities carried out by avian visitors include feeding and perching. On Jasmine, 34 (69.39%) out of 49 individual birds were seen perching on the plant. The remaining 15 (30.61%) individuals fed on the fruits. However, there was no significant difference between these activities on Jasmine (Mann-Whitney u test, W = 187.5, p= 0.72) although on the average, more individual birds perched on Jasmine than actually fed.

On Carissa, 26 out of a total of 58 (i.e. 44.83%) individuals observed on the plant were seen perching, while 32 of 58 (51.17%) fed on the fruits. Unlike Jasmine, the mean number of birds that fed on the fruits of Carissa was higher than those that perched, but the difference is not significant (Mann-Whitney u test: W = 220, p = 0.57). There was no significant difference observed in the number of birds feeding on the two plants (Mann-Whitney u test: W = 237.5, p= 0.28).

3.5 Other animal groups recorded on the two plants

Other animals were seen on Carissa; but none was seen on Jasmine. These animals included *Chlorocebus aethiops tantalus* (Tantalus Monkeys), *Sciurus niger* (Tree Squirrels) and *Gymnarionn* Species (Snails). A total of 15 individuals made up of 9Tantalus Monkey (60%), 3 tree squirrel (20%) and 3 snails (20%) were recorded (table 3). The snails spent the highest amount of time foraging while tantalus monkeys spent the shortest period of time (table 3). Tantalus monkeys were seen in their number plucking and eating the ripe fruits. Individual snails were seen on the leaves most of the time and were observed licking the flowers and eventually feeding on ripe fruits that are already opened by the coleopterans and birds. Tree squirrels were seen moving on the plant, but not feeding on the fruit.

Table 3: Result for other animal groups (N= 20 plants observed)

Animal	Mean number visit ±S.E	Mean time spent ±S.E	Activity
Tantalus Monkey	0.45±0.36	0.020 ± 0.018	foraging
Tree Squirrel	0.15±0.11	0.017 ± 0.015	movement
Snail	0.15±0.08	0.106 ± 0.074	foraging

4.0. Discussion

Plants tend to benefit from diverse animal mutualists, and plant-visiting animals on the other hand tend not to specialize on any one plant (Waser *et al.* 1996). Carissa is more diverse in terms of avian visitors than Jasmine and this may be attributed to differences in the morphological and chemical traits of their fruits especially colour, smell and nutritional content. In terms of colour, previous studies (Valido *et al.* 2011) have suggested that frugivorous animals can use visual stimuli to indicate nutritional rewards particularly, fruit colour (Schaeffer *et al.,* 2008). Willson and Whelan (1990) also pointed out that birds select fruits of certain colours because of their conspicuousness to the forager and colours indicate fruit maturity and facilitates food recognition sources. Another likely factor that can play a role in avian visitation to the two plants may be fruit texture; the fruits of Carissa are more fleshy and succulent than Jasmine which may therefore be easier to handle (chew) by most animals than the less fleshy fruit of Jasmine. In addition to these reasons, resource availability (fruit yield) may also encourage high avian visits to a plant (Lomascolo & Schaeffer 2010) although this was not directly measured in this study.

Avian visitors to both Carissa and Jasmine consists of different avian groups, these include the frugivores, insectivores and granivores. Frugivorous birds that visited the two plants include Common Bulbul, Speckled Mousebird, Yellow-fronted Tinkerbird, and Purple Glossy Starling. The Western Grey Plantain-eater and African Thrush visited only Carissa while Black-crowned Tchagra visited only Jasmine. Granivorous birds sighted on both Carissa and Jasmine are Northern Red Bishop and Village Weaver. Red-billed Firefinch, Speckled-fronted Weaver, Red-cheeked Cordon-blue and Yellow-mantled Widowbird were sighted on Jasmine, while Pin-tailed Whydah and Bronze Mannikins were seen only on Carissa. Insectivorous birds seen on the two study plants include Grey-backed Camaroptera, Yellow-crowned Gonolek and Variable Sunbird (although predominantly a nectarivore). Northern Crombec, Senegal Eremomela and Scarlet-chested Sunbird were recorded only on Carissa. The fact that Carissa had a higher diversity of avian fruit utilizers than Jasmine can be attributed to the nature of the fruit; the colour and its succulent nature both characters that may influence its being selected by avian visitors over Jasmine. Also, may be due to the fine-tuned abilities of the birds to discriminate for specific nutrient combinations (Jordano, 1988). Fuentes (1995) also pointed out that interspecific difference in fleshy fruits characteristics results in plant species having different visitors of avian

fruit utilizers.

Activities carried out by the different avian groups include perching and feeding. These activities varied between plants and between bird species. On Jasmine, more birds were seen perching than were seen feeding on fruits, while Carissa had more of fruit feeders than birds that perched. Only five bird species foraged on the fruits, these include: purple glossy starling, village weaver, common bulbul, speckled mouse bird, yellow-fronted tinkerbird. The granivores were seen perching except village weaver that was observed feeding on Jasmine fruits. The same bird had also been reported to exhibit nectar thieving on the Mistletoe *Tapinanthus globiferus* in the same habitat (Chaskda, 2005). Such unusual feeding behaviour by a granivore is reported to occur when preferred food becomes scarce (Fry *et al*., 2004) and this was the case during the period of this study as most wild grass seeds were not matured neither seed crops on adjoining farm lands. Insectivorous birds visited the two plants but their rate of visits to the two plants differed; more insectivores were recorded on Carissa than Jasmine. Five species foraged on Carissa fruits which are African thrush, common bulbul, speckled mousebird, Western grey plantain-eater and yellow-fronted tinkerbird. Though insectivorous visit to plants may be for the purpose of feeding on insects that visit fruits, these birds were only observed perching, except variable sunbird and northern crombec that were practically picking insects on Carissa fruits. Fruit consumption by frugivorous birds differed between the two plants. Frugivorous birds fed more on Carissa than Jasmine. Fruit selection by birds is a function of body size because the gape size sets limit for the size and shape of fruit consumed by birds (Valido *et a*l., 2011). Observations from this study tend to support this as smaller birds like yellow-fronted tinkerbird and village weaver were observed not swallowing Jasmine fruits but were rather removing the outer fleshy layer of the fruits and throwing the seeds away. By implication, these two birds may not be effective dispersers of Jasmine since seeds are dropped a short distance away from the parent plant. Larger birds like common bulbul, speckled-mousebird and purple glossy starlings could swallow Jasmine fruits whole which are smaller than Carissa fruits. The above mentioned birds along with African thrush and western grey plantain-eater were observed swallowing Carissa fruits. This reflects the findings of Jordano (1995) where frugivores (e.g., African thrush, warblers and redstarts) were considered legitimate dispersers of *Prunus mahaleb* because they could swallow the fruits whole, while pulp eating species (tits and chaffinches) peck the fruit without detaching it from the mother plant. This type of foraging behaviour of the birds is beneficial to the plants because they stand a better chance of dispersing the seeds of the plant.

Conclusion

Results of this study showed that the fruits of the two study plants, Jasmine and Carissa, are utilized by diverse animal species in the reserve. Not only are these plants important as food sources in the reserve, they also serve as perching substrate for birds. Though most animal species showed preference for Carissa to Jasmine fruits, this however, does not relegate Jasmine to being of less ecological importance. The two plant species are ecologically important as food resource for many bird and insect species as well as other animal species in the reserve. Carissa was recorded as an economic fruit tree to the Laminga community (Molokwu, 2010). Therefore, the management of this plant for ecological and economic purposes is of paramount importance. Carissa and Jasmine have been recorded as host plant species to the hemi-parasitic mistletoe, *Tapinanthus globiferus* which in turn has been shown to be a source of food for sunbird species in the reserve (Chaskda 2005). The dispersal of these plant species by animals that utilize them will help in improving the physiognomy of the reserve especially the savannah. Birds as agents of dispersal of these plant species may convey the seeds of these plants to degraded areas. This will contribute to the restoration of forest patches particularly in human modified landscapes (Mayfield *et al.* 2006).

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