FRUGIVOROUS BIRD SPECIES DIVERSITY IN RELATION TO THE DIVERSITY OF FRUIT TREE SPECIES IN RESERVED AND DESIGNATED GREEN AREAS IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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ABSTRACT

The diversity of frugivorous bird species in relation to tree species diversity was investigated in Designated and Reserved Green Areas of Abuja, Nigeria. The study estimated, investigated and examined trees species and avian frugivore in terms of their diversity. Point-Centered Quarter Method (PCQM) was used for vegetation analysis while random walk and focal observation was used for bird frugivore identification and enumeration. data was collected from six locations coinciding with the local administrative areas within the Federal Capital Territory. These were, the Abuja Municipal Area Council (AMAC), Abaji, Bwari, Gwagwalada, Kuje and Kwali. AMAC is designated as urban while the remaining five sites are designated as sub-urban. The highest number of fruit tree species was encountered in AMAC (30), followed by Abaji (29) while 27, 25, 19 and 11 fruit tree species were encountered in Kwali, Bwari Gwagwalada and Kuje respectively. The similarity or otherwise dissimilarity in fruit tree species composition between each pair of the enumerated sites showed Gwagwalada and Kuje as the most similar, and the similarity or otherwise dissimilarity in frugivorous bird species composition between each pair of the enumerated showed higher species similarity between the AMAC and each of the other sites, and between each pair of the sites than that of the fruit trees in the respective sites. Highest number of frugivore bird species was encountered in Kwali (41), followed by Bwari (39) and AMAC (38) while 35, 34 and 21 species were encountered in Gwagwalada, Kuje and Abaji respectively. The alpha (within-site) diversity of frugivore bird species at different sites using Simpson and Shannon-Wiener diversity indices showed that Gwagwalada is the most diverse of all the sites, followed by Kuje and Kwali respectively. The diversity indices of frugivores and fruit-trees were correlated, a weak relationship was observed (r= - 0.2323 and r = - 0.1626), and Null hypothesis was accepted. Also, ANOVA was carried out to test for significance between the sites and the tree physical structure parameters. The result showed no significant difference between the sites (F_{cal}=0.236603 and F_{Crit} =2.901295), and the null hypotheses was accepted. Again, there was significant differences between the tree physical structure parameters (F_{cal}=20.58803 and F_{Crit} =3.287382), the null hypothesis was rejected. It was therefore concluded that these reserved areas need more protection to enhance both the beta and alpha diversities in order to support more interactions.

Keywords: Frugivores, Fruit trees, Diversity, Interaction, Green Areas, Urban ecosystems.

INTRODUCTION

Biodiversity is significant for a wide range of reasons including the intrinsic value that it has to humanity. For ecologist, the primary concern with biodiversity is in its relationship with ecosystem functioning. Ecosystems with greater diversity are regarded as more complex and are expected to be more stable i.e. more resistant or resilient to disturbance. Thus, higher biodiversity is expected to bestow

greater stability to an ecosystem (Rooney *et al.*, 2006). The complexity-stability hypothesis was first put forward by MacArthur (1955) and Elton (1958). Although some studies (e.g. May, 1972) have cast doubt on this hypothesis, many others appear to support it (e.g. McCann 2000; Ives and Carpenter, 2007).

Biodiversity is viewed from several perspectives including genetic diversity, species diversity, functional diversity and habitat diversity. Each of these types provides some form of heterogeneity to the system and, in this way, affects both the structure and function of ecosystems. One way in which biodiversity can influence ecosystem function is through the increase in spatial heterogeneity (Chesson and Rosenzweig, 1991). Spatial heterogeneity is bestowed on the ecosystem system through the diversity of habitats it contains as well as its species composition. For example, a higher tree species composition can affect diversity of other species since trees can serve not only as a source of resources such as food and shelter but also influence abiotic conditions and create microhabitats. Bird species diversity, in particular, is expected to be influenced by tree species diversity since birds rely a great deal on trees as resources in one way or the other (e.g. nesting, roosting and feeding). According to Wiens and Rotenberry (1981), areas of higher habitat diversity (more complex in physical structure and composition) tend to support most bird species, because diverse habitat structure offer a variety of ecological niches occupied by different bird species at different time. Frugivorous bird species play a significant role in seed dispersal thus creating plant-frugivore interactions that constitute an important step in the reproductive cycles of many plants (Harper, 1977) and the sustenance of natural forest regeneration within the urban environment. Changes in bird species composition and abundance have been associated with changes in habitat heterogeneity (Shankar Raman, 2001).

As in the natural environment, biodiversity is also important in urban ecosystems. Urban ecosystems have been described as nodes of interaction between humans and nature (Pickett *et al*., 2001), and have dynamics similar to those of natural ecosystems. They are, however, faced with challenges that are peculiar to them. These include altered drainage as a result of increased impervious surfaces and other anthropogenic perturbations. Consequently, ecological factors that enhance resilience and stability are particularly important in urban ecosystems. Since enhanced diversity is associated with higher ecosystem stability, this has become an important area of interest for urban ecologists and conservation biologists.

The Federal Capital Territory of Nigeria is a planned area in central Nigeria designed to be the administrative capital of Nigeria. It includes a number of Designated Green Areas (DGAs), some of which are regarded as Reserved Green Areas (RGAs). DGAs are portions of land within the FCT where infrastructural developments are prohibited, but accessed by people and hold intact the representative samples of the actual fauna and flora before the urbanization. RGAs designated areas with total restrictions to both human activities and infrastructural development. Designated areas are crucial for the maintenance of biodiversity within FCT. It is therefore important to collect ecological information necessary for their management. This study is intended to provide some information on the relationship between tree species diversity and bird species diversity within the FCT as part of that process.

MATERIALS AND METHOD

Description of the Study Area

This study was conducted within the Federal Capital Territory (FCT), Abuja, Nigeria. According to NAPEP (2003), Abuja is on a 8,000 square-kilometer land area. The FCT is located between latitude $8^0\ 25^1$ and $9^0\ 25^1$ north of the equator and longitude $6^0\ 45^1$ and $7^0\ 45^1$ east of Greenwich Meridian and is bounded by Niger to the West, and North West, Nasarawa to the East, Kogi to the South and Kaduna to the North of the territory. This enormous area was considered essential in order to allow room not just for the capital city but also for a city region that will provide most of the needs of the city, including parks, gardens, reserved green areas, water, forestry, industrial, agricultural, defense, air transport and other needs (Danmole, 2004).

Data Collection

The study area was divided into two strata representing urban and sub-urban locations. The urban stratum comprised of the AMAC area while Abaji, Bwari, Gwagwalada, Kuje and Kwali were regarded as sub-urban. AMAC, the urban stratum, is highest density commercial, residential and government offices area of the FCT while the suburban areas are satellite settlements surrounding AMAC and separated from it by an expanse of sparsely inhabited mosaic of natural vegetation and farmland. The suburban sites are separated from each other by at least a distance of less than 3k and are linked to one another by natural corridors. Within the AMAC are natural and artificial corridors linking metapopulations.

Identification and Enumeration of Fruit Trees

Vegetation sampling was conducted by P.C.Q.M (Kevin, 2007; Machange, 1985). P.C.Q.M was carried out by measurement of distances from randomly chosen points to the

nearest woody plant species. Twenty random sampling points were located along a series of line transects passing through the stand (Compass direction). At each sampling point, 4 quarters (quadrants) were established using a cross. The individual nearest the point in each quadrant was located and enumerated.

Identification and Enumeration of Frugivores

Frugivores in each of the study site were identified using field guide book by (Borrow and Demey, 2004). Observation was carried out using the random walk/watch technique (T. Disley pers. Com. March, 2006; Joshi *et al.*, 2012). Random walks were carried out between 6.00 am to 6.00 pm to document what frugivores species are found in a particular study site. Interactions of frugivores with the fruit trees were observed by focal watch (Ihuma *et al.,* 2011).

Data Analysis

Species diversity is one of the most obvious and characteristic feature of a community. Two common approaches for measuring alpha diversity are species richness and evenness/heterogeneity (Ojo, 1996). Species richness simply refers to the number of species in the community while evenness/heterogeneity refers to the distribution of individuals among the species. In this study, species richness was computed as the total number of tree species encountered in each site. For the measurement of evenness/heterogeneity, Simpson's and Shannon-Wiener indices were computed for each of the sites using the Paleontological Statistics (PAST) software

Measurement of Correlation between Diversity of Fruit Trees and Diversity Frugivores

Pearson's correlation coefficient (r) was used to examine the correlation between diversity of fruit trees and frugivores using Simpson's and Shannon-Weiner diversity indices. This was done by using the Paleontological Statistics (PAST) software.

RESULTS

Fruit Tree Species Composition of Different Sites

The fruit tree species present at the various sites and the number of individuals encountered is presented in Table1. The highest number of fruit tree species was encountered in AMAC (30), followed by Abaji (29) while 27, 25, 19 and 11 fruit tree species were encountered in Kwali, Bwari Gwagwalada and Kuje respectively. A total of 3 unknown fruit tree species were encountered Kwali. Individual tree species mostly encountered include *Parkia biglobosia, Mangifera indica* and *Bridelia ferruginea* however, *Ixora coainea, Ficus thonningii, Vitex Spp Ficus* spp.

Table 1: Fruit Tree Species Composition of the Enumerated Sites and Number of Individuals encountered

S/No.	Fruit trees	Sites					
		AMAC	**Abaji**	**Bwari**	**Gwagwa**	**Kuje**	**Kwali**
1	*Annona senegalensis*	1	0	1	2	1	3
2	*Azadirachta indica*	3	3	3	0	0	0
3	*Bridelia ferruginea*	1	1	4	2	1	0
4	*Ficus benjamina*	1	0	0	0	0	1
5	*Ficus capensis*	1	0	0	0	1	0
6	*Ficus lyrata*	1	0	1	1	0	0
7	*Ficus thonningii*	1	0	0	0	0	0
8	*Gmelina arborea*	2	1	2	1	0	0
9	*Ixora coainea*	1	0	0	0	0	0
10	*Mangifera indica*	3	6	2	0	1	2
11	*Parkia biglobosa*	7	12	8	5	1	6
12	*Syzyguim guineinse*	2	1	1	2	0	0
13	*Terminalia catapa*	2	1	0	0	0	0
14	*Vitex doniana*	3	1	1	4	0	1
15	*Vitex* sp	1	0	0	0	0	0
16	*Anthocleista vogelii*	0	2	2	0	1	1
17	*Delonix regia*	0	1	0	1	0	1
18	*Prosopis africana*	0	0	0	1	5	6
19	*Ficus* sp	1	0	0	0	0	0
20	Unknown 1	0	0	0	0	0	1
21	Unknown 2	0	0	0	0	0	2
22	Unknown 3	0	0	0	0	0	3
	Total	30	29	25	19	11	27

Source: Field Survey, 2014; AMAC: Abuja Municipal Area Council

Frugivore Species Composition of Different Sites

The frugivores present at the various sites and the number of individuals encountered is presented in Table 2. The highest number of frugivorous species was encountered in Kwali (41), followed by Bwari (39) and AMAC (38) while 35, 34 and 21 species were encountered in Gwagwalada, Kuje and Abaji respectively. Frugivores species most frequently observed were *Pycnonotus barbatus Turdus pelios, Streptopelia semitorquata, Laniarius aethiopicus* and *Treron calva* however, frugivore species that are not observed frequently includes *Chrysococcyx caprius, Zosterops senegalensis* and *Lagonosticta rubricate*

Table 2: Frugivores at Different Sites and Number of Individuals Encountered

S/No.	Family	Bird Species	Sites					
			AMAC	Abaji	Bwari	Gwa	Kuje	Kwali
1	Turdidae	*Turdus pelios*	29	31	20	16	11	20
2	Pycnonotidae	*Pycnonotus barbatus*	40	35	34	24	21	23
3	Pycnonotidae	*Chlorocichla flavicollis*	10	0	3	8	0	6
4	Pycnonotidae	*Chlorocichla simplex*	0	0	12	0	0	0
5	Ploceidae	*Ploceus cucullatus*	14	0	11	9	5	13
6	Ploceidae	*Ploceus ocularis*	1	0	2	13	14	0
7	Ploceidae	*Anaplectes rubriceps*	7	16	1	7	9	8
8	Sturnidae	*Lamprotornis purpureus*	5	8	8	6	4	11
9	Sturnidae	*Phoeniculus purpureus*	4	3	2	5	2	8
10	Musophagidae	*Crinifer piscator*	11	17	7	11	24	7
11	Musophagidae	*Musophaga violacea*	2	1	2	10	31	7
12	Coliidae	*Colius striatus*	0	0	11	0	0	3
13	Campephagidae	*Campephaga phoenicea*	1	0	2	7	3	9
14	Timaliidae	*Turdoides plebejus*	2	0	1	4	23	7
15	Zosteropidae	*Zosterops senegalensis*	0	0	7	0	0	0
16	Columbidae	*Streptopelia senegalensis*	0	0	5	4	0	2
17	Columbidae	*Streptopelia semitorquata*	22	25	23	15	9	2
18	Columbidae	*Streptopelia vinacea*	1	2	13	9	3	1
19	Columbidae	*Treron calva*	10	26	14	5	11	2
20	Columbidae	*Turtur afer*	1	0	1	7	0	2
21	Oriolidae	*Oriolus auratus*	1	0	2	7	5	2
22	Cuculidae	*Centropus senegalensis*	3	3	20	10	3	2
23	Cuculidae	*Oxylophus levaillantii*	1	4	0	6	1	1

Table 2 *Cont'd*

S/No.	Family	Bird Species	Sites					
			AMAC	Abaji	Bwari	Gwa	Kuje	Kwali
24	Cuculidae	*Chrysococcyx caprius*	0	0	0	0	0	2
25	Malaconotidae	*Corvinella corvine*	0	0	1	5	15	3
26	Malaconotidae	*Malaconotus blanchoti*	1	0	1	10	11	1
27	Malaconotidae	*Laniarius aethiopicus*	21	21	10	5	2	2
28	Malaconotidae	*Dryoscopus gambensis*	1	0	0	9	0	0
29	Sylviidae	*Camaroptera brachyuran*	1	0	0	7	0	0
30	Sylviidae	*Phylloscopus trochilus*	2	4	6	7	1	6
31	Sylviidae	*Sylvia borin*	0	9	8	7	4	6
32	Sylviidae	*Hippolais polyglotta*	1	0	0	6	8	11
33	Sylviidae	*Cisticola cantans*	5	25	1	5	0	11
34	Sylviidae	*Acrocephalus scirpaceus*	0	8	3	0	7	16
35	Sylviidae	*Eremomela pusilla*	1	0	0	0	5	10
36	Sylviidae	*Sylvietta brachyuran*	3	6	1	0	5	7
37	Capitonidae	*Pogoniulus chrysoconus*	1	0	2	8	0	6
38	Capitonidae	*Lybius dubius*	8	3	12	7	6	9
39	Bucerotidae	*Tockus nasutus*	7	24	0	8	0	12
40	Platysteiridae	*Platysteira cyanea*	9	0	3	3	9	13
41	Coraciidae	*Eurystomus glaucurus*	0	0	5	0	6	11
42	Coraciidae	*Coracias abysinnicus*	4	13	2	0	6	9
43	Estrildidae	*Spermestes cucullata*	1	0	2	8	3	2
44	Estrildidae	*Lagonosticta rubricate*	1	0	0	0	6	0
45	Estrildidae	*Uraeginthus bengalus*	1	0	5	0	5	11
46	Psittacidae	*Agapornis pullarius*	3	0	5	0	6	10

Source: Field Survey, 2014; AMAC: Abuja Municipal Area Council

Similarity and Dissimilarity of Sites in terms of Fruit Tree Species Composition

The similarity or otherwise dissimilarity in fruit tree species composition between each pair of the enumerated sites is shown in Table 3 below. Gwagwalada and Kuje are the most similar, followed by Kwali and AMAC, Kwali and Abaji, Bwari and Kwali AMAC and Kuje AMAC and Gwagwalada and Abaji and Kuje respectively. A total of 29, 11, 5, 3, and 1 fruit tree species found in AMAC were not found in Kuje, Gwagwalada, Bwari, Kwali and Abaji respectively. 9 fruit tree species each were common to AMAC and Abaji, and AMAC and Bwari while 5 fruit tree species each were common to AMAC and Kuje and AMAC and

Kwali respectively. Only 7 fruit tree species were common to AMAC and Gwagalada. AMAC and Bwari are the most similar in terms of fruit tree species composition, followed by fragments AMAC and Abaji, Abaji and Gwagwalada and Abaji and Kuje respectively.

Table 3: Sorenson's Similarity Indices for Fruit Trees at Different Sites

Sites	**AMAC**	**Abaji**	**Bwari**	**Gwagwalada**	**Kuje**	**Kwali**
AMAC	*	0.72	0.72	0.58	0.45	0.40
Abaji	0.72	*	0.78	0.63	0.59	0.48
Bwari	0.72	0.78	*	0.63	0.63	0.42
Gwagwagwalada	0.58	0.63	0.63	*	0.38	0.50
Kuje	0.45	0.59	0.63	0.38	*	0.47
Kwali	0.40	0.48	0.42	0.50	0.47	*

Similarity and Dissimilarity of Sites in terms of Frugivorous Species Composition

The similarity or otherwise dissimilarity in frugivore species composition between each pair of the enumerated sites is shown in Table 4. Frugivore species similarity was higher between the AMAC and each of the other sites, and between each pair of the sites than that of the fruit trees in the respective sites. Abaji and Gwagwalada are the most dissimilar, followed by Kuje and Abaji and Abaji and Kwali. 21, 7 and frugivore species found in Kuje were not found in Abaji, Gwagwalada and AMAC respectively while 17 species found in AMAC were not found in Abaji. 30 frugivore species were common to Kuje and Kwali while AMAC and Kuje and AMAC and Kuje have 27 species in common. Kuje and Kwali are the most similar in terms of frugivores with all the 34 and 41 species respectively.

Table 4: Sorenson's Similarity Indices for Frugivores at Different Sites

Sites	AMAC	Abaji	Bwari	Gwagwalada	Kuje	Kwali
AMAC	*	0.67	0.94	0.86	0.93	0.88
Abaji	0.67	*	0.65	0.59	0.62	0.76
Bwari	0.94	0.65	*	0.83	0.94	0.89
Gwagwalada	0.86	0.59	0.83	*	0.87	0.88
Kuje	0.93	0.62	0.94	0.87	*	0.98
Kwali	0.88	0.76	0.89	0.88	0.98	*

Diversity of Fruit Trees at different Sites

The alpha (within-site) diversity of fruit trees at different sites is shown in Table 5. Both Simpson (D) and Shannon-Wiener (H) diversity indices show that AMAC (D=0.893333, H=2.478939) is the most diverse of all the sites, followed by Kwali (D=0.858711, H=2.152675) while While Kuje (D=0.743802, H=1.666333) and Abaji (D=0.763377, H=1.806897) have lower diversity index. However Bwari and Gwagwalada have the diversity of (D=0.832, H=2.033459) and (D=0.842105, H=2.010163) respectively

Table 5 : Alpha Diversity Indices for Fruit Trees at Different Sites

Variables	Sites					
	AMAC	Abaji	Bwari	Gwagwalada	Kuje	Kwali
Simpson index (1-D)	0.893333	0.763377	0.832	0.842105	0.743802	0.858711
Shannon Wiener index (H)	2.478939	1.806897	2.033459	2.010163	1.666333	2.152675
Species richness	15	10	10	9	7	11

Diversity of Frugivores at different Sites

The alpha (within-site) diversity of frugivores at different sites is shown in Table 6. Both Simpson and Shannon-Wiener diversity indices show that Gwagwalada (D=0.9650, H=3.457) is the most diverse of all the sites, followed closely followed by Kuje (D=0.9597, H=3.494) and Kwali (D=0.9630, H=3.449) respectively. Alpha diversity of frugivores in AMAC and Abaji were (D=0.9246, H=2.990) and (D=0.9237, H=2.731) respectively.

Table 6: Alpha Diversity Indices for Frugivore Species at Different Sites

Variables	Sites					
	AMAC	Abaji	Bwari	Gwagwalada	Kuje	Kwali
Simpson index (1-D)	0.9246	0.9237	0.9469	0.9650	0.9597	0.9630
Shannon-Wiener index (H)	2.990	2.731	3.234	3.457	3.494	3.449
Species richness	38	21	39	35	34	41

Correlation between Diversity of Fruit Trees and Diversity of Frugivores

The diversity indices of fruit trees observed to be visited by the avian frugivores were correlated with the diversity indices of the frugivores. Both the Simpson and Shannon-Weiner diversity indices were used. The correlation coefficient (r) for the diversity of fruit trees and the diversity of frugivores for all the sites was -0.2323 and -0.1626 for Simpson and Shannon-Weiner diversity indices respectively.

DISCUSSION

The fruit tree species present at each of the sites and the number of individuals encountered was presented. The highest number of fruit tree species was encountered in AMAC (30), followed by Abaji (29) while the least number of 11 fruit tree species were encountered in Kuje. In habitats within the sampled areas, fruit tree species were a subset of the total tree species sampled, although, variation may exist. The fruit trees are a fraction of the total number of all the tree species enumerated in each of the communities, therefore AMAC which had the highest number of tree species sampled also had the highest number of the fruit trees. Where there is no corresponding species match or otherwise, it therefore means that the vegetation cleared for urbanization did not completely destroyed the habitat and, this affirms the

assertion of (Mikinney, 2008) that urbanization decrease or increase species richness depending, on several variables. The variable identified here may be the fruit tree species composition of either the native or exotic fruit tree species. And in this case more species are documented in the urban area than the sub-urban. Urbanization has promoted increasing levels of biodiversity by the addition of non-native species combined with the native species in the pockets of vegetation islands (Mikinney, 2006). This also translates to the fact that resident frugovres in places like AMAC has the potential to switch from one food resource to another than other frugivores that are found in places with less fruit resources.

The frugivores present at the various sites and the number of individuals encountered was documented. The highest number of frugivorous species was encountered in Kwali (41), followed by Bwari (39), while the least number of frugivore species (21) were encountered at Abaji. This result differs because more frugivores were documented in Kwali with a lesser number of fruit trees. This result is not in variant with the recent research which asserted that, many species exhibit common trends of increased abundance and decreased diversity with increasing urbanization (Bradley *et al.,* 2008). These effects were observed in plant, spider, ant, and bird species (Bradley *et al.,* 2008). The abundance and diversity of species therefore reflects characteristics of the urban setting, indicating a low degree of diversity, which ultimately favors the success of generalists (Bradley *et al.,* 2008). Some of the generalist includes, *Pycnonotus barbatus, Turdus pelios, Chlorocichla simplex, Crinifer piscator, Treron calva* and *Streptopelia senegalensis,* and these avian frugivores feed on diverse fruit species. *Pycnonotus barbatus* was encounted, the highest number of time in all the sites followed by *Turdus pelios.* Unlike plant species, frugivores are mobile and can migrate between sites depending of available resources. Tree species in kwali are those typical of wood land and according to Savard *et al.,* (2000) large size, spatial heterogeneity, complex vertical structure, and diverse vegetation composition all contribute to higher bird species richness in woodlands. Also in addition to woodlands, urban forestry, including trees along streets, parks, plazas, and residential property can provide substantial habitat for various species (Wheater, 1999). The differences in frugivore composition among the site could have a link with food resources in the form of fruits that is available to frugivores at a particular time (The time/stability hypothesis). This is in line with the observation of Shankar Raman, (2001) that bird species changes in their species composition and populations of their

communities when their associated ecological niches are changed. Quantitatively, diverse population can exist within a habitat and also in habitats within a landscape (Usher, 1986). Fruit-producing tree species need adequate number of frugivores to consume and disperse their seed. Also, a good number of fruit-producing tree species are important to sustain the life of animals that depend wholly or partially on fruit as their diet either throughout or major part of the year. Species richness, resources available in space and time determines the level of interactions between the components within a boundary that configures an ecosystem to a domain level. Shift in domain can occur in ecosystem when processes that make it resilient to surprises are disturbed, unbalanced, or even not available.

The similarity or otherwise dissimilarity in fruit tree species composition between each pair of the enumerated sites indicated that Gwagwalada and Kuje are the most similar. This may be as a result of the fact that majority of the tree species here are native and the vegetation between Gwagwalada and Kuje are linked together with wide corridors that have arrays of native vegetation (Mikinney, 2006). According to Howe, (1977) habitat fragmentation is one of the most serious causes of diminishing biological diversity, while its main consequence, habitat loss is responsible for biodiversity loss and ultimate extinction of species. It is important to understand that, between habitats separated by distance, species found in one area maybe slightly different from those found in another place, this may be influenced by either the biotic or abiotic component of the ecosystem influencing the habitat at a particular time (Verma and Agarwal, 1983). For the alpha (within-site) diversity of fruit trees at different sites, both Simpson (D) and Shannon-Wiener (H) diversity indices showed that AMAC (D=0.893333, H=2.478939) is the most diverse of all the sites, while While Kuje (D=0.743802, H=1.666333) had lowest diversity index. The result as indicated means that AMAC had good vegetation mix and less homogenized, even though, high anthropogenic load on the ecosystem were observed, spatial and temporal heterogeneity of environments can result in the diversity of species in the communities (Chesson and Rosenzweigh, 1991).

The similarity or otherwise dissimilarity in frugivore species composition between each pair of the enumerated sites indicated that, the similarity was higher between the AMAC and each of the other sites, and between each pair of the sites than that of the fruit trees in the respective sites (Ss=0.67 to Ss=0.94). Specifically, highest similarity was observed between AMAC and Bwari (Ss=0.94) Abaji and Gwagwalada are the most dissimilar

(Ss=0.59). This result showed that, the forest island where the frugivore species reside had been existing for a long time before the urbanization, undisturbed, and therefore had more diversity, (Brown, 2004). It is important to understand that biological diversity refers to both the different types of species and the different functional roles of species. And Tilman *et al.*, (2001) therefore demonstrated that more diversity helped in the recovery of ecosystem functions (productivity, biogeochemical cycling) after a disturbance. This finding is very similar to Berke and Campanella's (2006) observation that a diverse economy can contribute to human community resilience (capacity to rebound following destruction). The alpha (within-site) diversity of frugivores at different sites, (both the Simpson and Shannon-Wiener diversity indices) showed that Gwagwalada (D=0.9650, H=3.457) is the most diverse of all the sites, Abaji was the least divers (D=0.9237, H=2.731). This is contrary to the finding that more biomass supports greater species diversity (Brown, 2004), because AMAC was more diverse in terms of tree species and fruit trees. Coincidentally, fruit availability may be responsible for the availability of these frugivore species at a particular time of the year. And the frugivores tend to "clump" together around these crucial resources, and this was described as clumped distribution, where the distance between neighboring individuals is minimized (Verma and Agarwal, 1983).

CONCLUSION

The diversity of fruit trees and that of frugivores were not highly correlated, even though, higher number of individuals was document in the AMAC. There was a great dissimilarity in tree species composition between AMAC and the other five sites and this was because of the presence of many exotic tree species in AMAC. The interactions between the frugivores and some of the fruit-trees are asymmetrical because, some of the exotic tree species are only used as stepping stones or corridors for the frugivores to cross from one island of vegetation to another. They do not enhance regeneration and recruitment of new seedlings because horticultural practices are needed for the propagation of the exotic species. Since native tree species are co-evolved with frugivore species resident in these areas, their relations is symmetrical and the interactions can lead to effective seed dispersal and seedling recruitment.

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