Research Article

Assessing the structural and populational dynamics in plant communities in botanical and zoological garden of Kano State, Nigeria

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Abstract

The study was carried out to investigate plant growth attributes, floristic composition and diversity in Kano Zoological and Botanical Garden, Kano State. 1km systematic line transect was laid with four (4) plots sized 30 by 30m demarcation at 50m interval which makes up a total area of 3600m^2. All woody plants were identified and classified into families while DBH and height were assessed and used to evaluate volume and Basal area. H$'$ index, D and evenness were computed. Floristic composition identified into 9 families, 15 species, 15 genera and 31 individual stands in the Zoological Garden while thirteen species and seven families reported from Biological Garden. The family of Fabaceae had the highest number of frequencies from the two study sites respectively. Other families like Myrtaceae, Arecaceae, Oleacaceae, Euphoboacea, Panaceae occurred once only. The total number of individual tree and species were 31; 28 and 15; 13 for ZG and BG respectively. The mean basal area, mean volume and mean DBH were 92.85m^2; 39.89m^2, 2.09m^{3}ha^1; 0.41m^{3}ha^{-1}, 0.53; 0.34m respectively. H^1, D and evenness were assessed as 4.28;4.22, 0.49; 0.44; and 0.33; 0.28 respectively. Plant species was diverse, less spaced and dense in composition compared to other studies conducted in the savannah landscape. Therefore, indigenous tree, shrub species and agroforestry trees could be introduced into the hotspot for better diversity, recreational, research and educational purposes.

Keywords: Composition, Diversity, Growth parameters, and Kano Zoological Garde

Received: 10/09/2024

Accepted: 31/10/2024

DOI: https://dx.doi.org/10.4314/jcas.v21i1.3

Resumé

L'étude a été menée pour étudier les attributs de croissance des plantes, la composition floristique et la diversité dans le jardin zoologique et botanique de Kano, dans l'État de Kano. Un transect de ligne systématique de 1 km a été posé avec quatre (4) parcelles de 30 sur 30 m de démarcation à 50 m d'intervalle, ce qui représente une superficie totale de 3600 m2. Toutes les plantes ligneuses ont été identifiées et classées en familles tandis que le DBH et la hauteur ont été évalués et utilisés pour évaluer le volume et la surface terrière. L'indice H1, D et l'uniformité ont été calculés. La composition floristique a été identifiée en 9 familles, 15 espèces, 15 genres et 31 peuplements individuels dans le jardin zoologique tandis que treize espèces et sept familles ont été signalées dans le jardin biologique. La famille des Fabaceae avait le plus grand nombre de fréquences sur les deux sites d'étude respectivement. D'autres familles comme les Myrtaceae, Arecaceae, Oleacaceae, Euphoboacea, Panaceae n'étaient présentes qu'une seule fois. Le nombre total d'arbres individuels et d'espèces était

de 31 ; 28 et 15 ; 13 pour ZG et BG respectivement. La surface terrière moyenne, le volume moyen et le DBH moyen étaient respectivement de 92,85 m2 ; 39,89 m2, 2,09 m3ha1 ; 0,41 m3ha-1, 0,53 ; 0,34 m. H1, D et la régularité ont été évalués à 4,28 ; 4,22, 0,49 ; 0,44 ; et 0,33 ; 0,28 respectivement. Les espèces végétales étaient diverses, moins espacées et denses dans leur composition par rapport à d'autres études menées dans le paysage de savane. Par conséquent, des espèces indigènes d'arbres, d'arbustes et d'arbres agroforestiers pourraient être introduits dans le point chaud pour une meilleure diversité, à des fins récréatives, de recherche et d'éducation.

Mots clés : Composition, diversité, paramètres de croissance et réserve zoologique de Kano

INTRODUCTION

The savanna ecosystem is characterized by sparse vegetation dominated primarily by grasses, with a few scattered trees (Wakawa *et al.,* 2017). Forest reserves face significant pressures from anthropogenic activities such as overexploitation of resources, grazing, and the conversion of forested areas for residential, industrial, and infrastructural uses, compounded by unstable climate conditions (Amonum *et al.,* 2019). Variations in precipitation are a major determinant of plant types and their suitability to different zones (Aregheore, 2009). However, many agro-ecological zones have shifted due to human activities and climate change, with areas once classified as Guinea savannah now resembling Sudan savannah and those categorized as Sudan savannah now resembling Sahel. This necessitates periodic assessments of vegetation status for effective management and conservation (Wakawa *et al.,* 2017). Tree composition and distribution are crucial for understanding forest stand status, regeneration, and diversity, which are essential for conservation efforts. The structure of forest estates is influenced by site ecological characteristics, species diversity, and the regeneration status of tree species (Salami, 2017; Amonum *et al.,* 2019). Recent studies emphasize the importance of understanding flora composition, species diversity, and forest structure for assessing forest sustainability, species conservation, and the development of management policies (Maame *et al.,* 2021). Tropical forests, housing the highest species diversity among terrestrial ecosystems, cover 52% of the globe's tropical regions and contain 34 global biodiversity hotspots (Rajiv and Suganthi, 2016). The abundance and diversity of tree species are critical for forest ecosystems and biodiversity (Nwabueze, 2017; Ozcelik *et al.,* 2008). Deforestation in tropical regions is a significant contributor to environmental challenges such as biodiversity loss and climate change, with tropical forests disappearing at a rate of 13.5 million hectares per year globally (Isabel *et al.,* 2016). Therefore, constant monitoring and management of flora components are essential to direct succession processes and maintain species and habitat diversity (Ezenwenyi *et al.,* 2023). Human population growth has led to increased tree disturbances due to activities such as firewood collection, charcoal production, and infrastructural development, impacting tree diversity, abundance, species composition, and conservation efforts (Omoro *et al.,* 2010). Overexploitation has rapidly diminished tree diversity, presenting significant environmental and economic challenges. Understanding tree species composition and diversity is crucial for planning and implementing biodiversity conservation efforts (Suratman, 2012). Sustainable development aims for coexistence between humans and biodiversity, with a higher number of tree species fostering ecological niches and associated species (Kanowski *et al.,* 2003). Trees provide essential ecosystem services, including species conservation, soil erosion prevention, and

habitat preservation for plants and animals (Armenteras *et al.,* 2009). Forests offer valuable ecological and social services such as biodiversity conservation, carbon storage, soil and water conservation, employment opportunities, enhanced livelihoods, agricultural production, and improved urban living conditions (Bello *et al.,* 2022; Salami *et al.,* 2020; Dagba *et al.,* 2017). This study aims to assess tree species richness, composition, the impact of human activities, and diversity in the Kano Zoological and Botanical Garden, with the goal of promoting sustainable utilization, management, and conservation of tree stands in the area.

MATERIALS AND METHOD

Study area

Kano Zoo is the largest zoo established in Nigeria which was officially opened in 1972 by the Military Governor of Kano State, Alhaji Audu Bako, and it changed to Kano Zoo named for him later. In the immaculately clean and tidy Zoological Garden, there is a collection of many tree species. The zoo is open seven days in a week and there is a restaurant with a cool sport to relax. It is strategically located within the garden. It opens from 7:30 in the morning to 6:30 in the evening. The gate fee is a hundred naira (Nigeria currency) per adult and fifty naira per child; organized group like associations or clubs may pay in groups or sometimes enter free (Azubuike and Azubuike, 2014).

Location of the Zoo

The entire Kano State occupies an area of 43,000 km lying between 10.30 north and latitude 12.03 north and longitude 8.32 east and is about 1549 feet above the sea level. The Kano Zoo is located 1 km Kano Zaria Road, west of Gyadigyadi Quarters (Figure 1).

Climate of the study area

Kano State carries Sudan savannah vegetation which merges in the month of May with 43ÚC Humidity: 12%, wind 29km/h and the lowest was recorded in the month of December with 28ÚC, and the total amount of rainfall annually is 696.4mm.

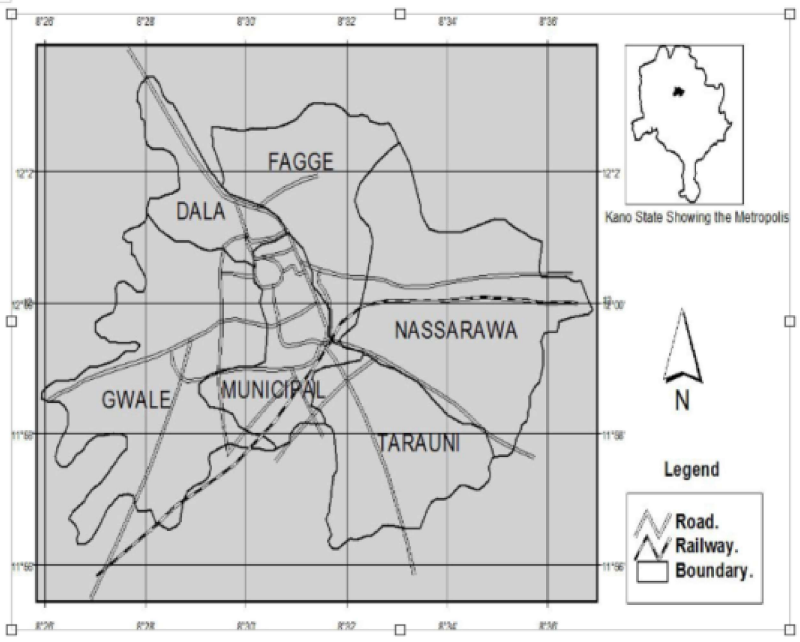

Figure 1: Map of Kano showing the location of the study area

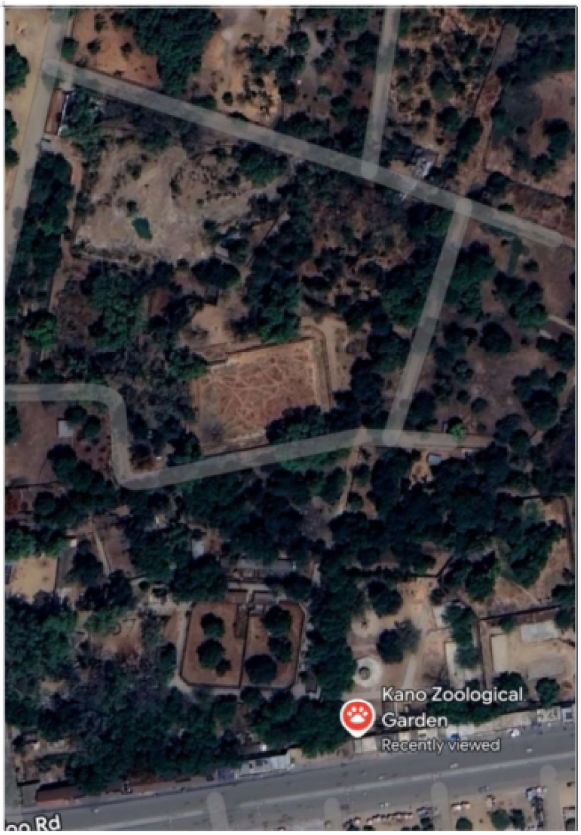

Figure 2: Aerial Photograph of Kano Zoological Garden

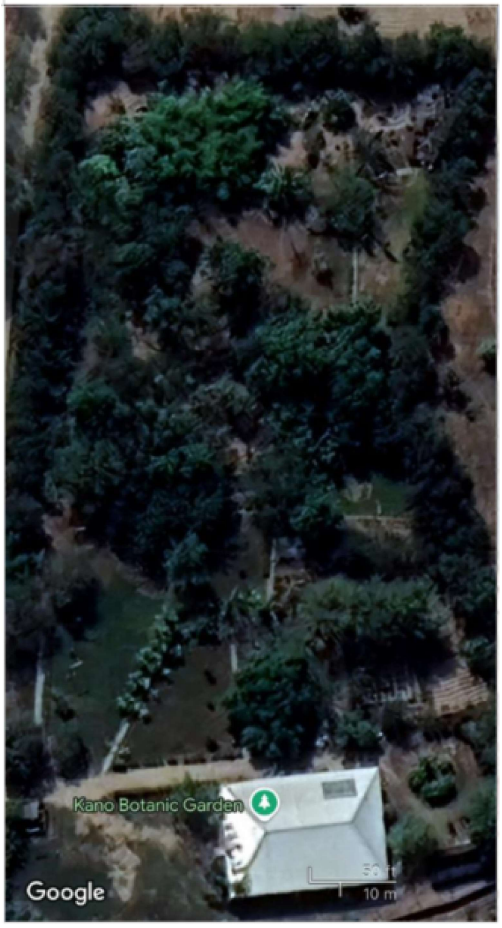

Figure 3: Aerial Photograph of Kano Botanical Garden

Data collection

Tree species

Data collected in the study area includes: the number of individual species; tree height, stem diameter e" 10 cm. Stem diameters and total height were measured using diameter tape and Haga altimeter respectively. Volume and basal area calculated

Sampling Procedure

The study area covered is estimated to be about 16 hectares of land. 0.78 % of the site was sampled and divided into plots of sizes 30×30 m each plot was systematically laid, thereby given a total of 4 sampling plots which is 0.78% of the total study area. The plots were laid 50m apart, within the study area.

Data analysis

Objective 1: to assess tree species structure, composition and diversity in Kano state Zoological and botanical Garden

Shannon-Wiener Index of diversity (H')

Species diversity within the Zoological and botanical garden were analyzed using the diversity index by Shannon and Weaver (1949), the index varies depending on the number of species present. It is higher when there are more species, indicating greater diversity.

Shannon-Weiner Index of diversity (H') was calculated following the work Kent and Coker (1992) and Magurran (2004)

$$H = -\sum_{i=1}^{s} p_i \ln p_i \; Equation[1]$$

Where: S = total number of species and pi = relative frequency of species.

ii. Simpson's index

The Simpson's index of diversity:

$$D=1-\left(\frac{\sum n(n-1)}{N(N-1)}\right) Equation[2]$$

Where: n is the total number of organisms of a particular species and N is the total number of individuals of all species.

Species evenness index

The Pielou evenness index varies between 0 and 1. It is 0 when there is a phenomenon of dominance and 1 when the distribution of individuals among species is homogenous. Pielou evenness index was calculated, using the stated formula as (Victor *et al.,* 2013):

$$H_s=\frac{H'}{lnS} Equation[3]$$

Where: *S* is the total number of species and H= diversity index.

Objective 2: determine the tree species distribution and structure in the study area

Forest structure

The structure of the Zoological Garden was analyzed using the distribution of stem diameter and height of tree species in the study area. The total height and diameter of the tree species measured within the 5 temporary sample plots group into class and frequency of each class was determined.

Basal area

Total basal area is the sum of basal area of all species present in the forest. Basal area (m^2/ha) was used to determine the relative dominance of a tree species. Diameter at breast height (dbh) was taken for the determination of tree basal area and calculated as:

$$B.A=\pi\frac{d^2}{4} Equation$$

Where: π = 3.142, d = diameter at breast height.

Table 1: Growth parameters for the Zoological and Botanical Garden

SN	Parameters	Zoological garden	Botanical garden
1.	No of individual species	31	28
2.	Number of species	15	13
3	Mean Volume (cm^3)	2.09	0.41
4.	Mean Basal (m)	92.85	39.89
5	Mean DBH (m)	0.53	0.34

Source: Field survey 2023

Table 2: Floristic Composition in Zoological Premises

S/N	Scientific Names	Common Name	Local Name	Family	Conservation status	Life form
1.	*Delonix regia* (Hook.) Raf.	Flamboyant Tree	Seke seke, ayin.	Fabaceae	Least concern	Tree
2.	*Ficus sycomorus* Linn	Mulberry Fig	-	Moraceae	Least concern	Tree
3.	*Cassia seamen* Linn	Watilles	-	Fabaceae	Least concern	Tree
4.	*Azadirachta indica A. JUSS*	*Neem Tree*	Dogoyaro	Meliceae	Not extinction	Tree
5.	*Mangifera indica* Linn	*Mango Tree*	Magwaro	Anacardiaceae	Nil	Tree
6.	*Khaya senegalensis* (Desr)A.Juss.	African mahogany	Madaci	Meliceae	vulnerable	Tree
7.	*Roystonea regia* (Kunth) O. F. Cook	Royal palm	Kwakwa	Arecaceae	Critically endangered	Tree
8.	*Tectona grandis* L. F.	Teak	Durumi	Lamiaceae	Not extinction	Tree
9.	*Oka earopaea* L. subsp. *europaea* var. *sylvestris*	Olive	Zaitun	Oleaceae	Not extinction	Tree
10.	*Acacia auriculiformis A.Cunn. ex Benth.*	Earleaf acacia, auri, earpod wattle	-	Fabaceae	Least concern	Tree
11.	*Hura crepitans Linn*	Sand box tree	-	Euphorbiaceae	Endangered	Tree
12.	*Eucalyptus camadulensis Denhn*	Red river gum	Turare	Myrtaceae	Near threaten	Tree
13.	*Albizzia jublirism* Benth.	Persian silk tree	-	Fabaceae	Least concern	Tree
14.	*Ficus politia*	Heart Leaved Fig	-	Moraceae	Vulnerable	Tree
15.	*Pinus carribean*	Caribbean pine	-	Panaceae	Least concern	Tree

Source: Field survey 2023

Table 3: Floristic Composition in Botanical Garden

S/N	Scientific Names	Common Name	Local Name	Family	Conservation status	Life form
1.	*Tamarindus indica* Linn	Tamarind	Tsamiya	*Fabaceae*	Least concern	Tree
2.	*Acacia seyel* Del	Shitta tree	Karo	*Fabaceae*	Least concern	Tree
3.	*Azadirachta indica A. JUSS*	Neem Tree	DogonYaro	*Meliceae*	Least concern	Tree
4.	*Khaya senegalensis* (Desr)A.Juss.	African mahogany	Madaci	*Meliceae*	Vulnerable	Tree
5.	*Terminalia mantaly H. perrier*	Umbrella Tree	Satellite	*Combretaceae*	Least concern	Tree
6.	*Albizia lebbeck* Benth	Flea Tree		*Fabaceae*	Least concern	Tree
7.	*Delonix regia* (Hook.) Raf.	Flamboyant Tree	Flower	*Fabaceae*	Least concern	Tree
8.	*Plumeria alba L.*	White Frangipani		*Apocynaceae*	Least concern	Tree
9.	*Mangifera indica Linn*	Mangifera	Magwaro	*Anacardiaceae*	Least concern	Tree
10.	*Piliostigma thonningii* (Schumach) Milne-Redh.	Monkey Bread		*Fabaceae*	Least concern	Tree
11.	*Cascabela thevetia* (L.) Lippold, Feddes Repert.	*Yellow Olianda*	Acid	*Apocynaceae*	Least concern	Tree
12.	*Monoon longifolium* (Sonn.) B.Xue & R.M.K.Saunders	Masquerade		*Annonaceae*	Least concern	Tree
13.	*Bauhinia thonningii*	Camel Foot tree		*Fabaceae*	Least concern	Tree

Source: Field survey 2023

Table 4: Showing the Density and Diversity indices of the Zoological Garden

S/N	Species	Frequency	Abundance	Density	R D	Pilnpi	Simpson
1.	*Flamboyant tree*	4	2	1	100	0	0.07
2.	*Ficus sycomorus*	1	1	0.25	25	0.35	0.01
3.	*Cacia seamen*	3	1.5	0.75	75	0.22	0.05
4.	*Neem tree*	4	1.3	1	100	0	0.07
5.	*Mango tree*	3	1.5	0.75	75	0.22	0.05
6.	*Khaya senegalensis*	5	2.5	1.25	125	0.28	0.08
7.	*Roystenea regia*	1	1	0.25	25	0.35	0.01
8.	*Tectona grandis*	2	1	0.5	50	0.35	0.03
9.	*Olive Tree*	1	1	0.25	25	0.35	0.01
10.	*Acacia auriclusformis*	1	1	0.25	25	0.35	0.01
11.	*Hura crepitans*	1	1	0.25	25	0.35	0.01
12.	*Eucalyptus senegalensis*	1	1	0.25	25	0.35	0.01
13.	*Aleizia_jubilrism*	1	1	0.25	25	0.35	0.01
14.	*Ficus politia*	1	1	0.25	25	0.35	0.01
15.	*Pinus carribean*	1	1	0.25	25	0.35	0.01
	Total			**7.5**	**750**	**4.22**	**0.44**

Source: Field survey 2023

Table 5: Showing the Density and Diversity indices of the Botanical Garden.

S/N	Species	Frequency	Abundance	Density	R. Density	Pilnpi	Simpson
1.	*Tamarindus indica*	2	2	0.5	50	0.35	0.03
2.	*Acacia seyel*	6	2	1.25	125	0.28	0.10
3.	*Azadirachta indica*	3	1.5	0.75	75	0.22	0.06
4.	*Khaya senegalensis*	1	1	0.25	25	0.35	0.02
5.	*Terminalia mentali*	5	5	1.25	125	0.28	0.10
6.	*Albizia lebbeck*	2	1	0.5	50	0.35	0.03
7.	*Delonix regia*	1	1	0.25	25	0.35	0.02
8.	*Plumeria alba*	1	1	0.25	25	0.35	0.02
9.	*Mangifera indica*	1	1	0.25	25	0.35	0.02
10.	*Phillostigma thungii*	2	2	0.5	50	0.35	0.02
11.	*Yellow olianda*	1	1	0.25	25	0.35	0.02
12.	*Moonoon Longifom*	1	1	0.25	25	0.35	0.02
13.	*Baubinia thonningii*	2	2	0.5	50	0.35	0.03
	Total			**6.75**	**675**	**4.28**	**0.49**

Source: Field survey 2023

Table 6 Diversity and Similarity Indices

SN		Diversity indices	Zoological garden	Botanical garden
1		Shanon weiner	4.28	4.22
3.		Simpson	0.49	0.44
4.		Evenness	0.33	0.28
5.		Similarity index	13.64%	

Source: Field survey 2023

Table 7 Percentage Diameter distribution of both BGF and ZGF

SN	Dbh	ZGF (Freq)	Percentage (%)	BGF (Freq)	Percentage (%)
1	21- 30	-	-	1	3.57
2	31-40	-	-	-	-
3	41-50	-	-	1	3.57
4	51-60	2	6.45	-	-
5	61-70	2	6.45	2	12.5
6	71-80	2	6.45	2	12.5
7	81-90	2	6.45	5	17.86
8	91 >	23	74.19	16	57.14
	Total	**31**	**99.997**	**28**	**96.425**

Source: Field survey, 2023

Discussion

Growth Characteristics and Percentage Distribution

The study investigated plant growth attributes, structure, and diversity indices in the Botanical and Zoological Gardens of Kano State. A key aspect of forest structure is the relationship between tree height and diameter. These measurements are crucial for estimating tree volume, site index, and other important forest growth and yield variables (Salami *et al.,* 2021a). In the study, the mean diameter at breast height (DBH) was 0.53 meters for the Zoological Garden (ZG) and 0.34 meters for the Botanical Garden (BG). The mean basal area was 92.85 square meters per hectare for ZG and 39.89 square meters per hectare for BG. Additionally, the mean volume was 2.086 cubic meters per hectare for ZG and 0.41 cubic meters per hectare for BG (Table 1). Salami *et al.* (2019) reported a mean volume of 0.15 cubic meters from Kurba Forest Reserve. The highest percentage of diameter distribution was observed in the range of 91 cm and above for both study sites, with values of 74.19% for ZG and 57.14% for BG (Table 7). The diameter ranges of 21 to 50 cm had no representation in ZG, while BG had one tree (3.57%) in the 21-30 cm and one tree (3.57%) in the 41-50 cm categories (Table 7). Salami *et al.* (2021a) reported a similar mean DBH of 0.56 meters from their study in Warwade Plantation, Dutse, Jigawa State. The tree growth variables measured in the *Azadirachta indica* plantation showed a mean volume of 0.17 cubic meters per hectare, with the 61-70 cm diameter class having the highest number of trees per hectare (33.33%), compared to the present study (Salami *et al.,* 2021b).

Floristic Composition, Density and Abundance

A total of fifty-nine individual trees were recorded across both study sites, with twenty-eight trees from the Zoological Garden (ZG) and thirty-one from the Botanical Garden (BG). The ZG had fifteen species, while the BG had thirteen species. The Fabaceae family was common to both sites, having the highest number of species, followed by *Meliaceae* and *Apocynaceae,* with *Combretaceae* recording the fewest species (Tables 2 and 3). In terms of frequency, *Khaya senegalensis* was the most

common species with a frequency of 5, followed by *Delonix regia* and *Azadirachta indica*, which also had a frequency of 5 in the BG (Table 4). *Acacia seyal* and *Terminalia menthalii* exhibited the highest frequency, abundance, and density (Table 5). The Fabaceae family was the most diverse, represented by seven species, with *Cassia arereh* having the highest number of individuals, averaging 10 trees per hectare, followed by *Tamarindus indica* with 9 trees per hectare and *Diospyros mespiliformis* with 8 trees per hectare (Salami *et al.,* 2022).

Diversity and similarity indices

Table 6 presents the ecological indices for both study areas. The Shannon-Weiner and Simpson indices for the Zoological Garden (ZG) were higher than those for the Botanical Garden (BG), with values of 4.28 and 4.22 for Shannon-Weiner, and 0.49 and 0.44 for Simpson's index, respectively. The evenness indices were reported as 0.33 for ZG and 0.28 for BG. The similarity index between the two sites was 13.64%. Comparisons of these ecological indices with those from other studies reveal better results for the current study, which may be attributed to improved management practices, favorable environmental conditions, and other site-specific factors. The lower population of individual tree species observed in the BG may be linked to anthropogenic impacts and the feeding environment for herbivores. For context, Salami et al. (2022) reported a Shannon-Weiner index of 1.94 for diversity in Kurba Forest Reserve, which is lower than the values found in this study. Similarly, Salami *et al.* (2019) measured a Shannon-Weiner index of 2.115 for the Canopy Structure of Secondary Forest at the Federal University Dutse, Jigawa State, which is also lower than the present study's findings.

Conclusion

Study inferred that Kano Zoological Garden showed case better yield of growth attributes compared to the Botanical Garden in term of DBH, Basal area and Volume. Similarly, ecological indices of the population measured were higher in ZG (Diversity and Evenness) while the similarity index between the study sites was so low. The hotspots were made up of mature stands with higher diameter range. Observations from the study areas is an indication of the best management practices applied compare to other savanna landscape in northern hemisphere.

The management of the Kano Zoological Garden should maintain the quality of the hotspots. More Agroforestry and savannah tree should be introduced into the hotspot for better diversity, recreational, research and educational purpose.

Acknowledgements: The research work was conceived by Salami and Kareem, while Oyelowo, Sulaiman and Salami carried out the survey and Akinyemi do the analysis of the data collected from the field, while Kareem and Salami drafted the manuscript.

The authors declared that there is no any conflict of interest.

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