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**Assessment of Species Diversity, Crown and Stem
Diameter Distribution of Avenue Trees
in Awka, Nigeria**

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ASSESSMENT OF SPECIES DIVERSITY, CROWN AND STEM DIAMETER DISTRIBUTION OF AVENUE TREES IN AWKA, NIGERIA

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ABSTRACT: The tree crown and stem are essential parts of the tree, indicating the tree's photosynthetic potential, growth, and health. This study assessed species diversity and distribution of crown and stem diameter of avenue trees in Awka metropolis of Anambra State, Nigeria, to provide baseline information for sustainable management. The study collected trees data from two randomly selected streets in each of the seven towns of the Awka metropolis. Crown diameter (CD), diameter at breast height (DBH), and coordinates of each tree species in each selected street were enumerated. The data collected were subjected to summary statistics, and Shannon-Wiener (H') and Simpson's (C) diversity indices were further computed. A total of 80 trees consisting of 24 species belonging to 13 families and 23 genres were assessed for the study. The result showed that *Azadirachta indica* were the most dominant avenue trees with relative density of 13.75% in the study area. The H' and C indices for the trees were 2.90 and 0.93, respectively. The DBH and CD distribution showed a fairly bell-shaped curve, with most tree species within the middle class. The study observed that the avenue trees diversity was relatively low. Therefore, increased planting is recommended to preserve avenue trees in the Awka metropolis.

Keywords: crown distribution, diameter at breast height, diversity, avenue trees, tree crown

1. INTRODUCTION

Avenue trees are usually of the same species or cultivar of trees, planted in rows equally spaced from one another to emphasize uniformity (Urban, 2008). They are public resources that are planted on municipal rights-of-way and make up a significant part of urban forests all over the world. The majority of avenue trees result from deliberate planting. Avenue trees were discovered to constitute a separate population of trees inside the urban forest, with less species variety than the surrounding urban tree populations. They are notable because of their aesthetic and physical influence on the quality of urban living, although making up a small percentage of the total urban forest (McPherson, 2000).

Avenue trees have a variety of benefits, including protecting local watersheds and improving stormwater

management, reducing air pollution, absorbing greenhouse gases, providing aesthetic beauty, lowering ambient air temperatures by shading asphalt, concrete, and surrounding structures, improving energy efficiency for local buildings (McPherson and Simpson, 2003). In addition to providing ecosystem services, the trees have reduced traffic speeds in residential areas, resulting in safer driving and fewer road accidents (Dumbaugh, 2005). Avenue trees have also been linked to several additional psychological advantages, including less crime, improved occupancy and foot traffic in commercial districts, better property prices, and lower turnover in residential areas (Miller, 1987). Finally, avenue trees support biodiversity by providing a natural habitat for birds, squirrels, and other urban species.

Species diversity is measured by combining species richness (the number of species present) and species

evenness (the abundance of each species). The Shannon Index is often used in ecology to integrate species richness and evenness into a single metric (Mumby, 2001). According to Isbell *et al.* (2011), Tree diversity offers a foundation for assessing a city's potential to maintain a healthy urban forest. Diverse urban forests, both in terms of structure and species composition, ensure their resilience to the challenges of the urban environment (Ordóñez and Duinker, 2014). When managing an urban forest, accounting for diversity can help support and enhance ecosystem services (i.e., benefits nature provides to human well-being) delivered and minimize management expenses (Conway and Vander-Vecht, 2015). There is mounting evidence that species diversity, in particular, enhances ecosystem resistance to bio and ecological disturbances (Dobbs *et al.*, 2014; Riley *et al.*, 2018). The diversity of trees along streets, more often than not maintained by the municipality (Steenberg, 2018), may depend on nursery stock availability (Conway and Vander-Vecht, 2015), geography and climate, operational and management needs (such as snow removal in colder climates and irrigation needs in warmer and drier ones), and tree crown formation and characteristics when implementing silvicultural treatments (Ramage *et al.*, 2012).

The term "tree crown" refers to the shape, size, and placement of tree structures in three-dimensional space and the constructional organization of the branching system (Godin *et al.*, 1999). Tree crowns form the boundary between the terrestrial biosphere and the atmosphere and determine light interception and gas exchange of carbon and water through photosynthesis and evapotranspiration (Strigul *et al.*, 2008; Santiago *et al.*, 2009). Crowns are one of the most physiologically and ecologically active components of trees. Understanding tree crown structure is vital for applications, including scaling biogeochemical fluxes, modeling vegetation dynamics, and developing remote sensing methods that are seen as crucial tools for monitoring terrestrial ecosystems. Information on crown width or diameter can provide valuable planning and management information for managers of urban forests.

Trees with large canopies can provide a more significant amount of shade and increase transpirational cooling resulting in reduced energy demand. Carbon sequestration is another benefit of trees that increases with larger tree crowns as they produce larger stems and maintain more significant quantities of wood over long periods. Diameter at breast height (DBH) is a vital tree growth variable easily measured with simple instruments and widely used in forest inventories. Earlier studies on tree diameter have shown that information about DBH can be used in the estimation of various tree and stand variables; volume (Akindele and

LeMay, 2006), height (Castedo-Dorado, 2005), crown dimensions (Chukwu *et al.*, 2017a). However, more giant trees also cause more conflicts with built infrastructure in the urban areas. When sidewalks and avenue trees conflict, there are losses in benefits provided by sidewalks and trees (Akbari *et al.*, 1999). Hence, it was imperative to assess species diversity, crown and stem diameter distribution of avenue trees in Awka, Anambra State, to provide information for sustainable urban forest management.

2. MATERIAL AND METHODS

2.1. Study Area, Sampling Procedure, and Data Collection

The study was carried out in Awka, Anambra State. Awka Capital Territory is an Urban city located in the Southeastern geopolitical zone of Nigeria, bounded by latitudes 6.20 °N and 6.28 °N and longitudes 7.00°E and 7.06° (Figure 1). The climate is tropical with mean rainfall and temperature of 1828 mm and 26.3°C, respectively, and lies below 300m above sea level in a valley on the banks of the Mamu River (Chukwu *et al.*, 2020).

This study randomly selected two streets from each of the seven towns of Awka Metropolis. Total enumeration of avenue tree with diameters at breast height (DBH) greater than 10 cm was made. The selected avenue trees were identified to species level; DBH (cm) and crown diameter (CD, m) were measured using Forest Suppliers steel diameter tape (Model: 345D) and Freemans Topline Fiberglass tape (Model: FBG50M13MTP), respectively. Coordinates and elevation (above sea level) of all the trees were also collected using a Garmin handheld geographic positioning system (GPS, etrex10). Shannon- Wiener and Simpson diversity indices were computed. The map was generated from the information (longitude and latitude) for individual tree locations by their family names. The data (longitude and latitude) was imported to the ArcGIS software (version 10.3.1) environment, and the location of each species was shown on the map (Figure 1).

2.2. Data Analysis

Data obtained for tree species composition were analysed to obtain relative density (RD, %), Relative abundance (Pi), Shannon-Wiener's Diversity Index (H'), and Simpson index (C) using the following expression:

$$RD = \frac{n}{N} \times 100 \quad (1)$$

$$P_i = \frac{RD}{100} \quad (2)$$

$$H' = - \sum_{i=1}^s P_i \ln P_i \quad (3)$$

$$C = 1 - \sum_{i=1}^n P_i^2 \quad (4)$$

Where; n= number of individual tree species, N= total number of trees, P_i = Relative abundance, RD= Relative density (%), H' = Shannon-Wiener index, C= Simpson index. \ln = natural logarithm and $i = 1, 2, \dots, n$.

The stem and crown diameters data were subjected to box plot summary statistics. The data collected were categorized, and frequencies were distributed using bar charts.

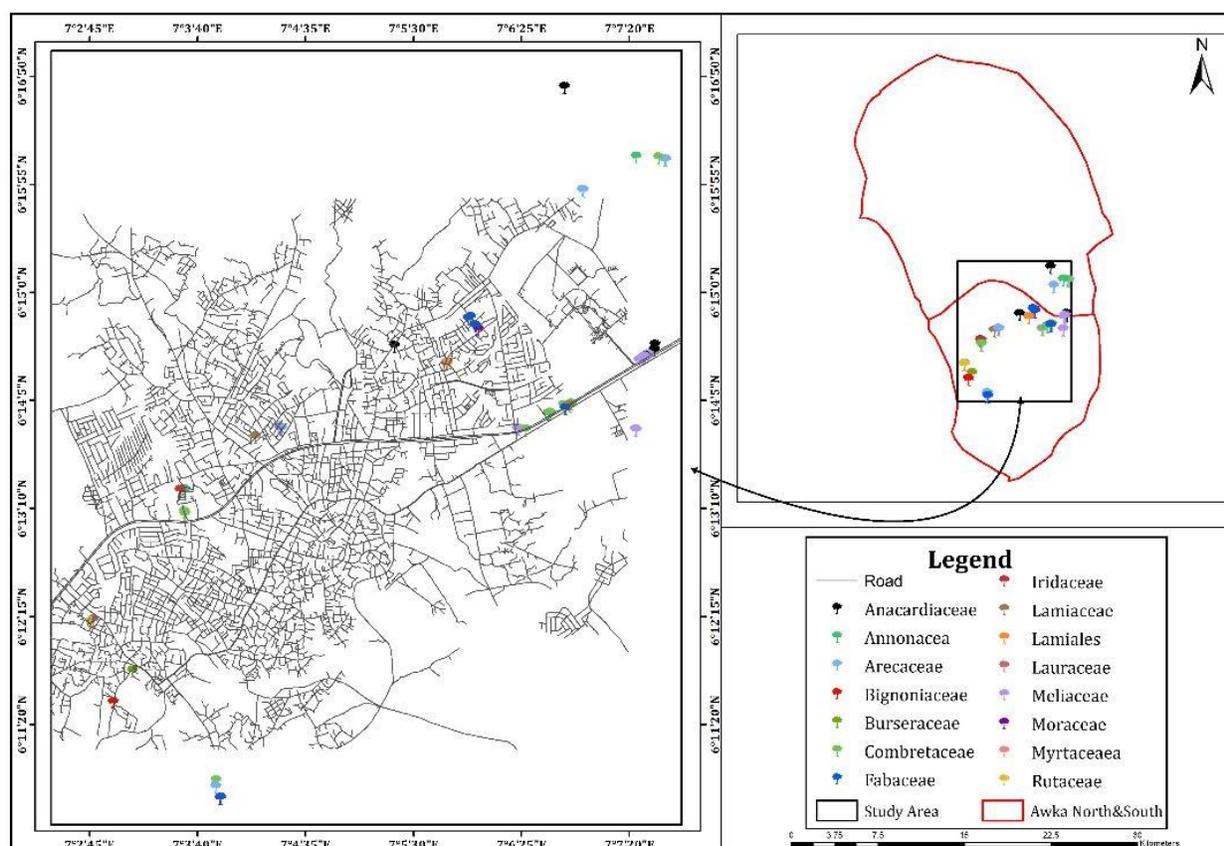


Figure 1: Map of the study area showing tree families' distribution

3. RESULTS

3.1. Tree Species Diversity

The study enumerated 80 trees consisting of 24 species distributed among 13 families and 23 genres. *Azadirachta indica* (RD=13.75%) was the most dominant tree species in the study area (Table 1). Shannon-Wiener's diversity index and Simpson's index are 2.90 and 0.93, respectively (Table 2). *Fabaceae* is the most dominant family in the study area, with the highest number of trees (13). However, *Arecaceae* and

Fabaceae had the highest family frequencies (4 each) in the study area (Table 1).

3.2. Breast Height and Crown Diameters Distribution

The distribution of diameter at breast height (DBH) from minimum to maximum ranged from 10.9 cm to 69.9 cm, and crown diameter (CD) ranged from 1.7 m to 21.6 m (Figure 2). The shape displayed by the DBH distribution is fairly bell-shaped, with the 20-29.9 cm DBH class having the highest number of trees (Figure 3). The distribution of crown diameter in the study area

showed a bell-shaped curve with the highest frequency of avenue trees in the 8-10.9 m CD classes (Figure 3).

Table 1. Relative diversity and abundance of avenue tree species in the study area

SN	Species	Family	F	RD(%)	Pi	Ln Pi	H'	Pi ²
1	<i>Anacardium occidentale</i>	Anacardiaceae	2	2.5	0.03	-3.69	-0.09	0.00
2	<i>Mangifera indica</i>	Anacardiaceae	7	8.75	0.09	-2.44	-0.21	0.01
3	<i>Annona muricata</i>	Annonaceae	1	1.25	0.01	-4.38	-0.05	0.00
4	<i>Polyalthia longifolia</i>	Annonaceae	2	2.5	0.03	-3.69	-0.09	0.00
5	<i>Archontophoenix cunninghamiana</i>	Arecaceae	1	1.25	0.01	-4.38	-0.05	0.00
6	<i>Caryota urens</i>	Arecaceae	1	1.25	0.01	-4.38	-0.05	0.00
7	<i>Cocos nucifera</i>	Arecaceae	4	5.0	0.06	-7.38	-0.18	0.00
8	<i>Elaeis guineensis</i>	Arecaceae	5	6.25	0.06	-2.77	-0.17	0.00
9	<i>Newbouldia laevis</i>	Bignoniaceae	6	7.5	0.08	-2.59	-0.19	0.01
10	<i>Dacryodes edulis</i>	Bursaceae	2	2.5	0.03	-3.69	-0.09	0.00
11	<i>Terminalia catappa</i>	Combretaceae	1	1.25	0.01	-4.38	-0.05	0.00
12	<i>Terminalia mantaly</i>	Combretaceae	10	12.5	0.13	-2.08	-0.26	0.02
13	<i>Albizia lebeck</i>	Fabaceae	5	6.25	0.06	-2.77	-0.17	0.00
14	<i>Delonix regia</i>	Fabaceae	6	7.5	0.08	-2.59	-0.19	0.01
15	<i>Pentaclethra macrophylla</i>	Fabaceae	1	1.25	0.01	-4.38	-0.05	0.00
16	<i>Dialium guineense</i>	Fabaceae	1	1.25	0.01	-4.38	-0.05	0.00
17	<i>Gmelina arborea</i>	Lamiaceae	2	2.5	0.03	-3.69	-0.09	0.00
18	<i>Vitex doniana</i>	Lamiaceae	1	1.25	0.01	-4.38	-0.05	0.00
19	<i>Persea americana</i>	Lauraceae	2	2.5	0.03	-3.69	-0.09	0.00
20	<i>Azadirachta indica</i>	Meliaceae	11	13.75	0.14	-1.98	-0.27	0.02
21	<i>Ficus exasperata</i>	Moraceae	4	5	0.05	-3.00	-0.15	0.00
22	<i>Treculia Africana</i>	Moraceae	1	1.25	0.01	-4.38	-0.05	0.00
23	<i>Eucalyptus globulus</i>	Myrtaceae	2	2.5	0.03	-3.69	-0.09	0.00
24	<i>Citrus sinensis</i>	Rutaceae	2	2.5	0.03	-3.69	-0.09	0.00
	Total		80	100	1.00		-2.90	0.07

Summary: Number of families=13, Number of tree species= 24, Shannon index= 2.90 and Simpson index= 0.93

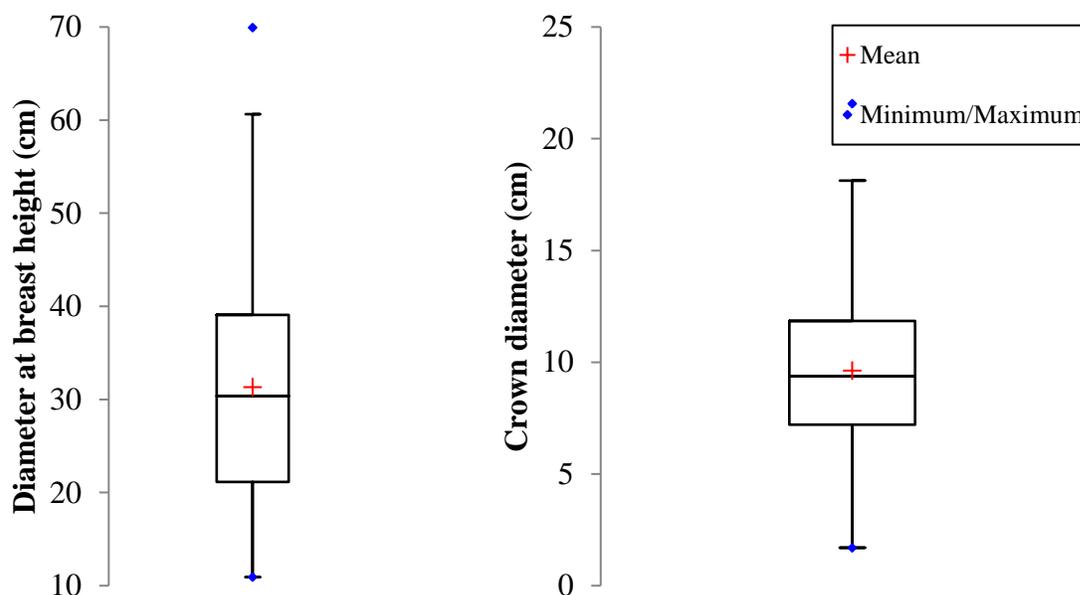


Figure 2: Summary statistics CD and DBH of trees in the study area

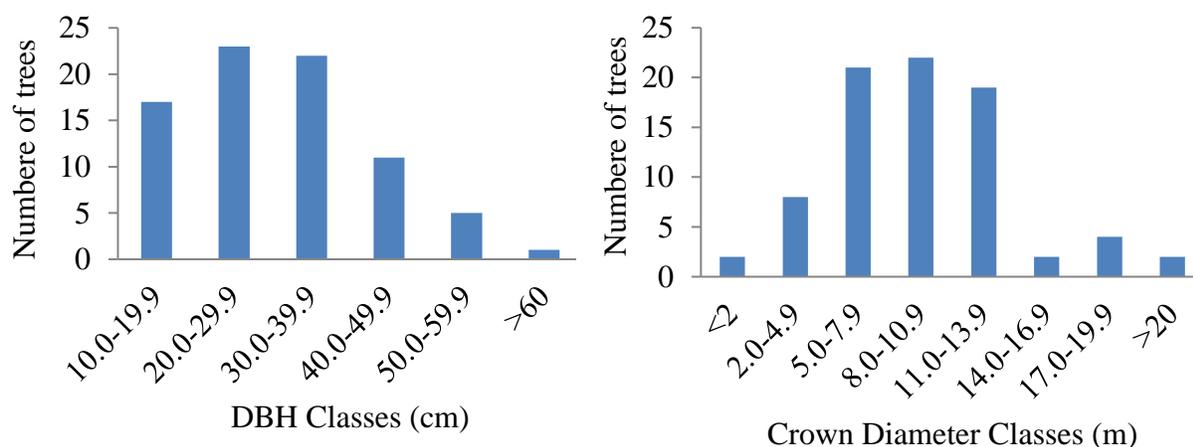


Figure 3: Distribution of DBH and crown diameter of avenue trees in the study area

4. DISCUSSION

This study collected and processed information on tree species, crown, and breast height diameters. This information is beneficial in sustaining avenue trees, making proper aesthetic choices, shading potentials, and sustainable management. Species diversity assessment is a way of auditing an ecosystem to understand its dynamics and quality and how disturbance factors impact it (Meer and Tella, 2018). Hence, this study reported 80 avenue trees distributed among 13 families belonging to 24 tree species. The numbers are lower than 25 families and 54 tree species encountered within

urban centre of Ibadan Metropolis in Oyo State, Southwestern Nigeria, by Agbelade *et al.* (2016).

Azadirachta indica is the most dominant trees species in the streets of Awka Metropolis, Anambra State. Borokini (2011) reported *Azadirachta indica* as one of the prominent trees within Ibadan Metropolis of Oyo State, Southwestern Nigeria. *Azadirachta indica* was also found to be the most abundant avenue tree in the Abuja Campus of the University of Port Harcourt, Nigeria (Eguakun and Nkwor, 2019). According to Dobrilovic (2009), people represent the main factor in trees' nature, distribution, and expansion in a designed landscape. People choose, arrange and remodel

according to their needs and wishes. Pretzsch (2014) also noted that the dominance of a tree species in an environment is greatly influenced by its structural value and functions. Dubey and Kashyap (2014) reported that *Azadirachta indica* possesses powerful dermatonic and anthelmintic, insect repellent, anti-bacterial, anti-fungal, anti-viral, anti-septic, anti-inflammatory, anti-ulcer and strengthens the body's overall immune responses. It is widely used to treat chronic malaria, bed bugs, ulcers, bad teeth, syphilis, leprosy, and spermicidal in preventing pregnancies and other diseases.

Shannon-Wiener diversity index (H) for the avenue trees in Awka Metropolis of Anambra State is lower than 3.35 reported for urban centre of Ibadan Metropolis of Oyo State, Southwestern Nigeria (Agbelade *et al.* 2016). The lower diversity index implies that Ibadan Metropolis is more diverse in tree species than Awka. However, Simpson's evenness for Awka metropolis was higher than 0.84 for urban centre of Ibadan Metropolis (Agbelade *et al.* 2016). The low diversity in Awka Metropolis might be attributed to overexploitation and displacement of avenue trees due to proximity to settlements, increased population, and urbanization in the study area.

This study provided information on tree growth characteristics (DBH and CD) of avenue trees in the Awka metropolis of Anambra State, Nigeria were, presented in Figure 2. The summary statistic was carried out to give an insight into the nature of the data. This study's mean and maximum stem diameter were lower than 122.8 cm and 342.5 cm, respectively, reported by Ezenwenyi *et al.* (2020) for open-grown forest tree species within Nnamdi Azikiwe University, Awka Campus in Anambra State, Nigeria. The lower mean might be due to the level of protection; the University campus tends to be more protected, hence the reason for the more giant trees. A similar trend was observed in crown diameter. The result agrees with Chukwu *et al.* (2017b) that high linear correlations exist between DBH and CD.

Tree stem and crown distribution effectively describe an urban forest because tree productivity, gaseous exchange, and health depend on them (Zarnoch *et al.*, 2004). From the result of the tree variable distribution in the study area, the fair bell shapes exhibited by DBH and CD are typical of an artificial forest, in which avenue trees also fall. However, the non-perfect Bell-shaped structures displayed by graphs might also be because the trees considered were open-grown. The result is comparable with Alo *et al.* (2017) and Chukwu *et al.* (2017b).

5. CONCLUSION

Based on the findings from this study, the following conclusions are made:

1. The species diversity of avenue trees in the Awka metropolis is relatively low, with *Azadirachta indica* the most dominant species.
2. The distribution of the stem and crown diameters of avenue trees in the study area followed a fairly bell shape, with more trees within the middle classes.
3. The study recommended that more trees be planted along streets in the study area.

AUTHORS' CONTRIBUTIONS

'Author OC' designed the study and performed the statistical analysis, 'Author OC' and 'Author CLU' wrote the first draft of the manuscript. 'Author CLO' and 'Author CKM' collected data for the study and managed the literature searches. 'Author CLO' reviewed the first draft of the manuscript. All authors read and approved the final manuscript.

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