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Research Article

Cluster analysis and ethno-botanical studies of some selected tree species in Kwara State University, Malete, Nigeria

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Abstract: Cluster analysis and ethno-botanical inquiry on some selected trees species in Kwara State University, Malate was carried out. This is with a view to finding out relationship between the morphological features and ethno-botanical uses of tree species in study area. Thirty line transects of 10m x 10m were laid out. Ten tree species were identified and their spatial distributions were studied. The spatial distributions were determined by frequency value, Shannon-Wiener's diversity and Menhinick's richness index. *Azadiracta indica* and *Eucalyptus citriodora* were the dominant species with frequency value 34.52% and 13.10% respectively. Morphological parameters of the tree species were subjected to hierarchical cluster analyses, vis: single, complete, average and centroid linkages. The complete and average linkages gave the clearest clusters. Tree species that consistently form clusters irrespective of the analysis type are: *Delonix regia* and *Terminalia ivorensis*. Others species occurred as outliers with some relationships with the clustered species. Dendrogram generated from morphological features of plant species with true nested relationship in both the complete and average linkages method showed in the results of cluster analysis have correlations with traditional medicinal uses of the tree species.

Keywords: Tree species, cluster analysis, dendrogram, frequency distribution, ethno-botany

1. Introduction

Cluster analysis is a useful tool in many data oriented disciplines (Kaufman and Rousseeuw, 2005). Cluster analysis is about pattern recognition, which is also known as unsupervised learning. In biology, cluster analysis is a useful tool for taxonomy - a branch of biology that deals with identifying and naming organisms. Plants are classified based on the relationship/similarities and differences of their characteristics. Plant taxonomists compare morphological parameters and genetic similarities and other characteristics to established functional relationships between plants (Abd El-Ghani, 2016). A tree is a well-defined large, long-lived woody plant, which reaches a height of at least 6m (20ft) at maturity in a given area. Generally, but not always a tree has a single main self-supporting stem called trunk or bole. The trunk gives off spreading outlets, twigs and foliage to make a crown (Seth, 2002; Orwa et al., 2009). Ethno-botanical uses of trees vary with species tree parts vis-à-vis: whole plants, seeds, bark, flower, fruit, foliage leaves to roots etc. Tree parts and medicinal plants in general are valuable resources for production of herbal drug. An appraisal study had shown that herbal drugs constitute as much as 25% of the total drugs in the United State of America, while in China and India is about 80%. Although the usage and economics of herbal drugs varies from country to country, traditional medicine is globally recognized health care system.

According to World Health Organization, traditional medicine is the sum total of all the knowledge and practical experiences, used in the analysis, prevention and treatment of physical, mental or social ailments handed down from generation to generation, whether verbally or in writing form (Abd El-Ghani, 2016). Traditional medicine practices, especially in developing countries

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like Nigeria, are generally non-documented and are associated with superstitions and mysticism. Although, there are efforts at verifications of efficacy of therapeutic claims of some medicinal plants through isolation of active compounds and study of biological activities; there are few efforts that probe into relationship between morphology of plants and their medicinal uses (Sommer and Ross, 2010). Moreover, herbal drugs preparations or prescriptions are often more than one plants or plant parts with claims of similar and synergistic functionalities (Adamu et al., 2005; Chronicle, 2005). It is therefore of interest to find out if there is correlation between plant morphological parameter and their ethno-botanical uses.

Cluster analysis is a plausible tool for looking for relationship between plant morphological data and medicinal uses. One of the assumptions of application of cluster analysis in biology taxonomy is that "all things being equal" a system of nested cluster would be found". This is due to the fact that evolution is believed usually to be a divergent process and the distribution of operational taxonomic unit in a phenetic space should to some extent reflect this. Hybridization and clonal variation are exceptions to this rule. There are different types of cluster analysis, in this study, we set to look for cluster in the morphological data of selected ten tree species at Kwara State University, Malete, using hierarchical clustering method comprising single, complete, average and centroid linkages (Almeidaa et al., 2007). The results were compared with information gathered from traditional medicine practitioners around the host communities to deduce correlations between morphological parameters and ethno-botanical uses.

Derivation of the system from dissimilarity co-efficient is a two-stage process. The study shall limit itself to the first stage. First stage is the derivation of a dendrogram, as a hierarchy with numerical levels. The levels at which each pair of objects meet in a Dendrogram are determined based upon the cluster method used (Sneath, 1996). There are certain facts and assumptions that influences the choice of the relationship method used in cluster analysis in biology. Relationships do not necessarily imply evolutionary (cladistics) relationship (Sneath, 1996). This study was aimed at identifying the taxonomic characters that may reflect relationship between the trees species at the study site.

2. Materials and methods

2.1. Study area and collection of plant specimens

This study area is Kwara State University, Malete, Moro Local Government Area, Kwara State, Nigeria. Kwara State lies between latitude 8° 10' and 19° 50'N and between longitude 3° 10'N and 6° 05'E. Fresh leaves were collected at study sites, Kwara State University, Malete (N08° 43'15" and E004° 28'47"). The voucher specimens of all the collected plants were deposited at the University of Ilorin Herbarium, Plant Biology Department. Identification and nativity was done using local floras (Keay et al., 1990).

2.1.1. Determination of frequency distribution

Thirty (30) different quadrats of 10m by 10m were established for each species using line transect. The occurrence of the selected species in each quadrat was recorded. The frequency of each species was determined as follows:

2.1.2. Status of the tree species

Some plant species were identified taxonomically according to Pascal and Ramesh (1987), Henry et al. (1993), and Matthew (1999). Plant species diversity index (H) was determined using Shannon-Wiener formular (Bhandari, 2003), while Menhinick's formula was used to determined species richness index (D) (Bhandari, 2003). For the ethno-botanical studies, samples were collected and taken to the traditional medicine practioners for confirmation of reported therapeutic usage of the trees species (Burkill, 1995; Akinsoji, 1996; Adamu et al., 2005; Chronicle, 2005; Abdulhameed & Sharma, 2008; Nodza et al., 2013).

$$Plant\ species\ diversity\ index\ \ (H)\ = \frac{NlogN - \sum filogfi}{\mathrm{N}}$$

N = Total number of species in the sample

fi = Number of all the individual species

$$Plant\ species\ richness\ index\ \ (D)\ = \frac{S}{\sqrt{\mathrm{N}}}$$

S = Number of species in the sample, N = Total number of individuals in the sample.

2.2. Morphological parameters of the foliage features

Codes (1, 2, 3, 4, and 5) were assigned to the character states (qualitative and quantitative) in accordance to the observation, measurement and range of variation of these characters among the operational taxonomic unit (OTU). The formular according to Hill (1980) was used to determine the character states for the quantitative features only.

K = 1.0 + 3.332 log n, where K = Number of States, n = Number of species (OTU'S)

The formula helps in the determination of number of states, which could be in range of two or more states called character values which is the transformation of qualitative characters to quantitative characters for the generation of the dendrogram by cluster analysis. The numerical code 1- represent short, 2- represent medium and 3- represent long.

2.3. Cluster analysis

An agglomerative hierarchical cluster analysis was performed using Euclidean dissimilarity (Kettenring, 2006). The morphological parameters of the selected tree species in each quadrant were determined and used for cluster analysis. Hierarchical clustering procedures are characterized by the tree-like structure established in the course of the analysis. The cluster analysis was carried out using a STATA Software (Version 16.0) application packages. This involves coding of morphological parameters, computation of dissimilarity co-efficient and drawing of Dendrogram.

2.4. Information on Ethno-botanical uses

Information on ethno-botanical uses of the selected tree species were gathered through interview of traditional medicine practitioners at surrounding host communities namely: Shao, Elemere, Okete, Malete, Gaa-Alanu, Gbugudu and Abe-Iya. Samples of the tree species were collected and taken to the traditional medicine practitioners for identification to facilitate information gathering on their usages herbalists in those areas for confirmation of reported medicinal usage of the tree species (Abdulhameed & Sharma, 2008; Nodza et al., 2013).

3. Results

3.1. Selected trees species in the study area

About 84 plants species were identified in the study area. The species belong to 9 families. Details of spatial distributions of the selected tree species in the study are summarized in Table 1. Among the tree species, *Azadiracta indica* and *Eucalyptus citriodora* were dominant with frequency value of 34.52% and 13.10% respectively. The species with least occurrence were *Mangifera indica, Terminalia ivorensis, Delonix regia* and *Vitex doniana*.

3.2. Morphological parameters

Details of coded character states of the selected tree species in the study are summarized in Table 2 and 3. Codes (1, 2, and 3) were assigned to the character states (qualitative and quantitative) in accordance to the observation, measurement and range of variation of these characters among the plant species used in the herbal drug preparations.

3.3. Cluster analysis

Cluster analysis is a multivariate procedure for detecting natural groupings in data. Clustering in this study defined by joining which comprises of hierarchical tree or linkage methods. The Dendrogram showed the linkage of each object or group of objects as a joining

Table 1: Spatial distribution of the selected trees species in the study area

	Species	Family	Frequency Values (%)	Diversity Index	Species Richness
1	*Delonix regia* (Hook) Raf	Fabaceae	5.95	1.88	0.55
2	*Azadiracta indica* A Juss	Miliaceae	34.52	1.41	3.16
3	*Terminalia ivorensis* A. Chev	Combretaceae	3.57	1.90	0.33
4	*Ficus Exasperata* Vahl	Moraceae	10.71	1.81	0.98
5	*Eucalyptus citriodora* Hook	Myrtaceae	13.10	1.78	1.20
6	*Vitellaria paradoxa* Gaertn.F	Sapotaceae	7.14	1.86	0.65
7	*Vitex doniana* L	Verbenaceae	5.95	1.88	0.55
8	*Bridelia ferruginea* Benth	Euphorbiaceae	9.52	1.83	0.87
9	*Mangifera indica* L	Anacardiaceae	3.57	1.90	0.33
10	*Tectona grandis* L	Verbenaceae	5.95	1.88	0.55

Table 2: Taxonomic description of qualitative characters of plant species

	Coded	Character State	
Qualitative Characters	1	2	3
Shape of crown	Globular	Conical	Cylindrical
Shape of leaf	Linear	Lanceolate	Oblanceolate
Leaf type	Simple compound	Pinnate compound	Bipinnate compound
Leaf texture	Thin	Thick	Leathery
Leaf base	Cuneate	Obtuse	Cordate
Petiole	winged	Puberulous	Glabrous
Fruit type	Berry	Drupe	Follicule
Flower type	Perfect	Imperfect	Bilateral

Table 3: Taxonomic description of calculated quantitative characters of plants species

	Coded	Character States		
Quantitative Characters	1	2	3	Instrument
Leaf length	Short	Medium	Long	Measurement Tape
Stem height	Short	Medium	Tall	Stem guage
Plant height	Short	Medium	Tall	Altimeter
Freq. Distribution	Small	Medium	Large	Transect line
Leaf area	Small	Medium	Large	Leaf area meter
Crown diameter	Short	Medium	Long	Spiegel Relaskope
Trunk diameter	Short	Medium	Long	Diameter calliper
Freq. of lichens	Small	Medium	Large	Transect line

Quantitative characters transformation for the generation of the dendrogram. The numerical code 1- represent short (< 5cm), 2- represent medium (5 – 15cm) and 3- represent long (> 15cm)

of branches in a tree. The root of the tree is the linkage of all clusters into one set, and the ends of the branches lead to each separate object. The separation of the plants parts and treatment usage is a normal process in herbal drugs preparation which can be standardized with the application of cluster analysis using different linkage methods on some of the selected plant species for ethno-botanical studies.

3.3.1. Single linkage cluster analysis

Single linkage dendrogram showing similarities and dissimilarities between the ten different tree species is presented in Figure 1. The distance (single linkage) between species 1 and 3 is minimal, and this shows that species 1 and 3 are similar. Species 2 is less similar to all the other species clusters. In the single linkage cluster analysis, there appear to be three main clusters, one containing the species 2 and 4, one with the species 1, 3, 7 and 9, and the other with the remaining species.

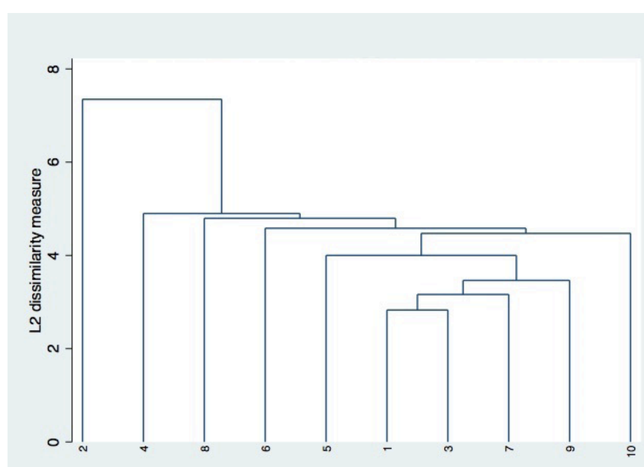

Fig. 1: Dendrogram of the results of single linkage cluster analysis

3.3.2. Complete linkage cluster analysis

Figure 2 shows a dendrogram shows similarities and dissimilarities between the ten different tree species. The distance (complete linkage) between species 1 and 3 is minimal, and this shows that species 1 and 3 are similar. Likewise, Species 8 clusters with species 10. Species 2 forms a distinct cluster and is less similar to all the other species. In the complete linkage cluster analysis, there appear to be three main clusters, one containing the species 1 and 3, one with the species 4, 8 and 10, and the other with the remaining species.

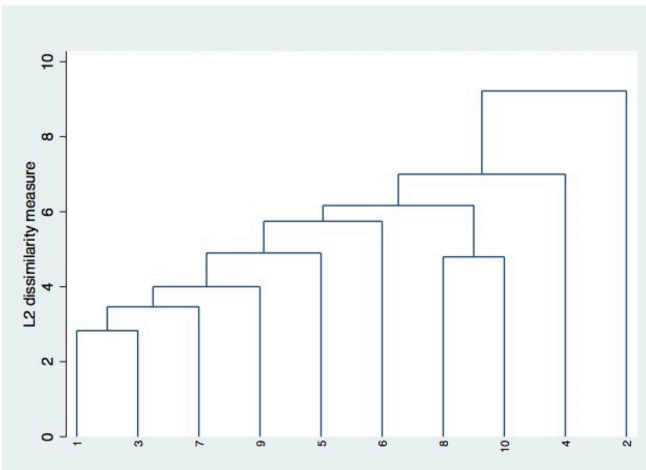

Fig. 2: Dendrogram of the results of complete linkage cluster analysis

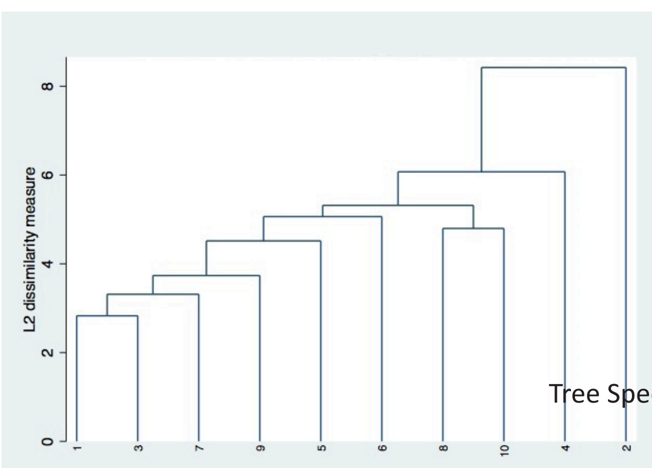

Fig. 3: Dendrogram of the Results of Average Linkage Cluster Analysis

3.3.3. Average linkage cluster analysis

Figure 3 shows a dendrogram showing similarities and dissimilarities between the ten different trees species. The distance (average linkage) between species 1 and 3 is minimal, and this shows that species 1 and 3 are similar. Likewise, Species 8 clusters with species 10. Species 2 forms a distinct cluster and is less similar to all the other species. In the complete linkage cluster analysis, there appear to be three main clusters, one containing the species 2, one with the species 4, 8 and 10, and the other with the remaining species.

3.3.4. Centroid linkage cluster analysis

Figure 4 depicts a dendrogram showing similarities and dissimilarities between the ten different tree species. The distance (centroid linkage) between species 1 and 3 is minimal, and this shows that species 1 and 3 are similar. Species 2 forms a distinct cluster and was less similar to all the other species. In the centroid linkage cluster analysis, there appear to be three main clusters, one containing the species 1 and 3, one with the species 2, and the other with the remaining species.

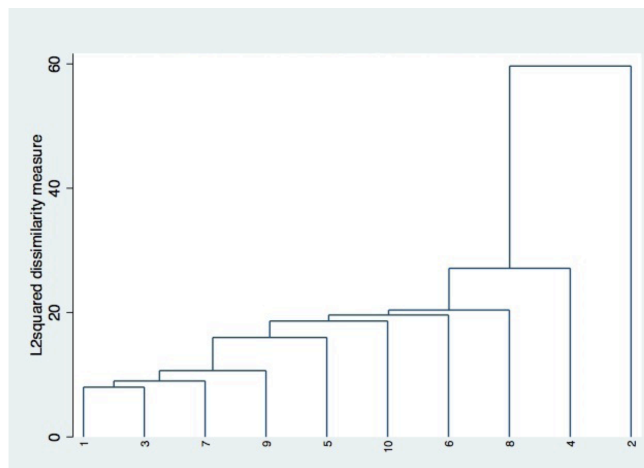

Fig. 4: Dendrogram of the Results of centroid linkage cluster analysis

3.4. Ethno-botanical Information on Selected Trees Species in the Study Area

Ethno-botanical information on selected tree species in the study area is presented in Table 4. The table shows that most of the trees have multiple therapeutically or medicinal uses. The trees species are of varied ecological status.

4. Discussion

It has been estimated that about 1.7 billion people rely on herbal drugs based health care system, and natural products, particularly those of plants origin, remained important sources of new drugs (Odugbemi, 2008). Information gathered from the traditional medicine practitioners indicates that tree species in the study area and the surrounding host communities played major roles in the health care system of the rural communities. The dominant plant species in the study area are: *Eucalyptus citriodora, Ficus exasperate* and *Azadiracta indica*.

Table 4: Ethno-botanical benefits of trees species in the study area

S/N	Botanical Name	Common Name	Family	Plant part used	Ethno-botanical uses
1	Delonix regia (Hook) Raf	Flamboyant tree	Fabaceae	Bark, fruit, twig, Seed, flower	Diuretic, anthelmintics, astringent, leucorrhoea
2	Azadiracta indica A Juss	Neem	Miliaceae	Bark, fruit, twig, Seed, flower, leaves	Malaria, skin diseases, jaundice, syphilis, eczema, ringworm, laxative, jaundice
3	Terminalia ivorensis A. Chev.	Black afara	Combretaceae	Leaves, bark, fruits, roots	Relieve abdominal inflammations, in treating leprosy, scabies and other skin diseases.
4	Ficus exasperata Vahl	Sand Paper tree	Moraceae	Leaves, bark, fruits, roots	For the treatment of urinary disease, gonorrhoea, scabies,stomach ailment
5	Eucalyptus citriodora Hook	Lemon-scented	Myrtaceae	Leaves,	Mouth wash, Nasal blocking, Malaria
6	Vitellaria paradoxa Gaertn.F	Shea Tree	Sapotaceae	Leaves, bark, fruits, roots	Against sunburn, inflammation, rashes , chapping, diarrhoea
7	Vitex doniana L	Black plum	Verbenaceae	Leaves, bark, fruits, roots	Bark, leaves, roots and fruits have medicinal value.
8	Bridelia ferruginea Benth	Ira	Euphorbiaceae	Leaves, bark, fruits, roots	Insomnia, mouth wash, diabetes, gonorrhoea Very useful for the children
9	Mangifera indica L	Mango	Anacardiaceae	Bark, fruit, twig leaves, seed	Diabetes, malaria, diarrhoea, high blood pressure, asthma, cough
10	Tectona grandis L	Teak	Verbenaceae	Bark, fruit, twig, seed oil	Headaches and swelling, dermatitis or vermifuge

Based on low frequency values and species richness of less than 1.0, *Mangifera indica, Terminalia ivorensis, Delonix regia, Vitex doniana* and *Tectona grandis* can be considered as rare species in the study area (Sax, 2002). According to Parthasarathy and Karthikeyan (1997) species having frequency value less than 10% can also be considered rare. Conversely, all selected tree species in the study area have multiple usages. This suggests that uncontrolled exploitation of rare species may lead to losses of biodiversity in the area. Land clearing for agriculture, uncontrolled logging, gathering of firewood, overgrazing, deforestation etc., had been identified as factors affecting biodiversity conservation in Nigeria (Durugbo et al., 2012). Practices such as tree debarking for herbal resources can threaten and endangers survival of some vulnerable or rare species. There is need to advocate for sustainable practices and conserve measures in order to preserve the biodiversity (Nodza et al., 2013).

According to Han and Kamber (2001) use of four hierarchical clustering algorithms can allow comparison and selection of suitable algorithms for a given data set. The four algorithms employed in this study are: minimum distance, maximum distance, mean distance and average distance method. The dendrograms obtained from the analysis of morphological parameters illustrates the variation within and between quadrants generated by the line transects. Dendogram obtained using maximum distance method is vertically expanded, but, that of minimum distance method is compressed. While those obtained using the mean and average distance methods are intermediate. This differentiation is useful in the classification of trees species (Okafor, 2010). Cluster species (1, 3) was found to be common to all the dendrogram irrespective of the cluster method used. But complete and average linkage derived dendrograms have two clusters of species (1, 3) and (8, 10) respectively, both of which coincidentally were gathered to have similar ethno-botanical benefits. Single linkage distance dendrogram has the least coefficient of dissimilarity. And maximum distance and mean distance method gave greater distortion of relationships that the other two clustering algorithms.

Delonix regia (1) and *Terminalia ivorensis* (3) were found to form clusters irrespective of the method used. But *Bridelia ferruginea* (8) and *Tectona grandis*

(10) form clusters in the complete and average linkage dendrograms. While species *Vitex doniana, Mangifera indica, Eucalyptus citriodora,* and *Vitellaria paradoxa* showed some affinity or outlier relationship with the tree species (1, 3). Similarly, *Ficus exasperata* and *Azadiracta indica* occurred as outliers and also of relationship with tree species cluster (8, 10). These patterns of relationship have correlations with ethno-botanical uses of the tree species. Hence, preservation of the bio-diversity becomes important for sustained exploitation of the tree species to meet health care needs. Functionally, other than herbal drug preparation, plants help improves air quality and aesthetics of our environment. Many communities are fast losing micro floral to expansion of cultivated land, over-grassing, infrastructure developments, mining operations etc., and awareness on plant bio-diversity as community resources that should be preserved and conserved is advocated (Gill, 1992; Sofowora, 1993; Igoli et al., 1999; Nodza et al., 2013). Scientific documentation of plant-biodiversity and traditional medicines knowledge will help to take advantage of these resources for incorporation and adaptation into modern medicine and drug developments initiatives (Ekpendu et al., 1998; Cox, 2005; Wang et al., 2005).

5. Conclusion

Rural communities exploit plants therapeutic applications and traditional medicine is still recognized health care system in developing countries. Results from this study re-echoed the need for comprehensive survey of indigenous tree species in order to take advantage of their medicinal potentials. Taxonomically, detail documentation would entail classifications in term of functional values such as afforestation, aesthetics, shelters and ethno-botanical uses. The implication of this study is that the Dendrogram generated from morphological features of plant species with true nested relationship in the complete and average linkages methods out of the four linkages methods used for cluster analysis, the results obtained showed that this type of correlation or relationship could be taken into consideration when involved in the ethno-medicinal practices of herbal drug preparation for health care needs of indigenous population using plants species. Likewise, establishment of KWASU Botanical Garden and Herbarium at the Department of Plant and Environmental Biology will facilitate collections, selections, identifications, classifications, conservations of indigenous tree species in its campus and host communities. Scientific documentation of traditional medicine recipes is encouraged.

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