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MORPHOMETRIC STUDIES OF THE GENUS *PTEROCARPUS* JACQ. (PAPILIONACEAE) IN NIGERIA

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ABSTRACT

Pterocarpus is a pantropical genus of trees in the family of Papilionaceae. The economic, medicinal and social values of these species had been greatly commended by various authors of related field. Inspite of the economic potentials of *Pterocarpus,* doubtful species are recorded and synonyms are often quoted as separatespecies. Consequently, the complexity and variation in the genus had led to various contradictions of identification within the genus. Therefore, the purpose of this study is to resolve the taxonomic complexity that exists in the genus *Pterocarpus* in Nigeria by employing morphometric techniques in classification and identification of the studied taxa. Five species of the genus *Pterocarpus*namely; *P. osun, P. santaliniodes, P. soyauxii, P. erinaceus*and *P. mildbraedii* were studied on the basis of macro features of the leaf, with a view to obtaining reliable characters for easy identification and delimitation of the species. Multivariate analysis such as Principal Component Analysis (PCA), Cluster Analysis (dendogram) and scree plots were employed to evaluate intra specific variations. The leaf shape varied among the taxa ranging from elliptic to ovate in all the species except in *P. soyauxii* that varied from lanceolate to elliptic. Moreover, the leaf apex of all the species was acuminate except *P. mildbraedii*that was mucronulate. Leaf length showed a stronger value (6.3), followed by leaf width (2.5), lamina length (1.8) and petiole length (1.4.). However, these characters (leaf length, leaf width, laminal length and petiole length) contributed to the delimitation of the taxa.The genus was clustered into 3 groups. The first group consists of *P.* soyauxii and *P.erinaceus;* the second group(*P.* osun and *P. mildbraedii*) while the third group contains *P. santaliniodes*only. Among these species, only *P. santaliniodes* distantly related and separated itself from other groups.

Keywords: *Pterocarpus*, identification, delimitation, Character, Nigeria.

Introduction

*Pterocarpus*Jacq. is a pantropical genus of trees in the family of Papilionaceae. It belongs to the sub-family Faboideae and the tribe Dalbergieae. Keay, (1989) reported that the genus comprises approximately 30 species of which about 15 occur in Africa, 10 in America and 5 in Asia. In Nigeria, 6 indigenous species are recorded (Gill and Husaini, 1981). The common name for this genus is camwood or rosewood. They occur in savanna, lowland evergreen or deciduous forest (Ebi and Ofoefule, 2000). The economic importance and uses of the genus generally cannot be underrated. They have wood that is valued for toughness, stability in use, and good for decoration (Lavin *et al.*, 2001). According to Ajiboye *et al*., (2010), the resin from the tree species is used for

dyeing, traditional fabrics, which gives them a fashionable dark purplish color. Generally, their colours make them favourite among woodworkers who use them to make xylophone , marimba keys, and guitars (Jansen, 2005).

In livestock management, *Pterocarpus* species contain nutritious fodder which is rich in energy, proteins and minerals such as phosphorus (Bosu, 2013) consequently; farmers usually prune the trees and integrate leaves in their agropastoral system, enabling the livestock to survive the dry season. Jansen, (2005) recorded some species *Pterocarpus* as nitrogen-fixing plants thus helping to improve nutrient-depleted farmlands. Medicinal uses of *Pterocarpus* are recorded by several authors. Osuagwu and Akomas, (2013) and Egbe*et al*. (1998) reported that the richness of the genus in alkaloid, phenols, saponins, tannins and flavonoids makes them useful in traditional herbal medicine as an antipyretic, anti-inflammatory, anthelmintic, tonic, haemorrhage, aphrodisiac, anti-hyperglycaemic and diaphoretic.

However, despite all these potentials of *Pterocarpus* species, their populations in Nigeria are limited and vulnerable (Burkill, 1995). Infact, in some literatures, doubtful species are recorded and synonyms are often quoted as separate species and because of little attention received from taxonomists, the complexity and variation in the genus had led to various contradictions and errors of identification within the species. Currently, there is no document showing the exact number of *Pterocarpus* species available in Nigeria and this call for serious attention to identify and separate the species from one another. One of the applications or tools used is morphometric. The word “morph” is a greek words meaning shape while metrics means measurement. Morphometrics also known as numerical taxonomy, is the application of various mathematical procedures to numerically encode character data from organisms under study (Abu Zaida *et al*., 2008). Morphometrics applications have their own importance in taxonomy and all systems of classification, all are based on principles of morphology (Gomez-Campo *et al*., 2001). Therefore, the objectives of the study are to re-assess the morphological characteristics, obtaining reliable taxonomic characters for easy identification and delimitation of the taxa.

Materials and Methods

Collections:

Fresh specimens were collected from different areas in Nigeria base on their availability. The specimens were identified and authenticated in Forest herbarium Ibadan. The existing voucher specimens of *Pterocarpus* deposited at the Forest Herbarium Ibadan (FHI).University of Ibadan Herbarium (UIH) was also used for this study. Prior to data collection, the available specimens were carefully examined and the choices of characters were determined following the procedures of Chukwuma *et al*., (2016).

Morphological studies:

Nineteen (19) morphological characters which consist of 11 quantitative and 8 qualitative macro characters were assessed from the available specimen obtained at the Forest Herbarium Ibadan (FHI) and fields. Qualitative characters assessed were leaf shape, leaf apex, leaf base, leaf surface, leaf margin, leaflet arrangement, fruit surface and fruit colour. The characters were observed with the naked eyes and lens where it is

necessary. The quantitative characters include; leaf length, leaf width, petiole length, petiole width, fruit length, fruit width, internode length, number of seed per samara, number of leaf per leaflets, length of pendicel and number of lateral nerves were measured using thread and 30cm ruler following procedure of Olowokudejo, (2010) and Soladoye *et al.*, (2010). The taxonomic relationships of the species using cluster analysis (dendrograms), principal components analysis (PCA) and scree plots were obtained. Specimens in the entire range of distribution of each species were studied. Mean and standard deviation were calculated for each character.

Results

Qualitative morphological characters of *Pterocarpus* species

Eight qualitative morphological characters which include leaf apex, leaf margin, leaf shape, leaf surface, leaf base, leaflet arrangement, fruit surface and fruit colour were examined in the study. The leaf margin, leaf surface and leaf arrangement of studied species are entired, glabrous and alternate respectively in all the species. The leaf shape of the species (*P. erinaceus, P. santaliniodes, P. osun and P. mildbraedii*) varies from elliptic to ovate except *P. soyauxii* that varies from lanceolate to elliptic. Most of the fruit colours vary from brown to brownish yellow.

Table1: Qualitative morphological characters of *Pterocarpus* species

Species	Leaf apex	Leaf margin	Leaf shape	Leaf surface	Leaf base	Leaflet arrangement	Fruit surface	Fruit colour
P. erinaceus	Slightly acuminate	Entire	Elliptic to ovate	Glabrous	Rounded	Alternate	Thorny	Brownish yellow
P. soyauxii	Acuminate	Entire	Lanceolate to elliptic	Glabrous	Rounded	Alternate	Smooth	Brownish yellow
P. Santaliniodes	Acuminate	Entire	Elliptic to ovate	Glabrous	Rounded or cuneate	Alternate	Rough	Brown
P. osun	Acuminate	Entire	Elliptic to ovate	Glabrous	Rounded or slightly cordate	Alternate	Thorny	Brown
P. mildbraedii	Mucronulate	Entire	Elliptic to ovate	Glabrous	Rounded	Alternate	Smooth	Brownish yellow

Plate 1: Photographs of selected *Pterocarpus* species

A.= *P. osun ;* B.= *P. erinaceus;* C.= *P. mildbraedii;* D.= *P. soyauxii;* E.= *P. santaliniodes*

Quantitative leaf morphological features of five selected *Pterocarpus* species

Result in Table 2 shows the quantitative leaf morphological features of five selected *Pterocarpus* species. The mean sizes of the leaves range from 6.6 x 2.6 cm in *P. soyauxii* to 10.0 x 5.6 cm in *P. mildbraedii*. The lamina length of the species studied ranges from 7.4 cm in *P. soyauxii* to 12.4 cm in *P. mildbraedii.* The mean size of the petiole varies from 0.3 cm x 0.2 cm in *P. soyauxii* to 1.1 cm x 0.1 cm in *P. mildbraedii*. The fruit size of the species range from 2.0 x 1.6 cm in *P. santaliniodea* to 3.1 x 3.0 cm in *P. mildbraedii* while the number of leaf per leaflet range from 5 to 16 in *P. osun*, 6 to 9 in *P. santaliniodes*, 6 to 11 in *P. soyauxii* while 7 to 15 occur in *P. erinaceus* and *P. mildbraedii*.

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Table 2: Quantitative leaf morphological features of five selected *Pterocarpus* species

Species	Fr. L. (cm)	Fr. W. (cm)	No of S./Sa.	No of Lf/Lftl	Le. of P. (cm)	No of Lat. Nerve.	Lf. L. (cm)	Lf. W. (cm)	Lamina L. (cm)
P. erinaceus	5.9 (2.6±0.7)	5.6 (2.3±0.6)	1.0 (0.5±0.1)	15.0 (11.3±0.7)	8.6 (6.2±0.3)	38.5 (35.3±0.5)	11.3 (6.9±0.4)	5.3 (3.7±0.2)	13 (8.3±0.5)
P. soyauxii	8.6 (2.1±0.8)	8.9 (2.3±0.9)	1.0 (0.4±0.1)	11.0 (8.2±0.4)	6.7 (4.3±0.3)	35.3 (31±0.6)	7.9 (6.6±0.2)	3.6 (2.6±0.1)	9.3 (7.4±0.3)
P. santaliniodes	5.1 (2.0±0.6)	5.3 (1.6±0.5)	1.0 (0.4±0.1)	9.0 (7.5±0.2)	12.9 (8.5±0.6)	24.3 (22±0.4)	9.5 (8.2±0.2)	5.0 (4.4±0.1)	11.3 (9.8±0.2)
P. osun	13.0 (3±1.2)	14.5(3.3±1.3)	1.0 (0.3±0.1)	16.0 (11.2±0.8)	6.8 (5.2±0.2)	16.8 (14.5±0.3)	10.6 (8.2±0.4)	5.5 (4.1±0.2)	13.4 (10.2±0.4)
P. mildbraedii	9.2 (3.1±1.0)	9.6 (3.0±1.0)	1.0 (0.3±0.1)	15.0 (9.3±0.6)	6.7 (5.2±0.2)	30.5 (24.2±0.9)	15.3 (10±0.8)	7.5 (5.6±0.4)	20.8 (12.4±0.8)

Mean (standard deviation-standard Error). N.B; Le- Length, W- width, Lat. Ner- Lateral Nerves, P –pendicel, Fr. –Fruit, Lf-Leaf, Lftl–Leaf let

Rescaled Distance Cluster Combine

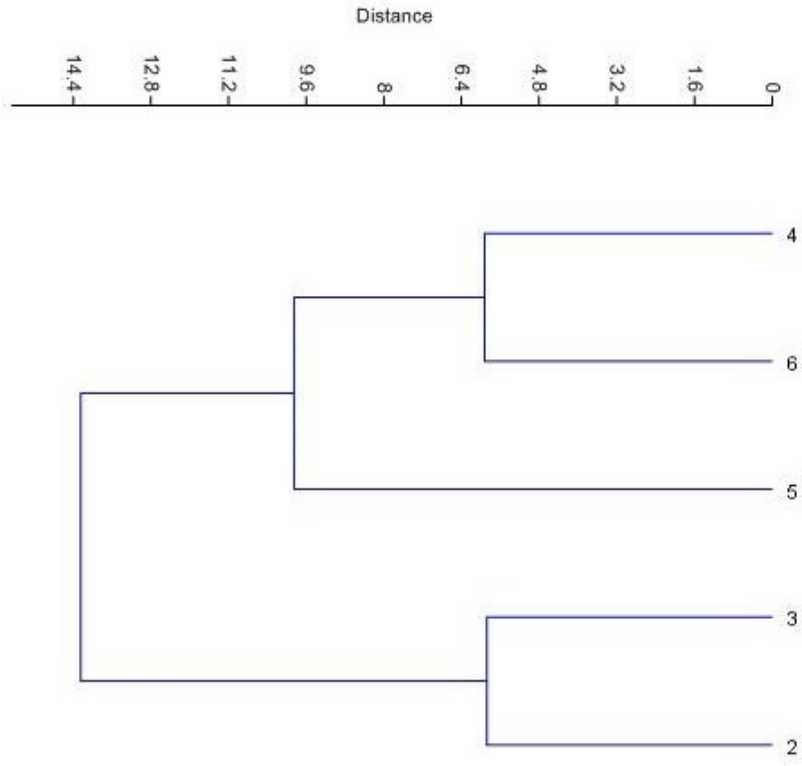

Figure 2: Dendrogram using Average Linkage (Among Groups)

P. erinaceus – 2, *P. soyauxii* – 3, *P. osun* – 4, *P. santaliniodes*– 5, *P. mildbraedii*– 6

Figure 2 shows the dendogram using average linkage among the groups. The dendogram separates the species into three main groups. The first group consists of *P.* soyauxii and *P.erinaceus;* the second group contains *P.* osun and *P. mildbraedii* while the third group contains *P. santaliniodes*only. *P. erinaceus* and *P. soyauxii*are confined together showing a very strong relationship while *P. mildbraedii* and *P. osun* also show similar characters. However, *P. santaliniodes* is distantly related and separated itself from other groups.

Correlation analysis of morphological characters

Principal component analysis of twelve examined characters is shown in Table 3. Twelve characters are examined in which four components are extracted. The first component is most highly correlated with fruit length (value 0.940), followed by the second and fourth components with petiole width (0.608 and 0.543, respectively), while the third component is correlated with number of lateral nerves with value 0.831.

Table 3: Principal component analysis (PCA) of twelve examined characters

Component Matrix[a]

Characters	Component			
	1	2	3	4
Leaf Length	.860	.476	.125	.135
Leaf Width	.806	-.578	.077	.099
Lamina Length	.881	-.429	-.118	.163
Petiole Length	.893	-.154	.282	.315
Petiole Width	-.558	.608	-.153	.543
Internode Length	.670	-.142	.676	.271
Fruit Length	.940	.243	.066	-.228
Fruit Width	.795	.542	-.220	-.160
No. Seed/Sam	-.699	-.021	.665	-.262
No. Leaf/Leaflets	.434	.435	.254	-.747
Length of P.	-.282	-.925	.045	-.250
No. of L. Ner.	-.453	.258	.831	.193

Application of scree plots to examine the characters of the genus *Pterocarpus*

Result in Figure 3 shows the scree plots that gives the weight of individual character in graphical form. Eigen value of +1 is taken to be determinant and those above the value are considered to be much stronger. Leaf length shows a stronger value (6.3), followed by leaf width (2.5), lamina length (1.8) and petiole length (1.4.), while those characters less than the Eigen value (+1) (5-petiole width; 6-internode length; 7-fruit length; 8-fruit width; 9-number of seed per samara; 10-number of leaf /leaflets; 11- length of pedicel; 12-number of lateral nerves) characterized the investigated taxa. However, the examined characters with value of +1 and above contributed immensely to the delimitation of the taxa of studied.

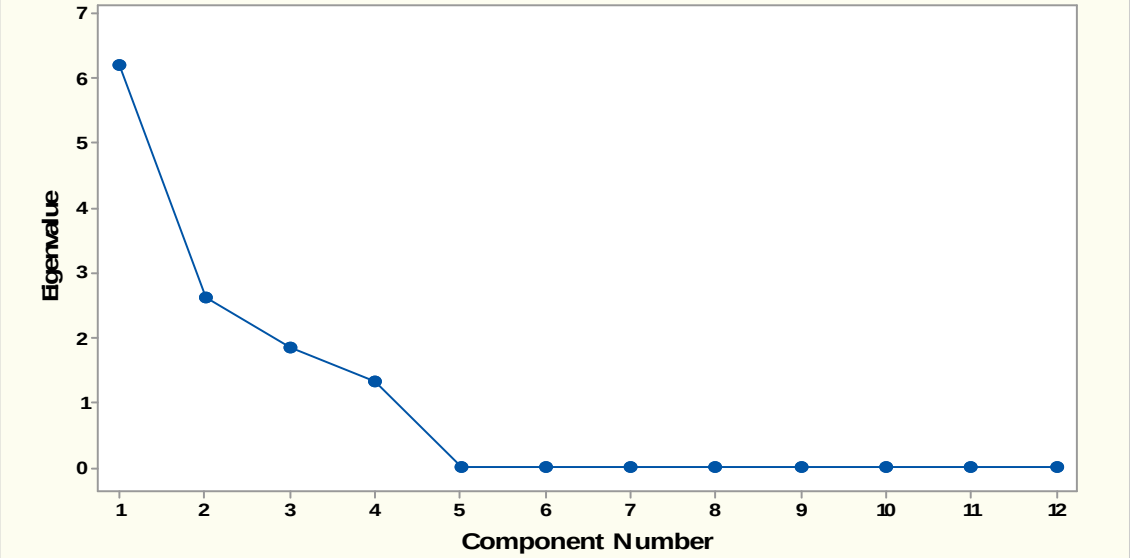

Figure 3: Screen plot of examined characters of the genus *Pterocarpus*

1-leaf length; 2-leaf width; 3-lamina length; 4-petiole length; 5-petiole width; 6-internode length; 7-fruit length; 8-fruit width; 9-number of seed per samara; 10-number of leaf /leaflets; 11- length of pedicel; 12-number of lateral nerves

Discussion

The genus generally is relatively uniform in the qualitative macro characters of the leaf except in the leaf shape of *P.* soyauxii, which varies from lanceolate to elliptic and leaf apex (*P. mildbraedii*), mucronulate. Similar report by Ayodele and Olowokudejo, (2006) showed the uniformity in the qualitative macro characters of the family Myrtaceae in which the leaf shape varied from linear to lanceolate in the tribe leptospermeae and from elliptic, oblong to ovate in the tribe Myrteae. Campey *et al*., (2000) reported that the leaf shapes and sizes that vary within the same plant may be due to the action of light intensity on the leaves, thereby affecting the carbohydrate balance which in turn affects the length of the cells in the direction of long axis. The leaf size, lamina length, petiole length and fruit size of *P. mildbraedii* is larger than other species of study and this distinguish it from other species. This concurred with Jones, (1986) who reported that the leaf sizes are useful aids in distinguishing varieties with similar flowering in perennial grass.

The closeness of these species base on their similar characteristics was observed between *P. erinaceus* and *P. soyauxii* and likewise between *P. osun and P. mildbraedii.* The characters such as Leaf length, leaf width, laminal length and petiole length generally delimit *Pterocarpus* species. Chiapella, (2000) and Gomez-Campo *et al*., (2001) emphasize methods of numerical taxonomy in classifying many plants as well as interpreting results of taxonomic studies. Therefore, variation in the vegetative and floral organs are important diagnostic tools, which could be

used in the delimitation of taxa, and the importance of these morphological features in taxonomic classification of plant species was noted by Nwachukwu and Edeoga (2006) and Stern, (2000). However, separation of *P. santaliniodes* from all other species is noteworthy and diagnostic in taxonomy classification.Although, the existence of the separation of *P. santaliniodes* is distant but at the same time shares characters with other species of study. Similar report by Opeyemi *et al.*, (2016) showed the relationship between *Jatropha* species through the method of numerical taxonomy, in which great affinity is noted between *J. podagrica* and *J. multifida* as compared with *J. gossypifolia* and *J. integerrim* that are distantly related. The components of characters such as fruit length, petiole width and number of lateral nerves contribute immensely in the classification of the genus *Pterocarpus* in Nigeria. However, numerical taxonomy is based on the numerical comparison of large number of equally-weighted characters, scored consistently for all the groups under consideration and in which individuals are grouped on the basis of observable similarities (Subrahmanyam, 2006).

Conclusion

This study employs the taxonomic tools such as morphology to distinguish and characterize the studied taxa. Collectively, all the characters are well defined taxonomically for the appropriate identification and classification of the studied *Pterocarpus* species. The study so far had established morphological features to be significantly diagnostic for the clarification of taxonomic and phylogenetic relationship in the genus *Pterocarpus.* More impotantly, the revision of neglected morphological characters and employment of new morphological features with latest techniques had further identifying and classifying the genus *Pterocarpus.* The characters such as leaf size (length and width), lamina length, petiole length and fruit size had contributed immensely in delimiting the taxa studied. Moreover, variation in leaf shape and apex of the studied species separated the taxa. Nevertheless the relevance of morphological characters in identification and classification of any species is not enough, therefore, it is recommended that further taxonomic tools such as anatomy, palynology, phytochemistry, are needed for proper classification of the species.

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