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Biosystematics, Morphological Variability and Status of the Genus *Khaya* in South West Nigeria

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ABSTRACT

There are about 900 different kinds of trees in Nigeria; some are easily recognized but many can only be named with certainty, when flower or fruits are available. Some tree species remain several years without flowering. For this reason, the use of vegetative characteristics to distinguish between tree families, genera or species is the norm. However, different individuals of the same species may present a variation in their morphology either naturally or in connection with local adaptations. Khaya species are among the important timber tree species in Nigeria as well as in some west and central African countries. There has been a serious and growing concern regarding the status and use of these forest resources in Nigeria. However, some researchers have pointed out that Khaya is one of the genus that is threatened by extinction because of the high level of exploitation with little or no regeneration. Therefore, it is crucial to investigate the current status of Khaya species for conservation and to conduct research that will provide up-to-date information on the morphological characteristics of species in this genus to enhance their taxonomic identification. The study area was south-western Nigeria. Four protected forest reserves and four unprotected (free) areas around each of the forest reserves were purposely selected for this study after a reconnaissance survey. Inventory of all Khaya species within these selected forests was then undertaken. Nine morphological characteristics were measured on every ten (10) randomly chosen leaves from each tree. Bark thickness of each tree was measured using bark gauge. Interestingly, discriminant analysis classified some species based on individual morphology into the different populations. This was an indication that some species have similar morphological features, with different species occupying the same geographical location. Adaptation has been seen as the reason for different species of mahogany co-existing in the same place and exhibiting the same morphological characteristics. However, this research work has provided some morphological traits that could still help to differentiate them despite their morphological similarities.

Keywords: Morphological variability, Biosystematics and Genus *Khaya*

INTRODUCTION

There are about 900 different kinds of trees in Nigeria (Keay *et al.* 1964); some are easily recognized but many can only be named with certainty, when flower or fruits are available. Identification of most tree species particularly the Khaya genus by taxonomists is a herculean task. Very often, the identifications of some the species must be based on vegetative material such as leaves, stems and bark (Duminil and Dimichele, 2009). Some tree species could stay for several years without flowering. For this reason, the use of vegetative characteristics to distinguish between tree families, genera or species is the norm. The genus Khaya belongs to the family of Meliaceae. Five species of the genus Khaya are believed to occur in Africa with four of them occurring in West Africa. These are: *Khaya anthoteca* (Welw.) C. Dc., *K. senegalensis* (Desv.) A. Juss, *K. ivorensis* A. Chev. and *K. grandifoliola* C. Dc. (Hutchinson and Dalziel, 1954). The West African species are commonly referred to as African mahogany. According to Okere and Adegeye

(2011), Khaya wood is a highly priced wood, often used for carpentry, joinery, furniture, cabinetry and decorative veneer. Identification of these species has long been based on morphological traits, which are measurable phenotypic characteristics of individual trees. Duminil and Michele (2009) pointed out that plant morphology is highly polymorphic and phenotypic characteristics may, in principle, allow plant species classification. However, different individuals of the same species may present a variation in their morphology either naturally or in connection with local adaptations. According to Whittall *et al.* (2004), some species of the same genus can be morphologically very similar and may be grouped into the same species despite the fact that they represent separate taxonomic entities. Another drawback of morphological characteristics for the differentiation of species is based on their accessibility. Indeed, it is often difficult to have access to the vegetative part of adult woody individuals, especially in tropical forest ecosystems (Duminil *et al.*, 2006). This problem increases when the diagnostic morphological characteristics are reproductive traits that are absent during most of the year.

Traditionally, morphological data have been used to delimit species and have continued to be widely used (Wiens and Penkrot, 2002). This approach is facilitated by recent methods that allow continuous quantitative characteristics and polymorphic characteristics to be included in phylogenetic analyses with little loss of information (Wiens, 2001). Not only are vegetative features heritable but they also vary substantially between tree species. Also, it is clear that phenotype is fundamentally based on the genotype (Hartwell *et al*., 2004). One of the reasons why morphological characteristics will be in continuous use for tree identification, especially in developing countries like Nigeria, is the high cost of molecular analysis. Identification of Khaya species, especially in south-western Nigeria has always been based on morphology that often changes with environmental conditions and developmental stages. Besides, field taxonomists often confuse their identification because almost all the species in this genus show high morphological resemblance.

There has been a serious and growing concern regarding the status and use of Khaya resources in Nigeria (Ajake, *et al.*, 2011). According to Batta *et al.*, (2013), Nigeria has one of the highest rates of deforestation in the world, having lost around 410,100 hectare of forest per year over the period 2005 to 2010. Alamu and Agbeja (2011) pointed out that Khaya is one of the genus that is threatened by extinction because of high level of exploitation with little or no regeneration. In Nigeria, the upsurge in ethno-botanical studies and scientific research into the use of plant species has further enhanced the pressure on populations of medicinal forest species as more people now use plants' for treating various body ailments (Okere and Adegeye, 2011). Excessive bark harvesting of Khaya species is one of the major factors constituting reduction in their population. Iwu (1992) showed that more than 70% of the Nigerian population depends on folk medicine for their health care delivery. In south western Nigeria, Khaya species still exist in the wild state. Also, efforts to establish plantation of Khaya species in South West Nigeria have not been successful due to *Hypsipyla robusta*, a wild pest believed to aggressively destroy their young plant. Therefore, their regeneration and long term conservation are at the mercy of the vagaries of nature and the profit driven herb collectors and timber merchants. Therefore, it is crucial to investigate the current status of Khaya species as well as research that will provide up-to-date information on the morphological characteristics of species in this genus to enhance their conservation and taxonomic identification.

MATERIALS AND METHODS

Study Area

The study was carried out in south-western Nigeria, which consists of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States (Figure 1). The area lies between longitude 2^0 31' and 6^0 00' East and Latitude 6^0 21' and 8^0 37'N with a total land area of 77,818 km^2 (Agboola, 1979). The study area is bounded in the east by Edo and Delta states, in the north by Kwara and Kogi states, in the west by the Republic of Benin and in the south by the Gulf of Guinea. The climate of South-western Nigeria is tropical in nature and it is characterized by wet season of about seven to eight months and dry seasons of about three to four months. The temperature ranges between 21°C and 34°C while the annual rainfall ranges between 1500mm and 3000mm (Agboola, 1979). The wet season is associated with the South West monsoon wind from the Atlantic Ocean while the dry season is associated with the North East trade wind from the Sahara Desert. Most of the soils in the study area developed from undifferentiated igneous and metamorphic, pre-cambrian basement complex rocks such as granite, biotite, gneiss, biotite schist, quartz schist and quartzite (Adesodun *et al*., 2007).

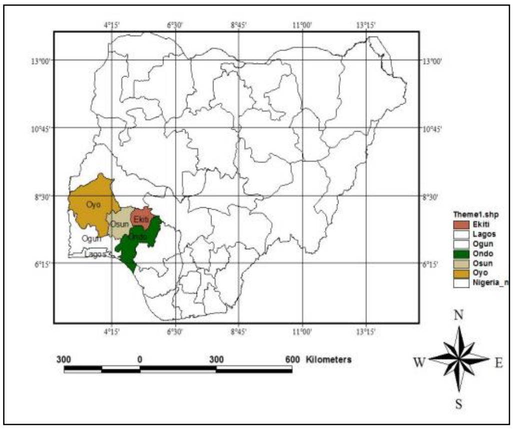

Figure 1: Map of Nigeria showing the study area (South-Western Nigeria)

Method of Data Collection

Inventory of Khaya species in southwestern Nigeria

Inventory of all Khaya species in four protected forest reserves: Eda in Ekiti State, Owo in Ondo State, Oke-Ila in Osun State and Opara in Oyo State respectively were selected for this study. In addition, four unprotected (free) areas comprising of Omuo, Iludofin, Omuo Oke, Eda in Ekiti State; Oyin, Oka, Okeagbe, Epinmi in Ondo State; Agbeye, Faji, Atioro, Asaba in Osun State; and Sabe, Irawo, Agoare, Saki in Oyo State, which are neighbouring the forest reserves were purposely selected after a reconnaissance survey aimed at identifying where Khaya species could be found. The inventory was carried out using key informants, forest guards, farmers or tree finders who know virtually every region and have the knowledge of where Khaya species could be found in the forest reserves and free areas. The length and breadth of each forest was covered and sampled trees were inventorized where found given that the remnant Khaya trees are sparsely distributed. The Geographic Positioning System (GPS) locations of each Khaya trees located were recorded. A Map of the South West showing the location of all sampled Khaya trees was generated using ArcView software.

Sample Collection and Morphometrics

Morphometric characteristics and their codes as used in this study are given in Table 1. Nine morphological characters were measured on every ten (10) randomly chosen leaves from each tree that was found. The leaves were taken from prominent branches of the crown, where they have adequate light interception. This was done to ensure that the shading effect on the leaves had been eliminated and that they are of the same age.

Table 1: List of Morphometric characteristics and Codes as used in this study.

Traits	Code	Unit
Leaflet Number	LN	
Leaflet Length	LL	cm
Leaflet Lamina Length (proxy to distance between two prominent veins)	LLL	cm
Leaflet Petiole Diameter	LPD	cm
Leaflet petiole length	LPL	cm
Leaflet Maximal Width	LMW	cm
Distance from base of the leaflet to the point maximal width	PMW	cm
Apex Length	AL	cm
Bark Thickness	BT	cm
Leaflet Surface Area	LSA	cm^2

Collections of leaf samples for morphological analysis were carried out in the protected and unprotected forests. Effort was made to collect samples from as many accessions as possible in each study area. Bark thickness of each tree was measured using bark gauge. Leaf morphometric analysis was conducted using Leaf Area Meter to capture the measurements of the various morphological characteristics.

Method of Data Analysis

Basal Area and Volume Estimation

The basal area of the different tree was calculated using the formula (eqn. 1):

$$BA = \frac{\pi D^2}{4} \ldots\ldots\ldots\ldots(1)$$

Where BA = Basal area (m^2), D = Diameter at breast height (cm) and π = Pie (3.142).

Total BA for each species was obtained by adding the BA of all individual trees encountered within each State and their mean BA was calculated by dividing the total BA by the number of trees.

The volume of individual trees was estimated using Newton's (Husch *et al.,* 2003). This equation is expressed as follows (eqn. 2):

$$V = \frac{\pi h}{24}\left(D_b^{\ 2} + 4D_m^{\ 2} + D_t^{\ 2}\right)\ldots\ldots\ldots.(2)$$

Where: V = Volume of tree (m^3); D_b = Diameter at the base (m^3); D_m = Diameter at the middle (m^3); D_t = Diameter at the top (m^3); H = Height (m)

Total volume for each species was obtained by adding the volume of individual trees encountered within each State. Their mean volume was calculated by dividing the total volume by the number of trees.

To reduce the measured variables based on their contribution to the observed morphological variation, principal component analysis (PCA) was performed. The similarity and dissimilarity among populations of each taxon was determined using discriminant analysis (Zar, 1999; Sokal and Rohlf, 2003). Variations in morphological traits among populations and individuals were determined using the ten (10) morphological traits, by conducting a one-way analysis of variance (ANOVA). PCA and discriminant analysis were performed using XLSTAT software package (Addinsoft SARL, Paris, France, 2009) on Excel platform, while ANOVA was conducted using SPSS version 16.0 software.

RESULTS

Geographical locations of the sampled African Mahogany trees in south-western Nigeria

A total 279 mahogany trees were found in the study area. Their geographical locations are presented in Figure 2. In Ondo State, a total of 96 trees consisting of *K. grandifoliola* (26 trees), *K. ivorensis* (20 trees) and *K. senegalensis* (50 trees) were encountered. Out of 56 mahogany trees found in Ekiti State, 38 trees were *K. grandifoliola*, 6 were *K. ivorensis* and 12 were *K. senegalensis*. The only mahogany species found in Oyo State was *K. senegalensis* (56 trees). A total of 71 trees oftwo mahogany species were found in Osun State, consisting of K. *grandifoliola* (54 trees) and *K. ivorensis* (17 trees).

Table 2 shows the mean basal area and volume of *Khaya* species sampled from south-western Nigeria. Mean basal area of *Khaya ivorensis* was found to be significantly higher in Ekiti State (0.49m^2) than in Ondo (0.19m^2) and Osun States (0.16m^2). Similar trend was observed for the mean volume of this species among the three states. Mean basal area and volume were not computed for Oyo state because *Khaya ivorensis* was not found in that state. The mean basal area and volume of *Khaya grandifoliola* were found to be significantly lower in Ondo state (0.25m^2, 4.49m^3) than in Osun State (0.31m^2, 4.86m^3). Significant difference did not exist in the mean basal area and volume of *Khaya senegalensis* in Ondo (0.11m^2, 0.74m^3) and Oyo (0.14m^2, 1.00m^3) states. However, they were significantly higher than the mean basal area and volume of the species in Ekiti state (0.03m^2, 0.12m^3). Figure 3 reveals the height distribution of sampled *Khaya* species in south-western Nigeria. Both *Khaya senegalensis* and *Khaya grandifoliola* dominated the low height classes. However, their number decreased as the tree height increased. The number of *Khaya grandifoliola* increased from 31 trees at 0-5m height class to 36 trees at 5-10m height class and gradually reduced to 7 trees at >30 m height class. Three trees were recorded for *Khaya ivorensis* at 0-5 m height class, their number increased to 6 trees at 5-10 m height class and 17 trees at 10-15 m height class. A gradual reduction was recorded for the population of *Khaya ivorensis* from 11 trees at 15-20 m height class to 1 tree at >30 m height class. Related trend was observed for *Khaya senegalensis* as shown the Figure 3.

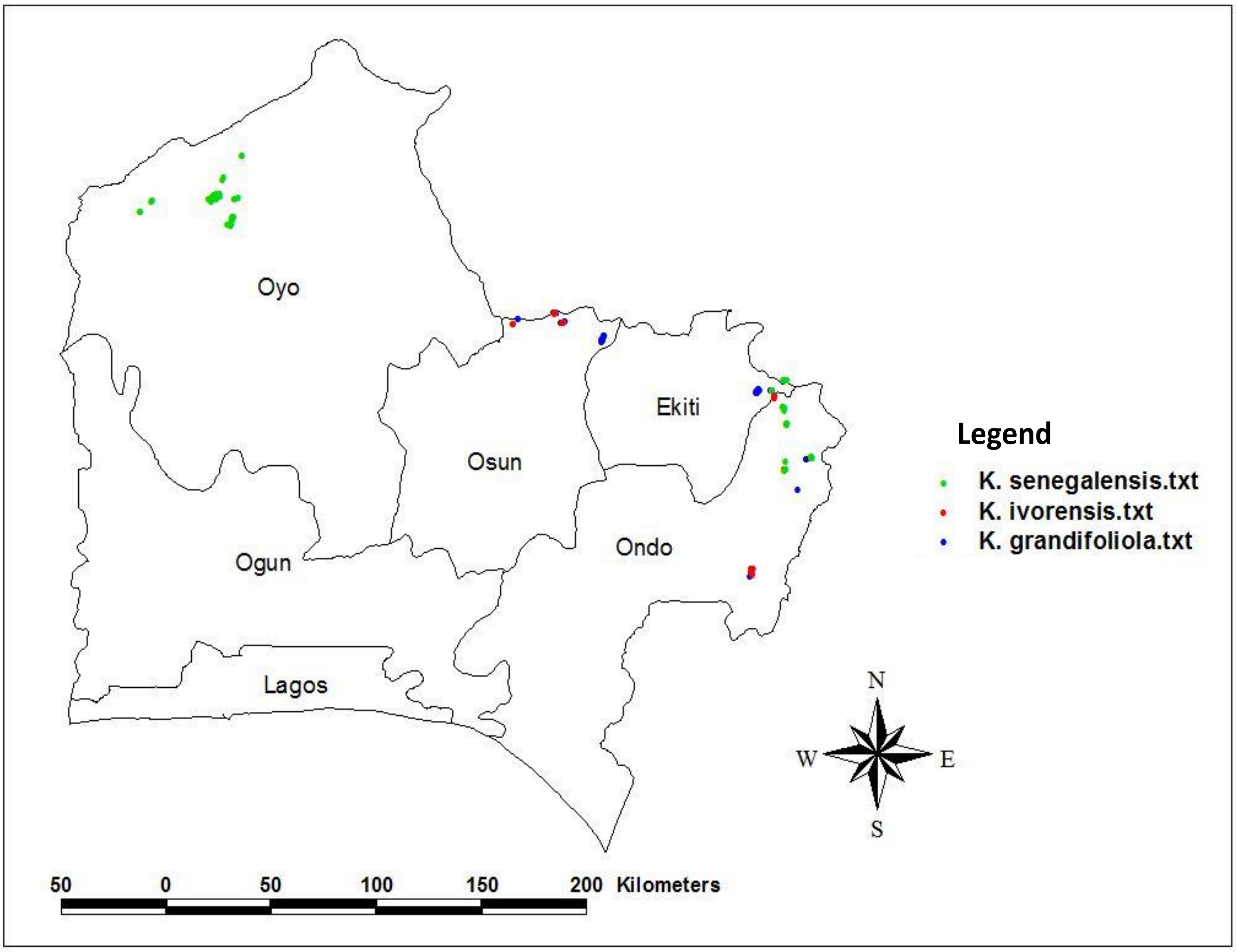

Figure 2: Map of South-Western part of Nigeria showing the distribution of the sampled Khaya Species

Table 2: Mean Basal Area (BA) and Volume of *Khaya* species trees in south-western Nigeria

States	*Khaya ivorensis*			*Khaya grandifoliola*			*Khaya senegalensis*		
	No. of Trees	Mean BA (m^2)	Mean Vol. (m^3)	No. of Trees	Mean BA (m^2)	Mean Vol. (m^3)	No. of Trees	Mean BA (m^2)	Mean Vol. (m^3)
Ondo	20	0.19^b	1.73^b	23	0.25^a	4.49^a	39	0.11^a	0.74^a
Ekiti	6	0.49^a	6.15^a	33	0.10^b	1.58^b	8	0.03^b	0.12^b
Osun	14	0.16^b	2.02^b	39	0.31^a	4.86^a	-	-	-
Oyo	-	-	-	-	-	-	54	0.14^a	1.00^a

Means in the same column with the same superscript are not significantly different

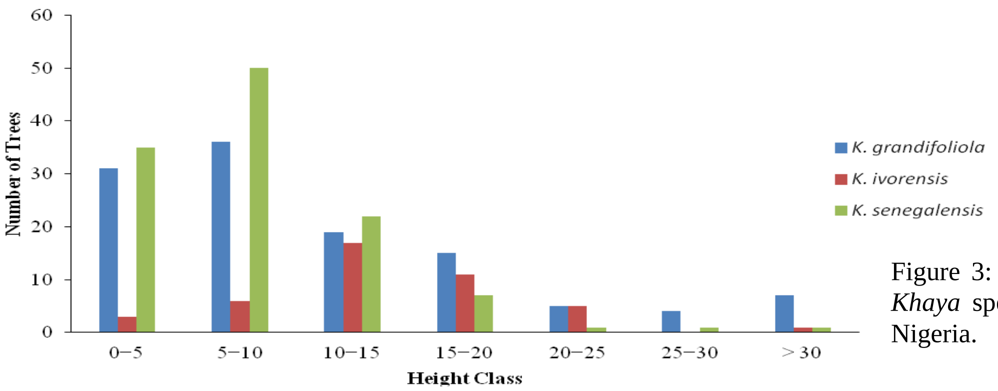

Figure 3: Height distribution of *Khaya* species in south-western Nigeria.

Figure 4 showed the diameter distribution of *Khaya* species in south-western Nigeria. Generally, more populations of each species was found in the first three diameter classes (0-10 cm, 10-20 cm and 20-30 cm). The greatest population of *Khaya grandifoliola* trees (21 trees) was found in 10-20 cm dbh class. This was followed by 0-10 cm diameter class with 25 trees and 20-30 cm class with 19 trees. The population of *Khaya ivorensis* was generally few in all dbh classes. The population of *Khaya senegalensis* in the first dbh class was 21. It increased to 25 trees at 10-20 cm dbh class and 30 trees at 20-30 cm dbh class. Thereafter, its population declined as the dbh class increased.

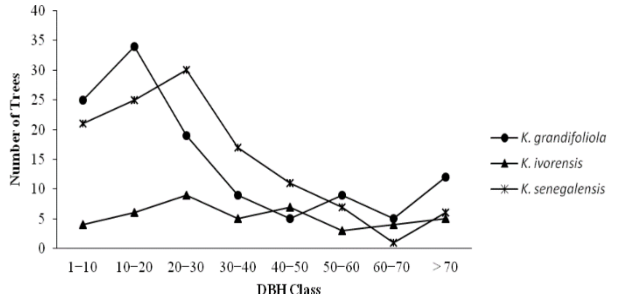

Figure 4: Diameter distribution of *Khaya* species in south-western Nigeria

Morphological Variability

Out of 279 mahogany trees found in the study area, only 247 trees were used for morphological analysis due to the difficulties in collecting leaf samples from 32 trees. The result of the Principal Component Analyses (PCA) for the ten morphological traits of *K. grandifoliola, K. ivorensis and K. senegalensis* is presented in Table 3. The principal components (i.e. PC1, PC2 and PC3) presented for each of the species are those that satisfied the Kaiser criterion (eigenvalues > 1). Those eigenvector values for each trait with high loadings for a principal component are indicated in boldface. The PCA reduced the ten morphological characteristics as input variables to three principal components (PC) explaining 73.5% and 72.5% of the total variance in *Khaya grandifoliola* and *Khaya ivorensis,* respectively. However, it was resolved to two principal components in *Khaya senegalensis* explaining 56.1% of the total variance in the original data. The first components (PC1) explained about 45.1%, 43.2% and 41.7% of the total variance in *K. grandifoliola*, *K. ivorensis* and *K. senegalensis* populations, respectively.

The variables which gave the highest contribution to the first principal components (PC1) in the three species were: leaflet length (LL), distance between two prominent veins (Lvein), leaflet petiole diameter (LPD, not included in *K. senegalensis*), leaflet maximum width (LMW), distance from the base of the leaflet to the point of maximal width (PMW) and leaflet surface area (LA). This is indicated by looking at the high positive loadings of the eigenvectors of the first component (PC1). The second component (PC2) was related to leaflet number (LN), leaflet petiole length (LPL), apex length (AL) and back thickness (BT); the results were similar in both *K. grandifoliola* and *K. ivorensis* except for *K. senegalensis* where leaflet petiole diameter (LPD) was not included. However, the third component (PC3) was related to distance between two prominent vein (Lvein), leaflet petiole length (LPL) and apex length in *K. grandifoliola* populations, while in *K. ivorensis*, it was directly related to leaflet petiole length (LPL), apex length (AL), back thickness (BT) and inversely related to distance between two prominent vein (Lvein).

The tests of equality of group means, a measure of discriminating power of predictor variable, showed that each species has a mean score that is significantly different in each of the ten (10) predictor variables (Table **4**). The classification results based on the morphological traits using discriminant analysis is presented in Table 5. Originally, (from the row total), 95 trees were identified as *K. grandifoliola*, 37 trees as *K. ivorensis* and 115 trees as *K. senegalensis*. Of the 95 trees taxonomically identified as *K. grandifoliola,* 71 trees were predicted correctly and 24 trees were incorrectly predicted. Of these 24 trees wrongly predicted, 21 trees were grouped with *K. ivorensis* and three (3) grouped with *K. senegalensis*. Out of 37 trees taxonomically identified as *Khaya ivorensis*, thirty-three (33) were correctly predicted, while 4 of the trees were determined to be *Khaya grandifoliola.* Similarly, 113 trees identified as *Khaya senegalensis* were correctly predicted, while the remaining 2 trees taxonomically predicted as *Khaya senegalensis* were verified to be *Khaya ivorensis*. This observation was also represented in percentage (%) as shown in the Table 5.

The result of the analysis of variance (ANOVA) for the comparison of ten (10) morphometric traits of *Khaya* genus showed that there was significant differences between the morphometric traits of *Khaya* genus investigated, except leaflet number. This variation was subjected to further statistically analysis (follow-up test) to hierarchically classify them and the result is presented in Table 6. Leaflet length was found to be significantly higher in *Khaya grandifoliola* (20.99 cm) than *Khaya ivorensis* (17.79 cm) and *Khaya senegalensis* (11.47 cm). Leaflet lamina length (LLL), which is the approximate distance between two prominent veins, was found to be significantly higher in *Khaya grandifoliola* (1.75 cm), but statistically the same for *Khaya ivorensis* (1.42 cm) and *Khaya senegalensis* (1.30 cm). Similarly, mean Leaflet petiole length (LPL) in *Khaya ivorensis* was found to be 1.25 cm which was significantly longer than that of *Khaya grandifoliola* (1.15 cm) while the shortest Leaflet petiole length was found in *Khaya senegalensis* (0.86 cm). The leaflet petiole diameter (LPD) was found to be significantly higher in *Khaya grandifoliola* (0.31 cm), followed by *Khaya ivorensis* (0.27 cm) and *Khaya senegalensis* (0.21 cm) respectively.

Leaflet maximum width (LMW) was found to be significantly higher in *Khaya grandifoliola* (9.53 cm) than *Khaya ivorensis* (7.65 cm) and *Khaya senegalensis* (4.43 cm). The same trend was observed for distance from the base to the Point of Maximum Width (PMW) and apex length (AL). There was no significant difference in bark thickness (BT) of *Khaya grandifoliola* (5.31 cm) and *Khaya senegalensis* (6.39 cm) trees. However, bark thickness in *Khaya grandifoliola* and *Khaya senegalensis* were significantly higher than that of *Khaya ivorensis* (5.38 cm). Finally, leaflet surface area (LSA) was significantly higher in *Khaya grandifoliola* (146.04 cm^2) than in *Khaya ivorensis* (99.05 cm^2), which is significantly higher than in *Khaya senegalensis* (36.69 cm^2).

Table 3: Principal component analysis for ten (10) morphological characters in *K. grandifoliola, K. ivorensis and K. senegalensis*

Variables	*K. grandifoliola*			*K. ivorensis*			*K. senegalensis*	
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2
Eigenvalues	4.507	1.761	1.078	4.316	1.715	1.236	4.172	1.442
Percent (%)	45.068	17.614	10.779	43.159	17.147	12.356	41.719	14.424
Cumulative percent (%)	45.068	62.682	73.461	43.159	60.306	72.662	41.719	56.142
Morphological trait								
LN	0.120	**0.531**	-0.105	-0.080	**0.671**	**0.223**	0.120	**-0.523**
LL	**0.447**	0.007	0.085	**0.422**	0.087	0.006	**0.457**	-0.013
LLL	**0.308**	0.021	**-0.549**	**0.303**	-0.074	**-0.304**	**0.396**	0.112
LPL	0.014	**-0.468**	**0.434**	0.101	**-0.310**	**0.573**	0.016	**0.368**
LPD	**0.382**	-0.188	0.154	**0.387**	-0.058	0.142	0.194	**-0.216**
LMW	**0.389**	-0.079	-0.017	**0.414**	-0.027	-0.059	**0.415**	0.166
PMW	**0.417**	-0.062	0.093	**0.373**	0.043	-0.186	**0.408**	0.077
AL	0.072	**0.417**	**0.676**	0.186	**0.511**	**0.458**	0.121	**-0.428**
BT	-0.113	**-0.524**	-0.039	0.048	**-0.417**	**0.509**	-0.053	**0.555**
LA cm^2	**0.449**	-0.062	-0.013	**0.466**	0.028	-0.047	**0.475**	0.087

Table 4: Tests of equality of group means

Morphological Traits	**Wilks' Lambda**	**F**	**df1**	**df2**	**Sig.**
Leaflet Number	0.912	4.652	5	241	0.000
Leaflet Length	0.384	77.438	5	241	0.000
Leaflet Lamina Length	0.771	14.299	5	241	0.000
Leaflet Petiole Length	0.635	27.743	5	241	0.000
Leaflet Petiole Diameter	0.619	29.702	5	241	0.000
Leaflet maximum Width	0.229	162.044	5	241	0.000
Base to Point of Maximum Width Distance	0.503	47.602	5	241	0.000
Apex Length	0.502	47.852	5	241	0.000
Back Thickness	0.807	11.530	5	241	0.000
Leaflet Surface Area	0.338	94.252	5	241	0.000

Table 5: Discriminant analysis classification results

		Species	**Predicted Group Membership**			**Total**
			K grandifoliola	*K ivorensis*	*K senegalensis*	
Original	Count	*Khaya grandifoliola*	71	21	3	95
		Khaya ivorensis	4	33	0	37
		Khaya senegalensis	0	2	113	115
	%	*Khaya grandifoliola*	74.7	22.1	3.2	100.0
		Khaya ivorensis	10.8	89.2	.0	100.0
		Khaya senegalensis	0.0	1.7	98.3	100.0

DISCUSSION

Although the result of the Analysis of variance (ANOVA) showed that all measured leaflet morphological traits were remarkably different among Khaya populations, the follow-up result revealed some similar morphological traits in different mahogany species in this study. Interestingly, discriminant analysis classified some species based on individual morphology into the population of different species. This is an indication that some species had similar morphological features with different species occupying the same geographical location. Hence, incorrect taxonomic identification may arise. This morphological similarity between different species occupying the same geographical location could possibly be attributed to semblance developed as a result of adaptation to diverse environmental conditions. These results are in sgreement with those of other studies which indicated that the conditions of the physical environment influence morphological traits of plants (Picotte *et al.*, 2009; Pither, 2003; Oyarzabal *et al.*, 2008).

In some studies, leaf morphology was found to vary obviously among populations. For instance, Danquah *et al.* (2011), observed considerable foliar morphometric variation within and among two species of African mahogany (*K. ivorensis* and *K. anthotheca)*. Their results clearly demonstrated high phenotypic diversity of several of the foliar morphological characteristics measured and differed significantly among populations. Similar results have been reported by Ofori *et al.* (2007) in their work on the growth dynamics of *Khaya* species in relation to shoot borer resistance. Furthermore, variation in leaf morphology in tree species is not uncommon. According to Bruschi *et al.* (2003) and Boratynski *et al.* (2007), high intra - and inter-population variation is among tree species. The results revealed that some morphological traits like: leaflet length (LL), leaflet petiole length (LPL), leaflet petiole diameter (LPD), leaflet maximum width (LMW), distance from the base to the Point of Maximum Width (PMW) and apex length can be used for distinctive identification of the species in the Khaya genus when carefully considered. More so, the number of these species in different height and diameter classes was relatively few. This is an indication that the species are becoming extinct. Particularly, if the present rate of exploitation for *Khaya ivorensis* persist, it will in a very short time become extinct. Reprehensibly, out of 43 tree species of *Khaya ivorensis* found in the study area, only 3 trees were recorded to occur at the 0-5 m height class and only 4 trees exist at the 1-10 cm diameter class. The implication of this is that when the existing *Khaya ivorensis* trees are exploited either through selective logging or destruction through bark collection for medicinal purposes, this species then may become extinct in south-western Nigeria.

CONCLUSION AND RECOMMENDATION

Adaptation has been seen as the reason for different species of mahogany co-existing in the same place and exhibiting the same morphological characteristics. However, this research has provided some morphological traits that could still help to differentiate them despite their morphological similarities. Reduction in the yield of mahogany and low frequency of individual trees was due to selective logging, coupled with constraints on natural regeneration. Efforts to establish plantations of *Khaya species* in West Africa have generally failed, because of their susceptibility to shoot borer attack. Enrichment planting as documented by Lawal and Adekunle (2013) should be adopted to save these species from extinction.

Also, the rate of harvesting the bark and leaves from these species has effect on their population growth rate, which could result in long-term population decline. Therefore, concerted effort should be made by individuals, organizations, agencies, State and Federal governments toward conserving the remaining *Khaya* species in south-western Nigeria. This is urgently and conspicuously necessary to ensure availability of these Mahogany species in Nigeria and the valuable resources they provide for the economy and citizens well-being.

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