MORPHOLOGICAL CHARACTERISTICS OF SOME *Millettia* SPECIES (FABACEAE - PAPILIONOIDAE) IN NIGERIA

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Abstract: In spite of a century long research on *Millettia* (Fabaceae-Papilionoideae) species, the taxonomy remains controversial. In attempt to resolve this problem, a detailed morphological study was conducted on some indigenous Nigerian species to elucidate their taxonomic relationships to present complementary data to aid the identification of the species. Morphological characters were assessed for stable, distinctive and diagnostic characters for the delimitation of these species. Qualitative characters were noted and recorded while the quantitative features were measured with a ruler and thread. All the data were recorded and subjected to appropriate statistical analyses. Results from the principal component analyses (PCA) were used to explore variations in the quantitative characters among *Millettia* species, and cluster analyses were used to ascertain systematic groupings of the taxa. Results from the macro-morphological examinations showed that the leaflet shape varied among species while leaflet types, apex, base, margin and arrangement are similar in all species. Occurrence of stipel, presence or absence of hairs on the leaf surface, pedicel and fruit clearly distinguished the species from one another. In general, other attributes such as leaflet length and width, lamina length, fruit length and width, number of leaflet pairs per leaf and number of lateral nerves of leaflets were species-specific. The similarity in morphology indicates interspecies relationships, which justify their groupings together in the same genus while the differences confirm their delimitation as distinct species. A new identification key has been constructed other than the ones used in the flora of West Tropical Africa.

Keywords: Delimitation, *Millettia* species, morphometric, Principal component analysis, qualitative characters

Introduction

According to International Union Conservation for Nature (IUCN, 2007), Nigeria has between 4,715 and 5,000 species of vascular plants of which 171 species are endangered. It is heartrending that majority of the forest environments have been removed as a result of human activities such that usual dense forest canopies have disappeared from many forested zones (Oduoye and Ogundipe, 2013). Important plant species have been eroded from the lofty vegetation, some are extinct, while many others are endangered (Ayodele, 2005). *Millettia* Wight & Arn. species are endangered either because of over-exploitation or degradation of their biotope. In effect, the overexploitation of the biotopes is causing a rarefaction of this genus (Banzouzi *et al*., 2008).

From broad taxonomic sense, *Millettia* is a large genus comprising of trees, shrubs or lianes (Keay, 1989; Lock, 1989; Sirichamorn *et al*., 2012). According to these authors their leaves are imparipinnate, with whole leaflets, usually opposite, with stipellae and pulvinus at the base of the rachis. The inflorescence is paniculate or pseudo-racmose. The flowers are generally longer than 1cm, with a violet, pink, blue or white corolla that is silky or glabrous outside. The calyx is campanulate and the standard is ovate or suborbicular. The wings are sometimes attached to the keel-petals, which are obtuse. Stamens are usually adherent, and the filament of the vexillary stamen is free at the base but adherent to the others in its middle. All the anthers are alike, ovoid and dorsifixed. The disc is between the stamens; annular or lobed or sometimes undeveloped. The ovary is pubescent, sessile or nearly so, with 3 or more ovules. The pod is coriaceous, leathery or woody, dehiscent in two valves. It is often flat, more rarely subcylindrical with two or more seeds. The seeds are orbicular or kidney-shaped with a ring-like aril, yellow or white, clasping the funicle. They are well separated from one another, but their disposition in the pod can vary.

The genus *Millettia* is indigenous to Nigeria, Cameroun, Congo, Cote d'Ivoire, Ghana and Togo (Orwa *et al*., 2009). It is widely distributed in tropical Africa and found abundant in south east of Nigeria. Traditionally, species of *Millettia* have been used to ameliorate pathological conditions. Certain species of this genus are widely used in Southeastern Nigeria for the treatment of diseases (Lotana *et al*., 2013). Due to their ethno-botanical values, they have been greatly exploited and depleted from Nigerian forest over many decades (Banzouzi *et al*., 2008).

Inspite of the great importance of *Millettia*, this genus is still confronted with the problem of misidentification. The various species of *Millettia* are sometimes difficult to recognize by the local populace (Aubréville, 1950; Hu *et al*., 2000). Although some morphological, phytochemical and molecular studies have been conducted on *Millettia*, many issues still remain unresolved. Taking into account its great diversity of uses and the taxonomic confusion among its species, *Millettia* deserves more attention.

The present work thus aims at ascertaining reliable taxonomic characters for easy identification and delimitation and also indicating relationships among species.

Materials and Methods

Plant collection

Dried herbarium specimens of all the species were studied morphologically at the Forest Research Institute of Nigeria, Ibadan. Data were taken from ten species of*Millettia*: *Millettia aboensis* (Hook.f.) Bak., *M. barteri* (Benth) Dunn., *M. chrysophylla* Dunn, *M. drastica* Welw. ex Bak., *M. dinklagei* Harms, *M. griffoniana* Baill., *M. macrophylla* Benth, *M. pilosa* Hutch & Dalz, *M. thonnningii* (Schum. & Thonn.) Bak. and *M. zechiana* Harms. A complete list of the specimens examined and the raw data file are shown in Table 1. All names of plants are according to the flora of West Africa (Hutchinson and Dalziel, 1958).

Morphological studies

Twenty-five morphological characters (Sixteen qualitative and nine quantitative characters) were studied for each specimen.

Qualitative studies

The qualitative characters include leaf shape, leaf base, leaf apex, leaf types, leaf arrangement, leaf surfaces, leaf margin,

petioles, fruit types, fruit shape, stipel, colours of petals, inflorescence type and pedicel surface. Qualitative characters were based on physical examination with naked eyes. Descriptive terminologies used were according to Hutchinson and Dalziel (1958).

Quantitative analyses

The morphometric analyses of the quantitative data are according to the method employed by Soladoye *et al*. (2010 and 2013) and Sonibare *et al*. (2004). The length of the leaflet was obtained by spreading the middle leaflet on a flat surface on the laboratory bench, while for the width the same median leaflet was chosen and measured to ensure uniformity. The measurement was taken to the nearest centimeters. Counts were taken of the number of leaflets and lateral nerves.

Statistical analyses

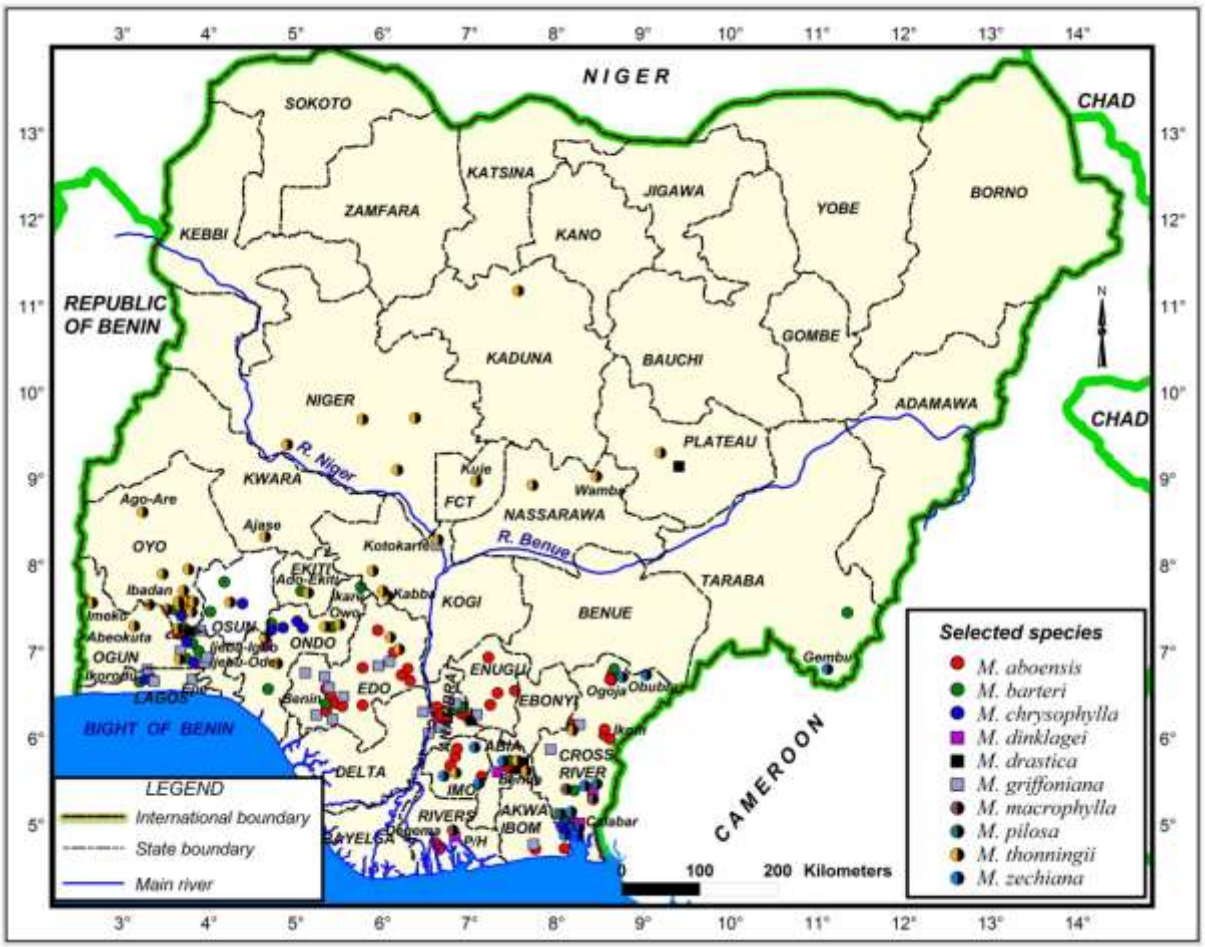
The values generated were then input into Microsoft Excel spreadsheet and raw data were coded to allow analysis using Statistical Package for Social Sciences (SPSS) for windows version 14. The observations were expressed as mean ± standard deviation and the values of the nine quantitative parameters that characterize each of the ten species were subjected to Principal Component Analysis (PCA) as well as cluster analysis.

Results and Discussion

Distribution of Millettia spp

The map (Fig. 1) shows the states in the country where the species are available. The distribution area of *Millettia* covers 21 of 36 states in Nigeria. *M. aboensis* grows in Anambra, Akwa-Ibom, Abia, Cross-river, Imo, Cross river, Abia, and Edo states. *M. barteri* thrives in Lagos, Ondo, Cross river, Osun, Abia, Ogun, Oyo, Adamawa, Taraba and Kogi states. *M. chrysophylla* is commonly found in Ogun, Oyo, Ondo and Osun states. *M. dinklagei* grows in Abia, Cross river and Akwa-Ibom. *M. drastica* is only recorded in southeastern Nigeria (e.g. Abia). *M. griffoniana* thrives in Kwara, Ogun, Lagos, Edo, Anambra, Ondo and Cross river states. *M. Macrophylla* is found in Cross river and River states. *M. pilosa* grows in Abia and Cross river. *M. thonningii* is the most widespread and abundant species of the genus, it is found in Oyo, Ogun, Ondo, Kwara, Benue, Niger, Imo, Sokoto, Bauchi, Plateau and Kaduna states. *M. zechiana* is found in Abia, Cross river, Imo, Niger, Bauchi and Sokoto.

Distributions of the taxa were given on map of Nigeria (Fig. 1) according to White (1983). Most of the Nigerian species of *Millettia* have fairly restricted distributions resembling the African taxa (Banzouzi *et al*., 2008). Using the distribution types presented in Table 1, *Millettia* species are very rare in northern Nigeria but are in abundance in southeastern part.



Source: Author's survey (2012)

Fig. 1: Map of Nigeria showing the distribution of *Milletia* species

Table 1: Site description of some of the specimens studied

Taxa	Collector/FHI/Source/Date
M. aboensis	* Ariwaodo, FHI 89212, savanna, Aji, Nsuka, AnambraState 8/12/77.
	* Akim, FHI 33837, secondary high forest, Okwesan F/R, Ishan, Benin 4/11/55.
	* Ejiafor, M.C, FHI 24671, forest Urhehue, Foretry Camp, Sapoba, Benin 22/11/48.
	* Odewo&Ugbogu, FHI 106215, high forest, Ukpon, Obubra, CrossRiver 27/1/02. * Ekwuno&others, FHI 95660, F/R Bende, Imo 7/9/81.
M.bateri	* Gbile and others FHI 93370, in the creeks at Majidun, Ikorodu, Lagos 28/5/80.
	* Soladoye and Ekwura, FHI 93389, Gashaka Game Reserve, Serti, Gongola 14/2/80.
	* Emioiogbo, J.A., FHI 61196, Gwatto river, Iyekuselu, Benin 2/1/69.
	* Daramola B.O, FHI 90259, on the roadside from Oke-Agbe, Ondo 22/6/79.
M. chrysophylla	*Ahmed & Chizea, FHI 19041, along Ibadan-Ijebu road, Ibadan, Oyo 20/9/48.
	* Okafor J.C and Latilo M.G FHI 57251, secondary high forest, Ominla, Ondo 21/9/65.
	* Olorunfemi and Daromola, FHI 71101, near Owenna river, Akure 2/8/74.
	* Gbile Z.O, FHI 84318, high forest, Ijebu-Igbo, Ogun 16/3/75.
M. dinklagei	* Olorunfemi, Binuyo&Babagbemi, FHI 96740, Ireje-Ajagba, road, Ondo 17/11/81.
	* Daramola, Macauley&Oguntayo, FHI 78438, Atimbo road, Calabar 2/9/75.
	* Okafor D.C, FHI 60336, marshy ground, PortHarcourt 12/08/66.
	* Daramola, Macauley&Oguntayo, FHI 78598, Oban road, Calabar 29/9/75.
M.drastica	* Okafor, J.C.&Ariwaodo, FHI 57613, farm regrowth, Ngwugwu valley, Bende 27/1/75
	* Daramola, B.O. FHI 61553, high forest, Ngelyaki, Gembu, Sardauna 6/7/68.
	* Emwiogbon&Akagu, FHI 72931, Mamu river forest reserve, Awka 10/3/74.
	* Okafor&Latilo, FHI 57620, high forest, Ohajia road, Bende, Umuahia 27/1/66.
M. macrophylla	* Adebusiyi J.K. FHI 43990, Oban group forest reserve, Calabar 11/9/60.
	* Daramola, Macauley&Oguntayo, FHI 78527, Oban group forest, Calabar 10/9/75.
	* Daramola B.O, FHI 56428, Oban group forest, Calabar 22/10/65.
	* Binuyo A., FHI 41439, high forest, Buden Dunlop Estate, Uwet, Calabar 10/8/59.
M. griffoniana	* Daramola&Ibhanesebhor, FHI 70319, Omo F/R, Ijebu-Ode, OgunState 14/2/73.
	* Jones A.P.D, FHI 627, sandy silt, Anoma-Amabo, Onitsha 9/2/43.
	* Jackson G., FHI 23636, Lagoon foreshore, Ikorodu, Lagos 15/2/69.
	* Harold E., FHI 11858, secondary regrowth bush, Miai, Onitsha 21/2/44.
M. pilosa	* Onyeachusum H.D.&Latilo M.O, FHI 54058, farm regrowth, Oban, Calabar 21/2/64.
	* Onochie C.F.A, FHI 36220, road side, Orem, Oban, Calabar 18/2/64.
	* Latilo&Oguntayo, FHI 70571, Old farm regrowth, Oban F/R, Calabar 11/3/73.
	* Latilo, FHI 70571, farmland, Calabar-Mamfe road, Akpai, Calabar 25/2/64.
M. thonningii	* Kennedy J.D., FHI 8654, high forest, Olokomeji F/R, Abeokuta, Ogun 1/1928.
	* Olorunfemi&Oguntayo FHI 86632, savanna, Iyere, Owo, Ondo 11/1977.
	* Onochie C.F.A., FHI 42088, Gwallo hill, Gwari, Niger 21/07/58.
	* Onochie C.F.A., FHI 39634, high forest, Dawaki F/R, Zongan Katal, Zaria 22/02/55.
M. zechiana	* Ariwaodo, FHI 99555, Itunta, Umuahia-Ikwuano, Imo 14/4/82.
	* Savory H.J&Kaey, R.W.O, 25169, Ikwette, Obudu, Ogoja 28/12/48.
	* Emwiogbon J.A, FHI 63917, Open Savanna, Uzuakoli, Bendel 8/3/72.
	* Daramola B.O., FHI 57414, Government quarters, Calabar 20/5/66.

Table 2: Variation in some morphological characters

Character / Species	Plant habit	Plant Height (m)	Leaf shape	Leaf apex	Leaf base	Leaf margin	Stipel	Leaf types	Leaf surface	Leaf arrangement	Leaf pairs	Petal colour	Inflorescence types	Pedicel surface	Fruit shape	Fruit surface
M. aboensis	Tree	4.0	Elliptic	Acuminate	Obtuse	Entire	Absent	Pinnately compound	Pubescent	Opposite	7-8	Purple	Woody raceme	Pubescent	Flat	Pubescent
M. barteri	Climber/shrub	9-12	Elliptic	Acuminate	Obtuse	Entire	Present	Pinnately compound	Pubescent	Opposite	7-10	Red/ pink	Panicle	Glabrous	Flat	Pubescent
M. chrysophylla	Small tree/ shrub	5.8	Oblong	Acuminate	Obtuse	Entire	Present	Pinnately compound	Pubescent	Opposite	2-4	White	Panicle terminal/ Subterminal	Glabrous	Flat	Glabrous
M. dinklagei	Small tree/ Shrub	4.5	Oblong-lanceolate	Acuminate	Obtuse	Entire	Absent	Pinnately compound	Glabrous	Opposite	3-6	White	Panicle Terminal	Glabrous	Flat	Glabrous
M. drastica	Small tree/ Shrub	3.7	Oblong	Acuminate	Obtuse	Entire	Absent	Pinnately compound	Glabrous	Opposite	7-9	Pale blue	Panicle	Glabrous	Flat	Glabrous
M. griffoniana	Tree	6.0-9.0	Elliptic	Acuminate	Obtuse	Entire	Present	Pinnately compound	Glabrous	Opposite	3-4	Purple/ lilac	Pendulous raceme	Glabrous	Flat	Glabrous
M. pilosa	Shrub	2.0	Elliptic	Acuminate	Obtuse	Entire	Present	Pinnately compound	Slightly pubescent	Opposite	8-10	Pale purple	Panicle	Slightly pubescent	Flat	Slightly pubescent
M. macrophylla	Tree	3.0	Elliptic	Acuminate	Obtuse	Entire	Present	Pinnately compound	Slightly pubescent	Opposite	5-6	Pink/ purple	Erect raceme	Glabrous	Flat	Slightly pubescent
M. thonningii	Tree	20.0	Elliptic	Acuminate	Obtuse	Entire	Absent	Pinnately compound	Pubescent	Opposite	2-4	Purple	Lateral raceme	Glabrous	Flat	Glabrous
M. zechiana	Shrub/ Tree	7.0-8.0	Oblong	Acuminate	Obtuse	Entire	Present	Pinnately compound	Slightly pubescent	Opposite	5-12	Purple	Raceme	Glabrous	Flat	Pubescent

Only two species (*M. barteri* and *M. thonningii*) of the 10 species occurring in Nigeria have wider ranges. Of the two, *M. thonningii* has the widest range of distribution. Furthermore, three species i.e. *M. dinklagei*, *M. drastica* and *M. pilosa* are restricted to southeast Nigeria, *M. chrysophylla* is found only in southwestern area while *M. thonningii* and *M. zechiana* are the only species found in the north. Based on the geographical distribution, *M. drastica* was found to be endangered and this is in congruence with the findings of Keay (1989).

The map does not show that the species can be found in every ecological zone within the country neither does it shows that the species cannot be cultivated in other areas. Orwa *et al*. (2009) pointed out that since some trees are invasive, a biosafety procedure must be followed on the planting site. According to Banzouzi *et al.* (2008), most *Millettia* species grow in forests (80%), woodland (8%), bushland (7%) and shrubland (5%).

Morphological characters

The quantitative parameters were examined with numerical methods (Sneath and Sokal, 1973). The mean and standard deviation of the quantitative morphological features employed in the study are indicated in Table 3. Table 4 shows the correlation matrix of the nine quantitative parameters. It is observed that there is highly significant (P≤0.01) positive correlation between leaflet length and leaflet width, leaflet length and petiole length, leaflet width and lamina length, leaflet width and petiole length, leaflet length and lamina length, petiole length and lamina length, leaflet length and internode, leaflet width and internode, petiole length and internode, lamina length and internode, fruit length and fruit width. It is shown that there is negative correlation between leaflet width and fruit width, internode and number of lateral nerves, fruit length and pedicel length, number of lateral nerves and pedicel length. The result from Table 4 explains that one character can give closer resemblance when used to distinguish members of a genus.

Table 3: Quantitative vegetative morphological characters of *Millettia* spp studied

Taxa	L.L	L.W	P.L	La.L	Intd	Fr.L	Fr.W	No. LtNv	Ped. L
M. aboensis	9.56±2.55	3.52±1.29	0.60±0.15	10.94±2.95	2.80±0.71	7.14±7.25	1.27±0.85	8.78±3.71	0.91±0.50
M. barteri	9.70±2.07	4.17±0.98	0.58±0.12	11.27±2.36	2.28±0.53	2.75±2.98	0.62±0.55	7.75±1.02	0.51±0.45
M. chrysophylla	16.12±3.20	7.10±0.89	0.85±0.21	18.15±3.45	4.10±1.31	0.73±0.29	0.28±0.08	13.67±3.56	0.25±0.10
M. drastica	9.20±1.79	3.59±0.69	0.43±0.13	10.30±1.85	2.94±0.48	13.74±6.70	2.47±1.02	9.57±1.51	0.59±0.23
M. dinklagei	7.33±1.20	3.40±0.53	0.40±0.00	8.55±1.31	2.17±0.39	1.43±1.72	0.82±0.69	11.83±0.75	0.30±0.11
M. griffoniana	8.10±1.93	3.48±1.01	0.44±0.13	9.14±2.51	2.63±0.73	2.75±2.66	0.93±0.85	10.60±2.30	0.48±0.37
M. macrophylla	13.30±2.95	6.61±1.50	0.81±0.19	16.20±2.78	4.23±1.35	4.53±5.78	0.81±0.61	10.29±1.11	0.77±0.55
M. pilosa	14.26±4.69	6.86±2.06	0.60±0.14	16.84±5.31	3.76±1.51	4.24±5.76	0.80±1.06	9.40±0.89	0.40±0.12
M. thonningii	6.89±1.52	3.38±0.67	0.50±0.10	8.11±1.46	2.05±0.45	7.12±5.53	1.41±0.82	6.40±0.88	0.93±0.38
M. zechiana	9.71±2.41	4.18±1.06	0.34±0.07	11.82±2.17	2.66±0.58	2.69±3.92	0.74±0.56	10.33±1.73	0.41±0.21

L.L – Leaflet length; LW – Leaflet width; P.L - Petiole length; La.L – Lamina length; Intd – Internode; Fr.L – Fruit length; Fr. W – Fruit width; No. Lt Nv – Number of Lateral Nerves; Ped. L –Pedicel length;
Units in centimeters (cm); All measurements represent mean±standard deviation

Table 4: Correlation matrix of quantitative macro-morphological characters in *Millettia* spp

Correlation	Leaflet Length	Leaflet Width	Petiole Length	Lamina Length	Internode Length	Fruit Length	Fruit Width	No of Lateral Nerves	Pedicel Length
Leaflet Length	1.000	.964[a]	.800[a]	.994[a]	.926[a]	-.273	-.461	.495	-.340
Leaflet Width		1.000	.790[a]	.978[a]	.913[a]	-.338	-.513[b]	.437	-.319
Petiole Length			1.000	.788[a]	.782[a]	-.218	-.417	.273	.073
Lamina Length				1.000	.931[a]	-.289	-.482	.461	-.312
Internode					1.000	-.100	-.271	.504[b]	-.172
Fruit Length						1.000	.963[a]	-.476	.564[b]
Fruit Width							1.000	-.418	.473
No of Lateral Nerves								1.000	-.728[b]
Pedicel Length									1.000

a = highly positive correlation; b = highly negative correlation; Highly significant at P≤0.01

Table 5: Cumulative principal component analysis (PCA) of macromorphological characters

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.438	60.427	60.427	5.438	60.427	60.427
2	2.050	22.778	83.205	2.050	22.778	83.205
3	.983	10.918	94.123			
4	.352	3.913	98.036			
5	.123	1.369	99.405			
6	.040	.440	99.845			
7	.012	.131	99.976			
8	.002	.023	100.000			
9	3.78E-005	.000	100.000			

Extraction Method: Principal Component Analysis; The components are represented by the following numbers: 1 – Leaflet length, 2 – Leaflet width, 3 – Petiole length, 4 – Lamina length, 5 – Internode, 6 – Fruit length, 7 – Fruit length, 8 – Number of lateral nerves, and 9 – Pedicel length

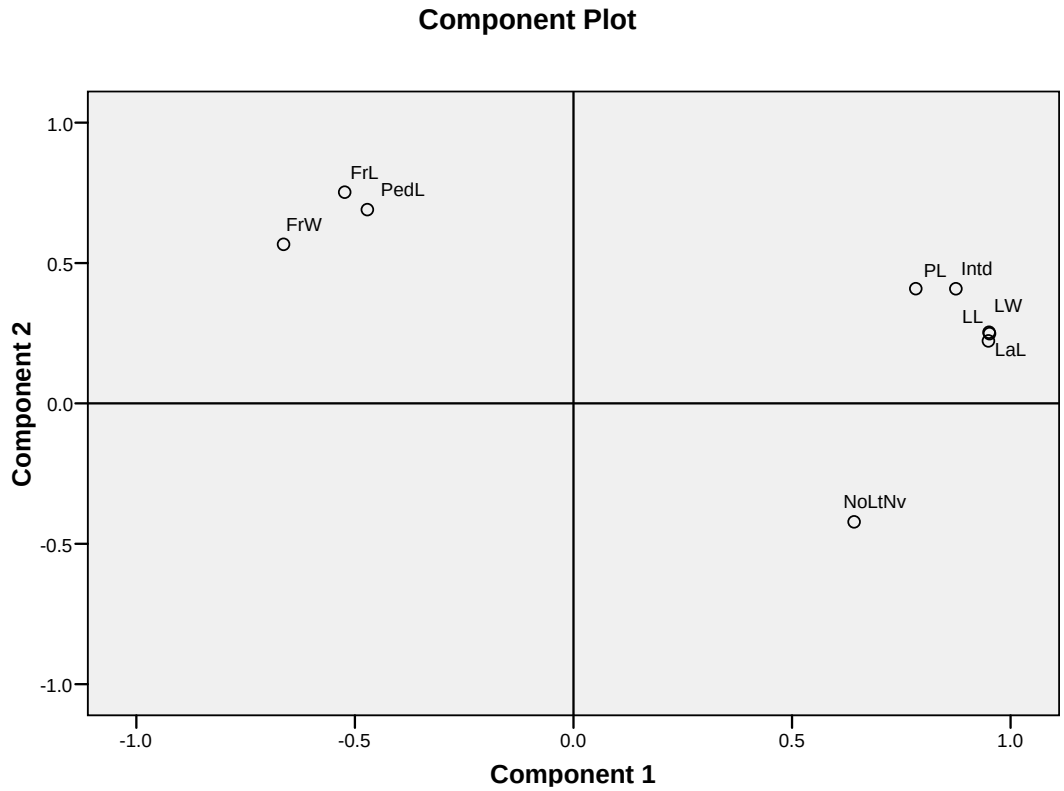
Table 6: Cluster analysis of morphological characters based on average linkage between groups

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2
1	7	8	2.672	0	0	6
2	5	6	4.460	0	0	4
3	2	10	7.189	0	0	4
4	2	5	15.195	3	2	7
5	1	9	21.415	0	0	7
6	3	7	25.786	0	1	9
7	1	2	29.480	5	4	8
8	1	4	52.683	7	0	9
9	1	3	90.139	8	6	0

1 – *M. aboensis*, 2 – *M. barteri*, 3 – *M. chrysophylla*, 4 – *M. drastica*, 5 – *M. dinklagei*, 6 – *M. griffoniana*, 7 – *M. macrophylla*, 8 – *M. pilosa*, 9 – *M. thoningii*, 10 – *M. zechiana*

a-*M. aboensis*,**b** – *M. barteri*, **c** – *M. chrysophylla*, **d** – *M. dinklagei*, **e** – *M. drastica*, **f** – *M. griffoniana*,**g** - *M. macrophylla*, **h** - *M. pilosa*,**i** - *M. thonningii*, **j** - *M. zechiana*

Plate 1: Macromorphology of the ten *Millettia* species



L.L – Leaflet length; LW – Leaflet width; P.L- Petiole length; La.L– Lamina length; Intd – Internode; Fr.L – Fruit length; Fr. W – Fruit width; No. Lt Nv – Number of Lateral Nerves; Ped. L –Pedicel length

Fig. 2: Component plot in rotated space for the 9 macromorphological characters

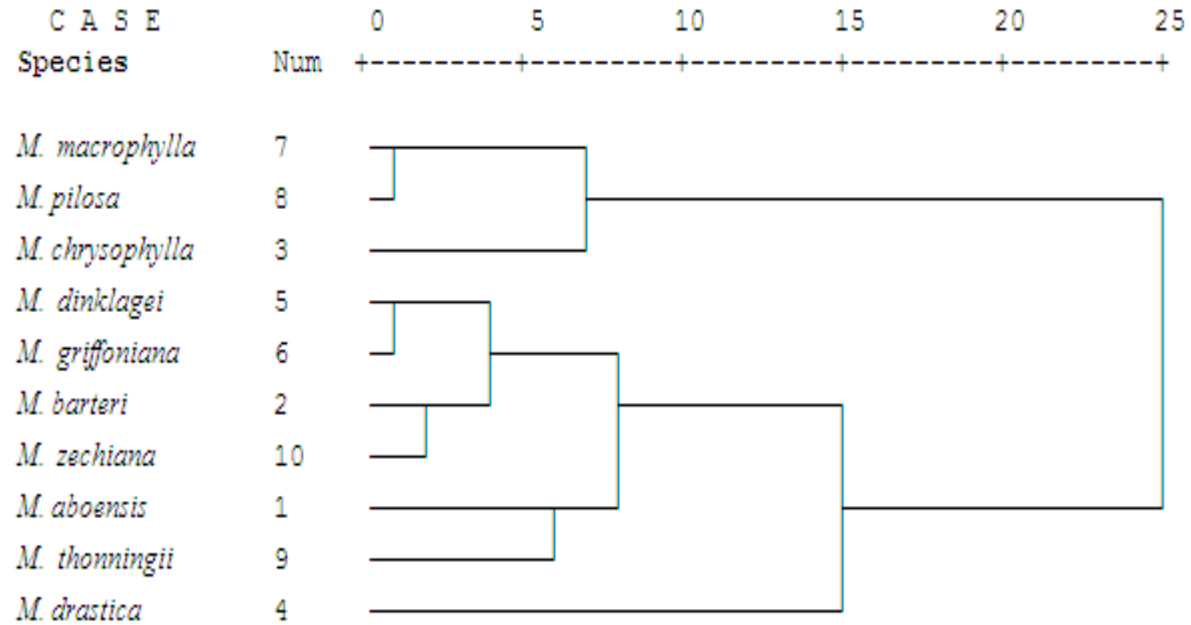


Fig. 3: Dendrogram using Average Linkage (Within Group) based on macro-morphological character

Results shown in Table 6 indicate the average linkage between groups based on agglomeration schedule. The coefficient of the cluster existing between *M. macrophylla* (7) and *M. pilosa* (8) is 2.672 while that existing between *M. aboensis* (1) and *M. chrysophylla* (3) is 90.139. This reveals that there is great variation in their morphometry. Similarly, the dendrogram shown in Fig. 3 revealed that greater relationship exists between *M. macrophylla* and *M. pilosa*, *M. dinklagei* and *M. barteri*, *M. barteri* and *M. zechiana*, *M. aboensis* and *M. thonningii* while *M. drastica* is found to be most far from all other species. In other words, there is a close resemblance between *M. macrophylla*, *M. pilosa* and *M. chrysophylla* while *M. drastica* is distantly separated from them. In the dendrogram, *M. drastica* was found to be morphologically most distant from all other species investigated in this study.

Based on the result of this work, it is evident that both the vegetative and floral characters play major roles in plant

systematics. Some of the vegetative features that play a major role in species delimitation include plant habit, leaves, petiole and stipels. The floral characters which were employed in this study include types of inflorescences, fruits, colour of petals and surface of pedicels. Saheed and Illoh (2010) recognized the usefulness of the vegetative and floral characters as being important in biosystematic analyses.

From the study, it is observed that *M. aboensis, M. griffoniana, M. macrophylla, M. thonningii* are trees, *M. barteri* is a climber or shrub, *M. pilosa* is a shrub whereas *M. chrysophylla, M. dinklagei, M. drastica,* and *M. zechiana.*

All the species show constant leaf shape, leaf apex, leaf base, leaf margin and leaf arrangement which are pinnately compound, acuminate, obtuse, entire and opposite respectively. Therefore, the occurrence of these constant characters in the *Millettia* species studied indicates that it is a generic character rather than diagnostic.

Having regard to the leaf surface, *M. aboensis, M. barteri, M. chrysophylla,and M. thonningii* are pubescent but *M. macrophylla, M. pilosa* and *M. zechiana* are slightly pubescent while *M. dinklagei, M. drastica* and *M. griffoniana* are glabrous. They are all characterized by presence of stipels except for *M. aboensis, M. drastica* and *M. thonningii* which have no stipel. There is variation in the number of leaf pairs. In *M. aboensis* the number ranges from 7 – 8, 7 – 10 in *M. barteri,* 2 – 4 in *M. chrysophylla,* 3 – 6 in *M. dinklagei,* 7 – 9 in *M. drastica,* 3 – 4 in *M. griffoniana,* 8 – 10 in *M. pilosa,* 5 – 6 in *M. macrophylla,* 2 – 4 in *M. thonningii,* 5 – 12 in *M. zechiana.*

The leaf morphological characters have also proven to have a taxonomic importance in delimiting *Euphorbia* species. The variation in leaf length, leaf width, petiole length, lamina length, internode length, lateral nerves have been shown to be of diagnostic value. In congruence with the morphometric studies carried out in some legume genera (e.g. *Indigofera, Senna*), Soladoye *et al.* (2010) use leaflet length, width and number of leaflet in the delimitation of species. The leaf size reveals considerable difference amongst the studied species. The highest value of leaflet length, leaflet width, lateral nerves, lamina length and petiole length was recorded in *M. chrysophylla* and smallest values in *M. thonningii*.

The floral characters are more reliable features on which classification systems and various other principles of systematic are based (Sharma, 2005). According to Singh (2005), floral characteristics have been found useful at all taxonomic levels, with significant contributions to the understanding of the phylogeny of angiosperms. The floral characters examined here in this study have useful assessing the relationships among the taxa.

The different types of inflorescences encountered among the ten species include woody raceme (*M. aboensis*), panicle (*M. barteri, M. drastica* and *M. pilosa*), panicle terminal or subterminal (*M. chrysophylla*), panicle terminal (*M. dinklagei*), pendulous raceme (*M. griffoniana*), erect raceme (*M. macrophylla*), lateral raceme (*M. thonningii*) and raceme (*M. zechiana*). The colour of the petal also show variation; purple in *M. aboensis, M. thonningii and M. zechiana,* red or pink in *M. barteri,* white in *M. dinklagei* and *M.chrysophylla,* pale blue *M.drastica,* pale purple in *M. pilosa,* purple or lilac in *M. griffoniana* and pink to purple in *M. macrophylla.*

The degree of hairiness on the fruit also differs varying from high pubescent (*M. aboensis, M. barteri* and *M. zechiana*), slightly pubescent *(M. pilosa* and *M. macrophylla*) and glabrous (*M.chrysophlla, M. thonningii, M. dinklagei, M.drastica* and *M. griffoniana.* The fruit size clearly delimits *M. drastica* from other species, it is longer and broader. The pair, *M. aboensis* and *M. thonningii* have close fruit size relationships.

Artificial key based on morphology for the taxonomic identification of Millettia species

1a. Plants shrubs or trees……..……..2
1b. Plants climbers……..*M. barteri*
2a. Leaf surface pubescent……3
2b. Leaf surface glabrous……4
3a. Stipel present……5
3b. Stipel absent……6
4a. Leaf shape oblong; leaflets 5.9-8.9 cm long and 2.5 cm wide; 3-6 pairs per leaflet; lateral nerves 11-13 pairs……*M. dinklagei*
4b. Leaf shape elliptic; leaflets 3.9-12 cm long and 1.2-5.8 cm wide; 3-4 pairs per leaflet; lateral nerves 6-15……*M. griffoniana*
5a. Inflorescence a raceme; petals pink or purple……*M. macrophylla*
5b. Inflorescence a panicle; petals white…*M. chrysophylla*
6a. Fruit surface pubescent; about 0.8-21.1 cm long and 0.2-2.9 cm wide….*M. aboensis*
6b. Fruit surface glabrous; about 0.7-22.6 cm long and 0.7-3.5 cm wide….. *M. drastica*
7a. Pedicel surface glabrous……8
7b. Pedicel surface slightly pubescent……*M. pilosa*
8a. Pedicel length 0.4-1.9 cm long……*M. thonningii*
8b. Pedicel length 0.2-0.9 cm long……*M. zechiana*

Conclusion

The study of the morphological characteristics of *Millettia* revealed a number of important morphological characters and these characters exhibit interesting interspecific variations that are of diagnostic significance for identification and delimitation. Vegetative and floral features furnish enough information for species identification with many distantly related groups. However, types of inflorescence provide additional information in distinguishing closely related species.

The striking difference observed in the data and figures of the characters such as leaflet length and width, lamina length, fruit length and width, number of leaflet pairs per leaf and number of lateral nerves of leaflets of the species studied are therefore of taxonomic importance. Also the similarities observed in the leaf types, leaf arrangement, leaf apex, leaf base, leaf margin and fruit shape of the species provides evidence for their genetic and evolutionary relationships and justification for their taxonomic grouping.

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Conflict of Interest

Authors declare that there is no conflict of interest related to this work.

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