

MORPHOMETRIC ANALYSIS OF LEAF CHARACTERS OF SOME SPECIES IN SELECTED PLANT FAMILIES IN NIGERIA: IMPLICATIONS FOR IDENTIFICATION AND CLASSIFICATION

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ABSTRACT

Anatomical characters of leaf, stem, fruit, and wood have been employed in the identification and classification of plants. However, many of these features are plastic and have proved to be inadequate in the establishment of a robust relationship between closely related taxa. This study was aimed at appropriating leaf macro-morphological characters in the identification and classification of member species. Fresh leaves of some economically-important species in Asteraceae, Convolvulaceae and Lorantheaceae were collected from different locations in Ondo, Osun, and Edo State. Characters such as leaf length (LL), leaf width (LW), petiole length (PL) and petiole width (PW) were measured with a line ruler (cm) and Vernier caliper (mm) and subjected to morphometric analysis. Data were analyzed and outputs were presented as bar charts and polygonal graphs. The characters assessed (LL, LW, PL, PW) varied and were statistically significant with Duncan Multiple Range Test (DMRT) at $p < 0.05$. Numerical analysis of the leaf morphological characters in the studied families proved to be viable for the circumscription and identification of member species. The study of plant forms and their quantitative analysis are critical to the understanding of morphological diversities in plants as these reveal natural groupings and differences better than qualitative features.

Keywords: Morphology, Leaf shape, Economic plants, Systematics, Nigeria.

INTRODUCTION

Leaf and wood anatomical characters have been employed in the identification and circumscription of economically-important plant groups in many parts of the world. These traditional characters, however, have been shown to be inadequate in the establishment of a robust relationship between closely related taxa. Morphometric analysis is a useful tool for characterization in many areas of plant science including agriculture, ecology, systematics, and evolution (Leiboff *et al.*, 2015; de Oliveira *et al.*, 2016; Rose *et al.*, 2016). The families Asteraceae, Convolvulaceae and Lorantheaceae are well known for their diverse medicinal and ecological significance. Asteraceae (sunflower family), a large clade of flowering plants, are mostly herbaceous plants (annual, biennial, or perennial) and may also present as shrubs, vines, and trees with widespread distribution from tropical regions to hot or semi-desert climates. The family is an economically important clade providing food, ornamentals and herbal medicines (Michel *et al.*, 2020). Medically, secondary metabolites from members of this family are important inhibitory agents against protozoan parasites and parasitic intestinal worms (Panda & Luyten, 2018).

Convolvulaceae (morning glory family) presents as herbaceous plants, woody climbers and trees. Members in this family are very important in the ecosystems as they contribute to soil stabilization. *Ipomoea* is the largest genus within the family. *Ipomoea* species are characterized by their showy flowers and vigorous growth habits. The genus is widespread, with species found in tropical and subtropical regions around the world (Austin, 1977). Notable members of this genus include the sweet potato (*Ipomoea batatas*), which is economically important as a food crop (Shrestha *et al.*, 2017).

Lorantheaceae (the mistletoe family) comprises mainly hemi-parasitic plants that attach to host trees and shrubs particularly cash crops such as *Theobroma cacao*, *Cola* spp., *Hevea brasiliensis*, *Psidium guajava* etc. (Philips, 1977; Gill & Onyike, 1990; Burkill, 1995; Ibrahim & Ayodele, 2011). Species in this family engage in intricate parasitic relationships that affect their host plants' health and growth. However, they are medicinally important in the treatment of skin diseases, rheumatism, coughs, hypertension, diabetes etc. (Adodo, 2002; Olapade, 2002).

The families were chosen based on their ecological significance and availability of specimens. The aim of this research, therefore, was to appropriate the morphometric data of the selected plant families in the identification and classification of member species. The specific objectives were to apply morphometric techniques to analyze the variations in forms in the Nigerian species of Asteraceae, Convolvulaceae and Lorantheaceae, and to evaluate the effectiveness numerical taxonomic approaches in resolving systematic ambiguities and improving species identification.

MATERIALS AND METHODS

Plant Collection and Preservation

Leaf samples of twenty (20) species in the Asteraceae family (*Ageratum conyzoides*, *A. houstonianum*, *Aspilia africana*, *Chromolaena odorata*, *Coreopsis barteri*, *Cyanthillium cinereum*, *Dicroma tomentosa*, *Elephantopus mollis*, *Emilia coccinea*, *E. paractermis*, *Eclipta prostrata*, *Lactuca taraxacifolia*, *Melanthera scandens*, *Mikania cordata*, *Sclerocarpus africanus*, *Tithonia diversifolia*, *Tridax procumbens*, *Vernonia adoensis*, *V. amygdalina* and *V. cinerea*), six (6) species in the Convolvulaceae family (*Calycobolus haudelottis*, *Hewittia sublobata*, *Ipomoea mauritana*, *I. involucrata*, *I. batatas* and *I. quamoclit*) and three (3) species in the Lorantheaceae family (*Tapinathus banguwensis*, *T. phragmanthera*, and *T. dodoneifolius*) were collected from different

locations in Ondo, Osun, and Edo State. Fresh samples were collected according to standard procedures. The plant specimens were pressed on the field and were taken to the herbarium for identification.

Plant Identification

The plant specimens were identified at the herbarium of Olusegun Agagu University of Science and Technology (OAUSTECH), Ondo State. Voucher specimens were deposited in the herbarium.

Assessment of Leaf Morphological Characters

Leaf characters such as leaf length (LL), leaf width (LW), petiole length (PL) and petiole width (PW) were measured with a line ruler (cm) and Vernier caliper (mm). Each measurement was replicated ten times. Values of LL/LW, LW/PL, LL/PL and PL/LL were calculated and used to make polygonal graphs. Adobe Photoshop software (version 2020) was used to remove the background of the graphs to enhance the visual presentation.

Data Analysis

Data were entered in Microsoft Excel spreadsheet and were analyzed using IBM SPSS Statistics software (version 25). Results of quantitative analysis are expressed as Mean±SD. Significant differences in means were assessed with Duncan Multiple Range Test (DMRT) at $p < 0.05$. Where necessary, results were expressed as bar charts and polygonal graphs. These graphs visually represented the variation in leaf parameters among the species.

RESULTS

Table 1 shows the sample collection locations and voucher numbers of the plants used in this study while Tables 2 – 4 show the quantitative parameters of the leaf morphology of the Asteraceae, Convolvulaceae and Loranthaceae species respectively. The polygonal graphs of the Asteraceae, Convolvulaceae and Loranthaceae species are presented in Figures 1, 6 and 11 respectively. Figures 2 – 5, 7 – 10, 12 – 15 are the bar graphs of the mean values of the leaf characters assessed for each of the families.

Table 1: Collection locations and voucher numbers of plants used in this study

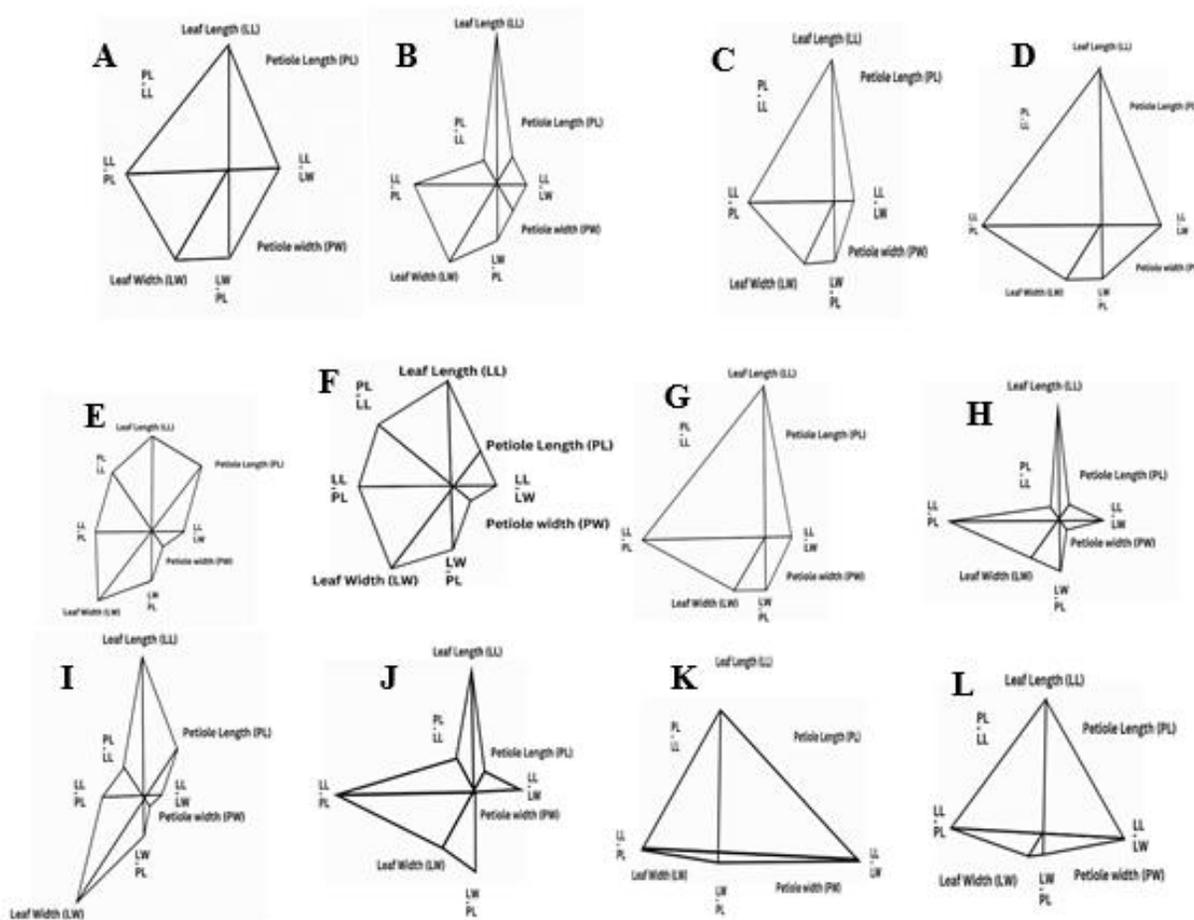
S/N	Family	Plant	Location	Voucher Number
1	Asteraceae	<i>Ageratum conyzoides</i>	Igbodigo, Okitipupa	OAUSTECH/H-00405
2		<i>A. houstonianum</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00705
3		<i>Aspilia africana</i>	Main Campus, OAUSTECH	OAUSTECH/H-00121
4		<i>Chromolaena odorata</i>	Main Campus, OAUSTECH	OAUSTECH/H-00322
5		<i>Coreopsis barteri</i>	Along Iseyin-Shaki Road	OAUSTECH/H-00216
6		<i>Cyanthillium cinereum</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00702
7		<i>Dicroma tomentosa</i>	Along Shaki-Igbeti Road	OAUSTECH/H-00280
8		<i>Elephantopus mollis</i>	Along Iseyin-Shaki Road	OAUSTECH/H-0052
9		<i>Emilia coccinea</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00544
10		<i>E. practermissa</i>	Main Campus, OAUSTECH	OAUSTECH/H-0091
11		<i>Eclipta prostrata</i>	Sakpoba Forest Reserve, Benin	OAUSTECH/H-00177
12		<i>Lactuca taraxacifolia</i>	New Garage, Okitipupa	OAUSTECH/H-00591
13		<i>Melanthera scandens</i>	Main Campus, OAUSTECH	OAUSTECH/H-00587
14		<i>Mikania cordata</i>	River bank, Idepe, Okitipupa	OAUSTECH/H-00249
15		<i>Sclerocarpus africanus</i>	Igbokoda Roadside	OAUSTECH/H-00339
16		<i>Tithonia diversifolia</i>	Awule Road, Akure	OAUSTECH/H-00568
17		<i>Tridax procumbens</i>	Main Campus, OAUSTECH	OAUSTECH/H-00537
18		<i>Vernonia adoensis</i>	LAUTECH Botanical Garden	OAUSTECH/H-00701
19		<i>V. amygdalina</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00546
20		<i>V. cinerea</i>	Igbodigo, Okitipupa	OAUSTECH/H-0094
21	Convolvulaceae	<i>Calycobolus haudelotti</i>	Sakpoba Forest, Benin	OAUSTECH/H-00197
22		<i>Hewittia sublobata</i>	Along Okitipupa-Igbotako Road	OAUSTECH/H-00263
23		<i>Ipomoea batatas</i>	Igbodigo, Okitipupa	OAUSTECH/H-00704
24		<i>I. involucreta</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00255
25		<i>I. mauritana</i>	Main Campus, OAUSTECH	OAUSTECH/H-00106
26		<i>I. quamoclit</i>	Igodan-Lisa, Okitipupa	OAUSTECH/H-00179
27	Loranthaceae	<i>Tapinanthus banguwensis</i>	Ode-Aye, Okitipupa	OAUSTECH/H-00137
28		<i>T. dodoneifolius</i>	Along Iseyin-Ipapo Road	OAUSTECH/H-0099
29		<i>T. phragmanthera</i>	Okitipupa-Irele Road	OAUSTECH/H-00148

Table 2: Quantitative attributes of the leaves of twenty (20) species in Asteraceae in Nigeria

S/N	Plant	LL (cm)	LW (cm)	PL (mm)	PW (mm)
1	<i>Ageratum conyzoides</i>	3.31±1.26 ^a	2.61±1.17 ^{bcde}	12.70±3.97 ^c	0.61±0.21 ^d
2	<i>A. houstonianum</i>	3.30±0.85 ^a	2.16±0.45 ^{bcd}	0.00±0.00 ^a	0.00±0.00 ^a
3	<i>Aspilia africana</i>	5.41±1.19 ^{bc}	1.92±0.41 ^{abcd}	7.40±1.90 ^b	0.66±0.28 ^d
4	<i>Chromolaena odorata</i>	7.30±1.55 ^{de}	3.68±1.50 ^{ef}	13.70±5.12 ^c	0.52±0.20 ^d

5	<i>Coreopsis barteri</i>	7.53±1.59 ^{de}	0.50±0.18 ^a	0.00±0.00 ^a	0.00±0.00 ^a
6	<i>Cyanthillium cinerum</i>	2.65±0.98 ^a	2.08±3.52 ^{bcd}	0.00±0.00 ^a	0.00±0.00 ^a
7	<i>Dicroma tomentosa</i>	6.53±1.88 ^{cde}	1.12±0.31 ^{ab}	0.00±0.00 ^a	0.00±0.00 ^a
8	<i>Elephantopus mollis</i>	6.52±1.29 ^{cde}	2.12±0.53 ^{bcd}	0.00±0.00 ^a	0.00±0.00 ^a
9	<i>Emilia coccinea</i>	6.64±1.60 ^{cde}	3.72±1.22 ^{ef}	0.00±0.00 ^a	0.00±0.00 ^a
10	<i>E. practermissa</i>	7.14±2.27 ^{de}	3.36±1.33 ^{def}	0.00±0.00 ^a	0.00±0.00 ^a
11	<i>Eclipta prostrata</i>	5.11±1.68 ^{bc}	1.84±1.74 ^{abcd}	0.00±0.00 ^a	0.00±0.00 ^a
12	<i>Lactuca taraxacifolia</i>	13.91±2.70 ^g	4.57±2.22 ^{fg}	0.00±0.00 ^a	0.00±0.00 ^a
13	<i>Melanthera scadens</i>	7.96±1.50 ^e	5.78±1.41 ^{gh}	26.18±14.43 ^{de}	0.62±0.24 ^d
14	<i>Mikania cordata</i>	4.28±1.55 ^{ab}	2.80±1.36 ^{cde}	29.00±14.31 ^e	0.39±0.20 ^c
15	<i>Sclerocarpus africanus</i>	4.15±0.45 ^{ab}	1.72±0.19 ^{abc}	6.30±3.74 ^b	0.24±0.11 ^b
16	<i>Tithonia diversifolia</i>	6.10±1.02 ^{cd}	3.86±1.38 ^{ef}	23.10±12.41 ^d	0.53±0.18 ^d
17	<i>Tridax procumbens</i>	5.12±1.05 ^{bc}	1.96±0.52 ^{abcd}	0.00±0.00 ^a	0.00±0.00 ^a
18	<i>Vernonia adoensis</i>	9.94±2.20 ^f	4.29±1.08 ^f	0.00±0.00 ^a	0.00±0.00 ^a
19	<i>V. amygdalina</i>	12.73±3.73 ^g	2.97±2.06 ^h	15.00±4.92 ^c	0.59±0.22 ^d
20	<i>V. cinerea</i>	3.39±1.07 ^a	2.54±1.31 ^{bcde}	13.90±4.73 ^c	0.52±0.18 ^d

LL = Leaf Length, LW = Leaf Width, PL = Petiole Length, PW = Petiole Width. Values are Mean±SD. Means with the same letter in a column are not significantly different with Duncan's Multiple Range Test ($p>0.05$).



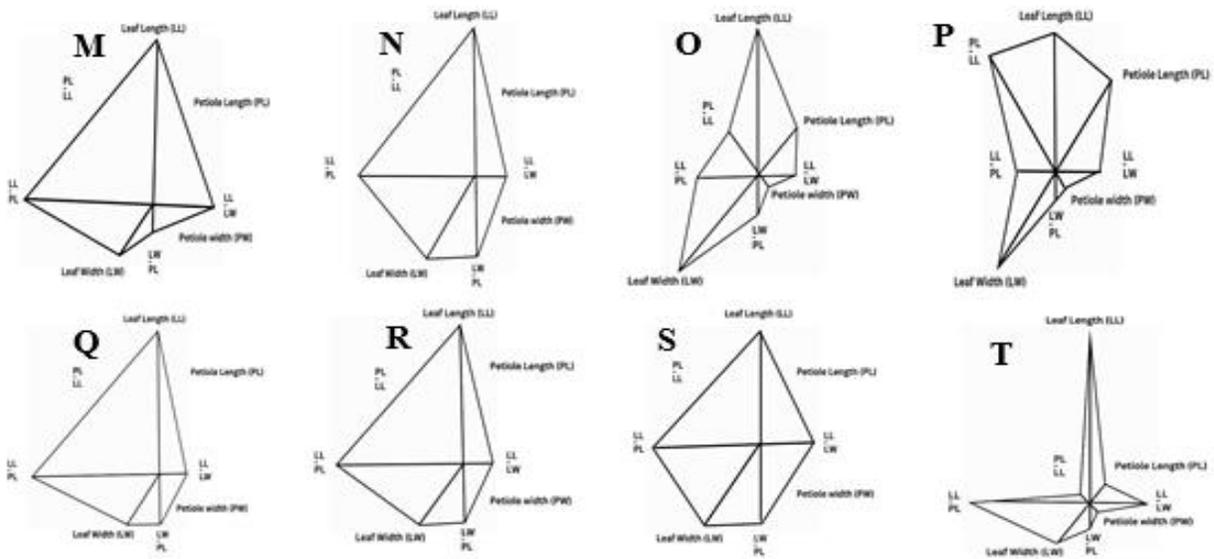


Fig. 1A-T: Polygonal graphs of: A, *Ageratum haustonianum*; B, *Chromolaena odorata*; C, *Cyanthillium cinerum*; D, *Eclipta prostrata*; E, *Vernonia cinerea*; F, *Ageratum conyzoides*; G, *Vernonia adoensis*; H, *Aspilia africana*; I, *Melanthera scandens*; J, *Sclerocarpus africanus*; K, *Coreopsis barteri*; L, *Dicroma tomentosa*; M, *Elephantopus mollis*; N, *Emilia coccinea*; O, *Tithonia diversifolia*; P, *Mikania cordata*; Q, *Lactuca taraxacifolia*; R, *Emilia pratermissa*; S, *Tridax procumbens*; T, *Vernonia amygdalina*

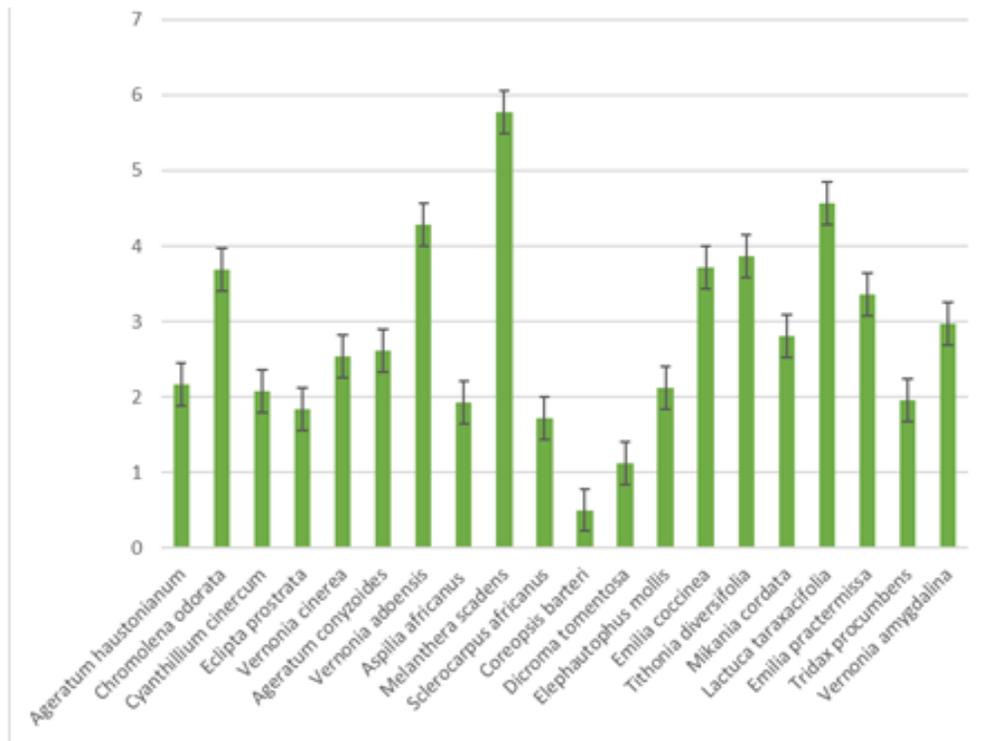


Fig. 2: Bar graph of the mean values of the leaf length (cm) of twenty species of Asteraceae in Nigeria

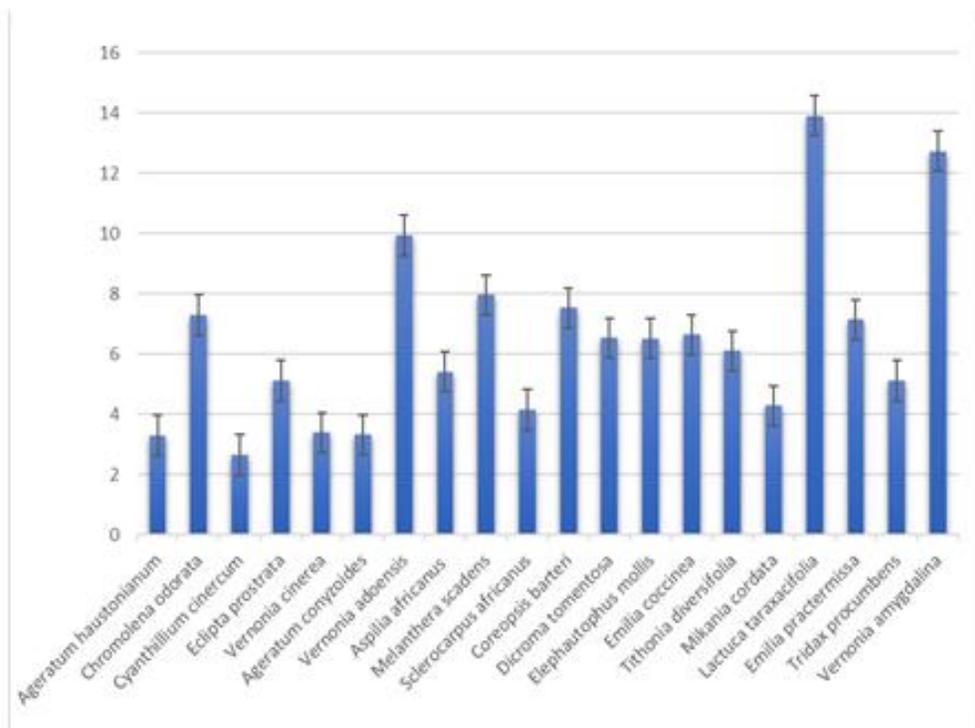


Fig. 3: Bar graph of the mean values of the leaf width (cm) of twenty species of Asteraceae in Nigeria

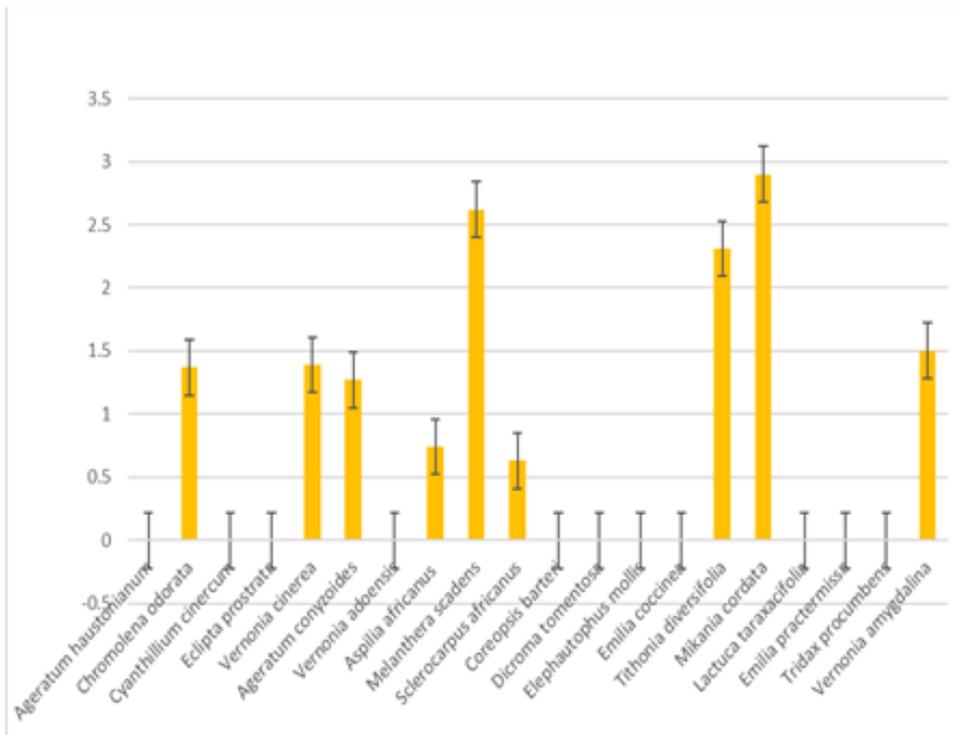


Fig. 4: Bar graph of the mean values of the petiole length (mm) of twenty species of Asteraceae in Nigeria

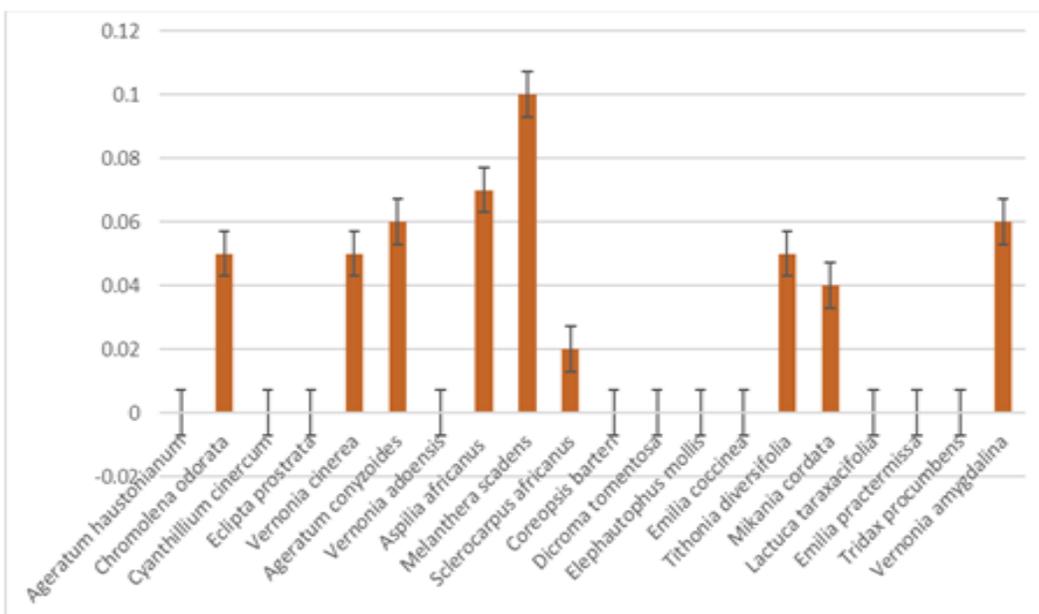


Fig. 5: Bar graph of the mean values of the petiole width (mm) of twenty species of Asteraceae in Nigeria

Table 3: Quantitative attributes of the leaves of six (6) species in Convolvulaceae in Nigeria

S/N	Plant	LL (cm)	LW (cm)	PL (mm)	PW (mm)
1	<i>Calycobolus haudelottis</i>	9.27±0.97 ^c	5.60±0.75 ^b	24.40±2.53 ^a	0.49±0.10 ^a
2	<i>Hewittia sublobata</i>	4.11±0.39 ^a	3.21±0.28 ^a	26.30±3.84 ^a	0.50±0.07 ^a
3	<i>Ipomoea batatas</i>	11.86±0.43 ^d	9.77±0.72 ^c	119.30±11.27 ^d	0.65±0.09 ^a
4	<i>I. involucrata</i>	4.88±0.36 ^a	4.59±0.37 ^{ab}	31.40±5.15 ^a	0.61±0.05 ^a
5	<i>I. mauritana</i>	9.28±0.46 ^c	5.53±0.44 ^b	54.30±2.36 ^c	0.62±0.10 ^a
6	<i>I. quamoclit</i>	6.81±0.35 ^b	5.41±0.31 ^b	36.90±3.76 ^a	0.96±0.02 ^b

LL = Leaf Length, LW = Leaf Width, PL = Petiole Length, PW = Petiole Width. Values are Mean±SD (n=10). Means with the same letter in a column are not significantly different with Duncan's Multiple Range Test (p>0.05)

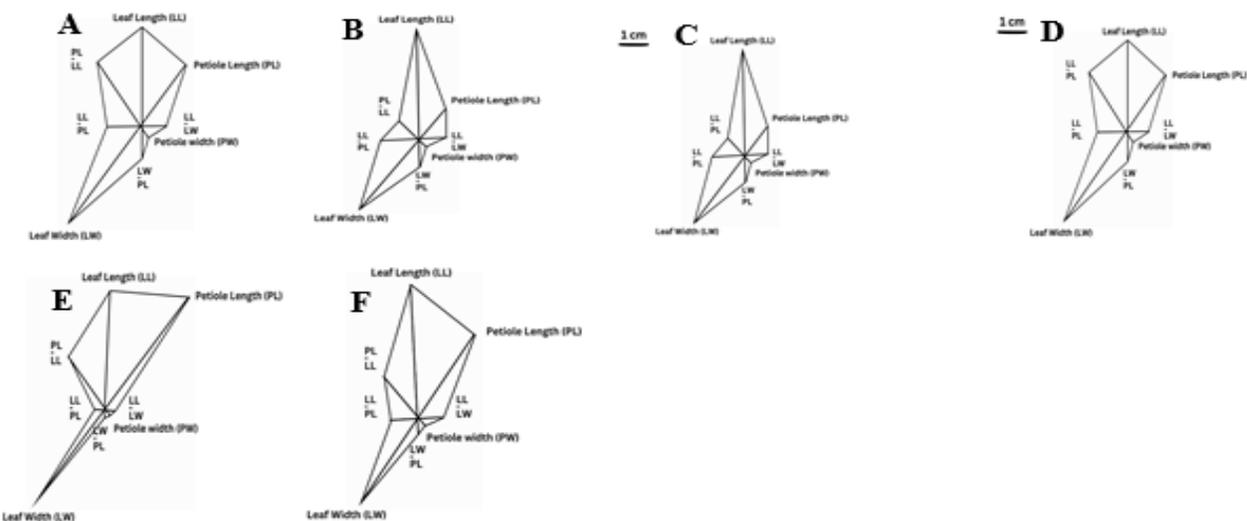


Fig. 6A-F: Polygonal graphs of: A, *Hewittia sublobata*; B, *Ipomoea mauritana*; C, *Calycobolus haudelottis*; D, *Ipomoea involucrata*; E, *Ipomoea batatas*; F, *Ipomoea quamoclit*.

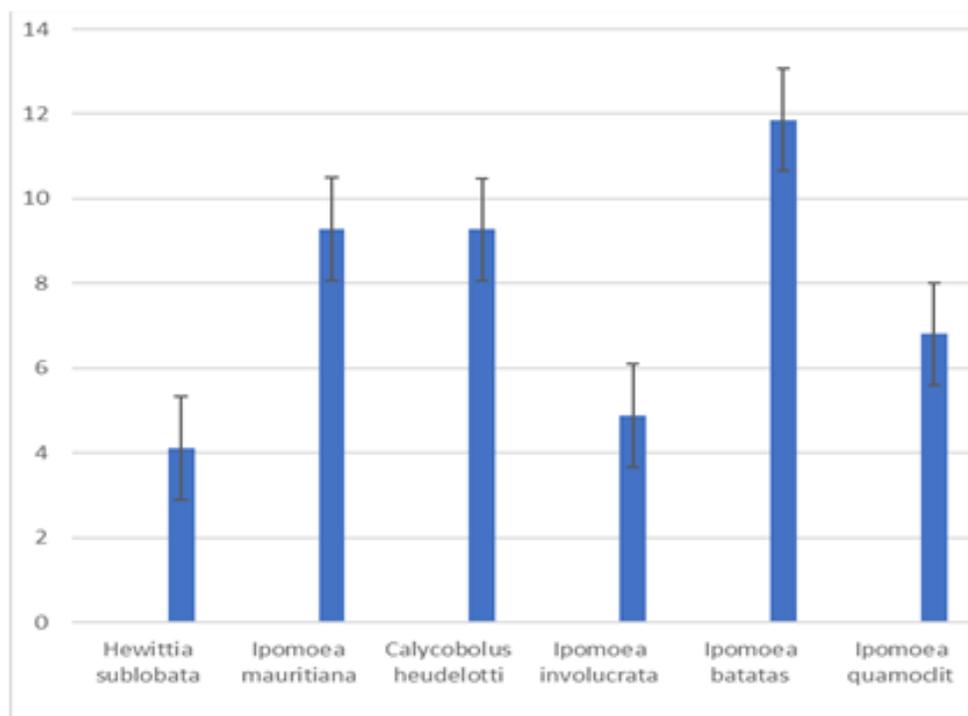


Fig. 7: Bar graph of the mean values of leaf length (cm) of six (6) species of Convolvulaceae in Nigeria

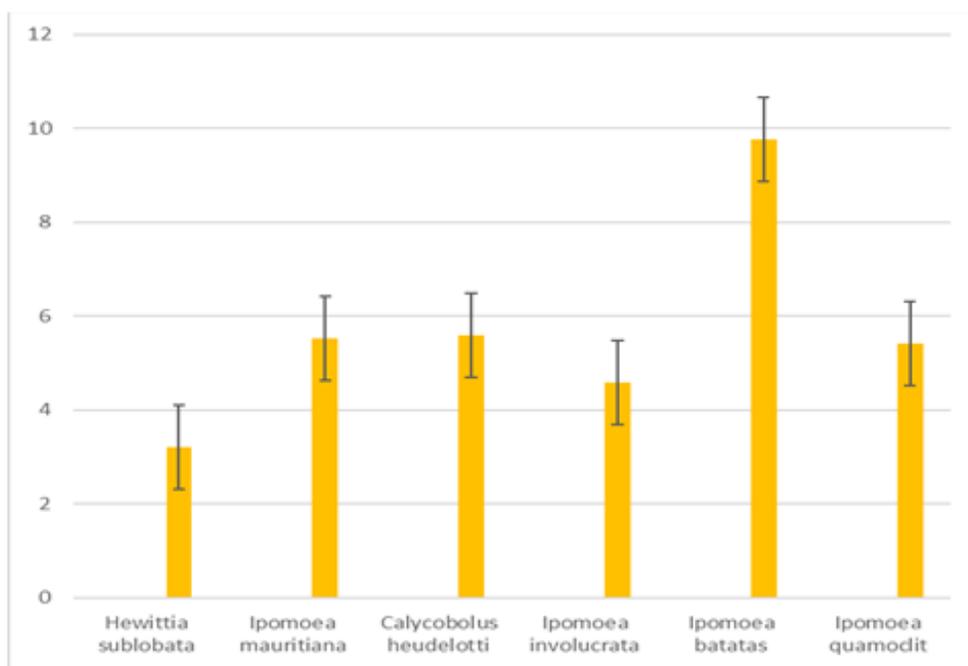


Fig. 8: Bar graph of the mean values of leaf width (cm) of six (6) species of Convolvulaceae in Nigeria

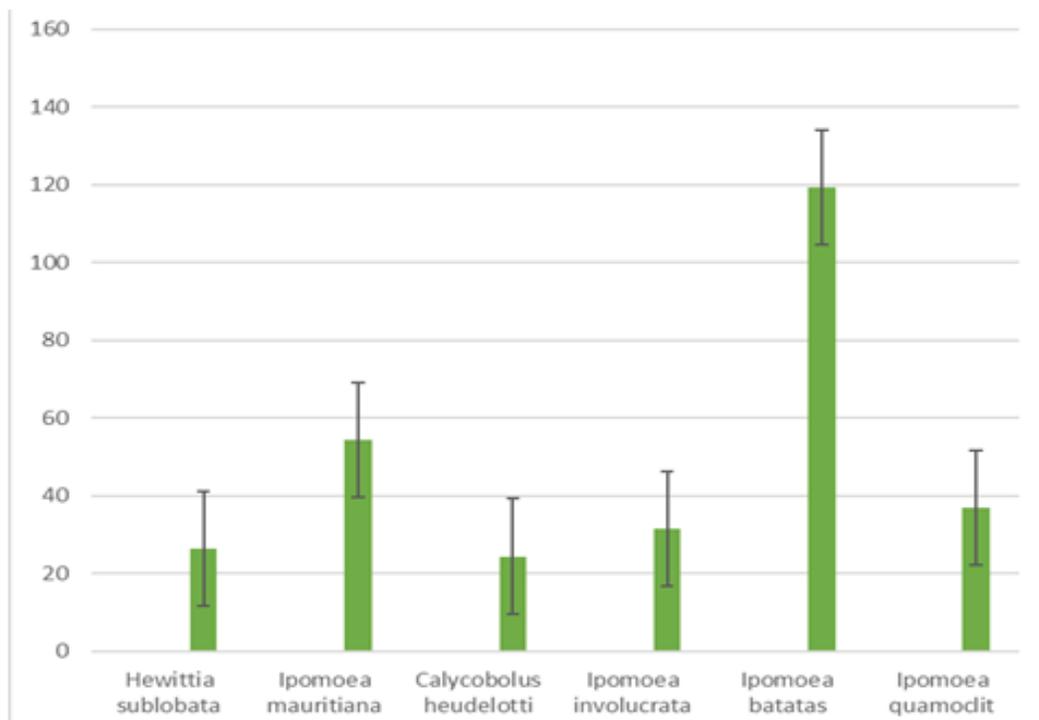


Fig. 9: Bar graph of the mean values of petiole length (mm) of six (6) Species of Convolvulaceae in Nigeria.

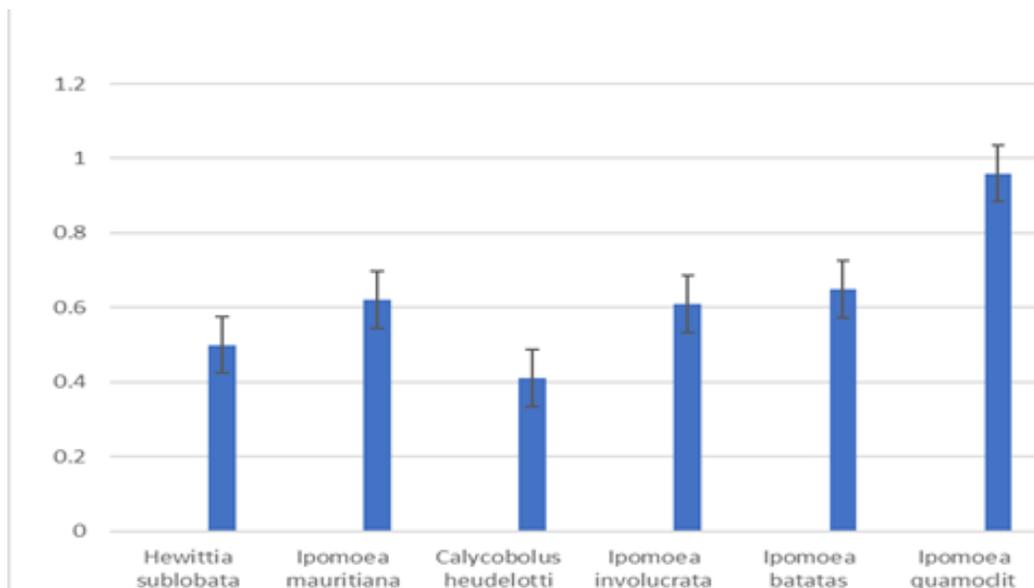


Fig. 10: Bar graph of the mean values of petiole width (mm) of six (6) Species of Convolvulaceae in Nigeria.

Table 4: Quantitative attributes of the leaves of three (3) species of Loranthaceae in Nigeria

S/N	Plant	LL (cm)	LW (cm)	PL (mm)	PW (mm)
1	<i>Tapinathus banguwensis</i>	7.80±0.58 ^a	4.24±0.26 ^c	6.20±0.55 ^a	0.78±0.10 ^c
2	<i>T. dodoneifolius</i>	10.45±1.18 ^c	3.16±0.33 ^a	18.04±2.39 ^c	0.66±0.12 ^c
3	<i>T. phragmanthera</i>	8.41±0.32 ^{ab}	3.87±0.24 ^{ab}	17.90±0.97 ^c	0.58±0.11 ^c

LL = Leaf Length, LW = Leaf Width, PL = Petiole Length, PW = Petiole Width. Values are Mean± SD (n=10). Means with the same letter in a column are not significantly different with Duncan's Multiple Range Test (p>0.05)

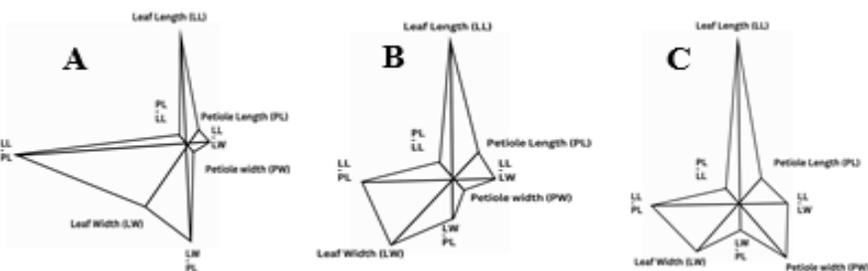


Fig. 11A-C: Polygonal graphs of: A, *Tapinathus banguensis*; B, *T. phragmanthera*; C, *T. dodoneifolius*.

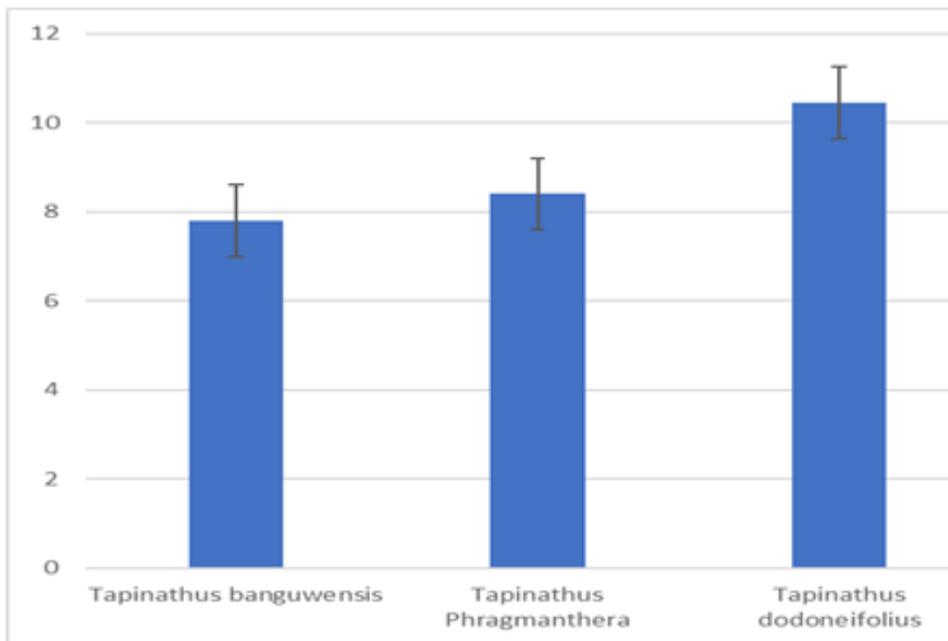


Fig. 12: Bar graph of the mean values of leaf length (cm) of three (3) species of Loranthaceae in Nigeria.

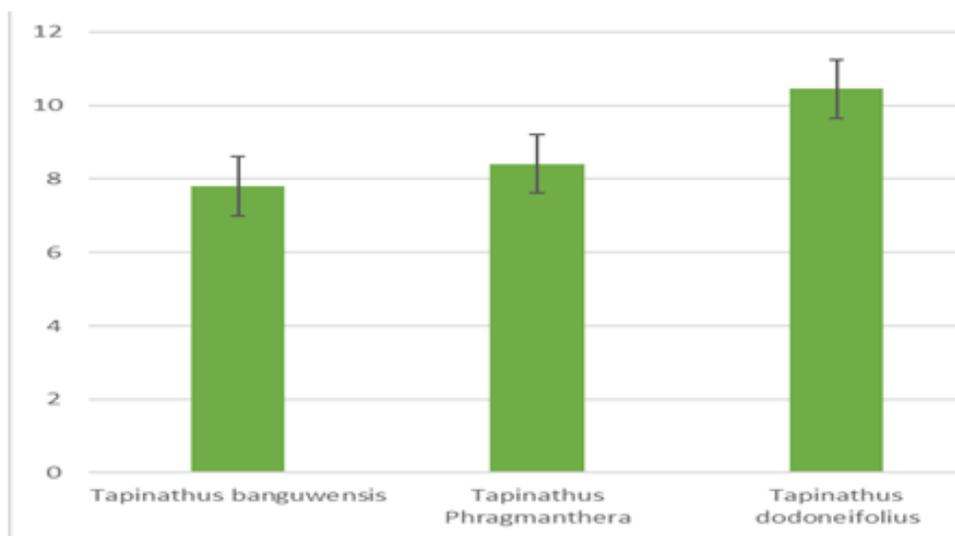


Fig. 13: Bar graph of the mean values of leaf width (cm) of three (3) species of Loranthaceae in Nigeria.

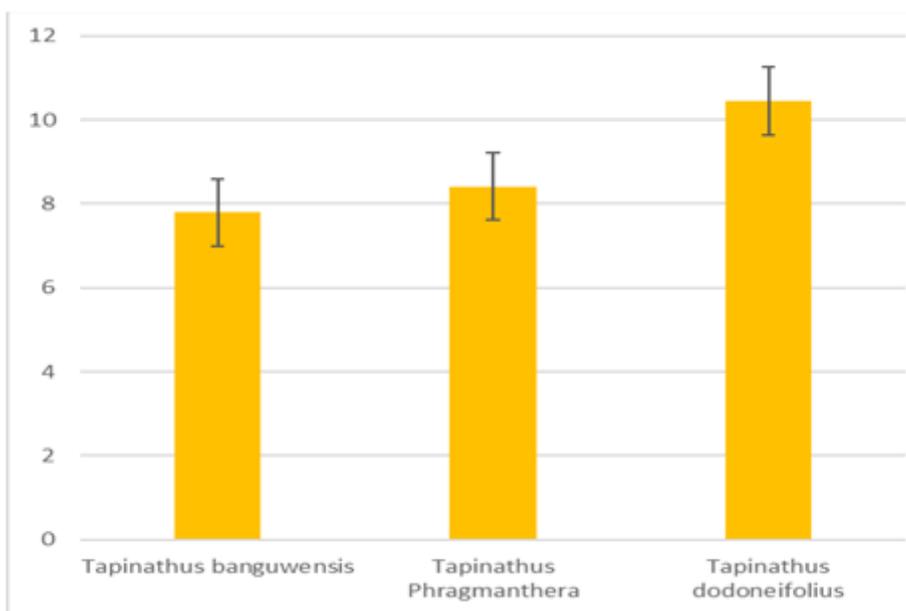


Fig. 14: Bar graph of the mean values of petiole length (mm) of three (3) species of Loranthaceae in Nigeria.

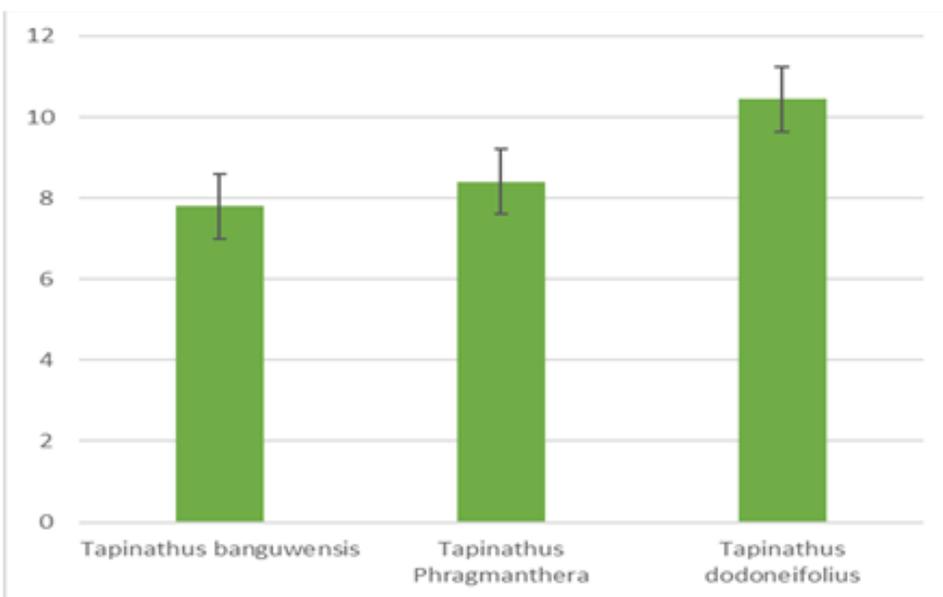


Fig. 15: Bar graph of the mean values of petiole width (mm) of three (3) species of Loranthaceae in Nigeria

DISCUSSION

Morphometric methods have been shown to be important in studies on plant development, population and systematics (Wiens, 2000; Bateman & Rudall, 2006). Several studies have indicated the functional value and significance of digital morphometrics in the identification and circumscription of plant taxa (Nicotra *et al.*, 2011; Punyasena & Smith, 2014; Chitwood & Otoni, 2017; Oso & Jayeola, 2021).

Leaf shapes are diverse and important for plant growth and development. The study of plant forms and their quantitative

analysis is critical to the understanding of morphological diversities in plants as these reveal natural groupings and differences better than qualitative features. The use of quantitative characters and methods in numerical taxonomy has proved useful in classification of organisms into groups (Sneath & Sokal, 1963). The findings of the current study further reiterate the significance of quantitative leaf morphological characters in species delimitation and circumscription, more so, that the two-dimensional shape of leaves has more discriminatory power than other plant organs (Cope *et al.*, 2012).

Numerical traits such as leaf length, width, petiole length, leaf area, venation patterns etc. are essential for modern plant taxonomy and ecology for the understanding of variation, ecological adaptation, evolutionary relationships, and conservation planning. These traits also indicate adaptation to habitat types, responses to climate change, and ecological differentiation among populations.

Plant character polygons are graphical tools used in plant taxonomy and identification to visually compare and analyze multiple plant attributes among closely related taxa. These representations help to reveal overall similarity, distinctness or trends in variations among species or populations. Taxonomists have discovered that species with similar polygon shapes are closely related (in this study for example, *Ipomoea mauritana* and *Calycobolus haudelottis*, and *Hewittia sublobata* and *Ipomoea involucrata*) while those with distinct polygon outlines are different taxa. Hence, these polygons serve diagnostic identification purposes. A similar study by Jayeola *et al.* (2001) employed polygonal graphs to differentiate three West African *Rhizophora* species. The fact that different species have characteristic leaf shapes is well established in this present study.

Although published reports on “morphometrics and plant character polygons” are scarce, the importance of plant species identification using digital morphometrics has been documented especially in areas such as plant morphology, mathematical biology, and computational modelling (Shipman & Newell, 2004, 2005; Cope *et al.*, 2012; Pennybacker *et al.*, 2016). In this study, the characters assessed and the polygonal graphs generated are suggestive of the leaf morphological diversities in the selected plant families. This implies that leaf shape and geometry are useful pointers for leaf function and evolution.

Conclusion

The study revealed that numerical analysis of leaf morphological characters in the studied families is a viable tool for the identification and classification of member species. This and similar studies are important in modern plant systematics.

Acknowledgement

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