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MORPHOLOGICAL CHARACTERIZATION OF SOME MEMBERS OF *Ocimum* L. (Lamiaceae) IN THE SOUTHWEST STATES OF NIGERIA

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ABSTRACT

The genus *Ocimum* (Lamiaceae) is made up of aromatic plants that have economic and medicinal benefits but their taxonomy has been difficult. In tandem with this, are other plants with emission of strong fragrance, but not of the *Ocimum* group. Morphological studies were conducted on certain *Ocimum species* in the southwest states of Nigeria to hdelimit some members of the genus. From the six states in the Southwest Nigeria, the seeds of one hundred and twenty accessions belonging to *Ocimum basilicum* L. (B-accessions), *O. canum* L. (C- accessions) and *O. gratissimum* L. (G-accessions) were collected. In three replicates in a single row, the seeds of each accession were planted in plastic pots of 10 litre capacity, filled with topsoil. Forty-five accessions were purposively selected based on the rate of germination. Data was collected on the qualitative and quantitative characters from vegetative, floral and fruit (nutlets) features. Statistical analyses of the quantitative data were performed using SAS/PC1 version 9.01. The results separated the B-accessions early on and confirmed that they were not part of the *Ocimum* group. The B-accessions, however, belonged to another genus *Hyptis* in the family. Based on leaf shapes, leaf colour, leaf apices, leaf pubescence, inflorescence arrangement and flower colours, five distinct morpho-types of *Ocimum*, were observed. This study revealed the existence of morphological variations among the C-accessions. These characteristics may be explored by plant breeders and taxonomists for sustainable utilization of the *Ocimum* germplasm.

Keywords: Characterization, Morphology, Ocimum, Species, Lamiaceae

INTRODUCTION

The genus *Ocimum* is a member of the Lamiaceae (mint) family, formerly known as Labiatae, which contains about 220 genera and nearly 4000 species worldwide (Hedge, 1992). Paton *et al*. (1999) described the family with distinctive features of a square stem, opposite and decussate leaves with many gland dots. The flowers exhibit a pronounced zygomorphic form, characterized by two separate lips. The family's essential oils have strong fragrances because they contain monoterpenes, sesquiterpenes, and phenylpropanoids (Nahak *et al*., 2011; Heinrich *et al*., 2003). The plant is commonly known as Basil.

In West Africa, about six species of *Ocimum* were recognized and existing over a large area of the region. These are also widely distributed in other parts of the world (Burkill, 1995). In Nigeria, Hutchinson and Dalziel (1963) reported five species that were spread to both Southern and Northern parts of the country while three species and a variety of one of these species were found in the Southwest.

Ocimum is an aromatic herb known for its distinctive exudation of a strong peculiar smell. It is increasingly clear that both consumers and the food industry are interested in aromatic herbs such as basils, not only as flavorings agents but also for their content in biologically active compounds. Different parts of the plants are useful in medicine, industrial products and cuisine. They have similarities in their morphological features, hybridization potential and thus resulting in complication or difficulty in their taxonomy (Paton and Putievsky, 1996; Zeljazkov *et al*., 2008; Shazia *et al*., 2011).

Information on the morphological characterization of Nigeria species is scanty. Thus, a comprehensive morphological study on some species of *Ocimum* in Southwest Nigeria was done to delimit members of the genus.

MATERIALS AND METHODS

Description of the study locality

The study was carried out in the southwest states of Nigeria namely: Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States (Figure 1). All the states in Southwest, Nigeria have common weather conditions throughout the year. There is a period of rainfall from March to November and a dry season from November to February. The regions lie between latitude 2° 3' and 6° 00' East and longitude of 6° 21' and 8° 37' N with a total land area of 77,818 km and a population of 27,722,332 in 2006 (NPC, 2006).

Figure 1: Map of Nigeria showing the Soth-Western States and the study locations

Survey of locations of *Ocimum* habitats and specimen collection

In this study, the seeds of *Ocimum* used were obtained from different localities in the six Southwestern states of Nigeria. The Global Positioning System (GPS) coordinates of the various locations were documented (Figure 1). Identification of the collected specimens was confirmed at the Forest Research Institute of Nigeria (FRIN), Herbarium and University of Ibadan Herbarium, both in Ibadan. The vouchers of the plant specimens were deposited at FRIN.

Three species of *Ocimum* were reported in the states until the time of the study. Accessions from the locations were grouped in line with this assumption that *Ocimum basilicum* (B-accessions), *O. canum* (C-accessions) and *O. gratissimum* (G-accessions). One hundred and twenty accessions of *Ocimum* were collected and the seeds of each accession were planted in plastic pots of 10-litre capacity, filled with topsoil, in three replicates on a single row at the Botanical Garden, Federal College of Education, Abeokuta. Forty-five accessions spreading across the study area were purposively selected, based on the rate of germination. After the seedling establishment, the plants from each accession were thinned to one plant per pot. The plants were nurtured in the open field from seedling stage to maturity.

Morphological studies of the *Ocimum* accessions

The morphological studies were done using *Ocimum* Descriptors described by Paton *et al.* (1999) and Singh *et al.* (2004).

Vegetative studies of the *Ocimum* accessions

Qualitative vegetative (non-measurable) and quantitative vegetative (measurable) characters were observed in all the accessions. Ten measurements were taken (to eliminate all bias for statistical analysis) for each of the randomly selected individuals for quantitative characters, using a metric ruler and Venier caliper where necessary.

Qualitative vegetative characters observed on the *Ocimum* accessions

The qualitative vegetative characters studied are growth habit, stem color at plant maturity, the stem texture and stem pubescence observed on mature plants excluding the first two nodes below the shoot, the leaf color, leaf shape, leaf apex, leaf margin (leaf apices, leaf pubescence and leaf venation were observed at 50 % flowering) and branching habits at plant maturity. Photographs of the fresh plant materials were taken using an ordinary camera.

Quantitative vegetative characters of the *Ocimum* accessions

The quantitative vegetative characters are the leaf lamina length (cm), and width (cm), measured using a metric ruler at the widest parts, the petiole length (cm) measured using a metric ruler, internodes length (cm) taken by measuring the distance between two nodes and number of leaves per node. Three measurements were taken for each of the replicates: days to germination, Plant height (cm) taken by measuring the plant stem from the soil level to the plant apices using measuring tape at 50 % flowering, The number of primary branches per plant was counted at the fruiting stage of the healthy mature plants. The plant canopy was taken at the widest point of the mature plant. The stem diameter (cm) was measured using a Venier calliper at the widest point.

Reproductive biology of *Ocimum* collected in Southwest Nigeria

The reproductive biology studies were carried out using Ocimum Descriptors described by Paton *et al.* (1999) and Singh *et al.* (2004).

Floral quantitative characters

Floral characters were observed at flowering. The qualitative characters are inflorescence type, flower position, bract persistence, cyme flower number, cyme branches, hairy annulus in calyx throat, posterior lobe, calyx margin, curve and color, corolla color, tube base and shape, filament color, anther (pollen) color, posterior stamen form, anterior stamen, posterior stamen attachment form, style type and color.

From ten randomly picked flowers in the inflorescence of each accession, ten measurements were taken for each quantitative floral character. The quantitative floral characters measured are calyx length, calyx width, corolla length, corolla width, filament length and style (ovary stalk) length, inflorescence length and number of flowers per inflorescence. Three measurements were taken (to eliminate all bias for statistical analysis) for each of the replicates: number of days to 50 % flowering, number of inflorescences per plant and days to 50 % fruiting.

Fruit (Nutlets) characters of the *Ocimum* accessions

All the accessions were observed for their qualitative nutlet characters which include fruit shape, fruit color at maturity, seed shape and seed coat color at maturity using digital imaging analysis. Ten measurements were taken for each of the quantitative characters which are: seed length, seed width and number of seeds per fruit.

Data analysis

The collected data were subjected to Analysis of Variance using the SAS/PC 9.1 version. Means were separated using Duncan's Multiple Range Test (DMRT). The relationship between characters was calculated using the Pearson correlation coefficient. Dendrogram grouped the accessions and revealed the phenotypic relationships of the species based on the quantitative morphological characters.

RESULTS AND DISCUSSION

Results

Qualitative vegetative morphological traits

All the accessions revealed considerable inter and intra-specific similarities (Table 1 and Plate1). They expressed similarity in their growth habit (erect shrub), stem shape (quadrangular), leaf venation (reticulate) and decussate arrangement (Table 1). Variations existed in the stem color among the accessions from light green to green and dark green while some have brown color at the base of the stem. There is variation in the stem pubescence, all the C-accessions and G-accessions have glabrous (smooth) stems leaf while of B-accessions have pubescent (hairy) stems. All the accessions expressed dense branching habits except the genotypes of G-accessions with intermediate branching patterns (Table 1).

Table 1: Qualitative vegetative characters of the species studied

Character	B- Accessions	C- Accessions	G- Accessions
Growth habit	Erect shrub	Erect herb	Erect shrub
Stem colour	Light green	Brown and green	Brown and green
Stem shape	Quadrangular(square shape)	Quadrangular(square shape)	Quadrangular(square shape)
Stem pubescence	Pubescence	Glabrous	Glabrous
Branching Habit	Dense	Intermediate	Dense
Leaf colour	Mint green	Olive, sage, lime and emerald green	Emerald Green
Leaf shape	Ovate	Ovate-lanceolate	Elliptic-lanceolate
Leaf margin	Serrulated	Serrated	Serrated
Leaf apices	Cuspidate	Acute	Aristate
Leaf pubescence	Pubescence	Sparsely pubescence	glabrous
Leaf venation	Reticulate	Reticulate	Reticulate
Leaf arrangement	Decussate	Decussate	Decussate

Key: B-accessions (*Ocimum basilicum*), C-accessions (*O. canum*) and G-accessions (*O. gratissimum).*

Plate 1: Decussate Leaf arrangement and different shades of green colour in *Ocimum*
A: G-accessions (*Ocimum gratissimum*), B-E: C-accessions (*O. canum*) and F: B-accessions (*O. basilicum*)

Quantitative vegetative morphological traits

All the accessions showed considerable intra- and inter-species variations in the mean values of the vegetative quantitative traits measured (Table 2): The leaf lamina length varied significantly between 12.76 cm in G201 and 2.36 cm in C101. The leaf lamina width varied significantly between 7.27 cm in B305 and 1.07 cm in C306. The petiole length ranged from 0.67 cm in C102 to 6.36 cm in B101; the Internode length ranged from 2.05 cm in C102 to 12.59 cm in B403. The number of leaves per node varied significantly between 21 in C304 and 5 in C102.

The leaf lamina length of 9.66 cm in B305 is significantly the highest ($P<0.05$) while B605 with a leaf lamina length of 2.86 cm is the lowest. The leaf lamina width varied significantly between 7.27 cm in B305 and 2.43 cm in B605. The petiole length ranged from 1.94 cm in B605 to 6.36 cm in B101; the Internode length ranged from 3.87 cm in B305 to 12.59 cm in B403. The number of leaves per node varied significantly between 10 in B404 and 6 in B504.

The leaf lamina length varied significantly between 6.21 cm in C503 and 2.36 cm in C101. The leaf lamina width varied significantly between 3.15 cm in C503 and 1.07 cm in C306. The petiole length ranged from 0.67 cm in C102 to 1.97 cm in C202; the Internode length ranged from 2.05 cm in C102 to 10.03 cm in C306. The number of leaves per node varied significantly between 21 in C304 and 5 in C102.

The leaf lamina length of 12.76 cm in G201 is significantly the highest ($P<0.05$) while G103 with a leaf lamina length of 3.43 cm is the lowest. The leaf lamina width varied significantly between 6.18 cm in G201 and 3.68 cm in G101. The petiole length ranged from 1.61 cm in G101 to 4.55 cm in G201; the Internode length ranged from 3.23 cm in G202 to 7.51 cm in G201. The number of leaves per node varied significantly between 10 in G204 and 6 in G201.

Table 2: Quantitative vegetative morphological traits

ACC	SPECIES	LLA(cm)	LLWA(cm)	PLA(cm)	ILA(cm)	NL
B101	*O.basilicum*	9.07^{bcd}	7.01^{ab}	**6.36^{a}**	7.87^{e}	10.10^{d-j}
B102	*O.basilicum*	8.64^{cde}	6.18^{c-e}	5.57^{b}	8.80^{d}	9.00^{g-o}
B201	*O.basilicum*	5.11^{j-m}	4.09^{hi}	2.56^{e-g}	6.46^{g}	6.43^{p-r}
B301	*O.basilicum*	6.94^{gh}	5.46^{ef}	2.46^{e-h}	6.95^{e-g}	8.03^{i-q}
B303	*O.basilicum*	9.41^{bc}	6.90^{a-c}	5.63^{b}	10.44^{b}	10.00^{d-k}
B305	*O.basilicum*	9.66^{b}	7.27^{a}	3.08^{ef}	3.87^{i-m}	9.50^{e-m}
B403	*O.basilicum*	8.27^{d-f}	6.03^{de}	4.76^{cd}	**12.59^{a}**	9.83^{e-l}
B404	*O.basilicum*	7.98^{ef}	6.13^{de}	4.81^{cd}	9.44^{cd}	10.27^{c-i}
B405	*O.basilicum*	8.27^{d-f}	6.29^{b-d}	5.33^{bc}	10.00^{bc}	9.20^{f-n}
B501	*O.basilicum*	5.51^{i-k}	4.12^{hi}	2.39^{f-h}	4.98^{h}	6.90^{n-r}
B502	*O.basilicum*	5.30^{i-l}	4.13^{hi}	2.19^{g-i}	3.96^{h-m}	7.67^{j-q}
B504`	*O.basilicum*	6.06^{h-j}	4.37^{g-i}	2.57^{e-g}	4.71^{hi}	5.73
B601	*O.basilicum*	5.95^{h-j}	4.73^{gh}	1.98^{g-k}	6.63^{fg}	7.17^{m-r}
B603	*O.basilicum*	6.18^{hi}	4.66^{gh}	4.05^{d}	9.42^{cd}	9.90^{e-k}
B605	*O.basilicum*	2.86^{tu}	2.43^{k}	1.94^{g-k}	7.70^{e}	9.53^{e-m}
B606	*O.basilicum*	5.93^{h-j}	3.69^{ij}	2.22^{g-i}	4.72^{hi}	7.27^{m-r}
C101	*Ocimum sp.*	**2.36^{u}**	1.21^{op}	1.51^{i-o}	3.07^{m-r}	8.07^{i-q}
C102	*Ocimum sp.*	4.45^{l-p}	1.70^{k-p}	**$.67^{o}$**	**2.05^{r}**	**5.47r**
C103	*Ocimum sp.*	4.92^{k-m}	2.23^{k-m}	1.64^{h-n}	4.38^{h-j}	10.80^{b-g}
C104	*Ocimum sp.*	3.98^{n-s}	1.68^{k-o}	$.90^{no}$	2.26^{p-r}	6.40^{p-r}
C105	*Ocimum sp.*	4.91^{k-m}	2.20^{k-m}	1.47^{i-o}	4.23^{h-k}	11.03^{b-g}
C201	*Ocimum sp.*	3.28^{q-u}	1.72^{k-p}	1.49^{i-o}	3.40^{j-o}	10.97^{b-g}
C202	*Ocimum sp.*	4.70^{k-o}	2.34^{kl}	1.97^{g-k}	3.47^{j-o}	9.30^{f-n}
C203	*Ocimum sp.*	4.15^{m-q}	2.04^{k-m}	1.15^{k-o}	4.00^{h-m}	12.30^{b-d}
C204	*Ocimum sp.*	2.74^{tu}	1.23^{n-p}	$.78^{no}$	2.76^{n-r}	13.07^{b}
C205	*Ocimum sp.*	3.00^{s-u}	1.43^{m-p}	$.97^{m-o}$	3.48^{j-o}	12.57^{b}
C206	*Ocimum sp.*	3.16	1.59	.88	2.93	8.50
C301	*Ocimum sp.*	2.79^{q-u}	1.16^{l-p}	$.93^{no}$	2.14^{m-r}	7.43^{i-q}
C303	*Ocimum sp.*	3.07^{r-u}	1.47^{m-p}	1.01^{m-o}	3.08^{l-r}	11.60^{b-f}
C304	*Ocimum sp.*	2.74^{tu}	1.32^{n-p}	$.79^{no}$	2.42^{o-r}	**21.07^{a}**
C305	*Ocimum sp.*	2.94^{s-u}	1.43^{m-p}	1.04^{l-o}	3.57^{j-n}	11.87^{b-e}
C306	*Ocimum sp.*	2.69^{tu}	**1.07^{op}**	1.04^{l-o}	10.03^{bc}	
C403	*Ocimum sp.*	3.36^{q-u}	1.57^{l-p}	$.94^{m-o}$	3.16^{k-q}	7.20^{m-r}
C405	*Ocimum sp.*	3.74^{o-t}	1.59^{l-p}	1.02^{l-o}	3.23^{k-p}	7.27^{m-r}
C501	*Ocimum sp.*	4.09^{o-n}	1.97^{k-o}	1.27^{j-o}	3.13^{k-q}	7.00^{n-r}
C503	*Ocimum sp.*	6.21^{hi}	3.15^{j}	1.84^{g-l}	3.86^{i-m}	7.67^{j-r}
C504	*Ocimum sp.*	3.48^{p-t}	1.65^{k-p}	1.17^{k-o}	3.38^{j-o}	6.57^{p-r}
C505	*Ocimum sp.*	3.08^{r-u}	2.20^{k-m}	$.91^{no}$	2.92^{m-r}	6.90^{n-r}
G101	*O. gratissim um*	7.37^{fg}	3.68^{ij}	1.61^{h-n}	3.42^{j-o}	6.10^{p-r}
G102	*O. gratissimum*	9.60^{bc}	5.10^{fg}	3.21^{e}	4.19^{h-l}	6.43^{p-r}
G103	*O. gratissimum*	3.43^{de}	4.37^{g-i}	3.15^{ef}	3.56^{j-n}	6.40^{p-r}
G201	*O. gratissimum*	**12.76^{a}**	6.18^{c-e}	4.55^{d}	7.51^{ef}	6.20^{p-r}
G202	*O. gratissimum*	7.89^{ef}	4.20^{hi}	2.12^{g-j}	3.23^{k-p}	7.60^{k-r}
G204	*O. gratissimum*	7.93^{ef}	4.49^{gh}	1.98	3.98^{h-m}	9.97^{d-k}
G205	*O. gratissimum*	6.91^{gh}	3.69^{ij}	1.80^{g-l}	3.55^{j-n}	9.00^{g-o}
		5.60	3.40	2.26	5.00	8.88

Means with the same letter along the column are not significantly different at $p < 0.05$ Key: LLA- Leaf Lamina Length, LLWA- Leaf Lamina Width, PLA- Petiole Length, ILA- Internode Length, NL- Number of leaf per node

The correlation analysis presented in Tables 3, 4 and 5 showed a significant correlation among the vegetative characters of B-, C- and G-accessions, respectively. The Pearson correlation coefficients among the vegetative characters as shown in Table 3 revealed that there are strong positive relationships among the characters. There are strong correlation between leaf lamina length and leaf lamina width at r=0.841; petiole length, and leaf lamina length and leaf lamina width at r=0.711 and 0.658, respectively. Internode length highly correlated significantly with leaf lamina length, leaf lamina width and petiole length at r=0.248, 0.241 and 0.432, respectively. The number of leaves per node significantly correlated with leaf lamina length, leaf lamina width, petiole length and internode length at r=0.203, 0.237, 0.257 and 0.238, respectively.

The Pearson correlation coefficient among the vegetative characters as shown in Table 4 revealed strong positive relationships among the characters: Leaf lamina length correlated significantly with leaf lamina width at r=0.860. Petiole length significantly correlated with leaf lamina length and leaf lamina width at r=0.572 and 0.635, respectively. Whereas, the internode length and number of leaves per node are not significantly related to other characteristics such as leaf lamina length, leaf lamina width and petiole length.

The Pearson correlation coefficients among the vegetative characters as shown in Table 5 revealed strong positive and negative relationships among the characters: Leaf lamina length significantly correlated with leaf lamina width at r=0.915. Petiole length significantly correlated with leaf lamina length and leaf lamina width at r=0.832 and 0.834, respectively. Internode length significantly correlated with leaf lamina length, leaf lamina width and petiole length at r=0.383, 0.349 and 0.372, respectively. The number of leaves per node significantly correlated with leaf lamina length, leaf lamina width and petiole length at r=0.188, 0.149 and 0.162, respectively.

Table 3: Pearson correlation coefficients among vegetative characters in the B-accessions

	LLLA	LLWA	PLA	ILA	NL
LLLA	1				
LLWA	0.841**	1			
PLA	0.711**	0.658**	1		
ILA	0.248**	0.241**	0.432**	1	
NL	0.203**	0.237**	0.257**	0.238**	1

** Significant at the 0.01 level (2-tailed).

Key: LLA- leaf lamina length, LLWA- leaf lamina width, PLA- petiole length, ILA- internode length, NL- number of leaf per node.

Table 4: Pearson correlation coefficients among vegetative characters in the c-accessions.

	LLLA	LLWA	PLA	ILA	NL
LLLA	1				
LLWA	0.860**	1			
PLA	0.572**	0.635**	1		
ILA	-0.013	-0.021	0.156	1	
NL	-0.238	-0.183	-0.088	0.101	1

** Significant at the 0.01 level (2-tailed).

Key: LLA- leaf lamina length; LLWA- leaf lamina width; PLA- petiole length; ILA- Internode length; NL- Number of leaf per node.

Table 5: Pearson correlation coefficients of the G-accessions

	LLLA	LLWA	PLA	ILA	NL
LLLA	1				
LLWA	0.915**	1			
PLA	0.832**	0.834**	1		
ILA	0.383**	0.349**	0.372**	1	
NL	-0.188**	0-.149*	-0.162*	-0.025	1

** Significant at the 0.01 level (2-tailed).

Key: LLA- leaf lamina length; LLWA- leaf lamina width; PLA- Petiole length; ILA- Internode length; NL- Number of leaf per node.

Dendrogram based on mean quantitative vegetative morphological traits

All the accessions were separated by dendrogram and distinguished them as individual genotypes at 0.0 dissimilarity coefficient i.e. 100% similarity and grouped them as one at 1.2 dissimilarity coefficient (Figure 2). Levels between these two extremes gave rise to different groupings as depicted in the dendrogram. As the similarity index increased the number of groups that were formed decreased with the merger of these groups. There were intra- and inter-specific variations, similarities and overlaps among the species or accessions. At 0.0 dissimilarity coefficient, none of the accessions was linked together. This implies that they are individual genotypes and none is duplicated. At 0.50 dissimilarity coefficient, all the accessions had formed six cluster groups.

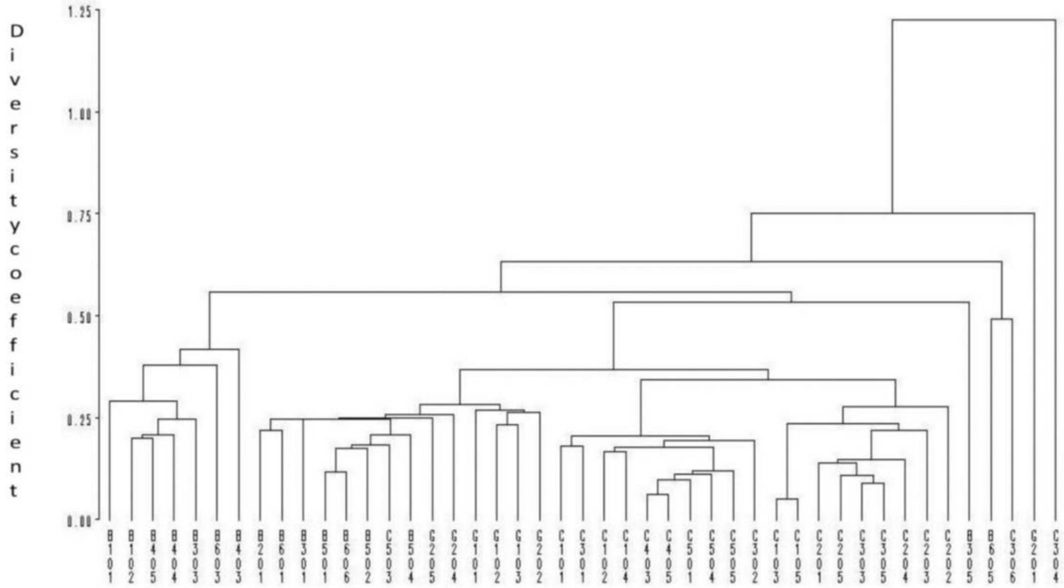

Figure 2: Dendogram based on mean quantitative vegetative morphological traits
Key: *O. basilicum* (B-accessions), *O. canum* (C-accessions) and *O. gratissimum* (G-accessions)

Reproductive biology of accessions collected in Southwest Nigeria

Floral qualitative morphological traits

The qualitative floral characters of the species studied as shown in Tables 5, Plate 2 and 3, revealed that all the species have toothed calyx margin, gamopetalous bilabiate (two lips) corolla, corolla tube dilating towards the mouth, white filament color and Lobe bifid style type. The inflorescence is determinate and verticillaster in all the accessions except the B-accessions with indeterminate inflorescence. Intermediate flower position occurs in all the accessions except the B-accessions with erect flower position. There are 3- cyme flowers in all the accessions but they vary in the B-accessions. Cyme branches are free and not fused to the stem in C102, C202, C504, and C505, the G- accessions and B-accessions while other accessions are fused to the stem.

The hairy annulus is present in all the calyx throats except the G-accessions. Posterior Lobe is present in all the accessions except C202, C203 and all the B- accessions. The calyx curve was bent down at the mouth in all the accessions except in all the B-accessions with a straight calyx curve. Calyx color ranged from green in all the accessions except C102, C103, C104, C202, C504 and C505 to violet green.

The corolla color ranged from white in C102, C103, C203, C206, C301, C303, C304, C305, C403, C405 to cream in C101, C104, C105, C201, C204, C205, C306, C501 and C503, and all the G-accessions, it was violet in all the B-accessions but violet white in C202 (Plate 2). The anther color is white in all the C-accessions except C103, C105 C202, C203 and C205 with brown color, G-accessions are yellow and B-accessions are dark brown (Plate 2). The anterior stamens are free in the accessions but inserted in B-accessions. The style colors ranged from white in C102, C105, C203, C204, C205, C303, C304, C305, C306, C403, C405, C501, C503 and all the G-accessions, to violet in C103, C201, C202, C504, C505 and all the B-accessions but violet white in C104 only. A considerable variability observed in the qualitative floral characters showed the B-accessions expressed uniqueness in ebracteate and indeterminate inflorescence, 3-4-6 cyme flower numbers, cyme free not fused to stem, straight calyx curve, violet or purple corolla color, gibbous corolla tube base, inserted stamen, dark brown anther (pollen) color, violet style color, and erect flower position. The C-accessions are unique in white anther (pollen) color, white or violet style color and the cyme branches are fused to the stem except C102, C202, C504 and C505. The G-accessions have yellow anther color, white style color, alternate verticillaster inflorescence arrangement and absence of hairy annulus in calyx throat.

Table 5: Qualitative floral characters of species studied

Character	B-accessions	C-accessions	G-accessions
Inflorescence Type	Intermediate	Determinate	determinate
Flower position	Erect	Lateral	Lateral
Bract persistence	Absent	Caduceus	Caduceus
Cyme flower number	3-4-6 flower	3-flower	3-flower
Cyme branches	Free not fused to stem	Fused to stem/Free not fused to stem	Free not fused to stem
Hairy annulus in calyx throat	Present	Present	Absent
Posterior lobe	Not decurrent	Decurrent	decurrent
Calyx margin	Toothed	Toothed	Toothed
Calyx curve	Straight	Bent down at mouth	Bent down at mouth

Calyx colour	Green	Green / Violet Green	Green
Corolla colour	Purple or violet	Cream / white / violet white / violet	Cream
Corolla tube	Dilating towards the mouth	Dilating towards the mouth	Dilating towards the mouth
Corolla tube base	Gibbous	Gibbous	Gibbous
Corolla shape	Gamopetalous Bilabiate 3/2	Gamopetalous Bilabiate 4/1	Gamopetalous Bilabiate 4/1
Filament colour	White	White	White
Anther (pollen) colour	Dark brown	White/ brown	Yellow
Posterior Stamen form	inserted	Bent / straight	Straight
Anterior stamen form	Inserted	Free	Free
Posterior stamen attachment	N/A	Midpoint of tube / base of tube	Base of tube
Style type	Lobe bifid	Lobe bifid	Lobe bifid
Style colour	Violet	Violet white / white/lilac or violet	White

Plate 2: Variations in calyx, corolla, anther and style colours
A: G-accessions (*Ocimum gratissimum*), B-F: C-accessions (*O. canum*) and G: B-accessions (*O. basilicum*)

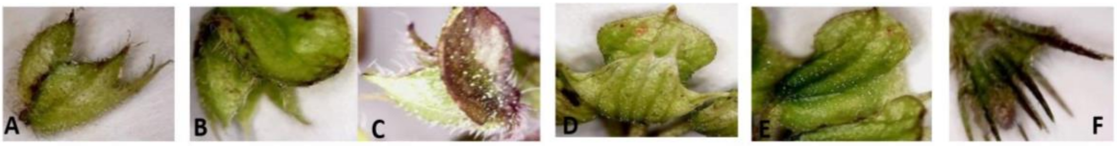

Plate 3: Bilabiate gamosepalous calyx in A-B (Front and Back Views); D-E (Front and Back Views) and urceolate gamosepalous in F

Quantitative floral traits of accessions collected in Southwest Nigeria

All the accessions showed considerable intra- and inter-species variations in the mean values of the floral quantitative traits measured. The calyx length ranged significantly from 0.55 cm in B603 to 0.74 cm in B201. The calyx width ranged significantly from 0.46 cm in C503 to 0.18 cm in C101. The corolla length ranged significantly from 0.68 cm in B606 to 0.94 cm in B305. The corolla width ranged significantly from 0.30 cm in B601 to 0.46 cm in B305. The filament length ranged significantly from 0.30 mm in B603 and B606 to 0.38 mm in B101. The style length ranged significantly from 0.42 mm in B501 to 0.50 mm in B102 and B404.

The calyx length ranged significantly from 0.24 cm in C101 to 0.96 cm in C306; the calyx width ranged significantly from 0.18 cm in C101 to 0.46 cm in C503; the corolla length ranged significantly from 0.25 cm in C101 to1.20 cm in both C503 and C504; the corolla width ranged significantly from 0.19 cm in C101 to 0.66 cm in C305; the filament length ranged significantly from 0.27 mm in C101 to 0.88 mm in C405; the style length ranged significantly from 0.41 mm in C101 to 1.43 cm in C103; the inflorescence length ranged significantly from 6.09 cm in C304 to 20.75 cm in C505 and the number of flower per inflorescence ranged significantly from 2.73 in C301 to 5.50 in C202.

The calyx length ranged significantly from 0.34 cm in G103 to 0.55 cm in G202. The calyx width ranged significantly from 0.19 cm in G103 to 0.35 cm in G202. The corolla length ranged significantly from 0.41 cm in G103 to 0.46 cm in G101. The corolla width ranges significantly from 0.29 cm in G103 to 0.36 cm in G202. The filament length ranged significantly from 0.40 mm in G204 to 0.50 mm in G101; the style length ranges significantly from 0.73 mm in G205 to 1.13 mm in G102; the inflorescence length ranged significantly from 6.7 cm in G202 to 11.0 cm in G103 and the number of flowers per inflorescence ranged significantly from 6.08 in G103 to 10.61 in G202.

Table 6: Quantitative floral traits of accessions collected in Southwest Nigeria

ACC	CALA (cm)	CAWA (cm)	COLA (cm)	COWA (cm)	FILA (mm)	SLA (mm)	INFLA (cm)	NFA
B101	0.65^{c-f}	0.30^{jk}	0.84^{de}	0.37^{h}	0.38^{l-n}	0.49^{e-g}	0.00	1.37^{jk}
B102	0.63^{c-g}	0.28^{j-l}	0.84^{de}	0.39^{h}	0.36^{m-o}	0.50^{e-g}	0.00	**1.17^{k}**
B201	0.74^{b-d}	0.37^{e-i}	0.82^{d-f}	0.37^{h}	0.36^{m-o}	0.48^{e-g}	0.00	1.27^{k}
B301	0.60^{c-g}	0.28^{j-l}	0.78^{f-i}	0.36^{hi}	0.33^{n-p}	0.46^{e-g}	0.00	1.47^{jk}
B303	0.59^{c-h}	0.27^{kl}	0.79^{e-h}	0.37^{hi}	0.33^{n-p}	0.48^{e-g}	0.00	1.43^{jk}
B305	0.65^{c-e}	0.24^{l}	0.94^{c}	0.46^{g}	0.34^{n-p}	0.49^{e-g}	0.00	1.60^{i-k}
B403	0.65^{c-e}	0.26^{kl}	0.86^{d}	0.38^{h}	0.34^{n-p}	0.49^{e-g}	0.00	1.47^{jk}

B404	0.63 $^{c-g}$	0.24 ^{l}	0.77 $^{g-j}$	0.36 ^{hi}	0.35 $^{m-p}$	0.50 $^{e-g}$	0.00	1.60 $^{i-k}$
B405	0.61 $^{c-g}$	0.26 ^{kl}	0.79 $^{f-h}$	0.38 ^{h}	0.32 $^{n-q}$	0.49 $^{e-g}$	0.00	1.47 ^{jk}
B501	0.58 $^{d-h}$	0.25 ^{kl0}	0.80 $^{e-h}$	0.39 ^{h}	0.31 $^{o-q}$	0.42 ^{g}	0.00	1.37 ^{jk}
B502	0.60 $^{c-g}$	0.27 ^{kl}	0.78 $^{f-i}$	0.36 ^{hi}	0.31 $^{o-q}$	0.43 ^{fg}	0.00	1.43 ^{jk}
B504	0.56 $^{d-i}$	0.25 ^{kl}	0.79 $^{f-h}$	0.38 ^{h}	0.35 $^{m-p}$	0.47 $^{e-g}$	0.00	1.47 ^{jk}
B601	0.60 $^{c-g}$	0.27 ^{kl}	0.72 $^{j-l}$	0.30 ^{j}	0.32 $^{o-q}$	0.44 ^{fg}	0.00	1.50 ^{jk}
B603	0.55 $^{d-i}$	0.25 ^{kl}	0.82 $^{d-g}$	0.37 ^{hi}	0.30 ^{pq}	0.42 ^{g}	0.00	1.27 ^{k}
B605	0.60 $^{c-g}$	0.26 ^{kl}	0.84 ^{de}	0.37 ^{hi}	0.31 $^{o-q}$	0.43 ^{fg}	0.00	1.43 ^{jk}
B606	0.56 $^{d-i}$	0.24 ^{l}	0.68 ^{lm}	0.35 ^{hi}	0.30 $^{o-q}$	0.42 ^{g}	0.00	1.40 ^{jk}
C101	**0.24 ^{l}**	**0.18 ^{m}**	**00.25 ^{r}**	**0.19 ^{k}**	**0.27 ^{q}**	**0.41 ^{g}**	9.27 $^{j-m}$	3.97 $^{f-h}$
C102	0.58 $^{d-i}$	0.41 $^{b-f}$	0.62 ^{n}	0.49^{g}	0.74 $^{d-f}$	0.85 $^{c-g}$	11.20 $^{h-k}$	5.40 $^{e-g}$
C103	0.47 $^{e-k}$	0.36 $^{f-i}$	0.77 $^{g-j}$	0.53 ^{f}	0.74 $^{c-f}$	**1.43 ^{a}**	13.24 $^{g-i}$	3.53 ^{gh}
C104	0.54 $^{d-k}$	0.37 $^{e-h}$	0.72 $^{j-l}$	0.59 $^{c-e}$	0.74 $^{c-f}$	0.87 $^{c-g}$	10.50 $^{i-l}$	3.20 $^{h-j}$
C105	0.45 $^{e-l}$	0.35 $^{g-i}$	0.75 $^{h-j}$	0.54 ^{f}	0.76 $^{c-d}$	1.01 $^{a-c}$	16.12 $^{d-f}$	4.13 $^{f-h}$
C201	0.33 ^{kl}	0.23 ^{l}	0.40 ^{q}	0.30 ^{j}	0.33 $^{n-p}$	0.53 $^{d-g}$	10.00 $^{j-l}$	3.57 ^{gh}
C202	0.49 $^{e-k}$	0.35 $^{g-i}$	0.67 ^{m}	0.56 ^{ef}	0.70 ^{fg}	0.87 $^{c-g}$	13.45 $^{f-h}$	5.50 ^{ef}
C203	0.36 $^{i-l}$	0.26 ^{kl}	0.69 $^{k-m}$	0.53 ^{f}	0.67 ^{g}	0.91^{g}	18.59 $^{a-d}$	4.00 $^{f-h}$
C204	0.45 $^{e-l}$	0.35 ^{hi}	0.73 $^{i-k}$	0.55 ^{ef}	0.57 ^{h}	0.87 $^{c-g}$	19.80 ^{ab}	2.90 $^{h-k}$
C205	0.46 $^{e-k}$	0.32 ^{ij}	0.75 $^{h-j}$	0.58 $^{d-f}$	0.71 $^{e-g}$	0.98 $^{a-d}$	18.37 $^{a-e}$	3.73 $^{f-h}$
C206	0.50 $^{e-k}$	0.40 $^{c-g}$	0.69 $^{k-m}$	0.55 ^{ef}	0.70 ^{fg}	0.91^{b-e}	7.61 $^{l-n}$	3.70 $^{f-h}$
C301	0.46 $^{e-k}$	0.36 $^{f-i}$	0.81 $^{d-g}$	0.64 ^{ab}	0.75 $^{c-f}$	0.95 $^{b-d}$	16.,82 $^{c-e}$	2.73 $^{h-k}$
C303	0.58 $^{d-i}$	0.41 $^{a-e}$	0.78 $^{f-i}$	0.63 $^{a-c}$	0.76 $^{c-e}$	0.89 $^{c-f}$	11.28 $^{h-k}$	4.00 $^{f-h}$
C304	0.60 $^{c-g}$	0.45 ^{ab}	0.81 $^{d-g}$	0.59 $^{c-e}$	0.78 $^{b-d}$	0.96 $^{b-d}$	**6.09 ^{n}**	3.47 ^{h}
C305	0.42 $^{g-l}$	0.32 ^{ij}	0.78 $^{f-i}$	**0.66 ^{a}**	0.74 $^{c-f}$	1.04 $^{a-c}$	15.82 $^{d-g}$	2.97 $^{h-k}$
C306	**0.96^{a}**	0.43 $^{a-d}$	0.77 $^{g-j}$	0.56 ^{ef}	0.75 $^{b-f}$	0.98 $^{a-d}$	11.63 $^{h-j}$	3.47 ^{h}
C403	0.59 $^{c-h}$	0.39 $^{d-h}$	1.09 ^{b}	0.57 $^{d-f}$	0.77 $^{b-d}$	1.35 ^{ab}	19.54 $^{a-c}$	3.23 $^{h-j}$
C405	0.49 $^{e-k}$	0.38 $^{d-h}$	.84 ^{de}	0.61 $^{b-d}$	**0.88 ^{a}**	1.03 $^{a-c}$	17.32 $^{a-e}$	3.37 ^{hi}
C501	0.80^{a-c}	0.41 $^{a-f}$	1.10 ^{b}	0.55 ^{ef}	0.80 ^{bc}	1.05 $^{a-c}$	15.69 $^{e-g}$	3.43 ^{hi}
C503	0.93^{ab}	**0.46 ^{a}**	**1.20 ^{a}**	0.56 ^{ef}	0.81 ^{b}	1.05 $^{a-c}$	19.71 ^{ab}	3.63 ^{gh}
C504	0.90^{ab}	0.45 $^{a-c}$	**1.20 ^{a}**	0.55 ^{ef}	0.79 $^{b-d}$	1.04 $^{a-c}$	18.50 $^{a-e}$	3.53 ^{gh}
C505	0.80 $^{a-c}$	0.40 $^{c-g}$	1.10 ^{b}	0.54 ^{f}	0.79 $^{b-d}$	1.05 $^{a-c}$	**20.75 ^{a}**	3.80 $^{f-h}$
G101	0.42 $^{g-l}$	0.23 ^{l}	0.46 ^{o}	0.30 ^{j}	0.50 ^{i}	.98 $^{a-d}$	8.45 $^{k-n}$	6.58 $^{c-e}$
G102	0.41 $^{g-l}$	0.25 ^{kl}	0.43 $^{o-q}$	0.35 ^{hi}	0.46 ^{ij}	1.13 $^{a-c}$	9.84 $^{j-l}$	9.18 ^{ab}
G103	0.34 $^{j-l}$	0.19 ^{m}	0.41 ^{pq}	0.29 ^{j}	0.42 $^{j-l}$	1.05 $^{a-c}$	11.00 $^{h-k}$	6.08 ^{de}
G201	0.37 $^{h-l}$	0.25 ^{kl}	0.44 $^{o-q}$	0.33 ^{ij}	0.47 ^{ij}	1.00 $^{a-c}$	10.07 $^{j-l}$	7.95 ^{bc}
G202	0.55 $^{d-j}$	0.35 ^{hi}	0.45 ^{op}	0.36 ^{hi}	0.44 ^{jk}	0.82 $^{c-g}$	6.70 ^{mn}	**10.61 ^{a}**
G204	0.44 $^{e-l}$	0.25 ^{kl}	0.42 $^{o-q}$	0.29 ^{j}	0.40 $^{k-m}$	0.97 $^{b-d}$	9.06 $^{j-m}$	7.63 $^{b-d}$
G205	0.43 $^{f-j}$	0.24 ^{l}	0.43 $^{o-q}$	0.30 ^{j}	0.43 ^{jk}	0.73 $^{c-g}$	10.29 $^{j-l}$	7.97 ^{bs}
Total	0.56	0.31	0.74	0.45	0.53	0.78	8.59	3.55

Means with the same letter are not significantly different at $P<0.05$.

Key: CALA-Calyx Length, CAWA-Calyx width, COLA-Corolla Length, COWA- Corolla width, FILA-Filament Length, SLA-Style Length, INFLA- Inflorescence Length, NFA- Number of Flower per inflorescence.

Pearson correlation coefficients of floral traits in B-accessions.

The Pearson correlation coefficients of the B-accessions (Table 7) revealed positive significant associations among the floral characters. The calyx width significantly correlated with calyx length at r=0.699. The corolla width correlated significantly with corolla length at r=0.663. When the calyx length increased the calyx width increased, and also the corolla length as well as the corolla width increased. The filament length correlated significantly with calyx length, calyx width and corolla length at r= 0.125, 0.091and 0.132, respectively. The style length significantly correlated with calyx length, corolla length and filament length at r= 0.125, 0.154 and 0.48, respectively.

Pearson correlation coefficients of floral traits in C-accessions.

The C-accessions showed strong significant relationships among the floral characters (Table 8). The calyx length significantly correlated with calyx width, corolla length, corolla width, filament length and inflorescence length at r= 0.435, 0375, 0.184, 0.256 and 0.081, respectively. Calyx width significantly correlated with corolla length, corolla width, filament length and style length at r= 0.565, 0.467, 0.560 and 0.153, respectively. The corolla length significantly correlated with corolla width, filament length, style length and inflorescence length at r=0.573, 0.630, 0.260 and 0.433, respectively. Corolla width significantly correlated with filament length, style length and inflorescence length at r=0.650, 0.209 and 0.215, respectively. Filament length significantly correlated with style length and inflorescence length at r= 0.266 and 0.219, respectively.

Pearson correlation coefficients of floral traits in the G-accessions

The G-accessions showed strong significant relationships among their floral characters (Table 9). The calyx width significantly correlated with calyx length at r= 0.621. The corolla length significantly correlated with calyx length at r= 0.214. The corolla width significantly correlated with calyx width and corolla length at r= 0.273 and 0.438 respectively. The filament length significantly correlated with calyx width and corolla width at r=0.278 and 0.252, respectively. The style length significantly correlated with calyx length, calyx width and filament length at r= -0.273, 0.303 and 0.494, respectively. The number of flowers per inflorescence significantly correlated with calyx length, calyx width, corolla width, style length and inflorescence length at r= 0.285, 0.151, 0.141, -0.301 and -0.197, respectively.

Table 7: Pearson correlation coefficients of floral traits in the B-accessions

	CALA	CAWA	COLA	COWA	FILA	SLA	NFA
CALA	1						
CAWA	0.699**	1					
COLA	0.136**	0.062	1				
COWA	0.057	-0.052	0.663**	1			
FILA	0.125**	0.091*	0.132**	0.038	1		
SLA	0.125**	0.046	0.154**	0.030	0.484**	1	
NFA	-0.065	-0.043	-0.054	-0.050	0.009	0.034	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).
Key: CALA-Calyx length, CAWA-Calyx width, COLA-Corolla length, COWA- Corolla width, FILA-Filament length, SLA-Style length, INFLA- Inflorescence length, NFA- Number of flower per inflorescence.

Table 8: Pearson correlation coefficients of floral traits of C-accessions

	CALA	CAWA	COLA	COWA	FILA	SLA	INFLA	NFA
CALA	1							
CAWA	0.435**	1						
COLA	0.375**	0.565**	1					
COWA	0.184**	0.467**	0.573**	1				
FILA	0.256**	0.560**	0.630**	0.650**	1			
SLA	0.065	0.153**	0.260**	0.209**	0.266**	1		
INFLA	0.081*	0.045	0.433**	0.215**	0.219**	0.133**	1	
NFA	-0.092*	0.001	-0.067	-0.044	0.015	-0.033	-0.088*	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).
Key: CALA-Calyx length, CAWA-Calyx width, COLA-Corolla length, COWA- Corolla width, FILA-Filament length, SLA-Style length, INFLA- Inflorescence length, NFA- Number of flower per inflorescence.

Table 9: Pearson correlation coefficients of floral traits of the G-accessions

	CALA	CAWA	COLA	COWA	FILA	SLA	INFLA	NFA
CALA	1							
CAWA	0.621**	1						
COLA	0.214**	0.131	1					
COWA	0.115	0.273**	0.438**	1				
FILA	-0.071	0.278**	0.090	0.252**	1			
SLA	-0.273**	0.303**	-0.132	0.145*	0.494**	1		
INFLA	-0.295**	-0.375**	-0.103	-0.051	-0.098	0.070	1	
NFA	0.285**	0.151*	0.115	0.145*	-0.055	-0.301**	-0.197**	1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level.
Key**:** CALA-Calyx length, CAWA-Calyx width, COLA-Corolla length, COWA- Corolla width, FILA-Filament length, SLA-Style length, INFLA- Inflorescence length, NFA- Number of flower per inflorescence.

Dendrogram based on floral morphological traits

The dendrogram based on floral morphological traits (Figure 3) separated all the accessions as individuals at 0.0 dissimilarity coefficient none of the accessions was linked together. At 0.3 dissimilarity coefficient, the accessions were grouped into three, separating all the accessions of B-accessions from the others. At 0.5 dissimilarity coefficient, there were two groupings and all the accessions were grouped into one at 0.7 dissimilarity coefficient.

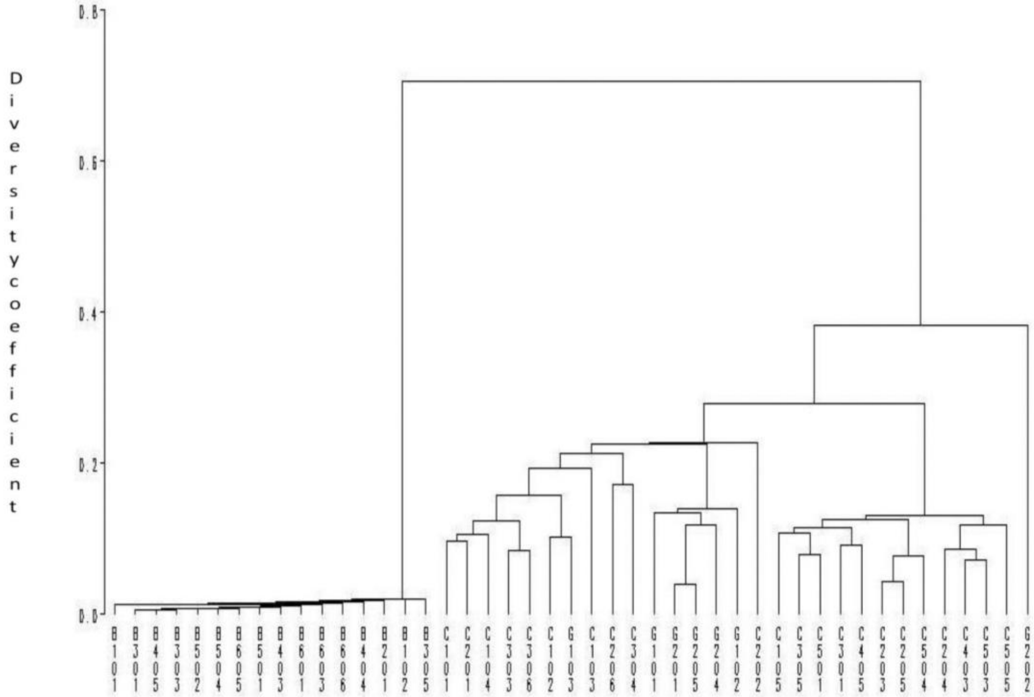

Figure 3: Dendogram based on mean quantitative floral morphological traits
Key: *O. basilicum* (B-accessions), *O. canum* (C-accessions) and *O. gratissimum* (G-accessions)

Quantitative morphology of reproductive and growth characters of accessions collected in Southwest Nigeria

All the accessions showed considerable variations in the mean values of the morphological quantitative traits measured. Days to germination ranged significantly from 5 days in B403, B404, B405 and B606 to 66 days in B301. The plant height ranged significantly from 37.23 cm in B102 to 187.00 cm in B305. The plant canopy ranged significantly from 48.93 cm in B102 to 136.00 cm in B403. The number of branches ranged significantly from 8.00 in B501 to 23.00 in B101. The stem diameter ranged significantly from 0.63 cm in B606 to 3.79 cm in B501. Days to 50 % flowering were lowest in B201 (53 days) and highest in B403 (163.33 days). Days to 50 % fruiting were lowest in B201 (84 days) and highest in B101 and B102 (209 days). The number of inflorescences varied between 340 in B606 to 15 in B102. The seed width ranged significantly from 1.12 mm in B305 to 2.52 mm in B404. The seed length ranged significantly from 1.90 mm in B305 to 3.96 mm in B603.

Days to germination ranged significantly from 6 days in C501, C503, C504 and C505 to 62.67 days in C103. The plant height ranged significantly from 15.03 cm in C304 to 85.67 cm in C203. The plant canopy ranged significantly from 18.67 cm in C102 to 90.33 cm in C203. Number of branches ranged significantly from 2.67 in C102 to 27.33 in C403. Stem diameter ranged significantly from 0.22 cm in C306 to 1.69 cm in C504. Days to 50 % flowering were lowest in C304 (69.00 days) and highest in C301 (186.00 days). Days to 50 % fruiting were lowest in C304 (84 days) and highest in C405 (232 days). The number of inflorescence per plant was highest in C503 (83.33) but lowest in C206 (10. 00). Seed width ranged significantly from 0.62 mm in C101 to 1.34 mm in C202. Seed length ranged significantly from 1.34 mm in C101 to 2.18 mm in C403.

Days to germination varied significantly between 24 days in G204 and 54 days in G205. Plant height ranged significantly from 54.67 cm in G101 to 142.00 cm in G204. Plant canopy ranged significantly from 48.00 cm in G101 to 115.00 cm in G205. Number of branches ranged significantly from 6.00 in G102 to 56.67 in G201. Stem diameter ranged significantly from 0.70 cm in G101 to 2.68 cm in G205. Days to 50 % flowering were lowest in G204 and G205 (171 days) and highest in G102 (233 days). Days to 50 % fruiting were lowest in G204 (194 days) and highest in G102 (265 days). Number of inflorescence per plant was highest in G205 (160.00) but lowest in G103 (10.67). Seed width ranged significantly from 0.98 mm in G102 to 1.04 mm in G202. Seed length ranged significantly from 1.17 mm in G103 to 1.34 mm in G102.

Pearson correlation coefficients and growth reproductive characters of the accessions collected in Southwest Nigeria

The Pearson correlation coefficients (Table 10) revealed strong positive associations among the morphological characters. Days to germination exhibited significant correlations with plant height, days to 50% fruiting, number of inflorescences per plant, seed width, and seed length, with r-values of -0.184, 0.322, 0.336, -0.340, -0.407, and -0.381, respectively. Plant height exhibited significant positive correlations with plant canopy, stem diameter, days to 50% fruiting, number of inflorescences per plant, seed width, and seed length, with r-values of 0.813, 0.536, 0.229, 0.444, 0.546, and 0.438, respectively. Plant canopy correlated significantly with stem diameter, number of inflorescences per plant, seed width, and seed length, with r-values of 0.598, 0.390, 0.459, and 0.322, respectively.

Stem diameter correlated significantly with the number of inflorescence per plant, seed width and seed length at r= 0.850, 0.365 and 0.290, respectively. Days to 50 % flowering correlated significantly with days to 50 % fruiting, seed width and seed length at r= 0.850, 0.660 and 0.232, respectively. Days to 50 % fruiting correlated significantly with seed length at r= -0.230. The number of inflorescence per plant correlated significantly with seed length at r= -0.638. Seed width and seed length correlated significantly at r= -0.956.

Table 10: Pearson correlation coefficients of quantitative morphology of reproductive and growth characters of the *Ocimum* accessions

	DTG	PH	PC	B/P	SD	D50%FL	D50%FR	N/INFL	SW	SL
DTG	1									
P/H	-0.184*	1								
P/C	-0.110	0.813**	1							
B/P	-0.010	0.080	0.080	1						
SD	-0.110	0.536**	0.598**	0.130	1					
D50%FL	0.322**	0.229**	0.197*	0.07	0.11	1				
D50%FR	0.336**	0.10	0.12	0.09	0.04	0.850**	1			
N/INFL	-0.340**	0.444**	0.390**	0.02	0.358**	-0.090	-0.207*	1		
SW	-0.407**	0.546**	0.459**	0.04	0.365**	0.660**	-0.150	-0.140	1	
SL	-0.381**	0.438**	0.322**	0.02	0.290**	-0.232**	0.230**	0.638**	0.956**	1

**. Correlation is significant at the 0.01 level (2-ailed). *. Correlation is significant at the 0.05 level (2-tailed)

Key**:** DTG-Days to germination, 50%DTFL- days to 50% Flowering, 50%FR- days to 50% fruiting, P/H- Plant Height, P/C-Plant Canopy, N/B- Numbers of branches per plant, S/D-Stem Diameter, N/INFL-No. of inflorescence/plant, SW- Seed width; SL- Seed Length.

The nutlet shape, color and texture of the *Ocimum* accessions studied.

The qualitative nutlet characters of the species studied (Table 11 and Plate 4) showed considerable variations in their shape, color at maturity, texture and scent. The *Ocimum species* (C-accessions) have an ellipsoid shape; a spherical shape exists in *O. gratissimum* (G-accessions) and a rhomboid shape in the B-accessions. The nutlet texture is pitted in all the accessions but rugose in the G-accessions. The nutlet colors ranged from black in C-accessions to dark brown in G-accessions and brown in B-accessions. A strong scent is observed in all the species except G-accessions with a mild scent.

Plate 4: Variations in nutlets size, shapes and colour
A: G-accessions (*Ocimum gratissimum*), B and C: C-accessions (*O. canum*) and D: B-accessions (*O. basilicum*)

Table 11: Nutlet shape, colour and texture of *Ocimum* accessions studied

S/N	Species	Accession	Shape	Nutlet indumentums	Nutlet texture	Nutlet colour	Scent
1	*Ocimum species*	C101	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
2	*O.species*	C102	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
3	*O.species*	C103	Ellipsoid	Glabrous	Pitted	Brown	Strong
4	*O.species*	C104	Ellipsoid	Glabrous	Pitted	Black	Strong
5	*O.species*	C105	Ellipsoid	Glabrous	Pitted	Brown	Strong
6	*O.species*	C201	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
7	*O.species*	C202	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
8	*O.species*	C203	Ellipsoid	Glabrous	Pitted	Black	Strong
9	*O.species*	C204	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
10	*O.species*	C205	Ellipsoid	Glabrous	Pitted	Brown	Strong
11	*O.species*	C206	Ellipsoid	Glabrous	Pitted	Black	Strong
12	*O.species*	C301	Ellipsoid	Glabrous	Pitted	Black	Strong
13	*O.species*	C303	Ellipsoid	Glabrous	Pitted	Black	Strong
14	*O.species*	C304	Ellipsoid	Glabrous	Pitted	Black	Strong
15	*O.species*	C305	Ellipsoid	Glabrous	Pitted	Black	Strong
16	*O.species*	C306	Ellipsoid	Glabrous	Pitted	Black	Strong
17	*O.species*	C403	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
18	*O.species*	C405	Ellipsoid	Glabrous	Pitted	Black	Strong
19	*O.species*	C501	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
20	*O.species*	C503	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
21	*O.species*	C504	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
22	*O.species*	C505	Ellipsoid	Glabrous	Pitted	Dark Brown	Strong
23	*O. gratissimum*	G101	spherical	Glabrous	Rugose	brown	Mild
24	*O. gratissimum*	G102	spherical	Glabrous	Rugose	brown	Mild

25	*O. gratissimum*	G103	spherical	Glabrous	Rugose	brown	Mild
26	*O. gratissimum*	G201	spherical	Glabrous	Rugose	brown	Mild
27	*O. gratissimum*	G202	spherical	Glabrous	Rugose	brown	Mild
28	*O.gratissimum*	G204	spherical	Glabrous	Rugose	brown	Mild
29	*O. gratissimum*	G205	spherical	Glabrous	Rugose	brown	Mild
30	*O. basilicum*	B101	Rhomboid	Glabrous	Pitted	brown	Strong
31	*O. basilicum*	B102	Rhomboid	Glabrous	Pitted	brown	Strong
32	*O. basilicum*	B201	Rhomboid	Glabrous	Pitted	brown	Strong
33	*O. basilicum*	B301	Rhomboid	Glabrous	Pitted	brown	Strong
34	*O. basilicum*	B303	Rhomboid	Glabrous	Pitted	brown	Strong
35	*O. basilicum*	B305	Rhomboid	Glabrous	Pitted	brown	Strong
36	*O. basilicum*	B403	Rhomboid	Glabrous	Pitted	brown	Strong
37	*O. basilicum*	B404	Rhomboid	Glabrous	Pitted	brown	Strong
38	*O. basilicum*	B405	Rhomboid	Glabrous	Pitted	brown	Strong
39	*O. basilicum*	B501	Rhomboid	Glabrous	Pitted	brown	Strong
40	*O. basilicum*	B502	Rhomboid	Glabrous	Pitted	brown	Strong
41	*O. basilicum*	B504	Rhomboid	Glabrous	Pitted	brown	Strong
42	*O. basilicum*	B601	Rhomboid	Glabrous	Pitted	brown	Strong
43	*O. basilicum*	B603	Rhomboid	Glabrous	Pitted	brown	Strong
44	*O. basilicum*	B605	Rhomboid	Glabrous	Pitted	brown	Strong
45	*O. basilicum*	B606	Rhomboid	Glabrous	Pitted	brown	Strong

Discussion

All the accessions of B, C and G-groups have different unique vegetative leaf characters. The accessions of B-group have unique ovate leaf shape, serrulate leaf margin, cuspidate leaf apices and pubescent leaves. The accessions of C-group have acute leaf apices and sparsely pubescent leaf. While the accessions of G- group have aristate leaf apices and glabrous leaf. Marrotti *et al*., (1996) observed four phenotypes of *Ocimum* species based on leaf size, leaf shape and leaf colour, plant height, branching and leafing. Taia (2005) and Carovic-Stanko *et al*. (2011) supported the effective use of vegetative morphology as the first step in the classification of intraspecific variability of basils. This study is in line with the result of Javamardi *et al*. (2002) that morphological studies of accessions of basils show a high level of variability. The plants accessions displayed phenotypic variability, which may be attributed to genetic distinctions between them, since they were planted and managed identically in a shared plot. The variability may also act as an adaptive feature, allowing the species to cope with diverse environmental conditions (Sultan, 1987). Variation in the shades of green leaf color in the *Ocimum species* may be attributed to the presence of other accessory pigments, such as carotenoids (yellow-orange) and anthocyanins (mostly red), embedded in the leaves along with chlorophyll. We found significant differences in the mean values of vegetative characters among and within the accessions at $p<0.05$. Jaric *et al*., (2010) observed the same result of morphometric analysis on *Ocimum basilicum* on different types of soil at ($p<0.05$).

The statistical analysis further corroborated the qualitative and quantitative vegetative morphological relationships observed between the studied species. The positive correlations observed between the characters within each of the three groups imply these traits are closely interconnected or dependent on one another. The positive correlation between leaf length and width with internode length, petiole length, and number of leaves indicates that as leaf length and width increase, so do internode length, petiole length, and number of leaves. This also implies adequate sunlight exposure for the plant parts, allowing for effective photosynthesis. The strong association observed among the vegetative traits of the B-group accessions, which are often found in the wild, could represent an adaptive strategy. Meanwhile, internode and pedicel development are tightly regulated by genetic factors (Harder and Prusinkiewcz, 2013). The strong correlation between plant height and other morphometric characters observed in all the accessions of *Ocimum* studied was also reported by Okunola, *et al.* (2016) among the *Ocimum* species they studied. The C- and G-accessions are often cultivated in homes and gardens for culinary and medicinal purposes. The vegetative morphological attributes expressed by these plants are taxonomic keys in delimiting the species since their leaves are the major part often consumed for vegetables, culinary, medicinal and industrial usage. The commercial production of basil medicinal oils is typically extracted from the leaves. Thus, based on the correlation analysis for the vegetative characters among the B-, C- and G-accessions, the characters that correlated highly significantly at 0.01 probability level ($P<0.01$) are closely interconnected and affected or dependent on another.

The dendrogram separated all the accessions as individuals at 0.0 dissimilarity coefficients meaning that all the accessions are individuals and none is duplicated. The overlapping fluctuations in the placement of some particular accessions in the dendrogram corroborated the observed closeness of the morphological attributes like the leaf length and width with internode length, petiole length and number of leaves in the Pearson correlation coefficients.

The inflorescence of B-accessions distinctively differs from all the studied accessions. It is indeterminate resembling the occurrence of single flowers within the plant, a characteristic of primitive angiosperm. This could explain their adaptive feature in the wild. Variations occur in the C-accessions as there are sessile and pedicellate cymes. Chowdhury *et al.* (2017) observed variation in the inflorescence type of *Ocimum species* evaluated. Several authors have emphasized the usefulness of inflorescence in characterizing plant species (Celep and Dogan, 2010; Inyama, *et al.,* 2015).

Considerable variations observed in the calyx could imply a strategy for seed dispersal and consequently survival and continuity of generations among the species. Intraspecific variations observed in the corolla color of C-accessions include cream, white, violet white and violet. This may account for the difficulty observed in distinguishing the members of the group based on morphological characters.

Meanwhile, B- and G-accessions are violet and cream colors, respectively. The arrangement of the petals within the lips is distinctively different in B-accessions with 3/2 petals arrangement i.e. three to two petals at the posterior and anterior lips respectively. The other groups have a 4/1 arrangement of petals at the posterior and anterior lips respectively.

The color of pollen is another trait that may be used in delimiting the studied accessions. The B-accessions are characterized by dark brown color while yellow pollen color is distinctively found in G-accessions. Variation occurs in C-accessions as brown, cream and white colors. The color of pollen, therefore, may serve as an additional morphological trait to understand the diversity among *Ocimum species* and varieties (Chowdhurry *et al.,* 2017).

The Pearson correlation coefficients for the B-accessions revealed positive associations between the floral characters, indicating that calyx and corolla dimensions increased proportionally (as calyx length and width increased, so did corolla length and width). The significant correlations between style and filament lengths suggest these structures play efficient roles in pollination and fertilization. Additionally, the positive associations among the reproductive traits indicate close interconnections or dependencies, with each trait affecting the others. The G-accessions showed significant correlations between number of flowers per inflorescence and calyx/corolla dimensions, style length, and inflorescence length. This supports the aggregation of small flowers into inflorescences, as increased calyx and corolla size invariably affected flower number per inflorescence, subsequently impacting overall inflorescence length. Moreover, these associations are tightly regulated by genetic factors. According to Sergant *et al.* (2007), flower size per inflorescence often varies negatively among angiosperms though the relation is less clear for some intrageneric comparisons.

The dendrogram separated all accessions as individuals at a 0.0 dissimilarity coefficient, indicating each accession possesses potentially unique, genotype-specific traits. The division into two groups at 0.5 dissimilarity coefficients based on quantitative reproductive traits corroborated the distinctive floral characteristics observed in B-accessions (e.g. erect flower position, fused campanulate calyx, violet corolla). This divergence substantiates the dissimilarity of B-accessions from the C- and G-accession taxa. Distinct features expressed in the qualitative fruit (nutlet) characters of B-accessions are rhomboid nutlet shape and brown nutlet colour. The C-accessions have ellipsoids nutlet shape and black nutlet colour while the G- accessions have spherical nutlet shape, rugose texture, dark brown nutlet colour and mild scent. Patel *et al*. (2015) observed subglobose nutlet shape and colour brown in *Ocimum gratissimum*, ellipsoid nutlet shape and black colour in *O. basilicum, O. xcitriodorum* and *O. americanum*, broadly ellipsoid nutlet shape and yellow with small black markings in *O. tenuiflorum*. The fruit (nutlets) is another useful trait in delimiting the studied taxa as the shapes of nutlets of the accessions from each of the groups differ conspicuously. Akinyemi and Ayodele (2015) used pod (fruit) and seed characters to delimit *Senna species*.

Despite pronounced variability in vegetative and reproductive morphology among the forty-five studied accessions, some similarities and overlap were evident. These commonalities support the classification of the accessions within the Lamiaceae family. Noticeably, common generic features as seen in their quadrangular (square) stem shape, decussate leaf arrangement, reticulate leaf venation, pubescence inflorescence stem, gamosepalous bilabiate calyx, persistent calyx, hairy annulus in calyx throat, toothed calyx margin, corolla tube dilating towards the mouth, gamosepalous bilabiate corolla, white filament color and bifid lobe style are diagnostic features of the members of the Lamiaceae. The petiolate leaves are arranged in a decussate manner where the arrangement of a pair of opposite leaves intersects the next at the right angle to those above or below or to form a cross and so on. Brites and Valladares (2015) discovered a greater leaf overlapping in opposite leaves than spirally arranged leaves along a shoot. Consequently, it decreases light interception efficiency (fraction of the light reaching the plant intercepted by the leaves). The corolla fell off in all the accessions and four round nuts developed in the persistent calyx. The bilabiate (two-lipped) corolla is a zygomorphic, sympetalous corolla with a limb divided into two lips. The function of the lower (anterior) lip in the bilabiate corolla is to assist in the safe landing of bees, pollinators that assist in the effective cross-pollination before fertilization and eventually the production of new generation for continuity. The bilabiate corolla is a special adaptation for insect visitors for cross-pollination. The overlapping features are growth habit, pubescent stem, branching habit, leaf shape, cyme flower number, calyx curve and calyx colour. The erect shrub was found in the accessions of the G-group while others are herbaceous. All the accessions are glabrous except the B-accessions that are pubescent. The leaf shape varies from elliptic-lanceolate in C and G-accessions to ovate in B-accessions. The leaf margin is serrated in C and G-accessions but serrulated in B-accessions.

CONCLUSION

The B-accessions were distinctly different from the other studied accessions, which were misidentified as O. bIasilicum belonging to *Ocimum* rather than *Hyptis suaveolens*. This study revealed five distinct *Ocimum* morphotypes. Additionally, several *Ocimum* morphotypes were observed across the southwest Nigerian states, with notable morphological variations among the *Ocimum* accessions. These characteristics could be utilized by plant breeders and taxonomists for sustainable exploitation of *Ocimum* germplasm resources.

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