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Morphological Description and Culm Anatomy in the Identification of *Kyllinga* Rottb. (Cyperaceae) from Some Parts of Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Comparative culm anatomical and morphological descriptions of 12 taxa of *Kyllinga* collected from different parts of Nigeria were carried out to enhance the identification of the taxa. The number of flower-head vary from 1 – 6 while the sizes vary from the flower-head in *K. erecta, K. erecta* var. *erecta, K. erecta* var. *polyphylla* and *K. peruviana* is one, *K. odorata, K. nemoralis,* and *K. pumila* 1-4, *K. erecta var. africana* 4, *K. tenuifolia* 3-4 and *K. brevifolia* 1-3. *K. erecta* var. *erecta* has 2-3 bracts, *K. erecta* 3-4, *K. erecta* var. *polyphylla* 5-6, *K. odorata* 3-6, *K. nemoralis* 4-6, *K. pumila* 1-5, *K. bulbosa* 5 and *K. peruviana* 3. The leaf sheaths are partly wrapped to the culm in *K. nemoralis, K. odorata,* and *K. pumila;* completely wrapped with overlap in *K. erecta* var. *erecta* and *K. peruviana* and completely wrapped without overlap in other species. *K. pumila, K. tenuifolia,* and *K. erecta var. africana* rhizomes are partly erect. *K. nemoralis* trails on the soil surface while the remaining trail beneath the ground. The culm anatomy in transverse view is triangular (*K. erecta, K. erecta* var. *erecta, K. erecta* var. *polyphylla* and *K. bulbosa*), triangular-hexagonal (*K. nemoralis, K. erecta var. africana*, *K. odorata* and *K. tenuifolia*), triangular-polygonal (*K. brevifolia*) or oval-circular (*K. pumila* and *K. peruviana*) with aggregation of vascular bundles on the peripheral and inner portions of the culm. *K. erecta* has 2-layers of vascular bundles, *K. peruviana* 4-layers of vascular bundles while others have 3-layers of vascular bundles. The number of flower-head, sizes, bract number, and culm anatomy were observed to be diagnostic among these species.

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Keywords: Cyperaceae; Kyllinga; Culm anatomy; flower-head; rhizome; leaf sheath.

1. INTRODUCTION

Among the monocotyledonous families, Cyperaceae is one of the largest family and of cosmopolitan distribution comprising over 5000 species in 120 genera [1]. Majority of the species grow in the wetland. Cyperaceae family comprised 24 genera and 303 species in West Africa [2] with 23 genera and 230 species in Nigeria [3]. *Kyllinga* Rottb. belongs to this family and is made of 18 species in West Africa [2] and 16 species in Nigeria [3]. Among the Nigerian *Kyllinga* species, Akobundu and Agyakwa [4] and Akobundu et al. [5] have listed four of these species as weeds of cultivated farmlands.

In Cyperaceae, the use of macro-morphological characters in their identification has been problematic [6], because they may exhibit phenotypic plasticity related to the habitat where the plants grow [7,8]. Also, gross morphological features of most of the species in Nigeria and West Africa have been described [2,3] however the morphological features are not always sufficiently reliable to provide clear boundaries between taxa [9]. This necessitated the use of anatomical features which are less strongly environmentally modified, as reliable taxonomic information in taxa separation [9,10,11]. Despite the works on West Africa species of *Kyllinga,* there are no comprehensive morphological and culm anatomical descriptions of the species from Nigeria. Therefore, this research work is conducted to describe the morphology and stem anatomy of the Nigerian species of *Kyllinga* to enhance the identification of the species.

2. MATERIALS AND METHODS

2.1 Source of Plant Materials

Twelve (12) species of *Kyllinga* species collected from different parts of Nigeria were properly identified in the Department of Plant Science and Biotechnology Herbarium. Representatives of these specimens were cultivated in ridges in the Centre for Ecological Studies University of Port Harcourt for 12 months. Thereafter, these samples were harvested, washed and characterized morphologically. The voucher specimens of these *Kyllinga* species were processed and deposited in the Department of Plant Sciences and Biotechnology Herbarium, University of Port Harcourt, Nigeria (Table 1). Also, the specimens were authenticated at Forest Research Institute of Nigeria (FRIN) Ibadan.

2.2 Morphological Description

Morphological characters of the all the species including the nature of the inflorescence and rhizome were described. The leaf length, width, and diameter of culm; length of internode, nature, and diameter of rhizome; number, length, and breadth of bracts; number, length, and breadth of flower-head were measured and documented using meter rule and digital veinier caliper.

Table 1. List of *Kyllinga* species studied

S/N	Species name	Locality	Collector/date of collection	Accession number
1	*Kyllinga tenuifolia* Steudel.	Choba, Rivers State	Ekeke & Ogazie/14/3/16	316
2	*Kyllinga odorata* Vahl.	Choba, Rivers State	Ekeke & Ogazie/04/8/16	317
3	*Kyllinga erecta* var. *erecta* Schumacher	Warri, Delta State	Ekeke & Ogazie/19/4/16	348
4	*Kyllinga nemoralis* (Forst.) Dandy ex Hutch	Obiga, Abia State	Ekeke & Ogazie/26/8/16	319
5	*K. erecta var. africana* (Kuek.) Hooper	Choba, Rivers State	Ekeke & Ogazie/26/8/16	301
6	*Kyllinga erecta* Schumacher	Choba, Rivers State	Ekeke & Ogazie/19/8/16	321
7	*Kyllinga erecta* var *polyphylla* (Kunth.) Hooper	Warri, Delta State	Ekeke & Ogazie/8/5/16	322
8	*Kyllinga pumila* Michx.	Choba, Rivers State	Ekeke & Ogazie/18/4/16	309
9	*Kyllinga brevifolia* Rottb.	Yenagoa, Bayelsa State	Ekeke & Ogazie/04/8/16	324
10	*Kyllinga bulbosa* P. Beauv.	Choba, Rivers State	Ekeke & Ogazie/19/8/16	310
11	*Kyllinga peruviana* Lam.	Lekki, Lagos State	Ekeke /19/12/16	326
12	*K. squamulata* Thonn. ex Vahl	Gboko, Benue State	Ekeke /17/7/16	402

2.3 Anatomy of the Flowering Stem (Culm)

At harvest, the middle part of the flowering stems (about 2 cm) was cut, fixed in FAA for 2 hours, dehydrated in series of ethanol (30%, 50%, and 70%) for 2 hrs each [12]. After dehydration and clearing the specimens were wax-embedded and sectioned at about 25-50 µm with a microtome. The sections were selected, de-waxed, stained with Alcian blue and safranin O [13], mounted on the glass slide, viewed, described, micro-photographed with a digital camera (T340B-LED-5M) and the anatomy of culm described.

3. RESULTS

3.1 Morphological Characteristics

The results of the morphological and anatomical descriptions of the *Kyllinga* species studied are presented in Figs. 1 – 11 and Tables 2 – 4. The rhizome and root of these species smell (Table 3) while the inflorescences (flower-heads) are mainly greenish to white in colour (Table 4).

3.1.1 *Kyllinga nemoralis*

Has thin rhizomes 1.65 – 2.09 mm thick, very profuse and trails on the soil surface (Table 2 and Fig. 1), shoots partly parked, bored in the internodes 9 – 12 mm long, with light purple scales; leaves 18 – 110 mm long, 10 – 35 mm wide, clustered at the base of the culm and leaf sheath partly wrapped to the culm (Tables 2 and 3, Fig. 1). The inflorescence consists of 1 – 4 unequal ovoid flower-heads, 9-10 mm long and 8 mm wide each subtended by a culm 42 – 137 mm long, and 4 – 5 leafy bracts 1 – 12.5 cm long and 0.1 – 3.5 cm wide (Table 4).

3.1.2 *Kyllinga erecta*

A perennial sedge of about 5.6 – 19.5 cm tall, with thin rhizome, 1.31 – 2.21 mm thick, trailing underground and produces numerous inter-twisted roots; internode 5 – 18 mm long; shoots not dense with light purple scales; leaves 25 – 52 mm long, 10 – 25 mm wide. The inflorescence consists of solitary, ovoid heads 4-8 mm long and 8-9 mm wide subtended by a culm 56 – 195 mm long with 3 – 4 unequal leafy bracts 15 – 45 mm long and 10 – 30 mm wide (Tables 2, 4 and Fig. 1).

3.1.3 *Kyllinga erecta var. africana*

Perennial sedge of 6.5 – 29.6 cm high, leaves 30.0 – 206.0 mm long, 2.0 – 4.0 mm wide, completely wrapped to the base of the culm and clustered at the base of the culm (Table 2). Rhizome thin, not profuse, or rarely seen, 2.74 – 3.74 mm thick, shoot heavily clustered together, partly erect with light purple scales and internode < 2.0 mm long (Table 3, Fig. 3). The inflorescence is subtended in in culms 65.0 – 29.6 mm long, with 4 – 5 leafy bracts, 15.0 – 122.0 mm long and 1.0 – 4.0 mm wide. Flower-head 4 (1-big and 3-small ones), greenish-white, 0.9 – 1.2 mm long and 10.0 – 13.0 mm wide (Table 4).

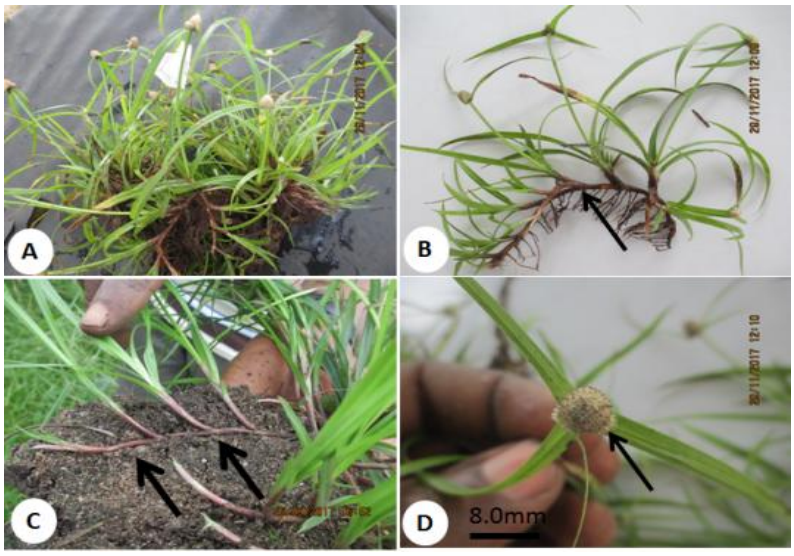

Fig. 1. Morphological features of *K. nemoralis* (A) cluster of plants; (B and C) arrows show trailing rhizome and (D) arrow show inflorescence head

Fig. 2. Morphological features of *K. erecta* (A) cluster of culms, (B) trailing rhizome and (C) inflorescence head

Fig. 3. Morphological features of *K. erecta var. africana* (A) cluster of plants, (B) arrow shows trailing rhizome and (C) inflorescence head

3.1.4 *Kyllinga erecta* var. *erecta*

An erect, perennial glabrous sedge about 6.0 – 41.0 cm tall with thick, pigmented (purple), underground trailing, 4.12 – 4.50 mm, segmented rhizomes that produce thick roots, shoots densely packed and scales with a deep purple (Table 3, Fig. 4). Internode 3.0 – 5.0 mm long, leaves 14.0 – 110.0 mm long, 20.0 – 30.0 mm wide, not clustered at the base of the culm

but leaf sheath completely wrapped to the base of the culm with overlap (Table 2). The inflorescence is supported in culm of about 60.0 – 410.0 mm tall, with solitary flower-head, greenish-white and 5.0 – 8.0 mm long and 5.0 – 6.0 mm wide with 2 – 3 leaf bracts 7.0 -79.0 mm long and 10.0 – 30.0 mm wide (Table 4).

3.1.5 *Kyllinga brevifolia*

An erect perennial sedge of about 24.3 – 38.1 cm tall, rhizome very thin (1.19 – 2.00 mm thick), short and not profuse. Rhizomes partly erect shoots clustered together with purple scales, internode 8.0 – 17.0 mm long (Table 3, Fig. 5). Leaves 21.0 – 116.0 mm long, 20.0 mm wide, not clustered at the base of the culm, leaf sheath completely wrapped to the base of the culm without overlap (Table 2). The inflorescence is supported in culm of about 243.0 - 381.0 mm tall, with 1 - 3 flower-heads, greenish-white and 6.0 mm long and 6.0 mm wide with 3 – 4 leaf bracts 9.0 - 81.0 mm long and 0.5 – 2.0 mm wide (Table 4).

Fig. 4. Morphological features of *K. erecta* var. *erecta* (A) cluster of culms, (B) trailing rhizome and (C) inflorescence head

Table 2. Morphological description of leaf, leaf sheath and average culm diameter

Species name	Leaf sheath nature	LL (cm)	LB (mm)	Nature of leaves	CD (mm)
K. tenuifolia	Completely wrapped	3.0– 11.5	2.0 – 3.5	Clustered at the base	1.14
K. odorata	Partly wrapped	11.9 – 14.2	3.0 – 4.0	Clustered at the base	1.34
K. erecta var. *erecta*	Completely wrapped with an overlap	1.4 – 11.0	2.0 – 3.0	Not clustered	1.20
K. nemoralis	Partly wrapped	1.8 – 11.0	2.0 – 3.5	Clustered at the base	1.18
K. erecta var. africana	Completely wrapped	3.0 - 20.6	2.0 – 4.0	Clustered at the base	1.22
K. erecta	Completely wrapped	2.5 – 5.2	1.0 – 2.5	Not clustered	1.03
K. erecta var *polyphylla*	Completely wrapped	2.4 – 11.6	4.0 – 4.5	Not clustered	1.74
K. pumila	Completely wrapped	6.7 – 23.7	2.0 – 3.0	Not clustered	1.28
K. brevifolia	Completely wrapped	2.1 – 11.6	2.0	Not clustered	1.01
K. bulbosa	Partly wrapped	16.1 – 19.1	3.0 – 4.0	Clustered at the base	1.15
K. peruviana	Completely wrapped with an overlap	3.8 – 18.4	4.0 – 5.0	Not clustered	3.53
K. squamulata	Completely wrapped without overlap	8.2 – 13.3	3.0 – 5.0	Clustered at the base	1.68

Note: LL- Leaf length, LB - Leaf breadth; CD – culm diameter

Fig. 5. Morphological features of *K. brevifolia* (A) cluster of plants, (B) rhizome and (C) inflorescence head

3.1.6 *Kyllinga pumila*

An erect, perennial glabrous sedge about 11.5 – 35.0 cm tall. Rhizomes are not profuse or rarely seen but partly erect, 1.80 – 2.35 mm thick, shoots clustered together with purple scales (Table 3, Fig. 7). The internode less than 2.0 mm long, leaves 67.0 – 237.0 mm long, 2.0 – 3.0 mm wide, not clustered at the base of the culm but leaf sheath completely wrapped to the base of the culm (Table 2). The inflorescence is supported in culm of about 11.5 – 35.0 cm long, with 1 – 4 flower-heads, greenish-white, 7.0 – 9.0 mm long and 7.0 – 9.0 mm wide having 1 – 5 leaf bracts 7.0 - 123.0 mm long and 0.5 – 3.0 mm wide (Table 4).

3.1.7 *Kyllinga odorata*

An erect perennial sedge of 1.6 – 32.0 cm tall, underground rhizome rarely seen, 1.43 – 3.16 mm thick, shoots are clustered together and with purple scales (Fig. 6). Leaves 11.9 – 14.2 cm long, 3.0 – 4.0 mm wide, clustered at the base of the culm, leaf sheath completely wrapped at the base of the culm. The inflorescence is subtended in culms 16.0 – 320.0 mm long, with 3 – 6 leafy bracts, 20.0 – 80.0 mm long and 1.5 – 4.0 mm wide. Flower-head 1 - 4, greenish-white or white, 11.0 – 13.0 mm long and 8.0 – 10.0 mm wide (Table 4).

Table 3. Morphological description of root and rhizome

Species name	Root	Internode (mm)	Rhizome/stolon nature/diameter range (mean) (mm)
K. tenuifolia	Strong smell	<2.0	Partly erect, 2.24 – 3.87 (3.04)
K. odorata	Strong smell/ thick/clustered	7.0 – 10.0	Underground trailing, 1.43 – 3.16 (2.37)
K. erecta var. *erecta*	Strong smells/thin	3.0 – 5.0	Underground trailing, 4.12 – 4.50 (4.29)
K. nemoralis	Partly smell/thin	9.0 – 12.0	Surface trailing, 1.65 – 2.09 (1.85)
K. erecta var. africana	Smell/thin	<2.0	Partly erect, 2.74 – 3.74 (3.28)
K. erecta Schumach	Strong smell/thick	5.0 – 18.0	Underground trailing, 1.31 – 2.21 (1.81)
K. erecta var *polyphylla*	Strong smell/thick	2.0 – 4.0	Underground trailing, 7.82-8.88 (8.45)
K. pumila	Strong smell	<2.0	Partly erect, 1.80 – 2.35 (2.16)
K. brevifolia	Strong smell/thin	8.0 – 17.0	Underground partly erect, 1.19 – 2.00 (1.42)
K. bulbosa	Strong smells/thin	5.0 – 7.0	Underground trailing/ trailing on soil surface, 0.48 – 1.32 (0.76)
K. peruviana	Smell/thick	4.0 – 9.0	Underground trailing, 7.88 – 7.94 (7.93)
K. squamulata	Smell	2.0 – 3.5	Not trailing with underground bulbs

Fig. 6. Morphological features of *K. odorata* (A) cluster of plants, (B) rhizome and (C) inflorescence head

Fig. 7. Morphological features of *K. pumila* (A) cluster of plants, (B) rhizome and (C) inflorescence head

3.1.8 *Kyllinga erecta var. polyphylla*

An erect perennial sedge of about 17.0 – 57.9 cm tall. Leaves 24.0 – 116.0 mm long, 4.0 – 4.5 mm wide, not clustered at the base of the culm, leaf sheath completely wrapped to the base of the culm without overlap (Table 2, Fig. 8). Rhizome is thick (7.82 – 8.88 mm thick) with minimal underground trailing, shoots are densely packed with light purple scales, internode 2.0 –

4.0 mm long (Table 3). The inflorescence is supported in culm of about 17.0 – 57.9 cm long, with solitary flower-heads, greenish-white or yellow, 8.0 – 10.0 mm long, 6.0 – 10.0 mm wide with 5 – 6 leafy bracts 22.0 - 148.0 mm long and 1.0 – 4.0 mm wide (Table 4).

3.1.9 *Kyllinga tenuifolia*

Perennial sedge of about 27.2 – 38.2 cm tall. Leaves 30.0 – 350.0 mm long, 2.0 – 3.5 mm wide, clustered at the base of the culm, leaf sheath completely wrapped to the base of the culm (Table 2 and Fig. 9). Rhizome not profuse (2.14 – 3.87 mm thick), not trailing, partly erect, shoots very densely packed together at the base with deep purple scales and internode less than 2.0 mm long (Table 3 and Fig. 9). The inflorescence is subtended in culms 272.0 – 382.0 mm long, with 3 – 4 unequal leafy bracts, 17.0 – 99.0 mm long and 1.5 – 3.0 mm wide. Flower-head conical, 3 – 4 unequal flower-heads, conical in shape, greenish-white, 8.0 – 11.0 mm long and 9.0 – 12.0 mm wide (Table 4 and Fig. 9C).

3.1.10 *Kyllinga bulbosa*

An erect perennial sedge, about 14 2 -16.3 cm tall. Leaves 16.1 – 19.1 cm long, 2.0 – 4.1 mm wide, clustered at the base of the culm (Fig. 10), leaf sheath partly wrapped to the base of the culm (Table 2). Stolon about 6 -10 cm long and base of culm swollen (Fig. 10C). Underground trailing rhizome not pronounced, 0.48 – 1.32 mm thick, and internode 5.0 – 7.0 mm long (Table 3). The inflorescence is supported in culm of about 142.0 – 163.0 mm long, solitary flower-head but partly with small ones, greenish-white or white (Fig. 10). Flower-head 9.0 – 11.0 mm long and 11.0 – 12.0 mm wide with 5 unequal leaf bracts 2.5 – 9.0 mm long and 2.0 – 4.0 mm wide (Table 4 and Fig. 10B).

3.1.11 *Kyllinga peruvina*

An erect perennial sedge of about 28.6 – 117.2 cm tall and shoots not clustered. Leaves 3.8 – 18.4 cm long, 4.0 – 5.0 mm wide, leaf sheath completely wrapped with overlap (Table 2, Fig. 11). Underground rhizome (7.88 – 9.94 mm thick), shoots not densely packed with light purple scales and internode 4.0 – 9.0 mm long (Table 3). The inflorescence is subtended in culm of about 28.6 – 98.2 cm long, with solitary flower-heads (Figure 11B), greenish-white, 8.4 – 10.8 mm long, 8.8 – 12.9 mm wide with 3-leafy bracts 30.0 – 50.0 mm long and 5.0 – 26.0 mm wide (Table 4).

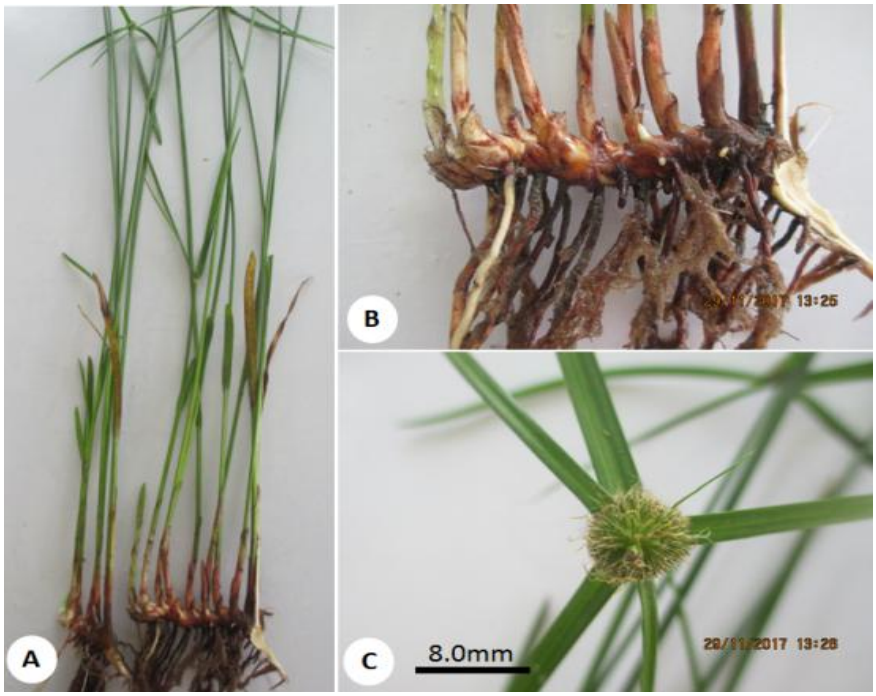

Fig. 8. Morphological features of *K. erecta* var *polyphylla* (A) cluster of culms, (B) trailing rhizome and (C) inflorescence head

3.1.12 *Kyllinga squamulata*

An erect perennial sedge of about 201.0 – 245.0 mm tall, leaves 82.0 – 133.0 mm long, 3.0 – 5.0 mm wide, leaf sheath completely wrapped without overlap (Table 2, Fig. 11). Underground rhizome (3.4 – 5.0 mm thick) with, shoots not densely packed with light purple scales, internode 2.0 – 3.5 mm long (Table 3). The inflorescence is subtended in culm of about 201.0 – 245.0 mm long, with 3-5 flower-heads (Fig.s 12C and 12D), greenish-white, 10.0 – 15.0 mm long, 8.0 – 15.0 mm wide with 5-leafy bracts 29.0 – 115.0 mm long and 2.0 – 4.5 mm wide (Table 4).

Fig. 9. Morphological features of *K. tenuifolia* (A) cluster of plants, (B) rhizome and (C) inflorescence head

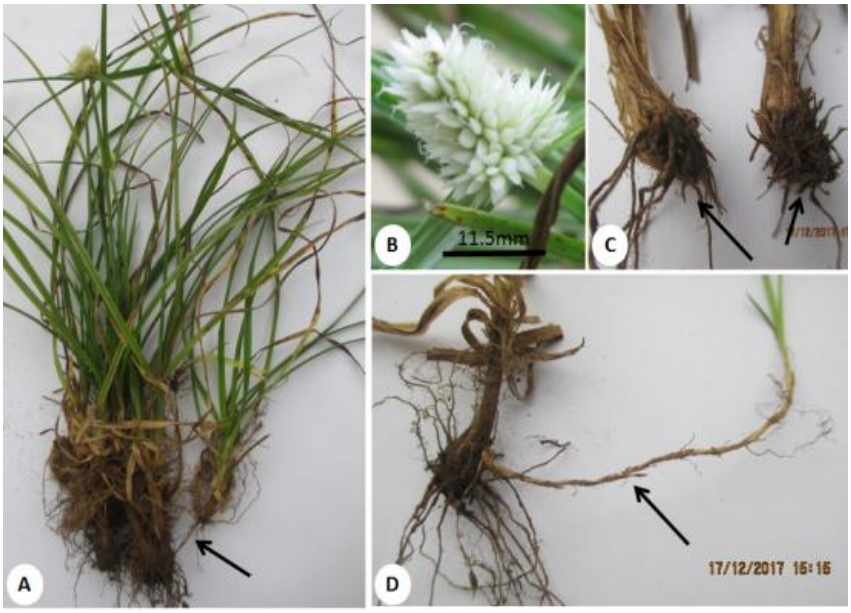

Fig. 10. Morphological features of *K. bulbosa* (A) cluster of plants, (B) inflorescence head (C) underground bulbs and (D) arrow shows trailing rhizome

Table 4. Morphological description of the inflorescence

Species name	FHL (mm)	FHB (mm)	BL (cm)	BB (mm)	NHPI	BN	CFH
K. tenuifolia	8 – 11	9 – 12	1.7 – 9.9	1.0 – 3.0	3 – 4	3 – 4	Greenish-white
K. odorata	11 – 13	8 – 10	2.0 – 8.0	1.5 – 4.0	1 – 4	3 – 6	Greenish-white or white
K. erecta var. *erecta*	5 - 8	5 – 6	0.7 – 7.9	1.0 – 3.0	1	2 – 3	Greenish-white
K. nemoralis	9 – 10	8	1.0 – 12.5	0.1 – 3.5	1 – 4	4 – 5	Greenish-white
K. erecta var. africana	0.9 – 1.2	10 – 13	1.5 – 12.2	1.0 – 4.0	4	4 – 5	Greenish-white
K. erecta Schumach	6 – 7	6 – 7	1.5 – 4.5	1.0 – 3.0	1	3 – 4	Greenish-white
K. erecta var *polyphylla*	8 – 10	6 – 10	2.2 – 14.8	1.0 – 4.0	1	5 – 6	Greenish-white or yellow
K. pumila	7 – 9	7 – 9	0.7 – 12.3	0.5 – 3.0	1 – 4	1 – 5	Greenish-white
K. brevifolia	6	6	0.9 – 8.1	0.5 – 2.0	1 – 3	3 – 4	Greenish-white
K. bulbosa	9 – 11	12 – 11	2.5 – 9.0	2.0 – 4.0	Mainly one but partly with small ones	5	Greenish-white or white
K. peruviana	8.4 – 10.8	8.8 – 12.9	0.5 – 2.6	3.0 – 5.0	1	3	Greenish-white
K. squamulata	10.0 – 15.0	8.0 – 15.0	2.9 – 10.0	2.0 – 4.5	3 – 5	5	Greenish-white

Note: FHL = Flower-head length, FHB = Flower-head breadth, BL = Bracts length, BB = Bract breadth, BN = Bract number, NHPI = No of head per inflorescence, CFH = Colour of flower-head

Fig. 11. Morphological features of *K. peruvina* (A) cluster of culms, (B) inflorescence heads and (C) trailing rhizome

Fig. 12. Morphological features of *K. squamulata* (A) clustered leaves (B) arrow shows bulb heads and (C and D) inflorescence

3.2 Culm Anatomy

The culm of the *Kyllinga* species studied are mainly triangular (Figs. 14C, 14G, 14O and 14S), triangular-hexagonal (Figs. 14A, 14E, 14K, and 14Q), triangular-polygonal (14I) or oval-circular (Figs. 14M, 14U and 14W). They have patches of sclerenchymatous cells and aggregation of vascular bundles on the peripheral and inner portions of the culm. The outermost series of the bundles consist of small and medium vascular bundles with the small ones in contact with the layers of the cells lying just beneath the epidermis while the larger ones are located towards the pith in the ground tissues and vary in number from species to species. The larger vascular bundles have two small and one large cavity (Fig. 13). Most of the species have 2-4 layers of vascular bundles (Fig. 14). *K. erecta* has 2-layers of vascular bundles (Figs. 14C and 14D), *K. peruviana* 4-layers of vascular bundles (Figs. 14U and 14V) while others have 3-layers of vascular bundles.

4. DISCUSSION

Among the *Kyllinga* species studied some distinctive morphological and anatomical features were observed. Some of which include the nature of the leaf sheath, rhizome, size and number of inflorescence head and the shape and number of the vascular bundle in the culm. The roots of all the taxa studied smell but vary in sizes.

Majority of the species studied have their leaves clustered at the base of the culm. The breadth of the leaves are less than or equal to 4.0 mm in most of the species but 4.0 – 5.0 mm in *K. peruviana* and *K. erecta* var. *polyphylla.* This character can split the taxa into two groups and have been reported by Lowe and Stanfield [3] and Hutchinson and Dalziel [14]. Furthermore, the leaf sheaths are partly wrapped to the culm in *K. nemoralis, K. odorata, K. squamulata,* and *K. pumila.* In *K. erecta* var. *erecta* and *K. peruviana* it is completely wrapped to the base of the culm with overlap while in the other members of the species studied it is completely wrapped to the culm but not overlapping. Similar observations have been made by Lowe and Stanfield [3] and Hutchinson and Dalziel [14] among the Nigerian and West African species and Getliffe-Norris [15] in South African species of *Kyllinga.*

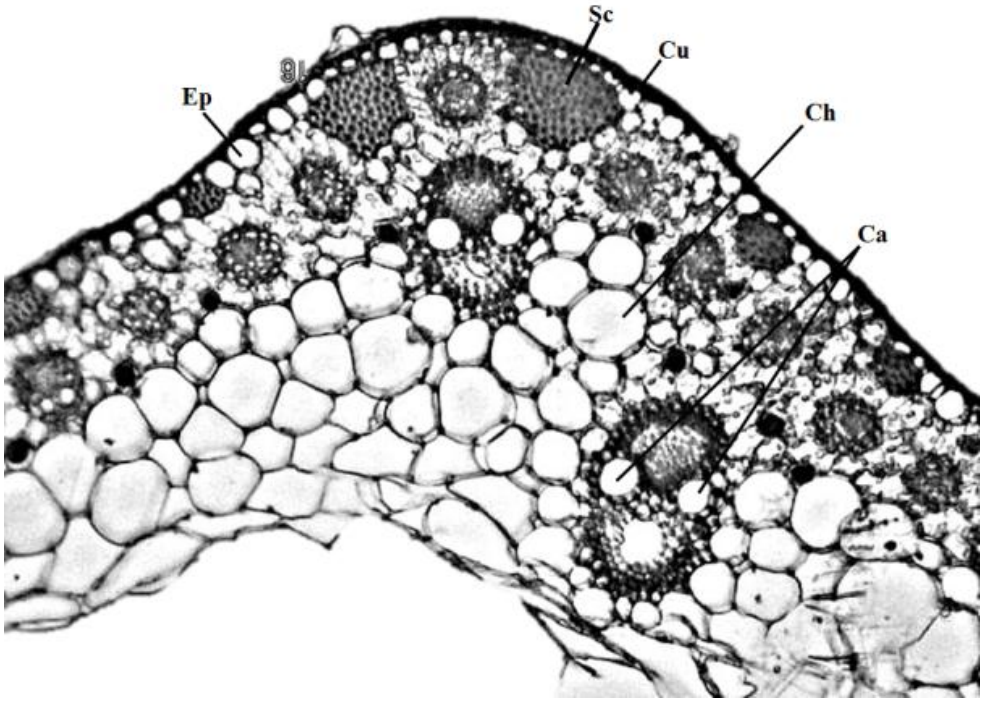

Fig. 13. Anatomical description of the culm (Ep- epidermis; Sc- sclerenchyma; Cu- cuticle; Ch- chlorenchyma; Ca- lysigenous cavity)

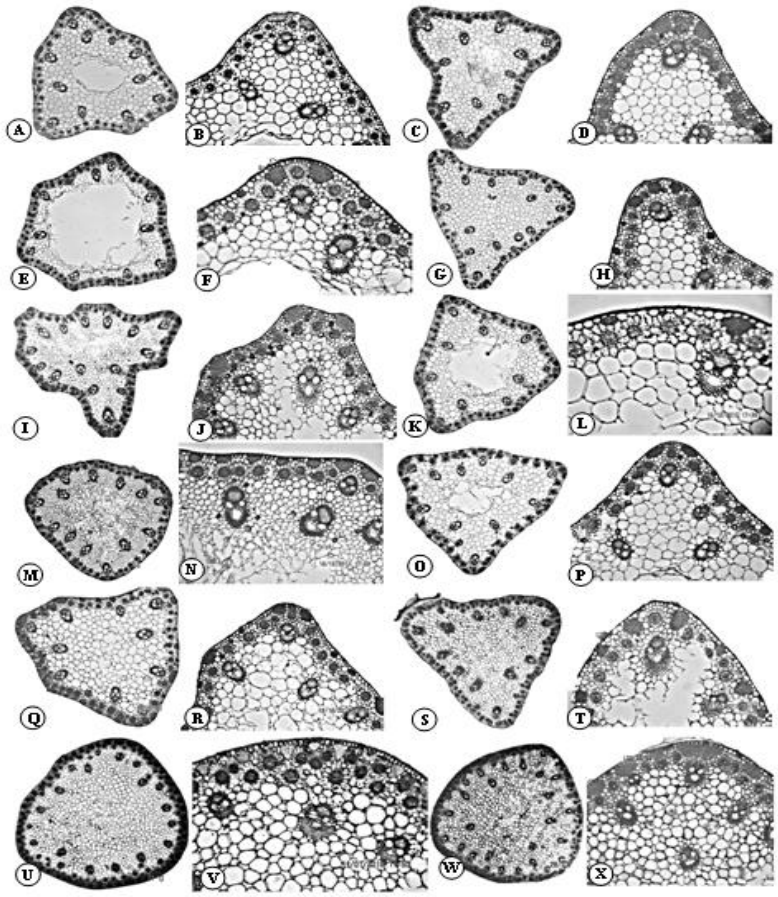

Fig. 14. Transverse section of culms of *Kyllinga* species: (A-B) *K. nemoralis;* (C-D) *K. erecta;* (E-F) *K. erecta var. africana;* (G-H) *K. erecta* var. *erecta;* (I-J) *K. brevifolia;* (K-L) *K. odorata*; (M-N) *K. pumila;* (O-P) *K. erecta* var *polyphylla*; (Q-R) *K. tenuifolia*; (S-T) *K. bulbosa;* (U-V) *K. peruviana* and (W-X) *K. squamulata*

The thickness (diameter) of the rhizome varied from 0.763 – 8.543 mm. *K. bulbosa* and *K. erecta* var. *polyphylla,* had the minimum and maximum rhizome diameters respectively. The rhizome of *K. pumila, K. tenuifolia,* and *K. erecta var. africana* are partly erect, that of *K. nemoralis* trails on the soil surface while in the remaining species studied the rhizomes trail beneath the soil. *K. peruviana* had the maximum average stem diameter of 3.53 mm while the average stem diameters of all other *Kyllinga* species studies were less than 2.0 mm. The length of the internodes in the *Kyllinga* species varied relatively. In *K. tenuifolia, K. pumila* and *K. erecta* var. *africana* the length of the internodes were less than 2.0 mm, in *K. erecta* var. *erecta* and *K. erecta* var. *polyphylla* it is 2.0 – 5.0 mm and 5.0 – 10.0 mm in *K. odorata K. bulbosa* and *K. peruviana* and more than 10.0 mm in *K. nemoralis, K. erecta* and *K. brevifolia.* In similar studies among other species of *Kyllinga* and Cyperaceae*,* the internodes are short in *K. melanosperma* or long in *K. intricata* Nees and *K. colorata* (L.) Druce [15], *Carex* [16], *Cyperus* [17] and other members of Cyperaceae [18,19]. This character confirms the placement of the taxa in Cyperaceae and could be used to distinguish the species.

The number of flower-head, sizes and bract number were observed to be diagnostic among the species. The flower-head in *K. erecta, K. erecta* var. *erecta, K. erecta* var. *polyphylla* and *K. peruviana* are one. In *K. odorata, K. nemoralis* and *K. pumila,* the flower-head 1-4, in *K. erecta var. africana* 4, *K. tenuifolia* 3-4 and *K. brevifolia* 1-3. Though some of these species have the same number of flower-head, the number of bracts varied among them. For instance, among the species with 1-flower-head,

K. erecta var. *erecta* has 2-3 bracts, *K. erecta* 3-4 bracts, *K. erecta* var. *polyphylla* 5-6 bracts and *K. peruviana* 3-bracts. Also, among the ones with 1-4 flower-head, *K. odorata* has 3-6 bracts, *K. nemoralis* 4-6 bracts, and *K. pumila* 1-5 bracts while *K. bulbosa* and *K. peruviana* have 5 and 3-bracts respectively. There are also slight differences in the sizes of flower-head length and breadth, bract length and breadth and colour of the flower-heads.

The shapes or outlines of the transverse sections of the culm of each species is constant but varied in the number of ridges and furrows from one species to another. The shapes are distinctive, diagnostic and could be used to group the species studied into groups namely; rounded, oval or circular culm, triangular culm with many ridges, furrows or edges (triangular, triangular-hexagonal, triangular-polygonal). This feature has been considered as a significant distinctive diagnostic character in *Kyllinga* (Getliffe-Norris, 1983). For instance, the outlines of culms in *K. nemoralis*, *K. erecta var. africana*, *K. odorata,* and *K. tenuifolia* are relatively the same with six protruded ends (triangular-hexagonal) but the number of vascular bundles in the cortex slightly varied among species. *K. nemoralis* has 11-vascular bundles; *K. erecta var. africana* and *K. tenuifolia* have 10 vascular bundles each while *K. odorata* has 9 vascular bundles. In *K. erecta* and *K. brevifolia,* the culm outlines are similar but the ridges in *K. brevifolia* are more pronounced than that of *K. erecta.* Also, the number of the vascular bundles in their ground tissues is 15 and 10 respectively. The culm outline of *K. erecta* var. *erecta*, *K. erecta* var. *polyphylla* and *K. bulbosa* are triangular but the edges in *K. erecta* var. *erecta* and *K. erecta* var. *polyphylla* are mainly acute while that of *K. bulbosa* is curved. The pith of *K. erecta* var. *polyphylla* is hollow compared to *K. erecta* var. *erecta.* Also, the number of vascular bundles in the ground tissue varied i.e. 13 and 11 in *K. erecta* var. *erecta* and *K. erecta* var. *polyphylla* respectively. In the way, culm outline in *K. pumila* and *K. peruviana* is rounded but the number of vascular bundles in the ground tissues is 13 and 20 respectively. A similar observation has been made by previous authors who worked on [15], *Carex* [16], *Cyperus* [17] and other members of Cyperaceae [18,19]. They noted conspicuous first order of bundles towards the inner limits of the assimilatory zone and associated sclerenchyma sheaths which were better developed centripetally.

5. CONCLUSION

The genus showed considerable similarity in its morphological and anatomical features which confirm their placement in the genus, however, we did not look at the effect of environmental factors on the anatomical and morphological features of these species, the specimens collected from the different ecological zone of Nigeria did not show differences in the characters evaluated. But the number of flower-head, size, and nature of rhizome, clustering of the leaves at the base of the culm, shape or outline of the culms, number, and arrangement of the vascular bundles in the culms were unique and diagnostic. These characters also show some level of intraspecific variation among the species studied.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Goetghebeur P. Genera Cyperacearum. Een bijdrage tot de kennis van de morfologie, systematiek en fylogenese van de Cyperaceae-genera. DPhil Thesis, Ghent University, Belgium; 1986.
2. Hutchinson J, Dalziel JM. Flora of West Tropical Africa. Crown Agent for Overseas Government and Administration Nill Bank London S. 1972;1.
3. Akobundu IO, Agyakwa CW. A handbook of West Africa weeds. African Book Builders Ltd., Ibadan, Nigeria; 1988.
4. Akobundu IO, Ekeleme F, Agyakwa CW, Ogazie CA. A handbook of West African weeds 3rd Edn. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria; 2016.
5. Lowe J, Stanfield DP. The flora of Nigeria sedges (Family Cyperaceae). Edited by Lowe, J. Ibadan University Press, University of Ibadan, Ibadan, Nigeria; 1974.
6. Naczi RFC. Insights on using morphologic data for phylogenetic analysis in sedges (Cyperaceae). Botanical Review. 2009;75: 67–95.
7. Szczepanik-Janyszek M, Klimko M. Application of anatomical methods in the taxonomy of sedges (Carex L.) from the section Muehlenbergianae (L. H. Bailey) Kuk. occurring in Poland. Roczniki

Akademii Rolniczejw Poznaniu–CCCXVI. 1999;2:97–107.
8. Stenstrom A, Jonsdottir IS, Augner M. Genetic and environmental effects on morphology in clonal sedges in the Eurasian Arctic. American Journal of Botany. 2002;89:1410–1421.
9. Metcalfe CR, Chalk L. Anatomy of the dicotyledons. Oxford University Press, Oxford; 1972;2.
10. Toivonen H, Timonen T. Perigynium and achene epidermis in some species of *Carex*, subg. *Vignea* (Cyperaceae), studied by scanning electron microscopy. Annales Botanici Fennici. 1976;13:49–59.
11. Menapace FJ, Wujek DE, Reznicek AA. The systematic significance of achene micromorphology in *Carex retrorsa* (Cyperaceae). Brittonia. 1986;39:278–283.
12. Johansen DA. Plant microtechnique. McGraw-Hill, New York; 1940.
13. Bukatsch F. Bemerkungen zur Doppelfärbung Astrablao-Safranin. Microkosmos. 1972;61:255.
14. Hutchinson J, Dalziel JM. Flora of West Tropical Africa. 2nd Edn., Crown Agents for Overseas Government, London; 1954.
15. Getliffe-Norris FM. Anatomy of the genus *Kyllinga* in South Africa. Bothalia. 1983;14(3&4):809-817.
16. Yasser AE, Ahmed MAE. Anatomical investigation of three emergent *Cyperus* species growing naturally on the canal banks of the Nile Delta. Egypt Journal of Scientific Agriculture. 2017;1:294-299.
17. Clare B, Colin S, Nigel B, David S, Paul AA. Consistent and variable leaf anatomical characters in *Carex* (Cyperaceae). Botanical Journal of the Linnean Society. 2013;172:371–384.
18. Shirley M, Marccus A. Anatomical features of species of Cyperaceae from Northeastern Brazil. Brittonia. 2009;61(2): 189–200.
19. Rodrigues AC, Estelita MEM. Morphoanatomy of the stem in Cyperaceae. Acta Bot. Bras. 2009;23(3): 889-901.

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