

## Survey of Foliar Trichomes in *Combretum* Loelf. (Combretaceae) in Parts of West Africa

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### Abstract

We studied the foliar trichome types, density and distribution among the genus *Combretum* Loelf. in parts of West Africa. Fresh and herbarium specimens were used. These specimens were fixed, peeled, trichome types identified and micro-photographed using a Leica WILD MPS 52 microscope camera on a Leitz Diaplan microscope. Generally, two major trichome groups were identified among these species studied. These include glandular trichomes: multicellular gland head with uniseriate stalk (MGU), cylindrical uniseriate clavate trichome (CUCT), unicellular gland with uniseriate stalk (UGHU), cylindrical uniseriate trichome (CUT), peltate gland head (PGH) and combretaceous eglandular (non-glandular) conical trichome (long and short types). The eglandular trichome types were the most widely distributed trichome found in the species and could be used to distinguish the genus. They occurred in all the species studied except *C. glutinosum* and *C. micranthum*. Among the glandular trichomes, cylindrical uniseriate trichome was the most dominant occurring in 11 species namely; *C. aculeatum*, *C. bracteatum*, *C. collinum* subsp. *binderianum*, *C. collinum* subsp. *hypopilinum*, *C. constrictum*, *C. capitatum*, *C. hispidum*, *C. nigricans*, *C. panuculatum*, *C. platypterum* and *C. zenkeri*. This is followed by multicellular gland head with uniseriate stalk (MGU) trichome type which occurred in 9 species (*C. bracteatum*, *C. collinum* subsp. *binderianum*, *C. collinum* subsp. *hypopilinum*, *C. constrictum*, *C. excelsum*, *C. hispidum*, *C. mooreanum*, *C. platypterum* and *C. racemosum*). The trichome density varied from  $1.25 \pm 0.44$  trichomes per 100 cells to 600 trichomes per 100 cells. The distribution/occurrence, density and type of these trichomes formed dependable character for delimitating *Combretum* species. The findings of this study showed that trichomes provide good taxonomic characters useful for in differentiating the genus *Combretum* in West Africa.

**Keywords:** *Combretum*, eglandular trichome, foliar trichome, Glandular trichome and trichome density

### 1. Introduction

Leaves can be classified in various ways, for example their shape and size, their texture and colour and the degree of hairiness to name but a few. These variable features are frequently reflected in different internal tissue arrangement. Some modifications are typical of plants that can grow under particular conditions, but other features may owe more to the genome than to the habitat (Airy Shaw 1985). The foliar epidermis is one of the most taxonomic characters from the biosystematics point of view. Taxonomic studies have been made on number of plant families base on their leaf epidermal characteristics (Bhatia 1984; Baranova 1972). Although taxonomists lately realized the importance of microscopic features of the epidermis, taxonomic monographs are now considered incomplete without them (Rejdali 1991).

The comparative systematic investigations of angiosperms base on the variations in trichome types have long been reported (Cowan 1950; Metcalfe & Chalk 1950; Elena *et al.* 2003; Shaheen *et al.* 2009; Chadaporn and Pranom 2010; Ilkay *et al.* 2014). The morphology, types, shapes and sizes (Lawrence 1951; Stace 1980) are of taxonomic value. The use of uniseriate glandular trichomes and calcium oxalate crystals in distinguishing between the genera *Diathus* and *Silene* have been reported (Metcalfe & Chalk 1950). Presently, (Jafari, *et al.*, 2002; Altaf, *et al.*, 2003; Agbagwa & Okoli, 2006; Saheed & Iloh, 2010 and Kiran, *et al.*, 2011; Frehat, *et al.*, 2011; Ahmed, *et al.*, 2011; Abduhaman, *et al.*, 2011) have stated the use trichomes, their morphology (shape, size, etc) and anatomy (number of glandular head, eglandular, serriated or non serriated, etc) in plant systematics. The length, size and density of trichomes have been described among the American *Combretum* and concluded

that the presence of particular type of trichome could be used to distinguish the genus (Stace 1969, 1980). However, West African species of *Combretum* have been basically classified based on their morphological attributes (Hutchinson & Dalziel 1954). Therefore, this work is aimed at surveying the types and distribution on trichomes among the *Combretum* as complementary data to delimiting the genus.

## 2. Materials and Methods

### 2.1 Source of Plant Materials

Leaves of herbarium and fresh specimens of *Combretum* species used for this study were collected from Forestry Research Institute of Nigeria Herbarium (FRIN) and University of Port Harcourt Herbarium. The list and herbarium numbers of the *Combretum* species studied is presented in Table 1.

### 2.2 Epidermal Studies

These leaf specimens were soaked in concentrated nitric acid or trioxonitrate (v) acid ( $\text{HNO}_3$ ), rinsed in distilled water, peeled with forceps, stained in 1 % aqueous safranin solution and mounted in glycerin. Thereafter, the leaf epidermal characteristics were determined based on the methods of (Dilcher 1974; Cutler 1978; Metchalfe & Chalk 1979 and Okoli & Ndukwu 2002) and the trichome micro-photographed using a Leica WILD MPS 52 microscope camera on a Leitz Diaplan microscope.

The trichome density (abundance) is computed following the methods of Olowokudejo (1990) used in *Annona* species.

• 0 (No)	Trichomes per 100 cells	glabrous
• 1 – 10	„ „ „ „	glabrescent
• 11 – 29	„ „ „ „	sparsely hairy
• 30 – 49	„ „ „ „	densely hairy
• >50	„ „ „ „	very densely hairy

Table 1. Information about the West African Voucher Specimens studied

S/N	Species name	Voucher information	Country
1	<i>C. aculeatum</i> Vent.	Dikwa division; Miss. A. McClintock; FHI 38989; 30/11/1954.	Cameroon
		Yola; Girls Sch., Adamawa; M.G. Latilo; FHI 63521; 24/10/1971.	Nigeria
		Yankari game Reserve; Bauchi; C. Geerling; FHI 41147; 30/10/1970	Nigeria
2	<i>C. acutum</i> Laws	River Oyinmi egde, Kabba, Kogi; Daramola & Adebisiyi; FHI 38412; 24/10/1958.	Nigeria
		Gold Coast, 3miles above Ajena, Bawku; Moton; FHI 48692; 29/11/1953.	Ghana
		North Dagemba district; FHI 45036	Ghana
3	<i>C. bauchiense</i>	Platuea; Dogon; Platuea; Hilary; FHI 56997; 25/02/1966	Nigeria
	Hutch. & Diels.	Bauchi; Bauchi; Holely; FHI 2067; Jan. 1929	Nigeria
4	<i>C. bracteatum</i> (Laws)	Aponum F/R, Akure/Ondo; Odewo et al.; FHI 90845; 7/6/1979.	Nigeria
	Engl. & Diels.	Atim, Calabar, C/R state; H.D. Onyeachusim; FHI 48155; 13/2/1964	Nigeria
		Ndoro/Umudike, Abia; J.C. Okafor & Ariwodo; FHI 57617; 27/01/1966	Nigeria
		Owerri/Aba Rd, Imo State; Latilo; et al. FHI 71624; 17/09/1975	Nigeria
5	<i>C. collinum</i> Fresen. Subsp.	Zalanya, Bauchi; Wit; Gbile & Daramola; FHI 48905; 28/4/1972	Nigeria
	<i>hypopilinum</i> (Diels) Okafor	Nimbria F/R, Kaduna; Opayemi & others; FHI 79526; 30/11/1976	Nigeria
		Bode Sadu, Jebba, Kwara; Eimunjese & Oguntayo; FHI 71461; 13/10/1974	Nigeria
6	<i>C. collinum</i> Fresen. subsp	New Bussa, Gbile; FHI 91497; 1972	Nigeria
	<i>binderanum</i> (Kotschy) Okafor	Ilorin, Oyo State; Oloranfemi & Oguntayo; FHI 88536; 1972	Nigeria
		Borgu G/R, Kwara; Child, D.S; FHI 30261; 1972	Nigeria
		Abuja; Onyeachusim & others; FHI 100679	Nigeria
7	<i>C. mooreanum</i> Exell	Borgu G/R, Kwara; Child, D.S; FHI 30259; 1972	Nigeria
		New Bussa, Gbile & others; FHI 91497; 1975	Nigeria
		Mokwa, Ngier State; FHI 95117	Nigeria
		Awum/Jebba FR; Onyeachusim & others; FHI 101459	Nigeria
8	<i>C. confertum</i> (Laws) Benth	Bendiga Ayuk, Ikom, C/R State; FHI 2817; 8/12/1950	Nigeria
		Akamkpa, C/R State; B.O. Daramola; FHI 56413; 19/10/1965	Nigeria
		Komgina, Cameroun; R.G. Lowe; FHI 18321; Dec. 1978	Cameroon
		Okobodo, Itu, C/R state; J.O. Ariwodo; FHI 88819; 1/11/1978	Nigeria
9	<i>C. constrictum</i> (Benth.) Laws	Edge of Orugi Creek, Kabba; Kogi; A.P.D. Jones; 630; 10/2/1943	Nigeria
		Oguta Lake, Imo State; Ekwuno & others; FHI 96294; 1/9/1981	Nigeria
		Taylor Creek, Bayelsa; FHI 16524; 10/5/1940	Nigeria
		Ibadan, Oyo; Ekwuno; P; FHI 96294	Nigeria
10	<i>C. cuspidatum</i>	Ile Boulay Island, Ivory Coast; G.J.H. Amoshff; FHI 14055; 14/11/1964	Ivory Coast
	Planch. ex Benth.	Abeokuta, Ogun State; C.F.A. Onochie; FHI 32443; 16/12/1952	Nigeria
		Benin, Bank of Abiala Creek, Edo; J.R. Charter; FHI 43263; 30/11/60	Nigeria
		Itu swamp, C/R State; L.G. Cooper; FHI 36729; 15/10/1957	Nigeria
11	<i>C. dolichopetalum</i>	Benin, Edo; Onochie; FHI 39274; Nov. 1956	Nigeria
	Engl. & Diels	Uyo, Etip Ediene, Akwa Ibom; Okafor & Latilo; FHI 57764; 23/1/1966	Nigeria
		Manu F/R, Awka, Enugu; E.T. Akagu; FHI 68056A; 7/3/1974	Nigeria
		Port Harcourt, Rivers; Jones; 6194; 6/1/1974	Nigeria
		Ntalakwu-Itu, Abia; Ariwodo & others; FHI 103536; 6/2/1982	Nigeria
12	<i>C. excelsum</i> Keay	Ogoja-Ikom, C/R State; Keay; FHI 28147; 7/12/1950	Nigeria
13	<i>C. fuscum</i> Planch.	Owena/Ondo, Olorumfemi & Daramola; FHI 71047; 19/7/1974	Nigeria
		Ubukpa/Nsuka, Enugu; Okafor & Emwiogbon; FHI 72267; 24/11/1973	Nigeria
		Oyo/Ibadan, Oyo; Keay & Jones; FHI 14625; 30/1/1946	Nigeria
		Awka/Onitsha, Anambara State; Latilo; FHI 27310; 14/8/1950	Nigeria
14	<i>C. ghasalense</i> Engl. & Diels.	Zaria, Kaduna; Peal; FHI 39645; 7/6/1957	Nigeria
		Damaturu, Yobe; Peal; FHI 23370; 24/6/1947	Nigeria
		Kano/Dangora; Latilo; FHI 27434; 24/4/1950	Nigeria
		Awum/Jebba FR; Onyeachusim & others; FHI 101455	Nigeria

Table 2. Continued: Information about the West African Voucher Specimens studied

S/N	Species name	Voucher information	Country
15	<i>C. glutinosum</i> Perr. Ex DC.	Zamfara, Zamfara State; Keay; FHI 70598; 29/6/1944. New Bussa; Gbile & others; FHI 91590; 1975. Awum/Jebba F/R, Onyeachusim & others; FHI 101398. Bauchi; Lely; FHI 2080.	Nigeria Nigeria Nigeria Nigeria
16	<i>C. hispidum</i> Laws	Ibadan, Oyo; Samuel, <i>et al.</i> ; FHI 32315; 25/1/1972. Ekiti 7 48N, 5 20E; Ekiti; Jones; FHI 77524; 20/1/1975. Ebonyi/Abakaliki, Ebonyi; Okafor & Emwiogbon; FHI 66030; 27/2/1973.	Nigeria Nigeria Nigeria
17	<i>C. insulare</i> Engl. & Diels.	Gambari F/R, Ibadan; Chizea, L.G.; 1975. Ibadan North F/R, Oyo State; Chizea; L.G.; FHI 23971; 23/02/50.	Nigeria Nigeria
18	<i>C. miranthum</i> G. Don	Tregina Rd, Minna; Chizea, L.G.; FHI 100444; 1975. Ibadan, Oyo State; Lowe; J.; FHI100181. Minna, Niger; Onyeachusim & others; FHI 100655. Katsina, Kastina State; MacGregor W.D.; FHI 2085	Nigeria Nigeria Nigeria Nigeria
19	<i>C. molle</i> R. Br. ex G. Don.	Adamawa, Adamawa; Latilo; FHI 28721; 19/11/1954 Zaria, Kaduna; Horum; FHI 55671; 21/12/1964 Gwari, Abuja; Onochie; FHI 35937; 27/5/1956 Yankari game Reserve, Bauchi; C. Geerling; FHI 43609; 2/13/1970	Nigeria Nigeria Nigeria Nigeria
20	<i>C. nigricans</i> var. <i>Elliotii</i> Engl. & Diels	Ilero/Oyo, Oyo; Latilo; FHI 58407; 23/3/1966 Yankari game Reserve, Bauchi; C. Geerling; FHI 38395; 22/10/1970 Pategi/Kwara; Eimujeze & Oguntayo; FHI 72829; 19/10/1974 Lokoja, Kogi State; Gbeli <i>et al.</i> ; FHI 64202; 20/9/1971	Nigeria Nigeria Nigeria Nigeria
21	<i>C. paniculatum</i> Vent.	Omo F/R, Ogun State; H.D. Onyeachusim; FHI 105622; Jan. 1977 Manu F/R, Awka, Anambara State; J.A. Emwiogbon; FHI 64000; 17/3/1972 Betem, Akamkpa, C/R state; J.O. Ariwodo; 28/01/1977	Nigeria Nigeria Nigeria
22	<i>C. platypterum</i> (Welw.) Hutch. & Diels.	Ikom, C/R State; Tunde & Oguntayo; FHI 86153; 1972 Oshun-Ijesa-Ilumoba Rd; Olorunfemi; J.O.; FHI 91915; 1975 Enugu-Nsuka Rd; Onyeachusim & others; FHI 100878 Ikom, C/R State; Latilo; FHI 31852	Nigeria Nigeria Nigeria Nigeria
23	<i>C. racemosum</i> P. Beauv.	Irewole; Tunde & Oguntayo; FHI 85465; 1972 Ajibo, West Nigeria; Odewo & others; FHI 102508 Udi Ngwo, Enugu; Jones; A.P.D; 260 Abeokuta, Ogun; J.D. Kennedy; FHI 2090	Nigeria Nigeria Nigeria Nigeria
24	<i>C. lamprocarpum</i> Diels.	Daddin, Kowa; Gombe; Wit; <i>et al.</i> ; FHI 65054; 3/5/1975.	Nigeria
25	<i>C. zenkeri</i> Engl. & Diels	Ibadan, Oyo; Chizea; L.G.; FHI 99179; 1975 Iwo, Oyo state; Olorunfemi & others; FHI 96534; 1975 Abeokuta, Ogun; A.F. Ross; FHI 2097	Nigeria Nigeria Nigeria

### 3. Results

The trichome types, density and distribution among the 25 *Combretum* species studies are as follows:

#### 3.1 Trichome Types

The types, density and distribution of trichomes found among the genus *Combretum* in parts of West Africa has been carried out. Generally, two major trichomes types (glandular and non-glandular) were identified in the genus *Combretum* studied. The glandular trichomes include: unicellular gland head with uniseriate stalk (UGHU), cylindrical uniseriate clavate trichome (CUCT), cylindrical uniseriate trichome (CUT), multicellular gland head with uniseriate stalk (MGU) and peltate gland head (PGH) while the non-glandular trichome comprised of the combretaceous conical trichome ECT (long and short types) (Figure 1 and Table 2).

##### 3.1.1 Non-glandular or Egladular Trichomes and Distribution

Non-glandular trichomes found in the species studied are presented in Figures 1A - 1C. It is represented by the conical trichome which is made up of the short type (Figure 1A) and long type (Figures 1B and C). The long and short trichomes were found in *C. zenkeri* while the long trichome type was found in *C. aculeatum*, *C. acutum*, *C.*

*bauchiense*, *C. bracteatum*, *C. collinum* Fresen. Subsp. *hypopilinum*, *C. collinum* subsp. *binderianum*, *C. confertum*, *C. constrictum*, *C. cuspidatum*, *C. dolichopetalum*, *C. fuscum*, *C. ghasalense*, *C. hispidum*, *C. insulare*, *C. lamprocarpum*, *C. molle*, *C. mooreanum*, *C. nigricans* var. *elliotii*, *C. paniculatum*, *C. platypterum* and *C. racemosum* (Table 1).

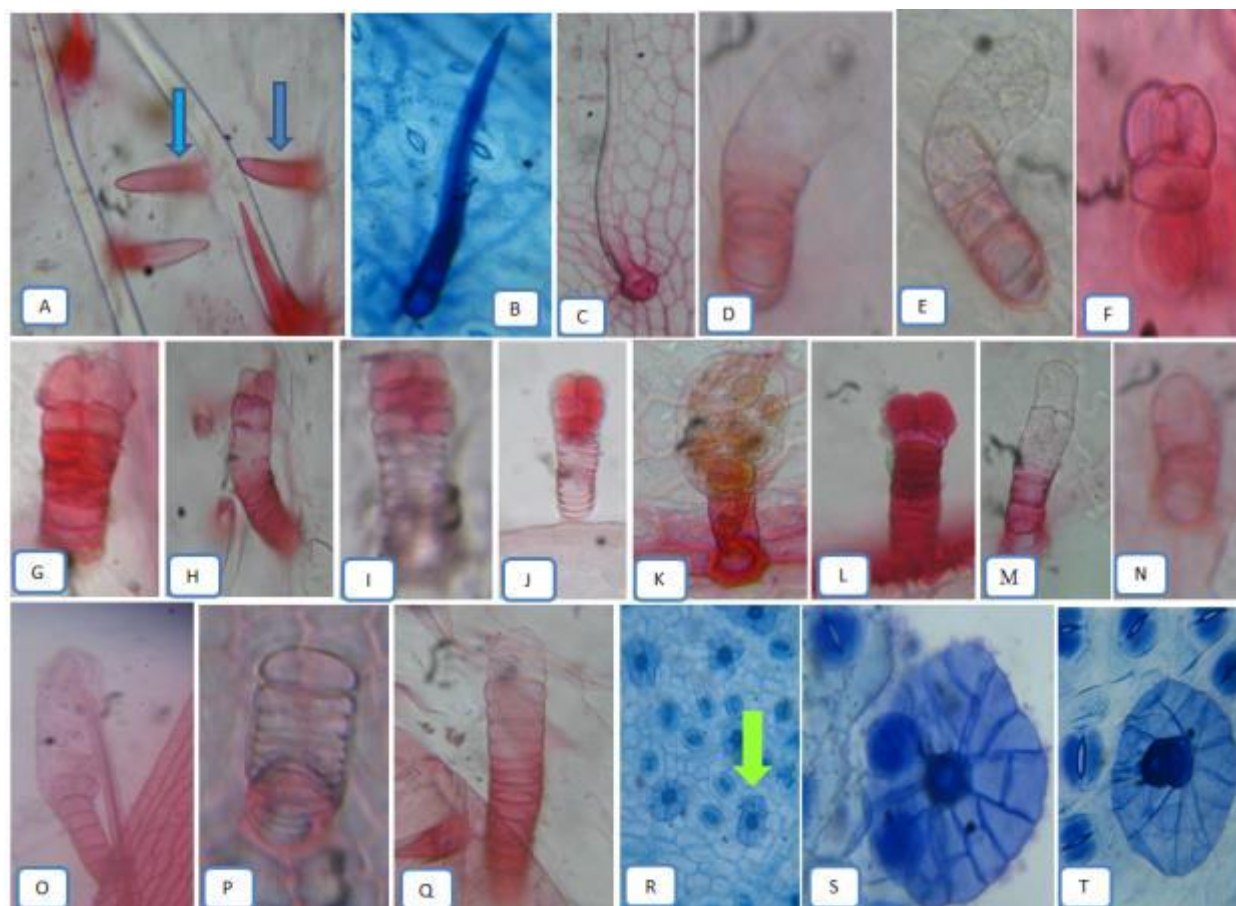


Figure 1. Types of trichomes in the *Combretum* species studied x1320: (A, B & C) Eglandular conical (arrows show short trichome), (D, E, F, H, I, J, K & L) Multicellular gland head/uniseriate stalk, (M & N) Cylindrical uniseriate clavate trichome, (O) Unicellular glandhead/uniseriate, (P & Q) Cylindrical uniseriate trichome and (R, S & T) Peltate trichome

### 3.1.2 Glandular Trichome Types and Distribution

Five glandular trichome types were identified among the *Combretum* species studied. These include multicellular gland head with uniseriate stalk, MGU trichome type (Figures 1D, E-L), cylindrical uniseriate clavate trichome type, CUCT (Figures 1M-N), unicellular gland with uniseriate stalk, UGHU (Figure 1O), cylindrical uniseriate trichome type, CUT (Figures 1P-Q) and Paltate gland head type, PGH (Figures 1R-T). Among the glandular trichomes, multicellular gland head trichome with uniseriate stalk occurred in *C. bracteatum*, *C. collinum* subsp. *binderianum*, *C. collinum* subsp. *hypopilinum*, *C. constrictum*, *C. excelsum*, *C. hispidum*, *C. mooreanum*, *C. platypterum* and *C. racemosum* (Table 2). The unicellular gland trichome with uniseriate stalk, paltate gland head trichome and cylindrical uniseriate trichome types occurred in 7 species each. Trichome with unicellular gland head and uniseriate stalk occurred in *C. collinum* Fresen. subsp. *hypopilinum*, *C. collinum* subsp. *binderianum*, *C. cuspidatum*, *C. hispidum*, *C. paniculatum*, *C. platypterum* and *C. zenkeri*. Paltate gland head trichome type occurred in *C. acutum*, *C. bauchiense*, *C. fuscum*, *C. ghasalense*, *C. glutinosum*, *C. micranthum* and *C. molle* while the cylindrical uniseriate trichome type occurred in *C. aculeatum*, *C. bracteatum*, *C. collinum* Fresen. subsp. *hypopilinum*, *C. collinum* subsp. *binderianum*, *C. constrictum*, *C. hispidum* and *C. nigricans* var. *elliotii*. Unicellular gland head trichome with uniseriate stalk was found in *C. aculeatum*, *C. acutum*, *C. confertum*, *C. constrictum*, *C. dolichopetalum*, *C. insulare*, *C. lamprocarpum* and *C. nigricans* var. *elliotii* (Table 1 and Figure 1).

Table 2. Trichome types, density and their distribution among the *Combretum* species studied

Species name	Glandular Trichome					ECT <sup>6</sup>	Range	Mean $\pm$ STD	Remark
	CUT <sup>1</sup>	CUCT <sup>2</sup>	UGHU <sup>3</sup>	MGU <sup>4</sup>	PGH <sup>5</sup>				
<i>C. aculeatum</i>	+	-	+	-	-	+	40 – 90	60.95 $\pm$ 14.35 <sup>k</sup>	Very densely hairy
<i>C. acutum</i>	-	-	+	-	+	+	11 – 28	19.85 $\pm$ 4.52 <sup>f</sup>	Sparsely hairy
<i>C. bauchiense</i>	-	-	-	-	+	+	168 – 104	138.9 $\pm$ 15.97 <sup>q</sup>	Very densely hairy
<i>C. bracteatum</i>	+	-	-	+	-	+	1 – 3	1.50 $\pm$ 0.61 <sup>a</sup>	Glabrescent
<i>C. collinum</i> Fresen. subsp. <i>hypopilinum</i>	+	+	-	+	-	+	550 – 600	575.60 $\pm$ 18.07 <sup>s</sup>	Very densely hairy
<i>C. collinum</i> subsp. <i>binderianum</i>	+	+	-	+	-	+	4 – 10	7.10 $\pm$ 2.02 <sup>d</sup>	Glabrescent
<i>C. confertum</i>	-	-	+	-	-	+	30 – 106	58.05 $\pm$ 21.26 <sup>j</sup>	Very densely hairy
<i>C. constrictum</i>	+	-	+	+	-	+	1 – 8	5.35 $\pm$ 2.03 <sup>c</sup>	Glabrescent
<i>C. cuspidatum</i>	-	+	-	-	-	+	1 – 3	1.75 $\pm$ 0.72 <sup>a</sup>	Glabrescent
<i>C. dolichopetalum</i>	-	-	+	-	-	+	1 – 3	1.50 $\pm$ 0.61 <sup>a</sup>	Glabrescent
<i>C. excelsum</i>	-	-	-	+	-	+	70 – 110	85.20 $\pm$ 14.02 <sup>l</sup>	Very densely hairy
<i>C. fuscum</i>	-	-	-	-	+	+	80 – 150	115.2 $\pm$ 20.60 <sup>o</sup>	Very densely hairy
<i>C. ghasalense</i>	-	-	-	-	+	+	104 – 190	136.95 $\pm$ 21.44 <sup>p</sup>	Very densely hairy
<i>C. glutinosum</i>	-	-	-	-	+	-	70 – 156	107.35 $\pm$ 24.03 <sup>n</sup>	Very densely hairy
<i>C. hispidum</i>	+	+	-	+	-	+	26 – 90	54.60 $\pm$ 20.01 <sup>i</sup>	Very densely hairy
<i>C. insulare</i>	-	-	+	-	-	+	2 – 8	4.45 $\pm$ 1.90 <sup>b</sup>	Glabrescent
<i>C. lamprocarpum</i>	-	-	+	-	-	+	3 – 9	6.00 $\pm$ 1.81 <sup>c</sup>	Glabrescent
<i>C. micranthum</i>	-	-	-	-	+	-	33 – 81	47.80 $\pm$ 14.60 <sup>g</sup>	Densely hairy
<i>C. molle</i>	-	-	-	-	+	+	76 – 198	143.0 $\pm$ 37.16 <sup>e</sup>	Very densely hairy
<i>C. mooreanum</i>	-	-	-	+	-	+	4 – 12	7.10 $\pm$ 0.02 <sup>d</sup>	Glabrescent
<i>C. nigricans</i> var. <i>elliottii</i>	+	-	+	-	-	+	31 – 81	51.60 $\pm$ 14.37 <sup>h</sup>	Very densely hairy
<i>C. paniculatum</i>	-	+	-	-	-	+	6 – 10	8.40 $\pm$ 1.27 <sup>e</sup>	Glabrescent
<i>C. platypterum</i>	-	+	-	+	-	+	1 – 2	1.25 $\pm$ 0.44 <sup>a</sup>	Glabrescent
<i>C. racemosum</i>	-	-	-	+	-	+	4 – 12	7.10 $\pm$ 2.02 <sup>d</sup>	Glabrescent
<i>C. zenkeri</i>	-	+	-	-	-	+	42 – 163	90.70 $\pm$ 44.50 <sup>m</sup>	Very densely hairy

<sup>1</sup>Cylindrical uniseriate trichome, <sup>2</sup>Cylindrical uniseriate clavate trichome, <sup>3</sup>Unicellular gland head/ uniseriate stalk, <sup>4</sup>Multicellular glandhead/ uniseriate stalk, <sup>5</sup>Peltate gland head, <sup>6</sup>Eglandular conical trichome, Note: + = Present, - = absent; values followed by the same letter in a column are not significantly different at 5% level using LSD.

### 3.2 Trichome Density and Leaf Surface

The trichome density in the *Combretum* species sampled varied from 1.25  $\pm$  0.44 trichomes per 100 cells for *C. platypterum* (glabrescent) to >500 trichomes per 100 cells for *C. collinum* subsp. *hypopilinum* (very densely hairy). The leaf surface of most the species are glabrescent. The trichome densities of these species include: *C. platypterum*, 1.25  $\pm$  0.44; *C. bracteatum*, 1.50  $\pm$  0.61; *C. dolichopetalum*, 1.50  $\pm$  0.61; *C. cuspidatum*, 1.75  $\pm$  0.72; *C. insulare*, 4.45  $\pm$  1.90; *C. constrictum*, 5.35  $\pm$  2.03; *C. lamprocarpum*, 6.00  $\pm$  1.81; *C. collinum* subsp. *binderianum*, 7.10  $\pm$  2.02; *C. mooreanum*, 7.10  $\pm$  2.02; *C. racemosum*, 7.10  $\pm$  2.02; *C. paniculatum*, 8.4  $\pm$  1.27 and *C. acutum*, 19.85  $\pm$  4.52. These species are sparsely hairy while *C. micranthum* is densely hairy with trichome density of 47.8  $\pm$  14.60. Other species of this genus studied are very densely hairy and their trichome densities are as follows: *C. nigricans* var. *elliottii*, 51.60  $\pm$  14.37; *C. confertum*, 58.05  $\pm$  21.26; *C. hispidum*, 54.6  $\pm$  20.01; *C. aculeatum*, 60.95  $\pm$  14.35; *C. excelsum*, 85.20  $\pm$  14.02; *C. zenkeri*, 90.70  $\pm$  44.50; *C. glutinosum*, 107.35  $\pm$  24.03; *C. fuscum*, 115.20  $\pm$  20.60; *C. ghasalense*, 136.95  $\pm$  21.44; *C. bauchiense*, 138.9  $\pm$  15.97 and *C. molle*, 143.0  $\pm$  37.16.

### 4. Discussion

The foliar trichome amongst members of the genus *Combretum* in West Africa is scarcely studied. In this work we surveyed the occurrence of different trichome types, the degree of hairiness on leaf surfaces/trichome densities of these species. The non-glandular trichome types were the most diversified and widely distributed trichome found in the species studied and could be used to distinguish members of this genus. For instance, among the species studied, this trichome type was not observed in two species namely; *C. glutinosum* and *C. micranthum*. This character therefore makes the two species distinct from the other ones and the species are further delimited based on their trichome densities (Table 2). *C. glutinosum* is very densely hairy with trichome of 70 – 156 (107.35  $\pm$  24.03) trichomes per 100 cells while *C. micranthum* is densely hairy with trichome density of 33 – 81 (47.80  $\pm$  14.60) trichomes per 100 cells. This further explains the occurrence of these species in different ecological zones (Ekeke, 2013). This is in line with the work of Stace (1980) who noted that the length, size and density of trichomes could



be influenced by environmental conditions. Also, the presence of a particular type of trichome has been used in the taxonomy of *Combretum* (Stace 1980). Since environmental conditions can influence the length and density of trichome, it can be used in placing these species into different geographical or ecological zones.

Five glandular trichome types were identified among the *Combretum* species studied (Table 2). Among the glandular trichomes, CUT was the most dominant occurring in 11 species namely; *C. aculeatum*, *C. bracteatum*, *C. collinum* subsp. *binderianum*, *C. collinum* subsp. *hypopilinum*, *C. constrictum*, *C. capitatum*, *C. hispidum*, *C. nigricans*, *C. paniculatum*, *C. platypterum* and *C. zenkeri*. This is followed by multicellular gland head with uniseriate stalk (MGU) trichome type occurring in 9 species (*C. bracteatum*, *C. collinum* subsp. *binderianum*, *C. collinum* subsp. *hypopilinum*, *C. constrictum*, *C. excelsum*, *C. hispidum*, *C. mooreanum*, *C. platypterum* and *C. racemosum*) Table 2. This showed that these species are related however, variation in number gland heads and the morphology of the trichomes could be used to further distinguish them. For instance, among these *Combretum* species with uniseriate trichome, *C. collinum* Fresen. subsp. *hypopilinum*, *C. collinum* subsp. *binderianum* and *C. hispidum* have MGU and ECT but the trichome densities differed from one species to the other. *C. collinum* subsp. *binderianum* is glabrescent while *C. collinum* Fresen. subsp. *hypopilinum* and *C. hispidum* are very densely hairy. Furthermore, *C. collinum* Fresen. subsp. *hypopilinum* has more trichomes than *C. hispidum*. Also, *C. platypterum* and *C. paniculatum* have CUCT and are glabrescent however; the presence of MGU in *C. platypterum* distinguishes it from *C. paniculatum*. Similarly, *C. bracteatum* and *C. constrictum* have CUT, but *C. constrictum* has UGHU and MGU which are not found in *C. bracteatum*. In the same vein, *C. zenkeri* and *C. cuspidatum* could be distinguished base on the density of trichomes on the leaf surface (Table 2). Though these two species have CUCT, *C. zenkeri* has trichome density of 42 – 163 ( $90.70 \pm 44.50$ ) trichomes per 100 cells while *C. cuspidatum* has trichome density of 1 – 3 ( $1.75 \pm 0.72$ ) trichomes per 100 cells. *C. mooreanum* and *C. racemosum* have only two trichome types (MGU and ECT). The analysis of variance of the trichome densities showed that there is significant difference in densities of the trichomes among the species studied (Table 2). This suggests that the variation in trichome density could be used in delimitating the genus and could complement the existing data on these species.

Trichomes have been reported to have contributed immensely to the taxonomy of the genus *Combretum* in particular and Combretaceae family at large. The unicellular combretaceous trichome type has been reported among the American species (Stace 1961, 1965) and glandular trichome with peltate head or without peltate head (stalk gland) (Solereder 1908; Stace 1969a, b, 1980; Metcalfe & Chalk 1979; Patricia 2002). Similarly, the trichomes recorded in this report are the same as those in the previous reports. Stace (1969) noted the value of the leaf epidermal characteristics and particularly the glandular trichomes in the identification and classification of the 37 species of *Combretum* in America. He used the wide range of trichome types found among the species to differentiate groups of species corresponding closely with the 11 sections recognized by Exell, rather than distinguishing individual species and suggested that these trichomes have great taxonomic value as that of any other organ in the genus. Also, Jordaan *et al.* (2011) reported peltate trichome in South African *Combretum* species as important taxonomic character. Trichome morphology, densities and types have been employed in distinguishing other genera other than *Combretum*. These have been employed to differentiate *Ajuga* in Turkey (Ilkay *et al.* 2014), *Croton* in Thailand (Chadaporn & Pranom 2010) and *Hibiscus* (Shaheen *et al.* 2009).

## 5. Conclusion

The findings in this study showed that trichomes in combination with other taxonomic characters can be used in differentiating the genus *Combretum* in West Africa and supports previous works on other members of this genus from other parts of the world.

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