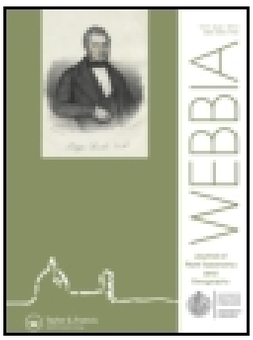

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ARTICLE

Leaf epidermis of the African genus *Mallotus* Lour. (Euphorbiaceae) section *Rottleropsis* Müll. Arg. and its systematic value

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ABSTRACT

The leaf epidermal information on the two African *Mallotus* species is updated with data derived from herbarium specimens using light and scanning electron microscopy. Stomata, indumentum and cuticular ornamentation are particularly informative. All the species have paracytic stomatal type and amphistomatic leaves with stomata on the adaxial surface being restricted to the midribs and big veins. Brachyparacytic stomatal type and abaxially restricted disc-shaped multicellular glandular trichomes distinguish *M. oppositifolius* var. *glabratus* from *M. oppositifolius* var. *pubescens*, while presence of hemibrachyparacytic stomata and cuticular striations differentiate *M. subulatus* from *M. oppositifolius*. However, the quantitative and leaf areole characters overlap considerably. Based on a suite of these characters, the distant relationship indicated between *M. oppositifolius* and *M. subulatus* and the suggestion to subsume section *Axenfeldia* in the polyphyletic section *Rottleropsis* is upheld with some cross-referenced data; also, an indented dichotomous key for separating the three taxa is presented.

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KEYWORDS
Africa; epidermis; leaf cuticle; *Mallotus*; micro-morphology; taxonomy

Introduction

Mallotus Lour. is a uni-ovulate Euphorbiaceous genus of pan (sub) tropical distribution where it forms important components of the forest vegetation (Keay 1989; Slik et al. 2003). It comprises species which may be trees, shrubs or very rarely climbers (Irvine 1961; Radcliffe-Smith 1989, 1996; Slik and van Welzen 2001; Wurdack and Hoffman 2005; Kulju et al. 2007). There are c. 150 species characterised by the presence of fairly conspicuous, globose to disc-shaped glandular hairs found mostly under the leaf surface and the inflorescences, and the presence of extrafloral nectaries in other parts of the plants (Sierra et al. 2010). The only two species present in tropical Africa and Madagascar (Kulju et al. 2007; Sierra et al. 2007) are *M. oppositifolius* (Geiseler) Müll. Arg. which has two varieties – *M. oppositifolius* var. *glabratus* Müll. Arg. and *M. oppositifolius* var. *pubescens* Pax – and *M. subulatus* Müll. Arg. The species are known to be distantly related and dispersed independently into Africa at different times (Sierra et al. 2010; van Welzen et al. 2014). Concerning classification, *Mallotus* belongs to the tribe Acalypheae, subfamily Acalyphoideae and subtribe Rottlerinae (Webster 1994), and its close relationship with *Macaranga* Thou. has been based on morphological and molecular data-sets (Slik and van Welzen 2001; Wurdack and Hoffman 2005; Sierra et al. 2006, 2007, 2010; Kulju et al. 2007; van Welzen et al. 2014).

The taxonomic relevance of leaf epidermis in the family has been pointed out but the available data on the two African species (Metcalfe and Chalk 1950, 1979; Levin 1986; Hussin et al. 1996; Zahra et al. 2014) have some gaps. Even the most recent report by Fišer et al. (2012) provides anatomical characteristics of the species still with some lacunae in the epidermal description; for instance, there is (1) incompleteness of data on stomata, wall pattern, etc., (2) fractional pictorial representation of leaf surfaces of the species and their features, and (3) lack of information that can be used to distinguish the two varieties of *M. oppositifolius* which are often confused when needed in folk medicine in the region. All these inadequacies necessitated the present study.

In addition, the existing sections recognised in the genus based on morphology, e.g. five sections by Mueller (1865, 1866) and Pax and Hoffmann (1914), and 10 sections and, recently, eight sections by Airy Shaw (1968), have some uncertainties in species composition. Hence, Slik and van Welzen (2001) pointed out the need for additional data for a reconsideration of this traditional section delimitation in the genus. Against this backdrop, we endeavoured to contribute to understanding section *Rottleropsis* by comparing, as far as possible, our findings with some reported leaf epidermal data by Hussin et al. (1996), Fišer et al. (2012) and Thakur and Patil (2014). Ancillary to the foregoing, the leaf areoles and vein termination characteristics were also studied, given the reported

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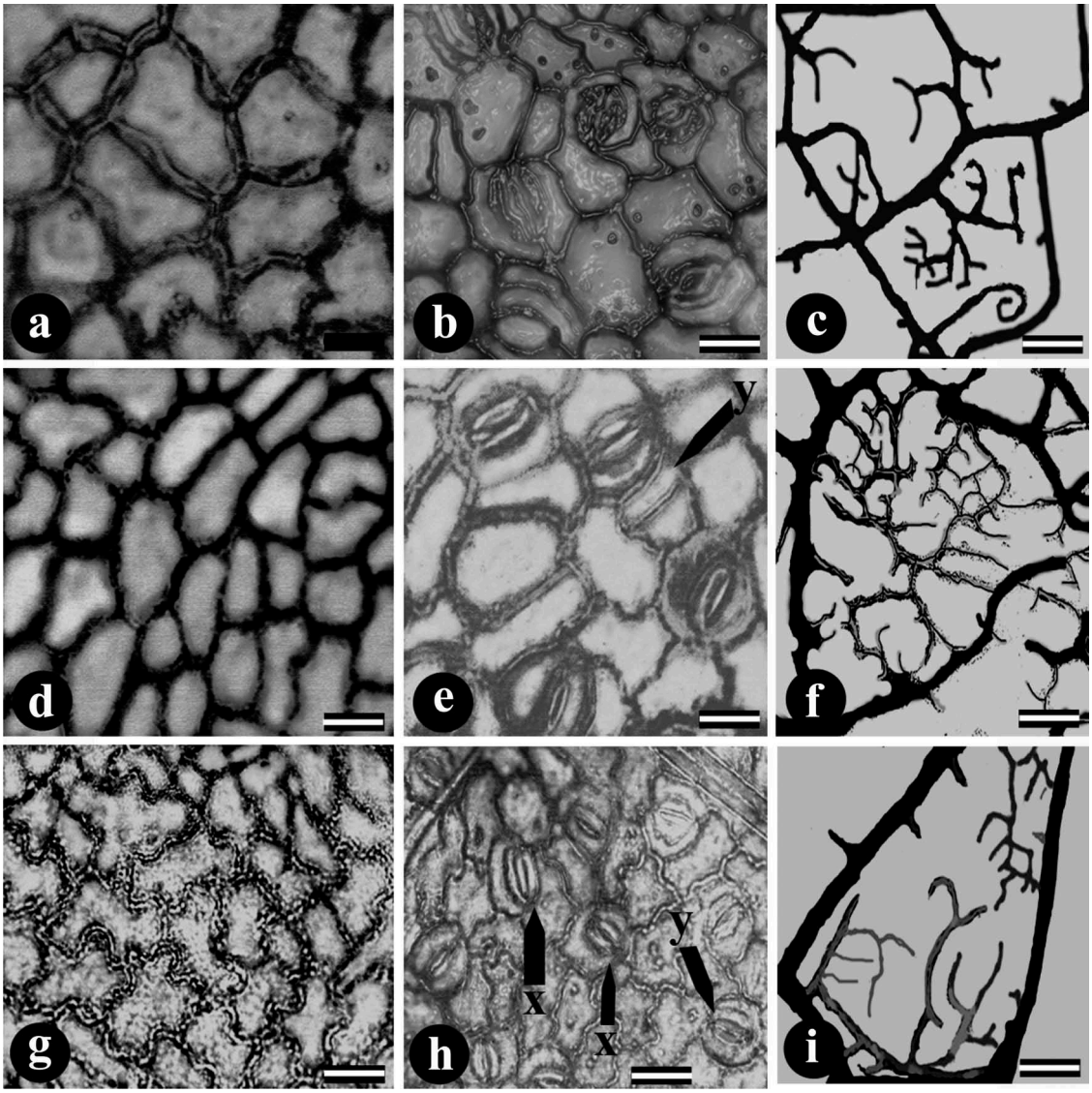

Figure 1. Leaf micro-features of the African *Mallotus* showing epidermal features and venation patterns. (a, b) *M. oppositifolius* var. *pubescens*. (d, e) *M. oppositifolius* var. *glabratus*. (g, h) *M. subulatus*. On the adaxial surface, note smooth periclinal walls and straight to curved anticlinal walls in *M. oppositifolius*; and wavy anticlinal walls and rough periclinal walls in *M. subulatus*. On the abaxial surface, note smooth periclinal walls and straight to curved anticlinal walls in *M. oppositifolius*; and wavy anticlinal walls and rough periclinal walls in *M. subulatus*. Venation patterns show veinlet termination number of one to two within the areoles and dissimilar areole shapes. (a, d, g) Adaxial surface; (b, e, h) abaxial surface; (c, f, i) venation patterns. x = hemiparacytic; y = brachyparacytic. Scale bar: 20 µm.

relevance of the characters in angiosperm taxonomy (Hickey 1973; Dilcher 1974; Alvin and Rao 1987; Araújo et al. 2010; de Almeida-Jr et al. 2012).

Therefore, the aim of the study is to update the existing taxonomic information on the two species in order to enhance adequate identificaton of the varieties of *M. oppositifolius* and distinguish the species more explicitly from *M. subulatus*.

The studied African *Mallotus* are medicinally useful, for treating malaria and as an antibiotic (Irvine 1961; Burkill 1994; Adekunle and Ikumapayi 2006; Harinantenaina et al. 2013; Bremer et al. 2015). This study will undoubtedly help in the identification of the leaf samples even when in fragmentary condition, the usual state of herbal materials sold in the African markets.

Material and methods

Herbarium specimens of the species were studied microscopically following the methods of Kadiri et al. (2009), de Almeida-Jr et al. (2012), Ogundipe and Kadiri (2012) and Kadiri and Olowokudejo (2016). The herbaria visited were those of the Universities of Lagos (LUH) and Ibadan (UIH), as well as the Forestry Herbarium, Ibadan (FHI), Nigeria. The herbarium abbreviations follow Holmgren et al. (1990), while details of the examined specimens are presented in

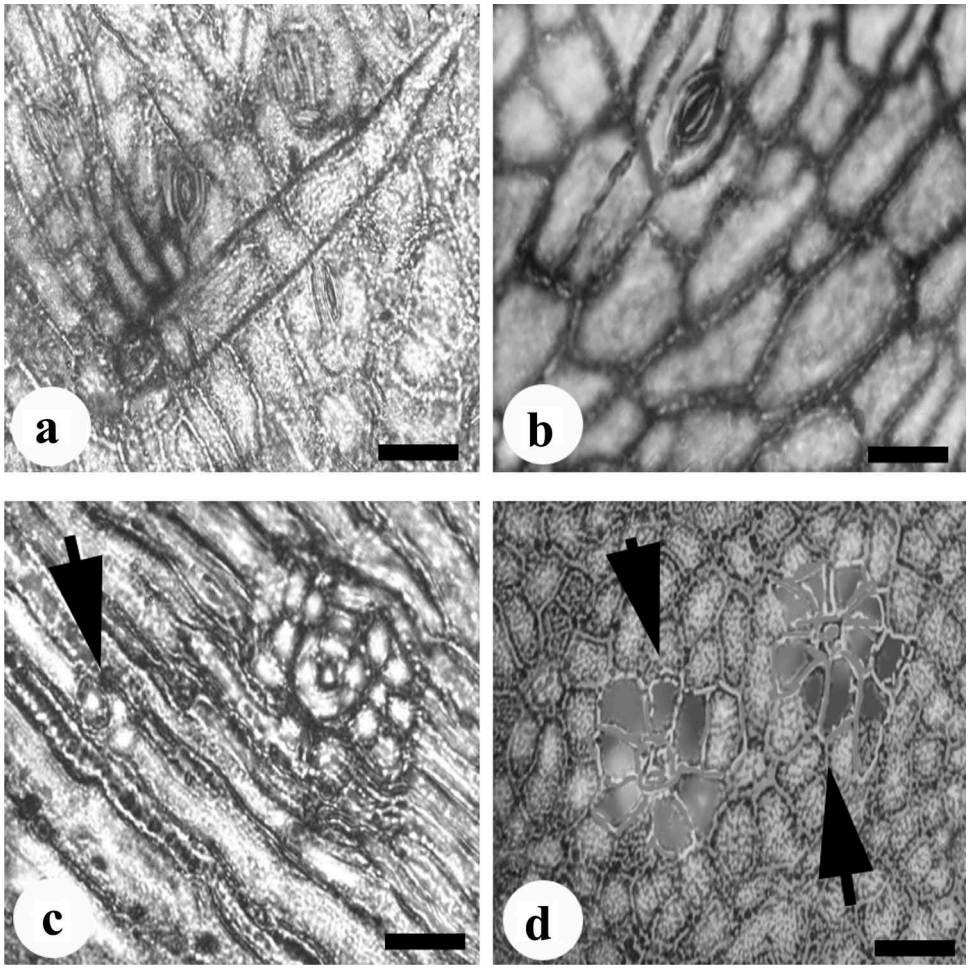

Figure 2. Leaf micro-features of the African *Mallotus* showing some epidermis features. (a) Vein of *M. oppositifolius* showing unicellular trichome and stoma. (b) Vein of *M. subulatus* showing stoma. (c, d) Trichome bases of *M. oppositifolius* var. *pubescens*; (c) midrib – young trichome base is arrowed; (d) lamina – peltate scales are arrowed. All adaxial surface except (c). Scale bar: 20 µm.

Appendix 1 and description of the studied leaf micromorphological features follows the terminologies of Stace (1965, 1991), Hickey (1973), Hussin et al. (1996), Araújo et al. (2010), Ghahremaninejad et al. (2012), de Almeida-Jr et al. (2012), Fišer et al. (2012) and Thakur and Patil (2014).

For epidermal study, 2–3 cm^2 pieces of leaves obtained from the standard median portion of the leaf lamina were first boiled in water so that the cells can swell to the maximum size before they were soaked in concentrated HNO_3 acid in capped specimen bottles for about 3–5 h for the epidermis (cuticle) to separate. Appearance of air bubbles indicated readiness of the cuticle for separation. Samples were transferred into Petri dishes containing water and the epidermal layers were teased off and rinsed in water; adhering tissues were brushed off using a soft artist brush, so as to recover the transparent epidermis, and then mounted on the glass slide. A few drops of ethyl alcohol were added in series: 50, 70, 75 and 100% so that the cells can harden in order to withstand further treatment. The mounted samples were stained with Safranin O in 5% alcohol for about 5 min before mounting in glycerine. All samples were covered with cover slips and then ringed with nail polish in order to prevent dehydration and an assessment of 20 randomly selected epidermal cells and stomata from 10 different microscope fields was conducted on 10 randomly selected leaves per taxon. For examination of leaf venation, 10 leaf samples per taxon were diaphanised soaked in sodium hypochlorite (both commercial and laboratory formulations) for c. 24–48 h at about 36°C in Petri dishes. The transparent portions were transferred into water, rinsed, placed on the slides and stained with a few drops of aqeous Safranin O. All slides were labelled appropriately and examined with an Olympus light microscope having a ToupView 3.7 microscope eyepiece camera- version UCMOS08000KPA-U-NA-N-M-CY-NA attached.

For scanning electron microscopy, small pieces (c. 7 mm^2) of the leaf were fixed on scanning electron microscope stubs with a double-sided tape and sputter coated with gold. The surfaces were observed and photographed under a JEOL JSM-T 20 scanning electron microscope at an accelerating potential of 20.0 kV at the Electron Microscopy Unit, Department of

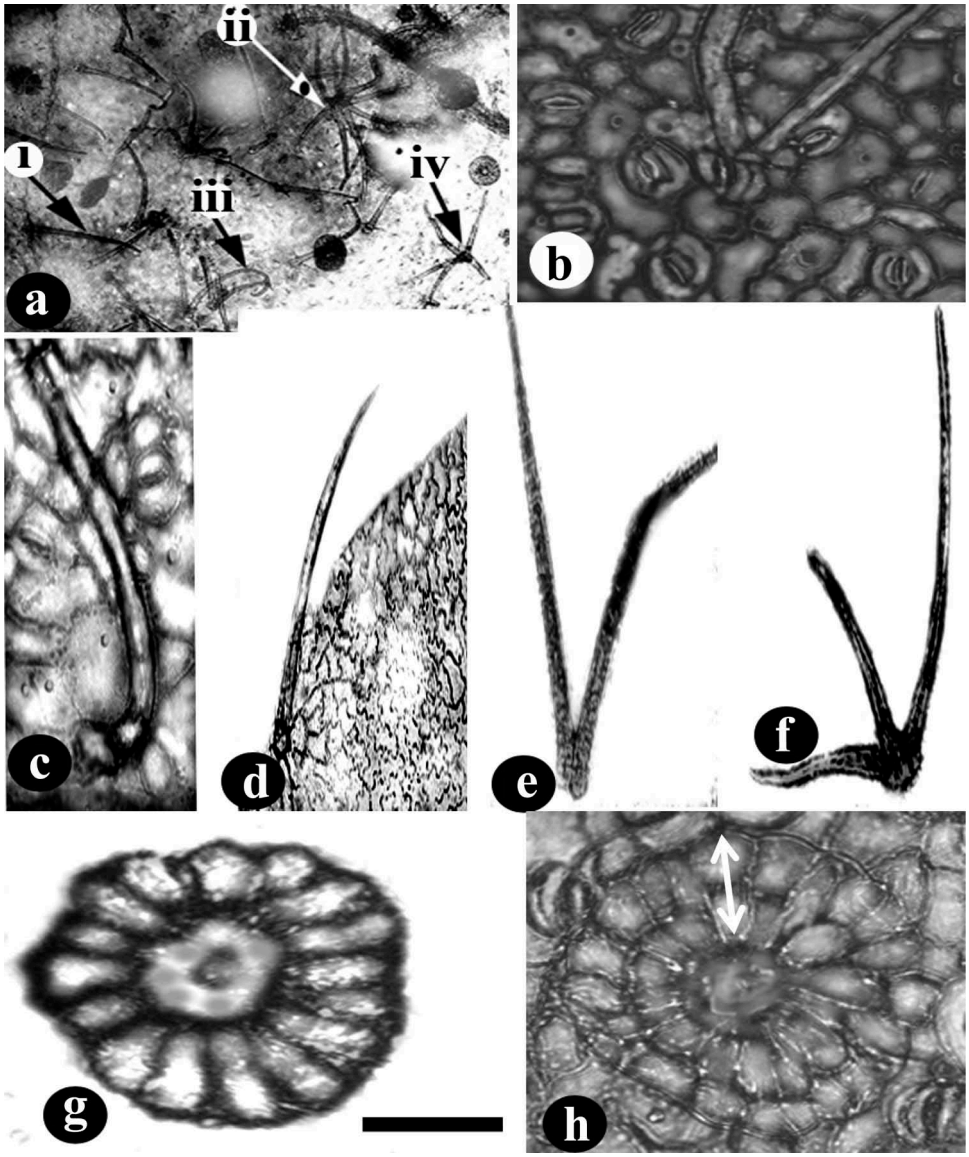

Figure 3. Leaf epidermal appendages of the African *Mallotus* as seen under light microscopy. (ai) Long uncellular conical trichome; (aii) eight-basally united unicellular trichomes; (aiii) two-basally united trichomes; (aiv) five-basally united trichomes. (a, e, f) *M. oppositifolius* var. *pubescens*. (b–d) *M. subulatus*; (d) upper surface. (g) Disc-shaped multicellular glandular trichome found in *M. oppositifolius* showing one ring of cells. (h) Disc-shape multicellular glandular trichome found in *M. subulatus* showing two rings of cells (arrowed).

Botany, University of Reading, UK. The structural patterns of the leaf surfaces were carefully assessed.

Results

A summary of the findings is presented in Figures 1–5 and Tables 1 and 2.

Epidermis

Non-stomatal cells and appendages

The epidermal cell shape is irregular on both surfaces of the epidermis in *M. subulatus* (Figure 1g, h; Table 1) whereas it is polygonal on the adaxial surface and irregular on the abaxial surface in *M. oppositifolius* (Figure 1a, b, d, e; Table 1). Similarly, the anticlinal wall pattern is similar on both surfaces of the epidermis; that is, straight to curved in *M. oppositifolius* (Figures 1a, b, d, e, 3b) and wavy in *M. subulatus* (Figure 1g, h). The periclinal wall is usually smooth in *M. oppositifolius* (Figure 1a, b, d, e; Table 1) but *M. oppositifolius* var. *pubescens* has rough abaxial surface (Figures 1b, 4c; Table 1) and smooth adaxial surface (Figure 4a; Table 2). Striations are either found on the periclinal walls on the adaxial surface or restricted to the stomatal area in *M. subulatus* (Figure 4g–j; Table 1), whereas they are absent in *M. oppositifolius* (Figure 4a–f).

Three different trichome types were recorded in the study, namely disc-shaped multicellular glandular type (Figures 3g, h, 5c–h; Table 1), long conical trichomes (Figures 3ai, c, d, 5b–d) and two- to eight-

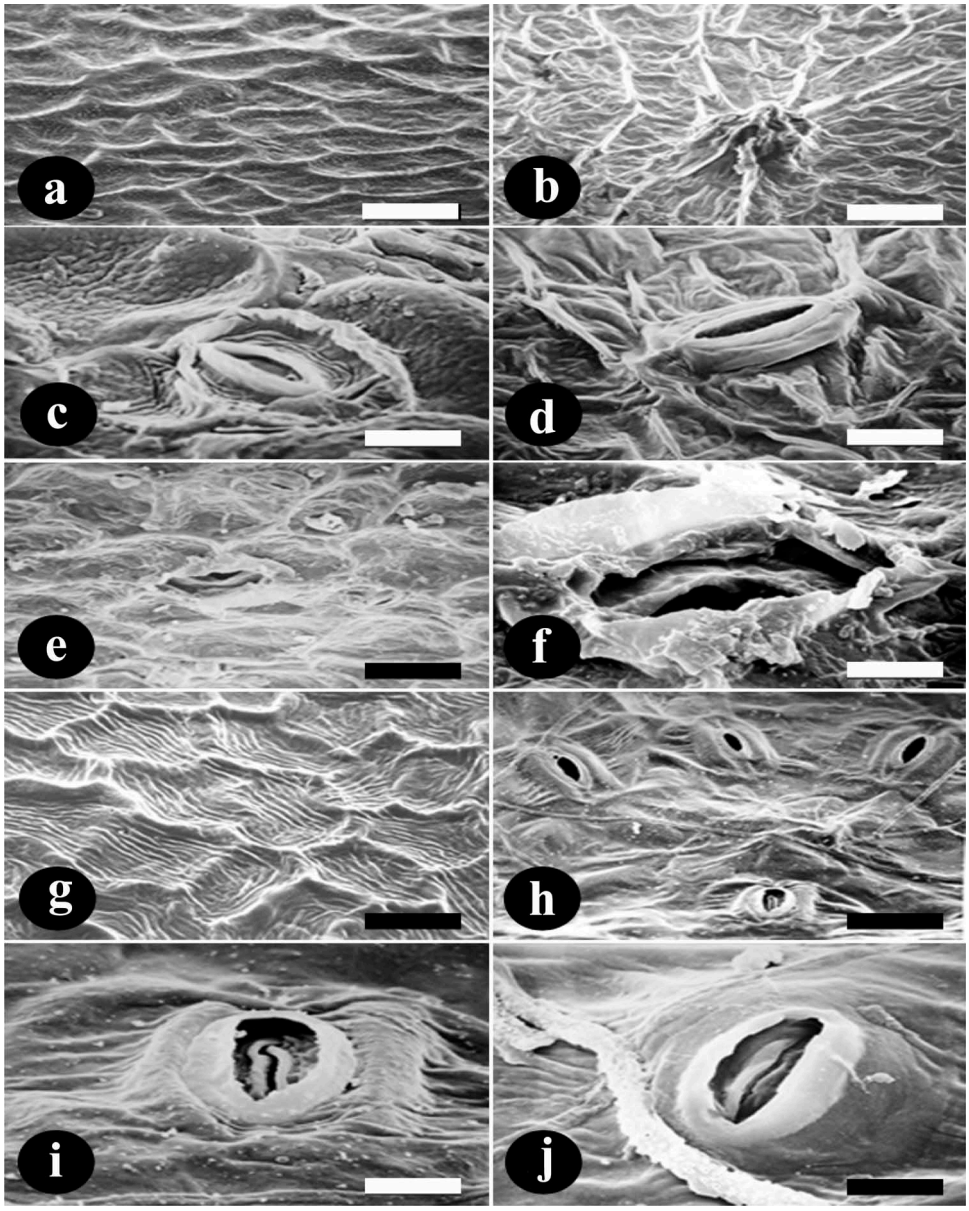

Figure 4. Leaf micro-features of the African *Mallotus* showing epidermis, as seen on the adaxial and abaxial surfaces. (a–d) *M. oppositifolius* var. *pubescens*; (b) showing sunken stoma; (c) showing superficial stoma. (e, f) *M. oppositifolius* var. *glabratus* showing sunken stomata. (g–j) *M. subulatus*. Note striations in (g) and superficial stomata in (h–j). Note also the size of the stomatal apertures in the photomicrographs. Scale bar: 5 µm.

basally united unicellular forms found on a cell (Figures 3aii–iv, b, e, f, 5a–c; Table 1). *Mallotus oppositifolius* var. *glabratus* may have disc-shaped multicellular glandular type (Figures 3g, 5g; Table 1) or without a trichome on the abaxial surface (Table 1). The disc-shaped multicellular glandular trichomes found in *M. oppositifolius* consist of a layer of cells arranged like a ring (Figures 3g, 5c–g; Table 2), whereas in *M. subulatus* the cells are arranged in two layers (Figures 3h, 5h; Table 2). Trichome bases of different sizes found on midrib (Figure 2c) and lamina (Figure 2d) were recorded in *M. oppositifolius* var. *pubescens*. They consist of one to three layers of surrounding cells with a central cell. Crystals of calcium oxalate were sparingly found, almost uniformly on both surfaces in the taxa except *M. oppositifolius* var. *glabratus* where they are absent (Figure 1d, e).

Quantitatively, the longest cells of 72.0 µm were encountered in *M. subulatus* while the two varieties of *M. oppositifolius* have the widest cells of 45.0 µm. The cells on the adaxial layer are longer than those on the abaxial surface in the two species studied (Table 2) and the number of interstomatal cells is usually one or two in *M. oppositifolius* var. *pubescens* and *M. subulatus*, but it is one to three in *M. oppositifolius* var. *glabratus* (Figure 1; Table 2).

Stomata

The leaves are amphistomatic (Figure 1; Table 1) with stomata restricted to midribs and big veins in

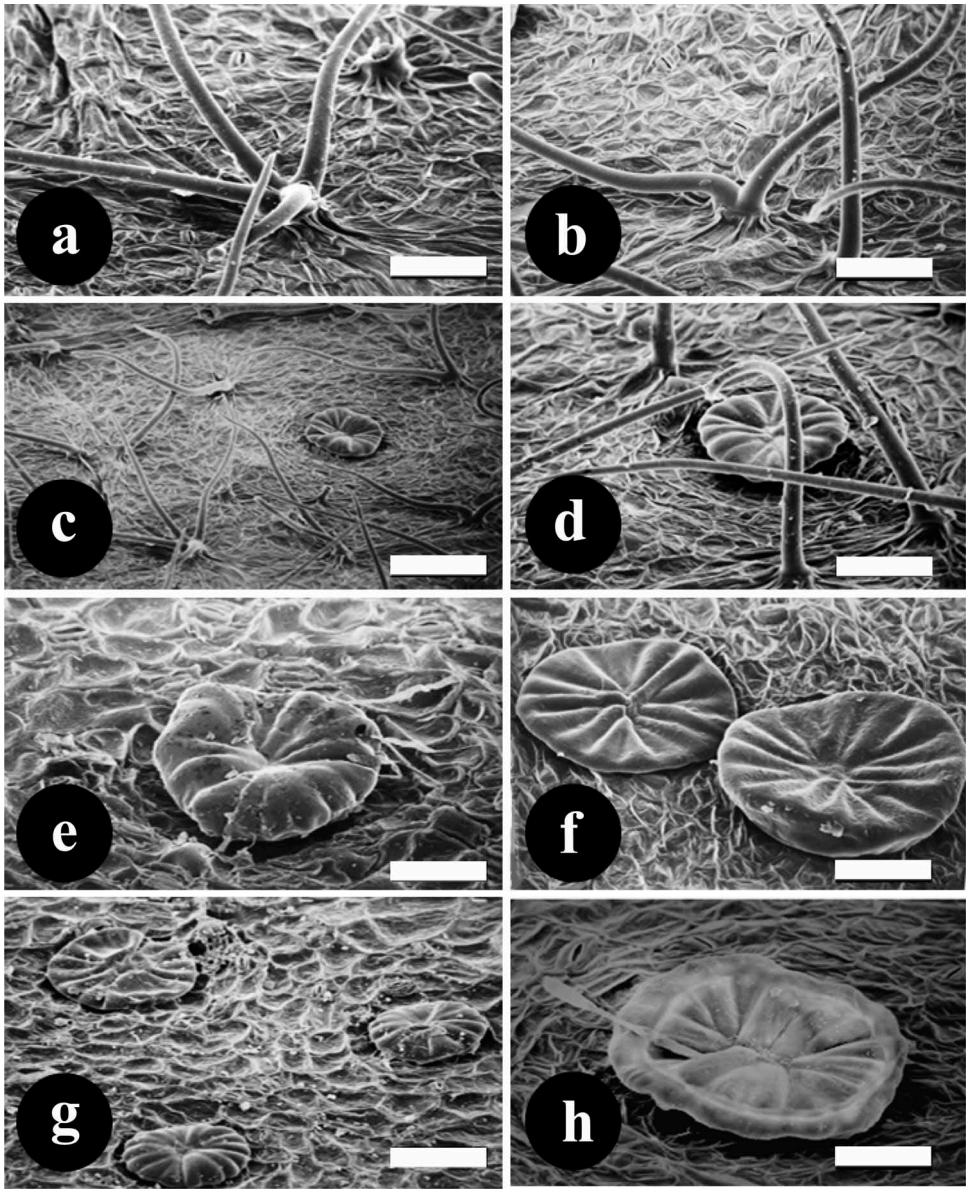

Figure 5. Leaf epidermal appendages of the African *Mallotus* as seen under scanning elcetron microscopy. (a–f) *M. oppositifolius* var. *pubescens*. Note uni-multi-basally united trichomes and disc-shaped multicellular forms. (g) Disc-shaped multicellular trichome of *M. oppositifolius* var. *glabratus*. (h) Disc-shaped multicellular trichome of *M. subulatus* showing two rings of cells. Scale bar: 5 µm.

the two species on the adaxial surface. Paracytic stomatal type was recorded in all the species but brachyparacytic was found accompanying in *M. oppositifolius* var. *glabratus* (Figure 1e; Table 1) while brachyparacytic and hemiparacytic were found additionally in *M. subulatus* (Figure 1h; Table 1). Stomatal position is both sunken and superficial in *M. oppositifolius* var. *pubescens* (Figure 4c, d; Table 1), it is sunken in *M. oppositifolius* var. *glabratus*(Figure 4e, f; Table 1) and superficial in *M. subulatus* (Figure 4h, I; Table 1). The stomatal rim can be smooth or rough and wide or narrow across the taxa (Figure 4; Table 1). Largest stomata were encountered in *M. oppositifolius* var. *glabratus* while shortest stomata were found in *M. subulatus* (Table 2).

Venation

The areole shape may be square or rectangular in *M. oppositifolius* var. *pubescens* (Figure 1C; Table 1) and *M. subulatus* (Figure 1i; Table 1) or imperfect triangular in *M. oppositifolius* var. *glabratus* (Figure 1f; Table 1). Veinlet termination number varied from one to two in the two species but the pattern of network may be open as recorded in *M. oppositifolius* var. *pubescens* (Figure 1c; Table 2) and *M. subulatus* (Figure 1i; Table 2) or closed in *M. oppositifolius* var. *glabratus* (Figure 1f; Table 2).

Discussion

An account of the leaf epidermis characters of the two African *Mallotus* species is presented without making

Table 1. Qualitative characteristics of the leaf epidermis and venation of the African *Mallotus*.

		Non-stomatal cells				Venation	Stomatal cells		
Taxa	Layer	Epidermal cell shape	Anticlinal wall pattern	Periclinal wall surface	Trichome type	Areole shape	Stomataltype	Stomata position	Stomatal rim
M. oppositifolius var. *pubescens*	Ad	Polygonal Irregular	Straight–curved	Smooth*, rough**	Multicellular stellate				
	Ab	Polygonal Irregular	Straight–curved	Rough***	Long conical, multicellular stellate, two- to eight-basally united unicellular	Square to rectangle	Paracytic	Sunken*, superficial**	Smooth–narrow
M. oppositifolius var. *glabratus*	Ad	Polygonal Irregular	Straight–curved	Smooth***	Multicellular stellate				
	Ab	Polygonal Irregular	Straight–curved	Smooth***	Absent	Imperfect triangle	Paracytic, brachyparacytic	Sunken***	Rough–wide
M. subulatus	Ad	Irregular	Wavy	Rough*, striated**	Long conical				
	Ab	Irregular	Wavy	Rough to smooth*, smooth to striated**	Long conical, multicellular stellate	Square to rectangle	Paracytic, brachyparacytic, hemiparacytic	Superficial***	Smooth–wide

Ab = abaxial; Ad = adaxial; * = under light microscope (LM); ** = under scanning electron microscope (SEM); *** = under LM and SEM.

any reference to evolution. However, the various studied characters of the African *Mallotus* are compared with those of other species which have been grouped with them in the section *Rottleropsis* and clade *Subulatus* based on morphology, anatomy and molecular data-sets (Hussein 1996; Sierra et al. 2010; Fišer et al. 2012). Leaf epidermis is a reliable taxonomic data source useful for showing differences and similarities among species (Metcalfe and Chalk 1950, 1979; Davis and Heywood 1963; Stace 1965; Raju and Rao 1977; Dehgan 1980; Baranova 1992; Olowokudejo 1993; Hussin et al. 1996; Kadiri et al. 2009; Ogundipe and Kadiri 2012; Thakur and Patil 2014; Kadiri and Olowokudejo 2016).

The anticlinal wall is unevenly thickened on both surfaces of the epidermis. In *M. oppositifolius* var. *glabratus*, it is thicker on the abaxial surface than the adaxial surface; this is contrary to even thickness reported by Fišer et al. (2012); but the differing cell size noted by them is also encountered in this study. Cell dimension of the two species is not up to three times as long as wide but cells that are up to five times longer than wide have been reported in the Asiatic *Mallotus* species (Hussin et al. 1996). Quantitative characters can still be taxonomically useful despite their overlapping nature (Stace 1965). Both qualitative and quantitative characters of the leaf epidermis are very useful for discriminating the species. The leaves are amphistomatic; though stomata on the adaxial surface are scattered on the secondary (bigger) veins and midribs in the two species; this was reported by Fišer et al. (2012) but amphistomatic as a term has not been used to describe the genus by any earlier worker. Only paracytic stomata have been reported so far for the genus (Hussin et al. 1996; Fišer et al. 2012) but two other mature types were encountered in this study. The stomatal definitions are as provided by Stace (1991). In line with this observation, anomocytic and anisocytic stomatal types have been reported in the Asiatic *M. stenanthes* Müll. Arg. (Thakur and Patil 2014); these are known to occur in certain other genera of the family Euphorbiaceae (Metcalfe and Chalk 1979). Thus, this observation points to the possibility of several types of stomata in the genus. In addition, the range variation of stomatal length is 3.6–16.5 µm in *M. subulatus*, 9.4–15.5 µm in *M. oppositifolius* var. *pubescens* and 11.3–16.0 µm in *M. oppositifolius* var. *glabrous*. Cell shape is irregular in *M. subulatus* whereas it may be polygonal or irregular in *M. oppositifolius*. Cuticular striations are present in *M. subulatus* but they are absent in *M. oppositifolius*. Three types of trichomes were found: (1) multicellular disc-shaped multicellular glandular type, (2) long conical trichomes and (3) two- to eight-basally united unicellular forms. Fišer et al. (2012) also reported these types in addition to glandular unicellular type among others in *Mallotus* but Hussin et al. (1996) reported only stalked stellate, simple multicellular with two or three arms, papillae-lined crypts, stellate and simple short unicellular forms in the Asiatic species. Morphologically, in our species, disc-shaped multicellular glandular trichomes have two rings of cells in *M. subulatus* whereas a ring of cells was found in *M. oppositifolius*, the latter being similar to the report of Fišer et al. (2012). This observation is in line with the

Table 2. Quantitative characteristics of the leaf epidermis and venation of the African *Mallotus*.

	Non-stomatal cells					Stomatal cells		
		Cell size (μm)				Stomatal size (μm)		Venation
Taxa	Surface	Length	Width	No. of cell layers of disc-shaped multicellular glandular trichome	No. of inter-stomatal cells	Length	Width	Veinlet termination and networking
M. oppositifolius var. *pubescens*	Adaxial	52.5–62.0	32.4–45.0					
	Abaxial	23.5–41.1	14.5–27.1			9.4–15.5	3.6–9.4	1–2, open
M. oppositifolius var. *glabratus*	Adaxial	21.6–59.4	18.0–45.0	1	ND			
	Abaxial	31.8–54.0	14.1–31.8	1	1–3	11.3–16.0	4.7–9.4	1–2, closed
M. subulatus	Adaxial	21.6–72.0	14.4–39.6	Absent	ND			
	Abaxial	23.5–40.0	9.4–17.6	2	1–2	3.6–16.5	2.4–4.7	1–2, open

Figures in ranges show minimum and maximum measured values. ND = not determined.

taxonomic usefulness of trichome morphology in certain angiosperm families reported by Carpenter et al. (2005). In the same vein, the taxonomic relevance of other epidermal appendages such as trichome base and crystals of calcium oxalate was pointed out by Fišer et al. (2012). There are young and persistent old trichome bases which are composed of one to three surrounding cells with a more or less circular ring at the centre along the midrib on the abaxial surface and lamina on the adaxial surface of *M. oppositifolius* var. *pubescens*; but trichome bases were reported by Fišer et al. (2012) only on the adaxial surface in the genus. Hair base as a character has been shown to be taxonomically useful for distinguishing the related *Hancea* Seem and *Blumeodendron* Kurz from *Mallotus* (Fišer et al. 2012). Crystals of calcium oxalate are sparingly distributed in the leaves of all taxa except *M. oppositifolius* var. *glabratus* where they are absent; this follows the taxonomic importance of the structure as hinted at by Fišer et al. (2012).

Areole shapes of the species varied limitedly and they complement other epidermal data. The use of leaf architecture in species delimitation has been reported (Hickey 1973; Levin 1986; Alvin and Rao 1987; Araújo et al. 2010; de Almeida-Jr et al. 2012; Ghahremaninejad et al. 2012).

Based on these features, the two African species share some similarities with certain other species in the section *Rottleropsis*, e.g. *M. dispar* Muell. Arg., and section *Axenfeldia* (Baill.) Pax & K.Hoffm, e.g. *M. kingii* Hook. f. This corroborates the opinion to combine the two sections and the decision on polyphyly (Sierra et al. 2007, 2010). Also, there are some similarities among the African *Mallotus* and species such as *M. claoxyloides* (F.Muell.) Müll. Arg., *M. coudercii* (Gagnep.) Airy Shaw, *M. ficifolius* (Baill.) Pax & K.Hoffm., *M. glabriusculus* (Kurz) Pax & K.Hoffm., *M. macularis* Airy Shaw, *M. megadontus* P.I.Forst. and *M. subulatus* which are recognised in the clade *Subulatus* (Sierra et al. 2010). Although the number of species considered for this analysis was small, the observations we have recorded are insightful. However, based on the studied leaf epidermis features, an indented dichotomous key for separating the two species has been prepared.

An indented dichotomous key for separating the species of the African *Mallotus* based on leaf epidermis characters

1. Cuticular striations absent, hemiparacytic stomata absent, anticlinal wall straight-curved..... 2

2a. Brachyparacytic stomata absent, trichome present on abaxial surface..... ..... ***M. opppositifolius*** var. ***pubescens***

2b. Brachypracytic stomata present, trichome absent on abaxial surface..... ..... ***M. opppositifolius*** var. ***glabratus***

1. Cuticular striations present, hemiparacytic stomata present, anticlinal wall wavy..... ***M. subulatus***

Conclusion

The features of the leaf epidermis of the two African *Mallotus* species have been illustrated to show the existing differences and similarities. The three taxa studied are quite distinguishable based on both stomatal, e.g. type, position and dimension, and non-stomatal characters such as striations, trichome types, epidermal cell shapes and size, as well as the anticlinal and periclinal wall patterns. Though the quantitative and leaf areole features overlap considerably, they were also found to have some complementary taxonomic values.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1.

List of specimens examined in herbaria

The record follows name of collector(s), date of collection and herbarium number, respectively, while codes in parentheses represent the collectors' numbers.

M. oppositifolius (Geiseler) Müll. Arg. var. glabratus Müll. Arg

Agbaje, A.O. & Kadiri, A.B. (**ABK&A-012**), 19/3/2010, LUH 1666; Ahmed & Chisea, 10/7/1948, FHI 19768; Ajayi, O., 29/3/2008, LUH 980; Alimi, W.A., 13/3/2010, LUH 1686; Bump, A., 1/4/1958, FHI 36919; Daramola, B.O. (**BO-35**), 19/4/2012, LUH 4962; Eimunjeze & Oguntayo, 16/5/1974, FHI 70219; Eimunjeze & Oguntayo, 15/5/1974, FHI 70158; Emwiogbon, J.A., 14/7/66, FHI 60391; Emwiogbon, J.D. (**JAE-262**), 14/7/1966, FHI 60219, Emwiogbon, J.D., 4/3/1978, FHI 63905; Evans, A., 20/4/69, UIH 11565; FHI 66072; Daramola, B.O. (**BO-904**), 23/9/1978, FHI 86418; FHI 94596; Okafor & Emwiogbon, 28/2/1973, Freeman, R.A. (7), 1/1982, UIH 19780; Gledhill, D. (**767**), 5/4/1967, UIH 10518; Gledhill, D., 5/12/1967, UIH 10482; Jean Louis (**10268**), 11/7/1938, FHI 74963; John Louis (**940**), 4/1/1936, FHI 74950; Jones, A.P.D. (**1362**), 16/3/1942, FHI 6161; Jones A.P.D. (**1575**), 24/10/1943, 7090; Jones, A.P.D. (**2484**), 25/10/1945, FHI 13757; Kadiri, A. B. (**ABK-015**), 31/5/2010, LUH 1818; Kadiri, A.B. (**ABK-011**), 3/2010, LUH 3185; Kadiri, A.B. (**ABK-067**), 29/8/2008, LUH 979; Latilo, M.G., 30/5/1963, FHI 47657; Lowe, J. (**179**), 10/12/1968, UIH 1894; Lowe, J. (**382**), 20/3/1964, UIH 1896; Lowe, J., 5/5/1978 (**3561**), UIH 17751; Lowe, J. (**1845**), 11/11/1975, UIH 16660; Lowe, J. (**353**), 16/3/1964, UIH 1895; Lowe, J. (**3573**), 5/3/1978, UIH 17764; Lowe, J. (**3668**), 26/3/1978, UIH 17856; Lowe, J. (**4885**), 15/4/1989, UIH 21355; Lowe, J. (**4886**), 22/2/1990, UIH 21494; Lowe, J. (**834**), 15/1/1966, UIH 1897; Lowe, J. (**878**), 10/2/1966, UIH 1898; Lowe, J. (**942**), 26/3/1966, UIH 1899; Lowe J. (**944**), 21/3/1966, UIH 1900; Lowe, J., 15/4/1975, UIH 6081; Lowe, J. 4/4/1951, UIH 6201; Mafe, A., 15/3/2010, LUH 1735; Magbagbeola & others (**MAOA-86**), 27/4/1981, Morton, A.J.C. (**434**), 26/3/1933; Morton, J.K. (**GC-7717**), 10/1952, FHI 7717; Odewo, T.K., 27/3/2013, LUH 5649; Odewo, T.K. (**TK-040**), 7/4/2013, LUH 5612; Odewo, T.K., 3/4/2010, LUH 2657; Odewo, T.K. (**TK-011**), 17/11/2009, LUH 2112; Odewo, T.K., Ogundipe, O.T. & Kadiri, A.B., 20/9/2008, LUH 978; Odewo & Oni (**TKO-215**), 25/10/1996, UIH 18503; Odewo & Daramola (**TKO-548**), 23/1/1978, FHI 85339; Ogechi, J.A. & Kadiri, A.B. (**ABK&O-012**), 21/4/2010, LUH–; Okafor, M., 15/3/2010, LUH 1729; Okafor, M., 15/3/2010, LUH 1731; Okafor, M., 15/3/2010, LUH 1740; Okafor & others, 17/2/1966, UIH 12398; Okafor, J.C. & Latilo, M.G., 23/1/1966, FHI 57796; Okusi J.A., 30/8/1937, UIH 1892; Olorunfemi, J. (**OOA-176**), 5/8/1964, FHI 54965; Omoloba, O.T., 13/2/2010, LUH–; Owoyemi, A.O. & Kadiri, A.B. (**ABK-010**), 16/2/2010, LUH 1627; Oyenekan, M., 25/8/2013, LUH 6365; Oyinloye, O.F. & Kadiri, A.B. (**ABK&O-014**), 17/2/2010, LUH–; Roy, C. & Opayemi, J., 24/1/1974, LUH 797; Roy, C. & Opayemi, J., 24/1/1974, LUH 79; Roy, C. and Opayemi, J., 14/1/1974, LUH 977; Stella, C.O., 15/3/2010, LUH 1702; Umana, O. A., 15/2/1954, FHI 29147; van Meer, P.P.C. (**1667**), 18/5/1968, FHI 22072; Williamson, K.R.M., 20/12/1972, UIH 13863; Williamson, K.R.M. (**KW-38**), 5/8/1972, UIH 13654.

M. oppositifolius (Geiseler) Müll. Arg. var. pubescens Pax

Leonard, J. (**587**), 12/9/1946, FHI 74969; Macgregor, W.A. (**358**), 16/10/1950, FHI 2551.

M. subulatus Müll. Arg.

Ariwaodo (**AOA-86**), 8/3/1978, FHI 90446; Ariwaodo (**UFH-349**), 21/3/1977, FHI 88678; Binuyo, A., 10/4/59, FHI 41211; Binuyo & Daramola, 12/2/1986, FHI 35522; Binuyo, A., 16/11/1961, FHI 45464; Daramola & others, 9/9/1975, FHI 86108; Daramola & others, 28/12/1976, FHI 86162; Daramola, B.O. 4/2/1987, FHI 105327; Ekwuno, P., 9/12/1966, FHI 60456; Ekwuno & others (**E&O 628**), 16/8/1978, FHI 87655; Ekwuno & others (**805**), 24/8/1978, FHI 87732; Ekwuno & others (**E&O-628**), 1/9/1981, FHI 96285; Ekwuno & others (**PFO-632**), 7/2/1981, FHI 95979; Emwiogbon, 4/9/1973, FHI 70130; Emwiogbon & Akapu (**JAE-624**), 10/3/1974, FHI 72995; Emwiogbon & Onyeachusim, 10/10/1972, FHI 65878; Emwiogbon & Osanyinlusi (**EO- 386/77**), 12/10/1977, FHI 87276; Emwiogbon & Osanyinlusi (**EO-315/77**), 4/10/1977, FHI 86976; Emwiogbon & Osanyinlusi (**EO-76/77**), 4/10/1977, FHI 87038; Emwiogbon, J.A. (**JAE-261**), 2/2/1972, FHI 63861; Emwiogbon, J.A., 14/7/1966, FHI 60220; Emwiogbon, J.A., 1/6/1972, FHI 65681; Emwiogbon, J.A., 30/3/1973, FHI 73548; Gbile, Z.O., 5/8/75, FHI 71830; Ibhanesebhor & Oguntayo, 1/6/1972, FHI 65148; Ibhanesebhor & Oguntayo, 31/5/1972, FHI 65118; Ibhanesebhor & Oguntayo, 1/6/1972, FHI 65150; Jones, A.P.D. (**2520**), 5/6/1942, FHI 5032; Jones, A.P.D. (**2579**), 14/1/1943, FHI 4825; Kadiri, A.B. & Adesalu, T.A. (**ABK&TA-076**), 18/3/2011, LUH 3715; Keay, R. W.J. 10/11/1947, FHI 22281; Kennedy, J. D. (**42/32**), 15/10/1977, FHI 87347; Latilo & Oguntayo, 22/2/1973, FHI 67641; Latilo & others, 10/10/1974; FHI 71705; Latilo, M.G., 30/4/1952, FHI 30916; Latilo, M.G., 14/8/1950, FHI 27307; Leonard, J. (**439**), 28/8/1946, FHI 74968; Lowe, J. (**3785**), 18/2/1979, UIH 1842; Lowe, J. 18/2/1979, UIH 18420; Motuba, I.M., 16/8/1946, FHI 15243; Motuba, J.U., 12/2/1934, FHI 12554; Nemba & Thomas, 24/11/1986, FHI 105500; Odewo & Oni (**TKO-182**), 22/10/1976, FHI 79752; Okeke & Co., 16/8/1974, UIH 15906; Okeke & others, 16/8/1974, FHI 73387; Olorunfemi & others (**OOA-32**), 17/7/1980, FHI 93513; Olorunfemi & others (**OOA-79**), 10/9/1980, FHI 93560; Onochie & others, 16/3/1953, FHI 31175; Onochie, C.F.A., 31/1/1957; FHI 36209; E & O, 12/9/1982, FHI 95609; Onochie, C.F.A., 29/9/1953, FHI 34135; Onochie, C.F.A., 12/3/1955, FHI 34807; Onyeachusim & Latilo, 13/2/64, FHI 48157; Oxon, J.F. D., 14/11/1944, FHI 12555; Redheed, A. (**702**), 17/8/1964, UIH 12271; Reid, J.C. (**593**), 2/3/1986, UIH 21084; Ugbogu & Odewo, 23/6/2001, FHI 106179.