

# A preliminary leaf epidermal and pollen morphology of some West African species of *Desplatsia* Bocq

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*Desplatsia* is a genus made up of about four to eight species which are mostly trees native to tropical Africa. The leaf and pollen characters of three West African species of *Desplatsia* were investigated using light microscopy. The study was aimed at investigating the leaf epidermis and pollen morphology of the species to further enhance the understanding of the taxonomic relationships in the genus. The epidermal cells were isodiametric, polygonal to irregular with straight, curved to wavy anticlinal cell walls. The species were hypostomatic with anisocytic and staurocytic stomata types. The adaxial and abaxial walls of *Desplatsia chrysochlamys* were characterised by three-celled head multicellular glandular trichomes with highest number of cells and stomata and striated adaxial surface. The four-armed branched and stellate trichomes with the largest stomata size of 19.5  $\mu\text{m}$   $\times$  15.6  $\mu\text{m}$  distinguished *D. dewevrei* from *D. subericarpa* in which the largest cells, lowest number of stomata and size were recorded. The pollen grains were medium in size 26.5  $\mu\text{m}$ –47.5  $\mu\text{m}$ , tricolporate with long colpi. However, the subprolate, baculate exine surface, small ora and lumen width separated *D. chrysochlamys* from *D. dewevrei* and *D. subericarpa* in which prolate, perforated exine surface and colpi margo were recorded. A key is provided for the identification of the species. Therefore, the ora size, lumen width, number of epidermal cell and stomata are additional taxonomic characters that can be used for species delimitation in the genus.

## Introduction

*Desplatsia* Bocq. a native to Tropical Africa was first described by Bocquillon in 1867, with a single species *Desplatsia subericarpa* (Brink 2009). It is made up of four to eight species mostly trees (Bayer & Kubitzki 2003; Brink 2009; Burret 1926; Hutchinson 1967). The genus is currently placed in the tribe Grewieae in the subfamily Grewioideae alongside *Duboscia* Bocq., *Microcos* Linn. and *Grewia* Linn. in the expanded Malvaceae (Brunken & Muellner 2012). Many species of the genus occur in bushy places or in cleared or sunny borders of woods in the forest, woodland and savanna habitats while some of the species show a fair amount of adaptability to the surrounding environment (Burkill 2000; Hinsley 2006). The leaf is simple, dentate, serrate but rarely denticulate with persistent, subulately divided stipules. The inflorescence is a 4–10-flowered cyme with a boat-shaped sepal and very small petals. The large globose to ellipsoid and angular fibrous juicy ripe fruit of *Desplatsia* species are boiled to obtain a black dye used for cloth and stains like printers ink (Brink 2009). In west tropical Africa, the genus is represented by three species, viz. *Desplatsia chrysochlamys* (Mildbr. & Burret) Mildbr. & Burret., *Desplatsia dewevrei* (De Wild. & T. Durand) Burret., and *Desplatsia subericarpa* Bocq.

Previous systematics of *Desplatsia* species rest on floral, fruit and a few leaf morphological characters (Burret 1926; Cronquist 1981; Hutchinson & Dalziel 1954; Masters 1868). The phylogenetic relationship of the genus to other genera in the tribe Grewieae based on molecular data has been reported (Brunken & Muellner 2012). Anatomical data have provided valuable taxonomic information at the subfamily, tribe, generic and species levels for different groups of plants (Stuessy 2009), including the delimitation of species in the expanded Malvaceae family (Bayer & Kubitzki 2003). Nonetheless, the taxonomic significance of leaf anatomical features in providing characters of taxonomic value has been exclusively demonstrated by several workers (Carlquist 1961; Metcalfe & Chalk 1979). Many works have shown that the shape of epidermal cells, types and arrangement of stomata as well as the size, type, distribution and number of cells in trichomes are important taxonomic characters which can be used in delimiting species boundary (Shokefun et al. 2014b; Stace 1984). Also of taxonomic importance is the pollen features which have been utilised over the years in resolving phylogenetic relationship problems (Judd & Olmstead 2004; Perveen et al. 2004). The present study is, therefore, aimed at investigating the leaf

epidermis and pollen morphology of the three West African species of *Desplatsia*.

## Materials and methods

### Source of plant materials

Fresh plant specimens collected from different localities in Nigeria and herbarium specimens from the Forestry Herbarium Ibadan (FHI) were used for the study. The fresh specimens have been presented in the University of Ibadan Herbarium (UIH). Table 1 gives the list of specimens studied.

### Micro morphological study

#### Preparation of epidermal peel

The dried fresh and herbarium leaf specimens of the three species of *Desplatsia* were first rehydrated by soaking in boiled water for about 20 min before use. The specimens were cut at the median portions and soaked in concentrated Trioxonitrate (VI) acid for about 8 h, depending on the texture of the leaves according to the procedure described by Ibrahim et al. (2009). The appearance of air bubbles indicated the readiness of the epidermises to be separated. The samples were then transferred to Petri dishes containing water and with the use of fine forceps and dissecting needle the upper and lower epidermal cell surfaces were separated (Ibrahim et al. 2012). These were cleared with camel hair brush in water to remove residual mesophyll layers. The peels were stained with toluidine for 3–5 min, rinsed in water and mounted in glycerol on clean glass slides. The slides were observed and studied using the light microscope. Twenty-five measurements of each of the characters were taken at random. The stomata index (SI) was calculated using the formula (Salisbury 1927) see equation 1.

$$SI = \frac{S}{S + E} \times 100\%$$

where S = No. of stomata per unit area;

E = No. of epidermal cells in the same unit area. [Eqn 1]

#### Pollen morphology

The dried flower and floral buds from herbarium specimens were assessed for pollen morphology using acetolysis method according to Erdtman (1952, 1960), as described by

Shokefun et al. (2014a). The floral buds were crushed in a centrifuge tube. Three millilitres of freshly prepared acetolysis mixture (9 parts acetic anhydride to 1 part concentrated Tetraoxosulphate VI acid) was added to the content in the tube. The content was heated in a water bath from 70°C to boiling point and stirred occasionally. The centrifuge tubes and content were left in boiling water for 3 min and then centrifuged at 4000 rpm. for 5 min while still hot. The supernatant was decanted, washed with water and centrifuged repeatedly for four times. Fifty per cent glycerin was added and left standing for 2 h. The tubes were shaken vigorously using a whirl mixer and centrifuged at 4000 rpm. for 10 min. The supernatant was finally decanted off, and the tube was inverted over filter paper and left overnight. One hundred per cent glycerol was added to the tubes, shaken and poured into labelled storage vials. The pollen grains were mounted in unstained glycerin jelly. The slides were examined with a Fisher Scientific illumination microscope under (E 40; 0.65), oil immersion (E 100; 1.25), using  $\times 10$  eye piece. The pollen measurements were based on 20 records from each specimen. Microphotographs were taken using Leica CME with Digital Microscope Eyepiece attachment and Photo Explorer.

## Results

### Leaf epidermal surface

#### *Desplatsia chrysochlamy*

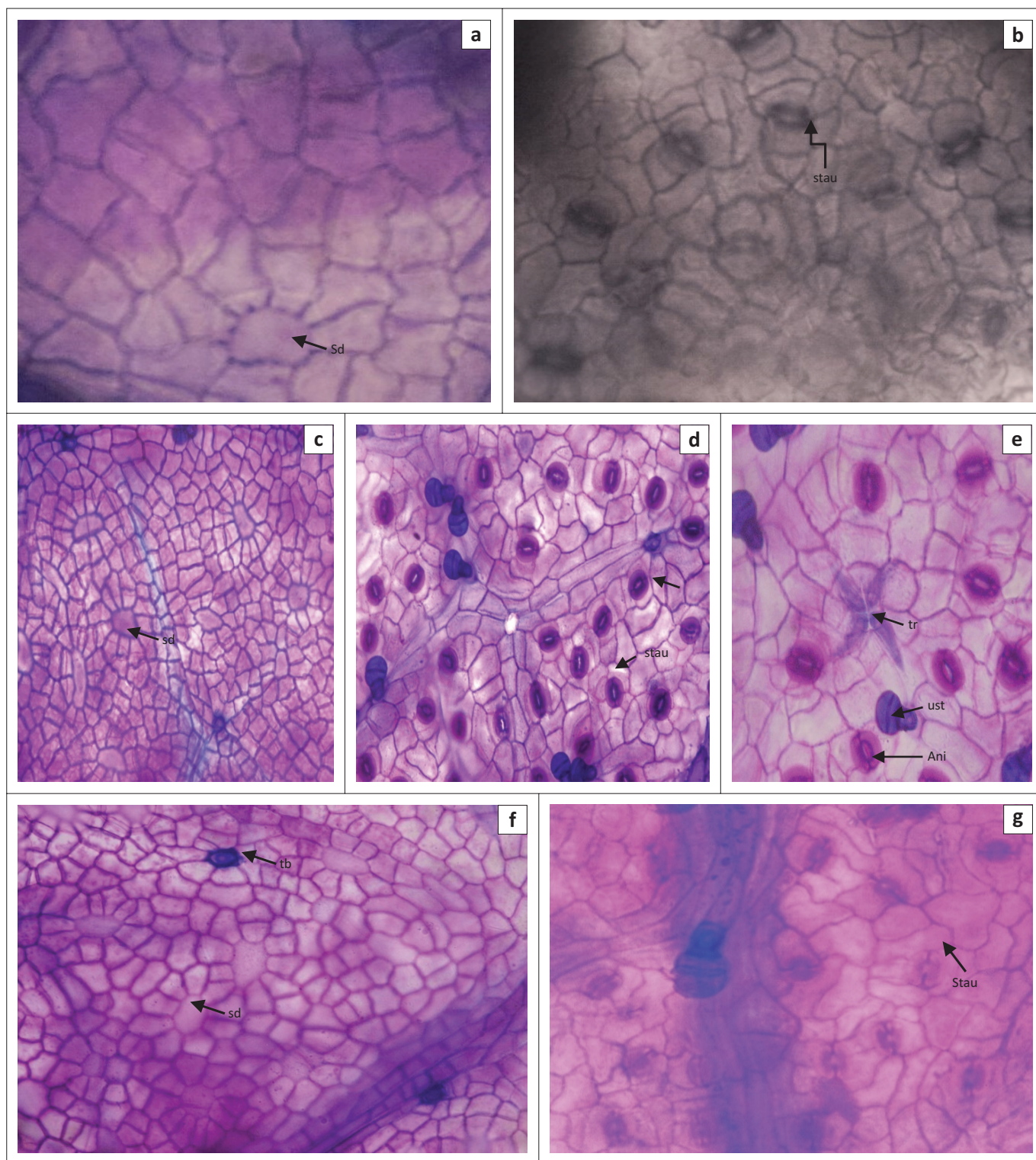
The epidermal cells on the adaxial surface are isodiametric, polygonal to irregular with straight curved to wavy anticlinal walls (Figure 1a). The epidermal cell width was 12.5  $\mu\text{m}$ –20.0  $\mu\text{m}$  and the number of epidermal cell count ranges from 480 to 600 per  $\text{mm}^2$  on the adaxial surface with 2.5  $\mu\text{m}$ –5.0  $\mu\text{m}$  cell wall thickness. The adaxial epidermal cells are striated. Stomata and crystals were absent on this surface. Two to three-celled head uniseriate and multicellular glandular trichomes were sparsely distributed on the adaxial surface. Secretory cavities were few on the adaxial surface (Figure 1a). The epidermal cells on the abaxial surface were polygonal to irregular with curved to wavy anticlinal walls (Figure 1b). The cell width was 10.0  $\mu\text{m}$ –12.5  $\mu\text{m}$  and the number of epidermal cell count ranges from 378 to 528 per  $\text{mm}^2$  on the abaxial surface. Uniseriate, two- to three-armed branched trichomes and two- to three-celled head uniseriate glandular

**TABLE 1:** List of *Desplatsia* specimens studied.

Serial number	Taxa	Locality	Collectors	Voucher number	Date
1.	<i>Desplatsia chrysochlamy</i>	Nsuaem, Takoradi, Ghana De Yapo forest, Abidjan, Ivory Coast	Enti and Agyakwah Boughey, A.S	FHI 24525 FHI 51791	19-5-1970 27-7-1954
2.	<i>Desplatsia dewevrei</i>	Ibadan, Oyo Nigeria Okomu, Edo state, Nig Akure, Ondo state, Nig Ijebu, Ogun state, Nig Onitsha, Anambra, Nig Niapidou west, Ivory Coast Queen Elizabeths forest, Akure, Ondo	A.P.D Jones Odewo, Olorunfemi, Ariwaodo R.W.J Keay Macauley, O Anetoh, G. Leeuwenberg, A.J.M Shokefun, E.O & Odewo	FHI 13639 FHI 101752 FHI 25494 FHI 17615 FHI 36427 FHI 51453 SEO 0010	22-10-1945 3-7-1984 28-10-1949 20-5-1967 1952 19-2-1959 13-12-2008
3.	<i>Desplatsia subericarpa</i>	Urhobo, Edo state, Nig Calabar, Cross River, Nig Akamkpa, Cross River, Nig Idanre, Ondo, Nig Ijebu-Ode, Ogun, Nig Tafo, Ghana FHI experimental plantation, Owena, Ondo	Ibhanesebhor, Adejimi Onochie C.F.A Daramola, O.O Magbagbeola, A Tamajing, S. Kodaiko Shokefun, E.O	FHI 82513 FHI 36347 FHI 104823 FHI 94815 FHI 20744 FHI 12912 SE 00001	8-11-1976 12-2-1957 16-2-1993 25-11-1980 20-11-1946 20-12-1945 23-10-2014

FHI, Forestry Herbarium Ibadan; Nig, Nigeria.





Ani, anisocytic stomata; sd, secretory duct; Stau, stauromorphic stomata; tb, trichome base; tr, trichome; ust, uniseriate trichome.

**FIGURE 1: Microphotograph of the leaf epidermal surfaces of West African species of *Desplatsia*.** (a) *Desplatsia chrysochlamy*, Adaxial showing secretory duct, straight, curved and wavy anticlinal cell wall; (b) abaxial surface showing stauromorphic stomata, polygonal and irregular epidermal cells (c) *D. dewevrei*, adaxial surface showing secretory ducts and polygonal or irregular epidermal cells; (d) abaxial surface showing stauromorphic stomata and trichome base on veins; (e) Abaxial showing curved to wavy anticlinal walls, 4-armed branched trichome, 2-celled head uniseriate glandular trichomes and anisocytic stomata; (f) *D. subericarpa* adaxial showing trichome base and secretory ducts; (g) abaxial surface showing stauromorphic stomata and uniseriate glandular trichome.

trichomes were recorded on the abaxial surface (Table 2). The species is hypostomatic with anisocytic and stauromorphic stomata types (Figure 1b). The stomata size was  $15.0 \mu\text{m} \times 13.0 \mu\text{m}$  and the SI was 17.2% while the stomata count per field of view was  $101 \text{mm}^{-2}$ – $132 \text{mm}^{-2}$  (Table 3).

#### *Desplatsia dewevrei*

On the adaxial surface, the epidermal cells were largely polygonal to irregular with curved to wavy anticlinal walls (Figure 1c). The epidermal cell width was  $7.5 \mu\text{m}$ – $17.5 \mu\text{m}$  while the number of epidermal cells ranged from 314 to

**TABLE 2:** Qualitative leaf epidermal characters of some *Desplatsia* species in West Africa.

Serial number	Taxa	Cell shape Adaxial	Abaxial	Anticlinal wall Adaxial	Abaxial	Types of trichome		Type of stomata	Cuticle ornamentation Adaxial	Abaxial
1.	<i>Desplatsia chrysochlamy</i>	Isodiametric, polygonal, irregular	Polygonal, irregular	Straight, curve, wavy	Curve/wavy	2&3-celled ust & mct	2&3-armed, 2&3-celled ust	Anisocytic, staurocytic	Striated	Not striate
2.	<i>Desplatsia dewevrei</i>	Polygonal, irregular	Polygonal, irregular	Curve, wavy	Curve/wavy	S, 2&3-armed, 2-celled ust	2&4-armed, Ss, 2-celled ust	Anisocytic, staurocytic	Not striated	Not striated
3.	<i>Desplatsia subericarpa</i>	Isodiametric, polygonal	Irregular	Straight, curve, wavy	Wavy	S, 2-armed, 2-celled ust	S, 2-armed, 2-celled ust	Anisocytic, staurocytic	Not striated	Not striated

mct, multicellular glandular trichome; Ss, sessile stellate; ust, uniseriate glandular trichome.

**TABLE 3:** Quantitative epidermal and stomata characters of some *Desplatsia* species in West Africa.

Serial number	Taxa	Epidermal cells						Stomata			Index %
		Number/mm <sup>2</sup>		Cell width		Thickness(μm)		Number/mm <sup>2</sup>	Size (μm)		
		Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial		Length	Width	
1.	<i>Desplatsia chrysochlamy</i>	480–600 590 ± 90.0	378–528 474 ± 54.3	12.0–20.0 16.8 ± 1.28	10.0–12.5 10.5 ± 0.40	2.5–5.0 4.5 ± 0.30	5.0 5.0 ± 0.00	101–132 119 ± 11.0	15.0–17.5 16.0 ± 0.02	10.0–15.0 13.0 ± 0.08	17.2
2.	<i>Desplatsia dewevrei</i>	314–430 387 ± 49.1	166–194 228 ± 13.1	7.5–17.5 12.1 ± 13.1	10.0–12.5 10.8 ± 0.05	2.5–5.0 4.5 ± 0.00	2.5 2.5 ± 0.00	84–93 89 ± 13.8	17.5–20.0 19.5 ± 0.50	15.0–17.5 15.6 ± 0.30	28.1
3.	<i>Desplatsia subericarpa</i>	289–323 306 ± 14.8	197–210 203 ± 5.03	10.0–25.0 17.5 ± 2.00	10.0–15.0 12.5 ± 1.00	2.5 2.5 ± 0.00	2.5 2.5 ± 0.00	52–77 62 ± 10.1	15.0–17.5 16.3 ± 0.50	10.0–15.5 12.0 ± 0.83	24.3

**TABLE 4:** Qualitative and quantitative pollen morphological characters of some *Desplatsia* species in West Africa.

Serial number	Taxa	Pollen shape	Exine surface	Colpi margo	Polar view (μm)	Equator view (μm)	Exine (μm)	Colpi length(μm)	Ora size (μm)		Lumina width(μm)	PA/ED%
									Width	Length		
1.	<i>Desplatsia chrysochlamy</i>	Subprolate	Baculate	Absent	39.0–41.5 40.1 ± 0.30	28.0–35.0 31.2 ± 0.60	1.2–1.8 1.5 ± 0.60	34.0–37.5 35.4 ± 0.56	1.7–2.5 2.1 ± 0.42	4.5–5.2 4.9 ± 0.19	1.8–3.5 2.6 ± 0.54	129
2.	<i>Desplatsia dewevrei</i>	Prolate	Perforated	Present	37.5–41.2 39.5 ± 0.35	26.2–32.5 29.0 ± 0.10	2.5–2.7 2.6 ± 1.00	25.0–35.0 31.7 ± 0.80	3.5–5.0 4.3 ± 0.25	10.0–12.5 11.3 ± 2.00	3.5–5.0 4.3 ± 1.10	136
3.	<i>Desplatsia subericarpa</i>	Prolate	Perforated	Present	37.5–47.5 43.0 ± 1.60	27.5–31.2 29.2 ± 0.25	2.5–3.0 2.8 ± 0.56	30.0–37.5 34.2 ± 0.69	3.7–7.5 5.6 ± 0.11	7.5–10.2 8.9 ± 1.13	2.2–4.3 3.3 ± 0.87	147

430 per mm<sup>2</sup> on the adaxial surface and cell wall thickness 2.5 μm–5.0 μm. Stomata and crystals were absent on this surface. Sparsely distributed two-celled head uniseriate glandular trichomes were present on the surface (Table 2). On the adaxial surface, secretory cavities were present and they are distributed throughout the surface. The shape of the epidermal cells on the abaxial surface is polygonal to irregular with curved to wavy anticlinal walls (Figure 1d). The epidermal cell width was 10.0 μm–12.5 μm and the number of epidermal cell ranged from 166 to 194 per mm<sup>2</sup> on the abaxial surface. The cell wall was 2.5 μm thick. Stellate sessile, two- to four-armed unbranched trichomes and two-celled head uniseriate glandular trichomes were present on the abaxial surface (Figure 1e). The species was hypostomatic with abundant elliptic shaped stomata that were anisocytic and staurocytic (Figure 1d and e). The stomata size was 19.5 μm × 15.6 μm and the SI was 28.1% while the stomata per field of view was 84 mm<sup>2</sup>–93 mm<sup>2</sup> (Table 3).

### *Desplatsia subericarpa*

Epidermal cells on the adaxial surface were isodiametric or polygonal with straight or curved anticlinal walls (Figure 1f). The cell width was 10.0 μm–25.0 μm and the number of epidermal cell ranged from 286 to 323 per mm<sup>2</sup> on the adaxial surface and 2.5 μm cell wall thickness. Stomata and crystals were absent on this surface. Two-celled head glandular trichomes and trichome bases were sparsely distributed on the adaxial surface (Figure 1f). However, short simple unbranched and two-armed branched trichomes were present on the adaxial midrib. Secretory cavities were found throughout the epidermal cells on the adaxial surface (Figure 1f).

On the abaxial surface, the epidermal cells were irregular with wavy anticlinal walls (Figure 1g). The epidermal cell width was 10.0 μm–12.5 μm while the number of epidermal cell ranged from 197 to 210 per mm<sup>2</sup> on the abaxial surface with thin cell wall. Simple unbranched trichomes and two-celled head uniseriate glandular trichomes (Figure 1g) were present on the abaxial surface. However, a two-armed branched trichome was sparsely recorded on the abaxial midrib. The species was hypostomatic with anisocytic and staurocytic stomata types (Figure 1g). The stomata size was 16.3 μm × 12.0 μm and the SI was 24.3% while the stomata per field of view was 52 mm<sup>2</sup>–77 mm<sup>2</sup> (Table 3).

## Pollen morphology

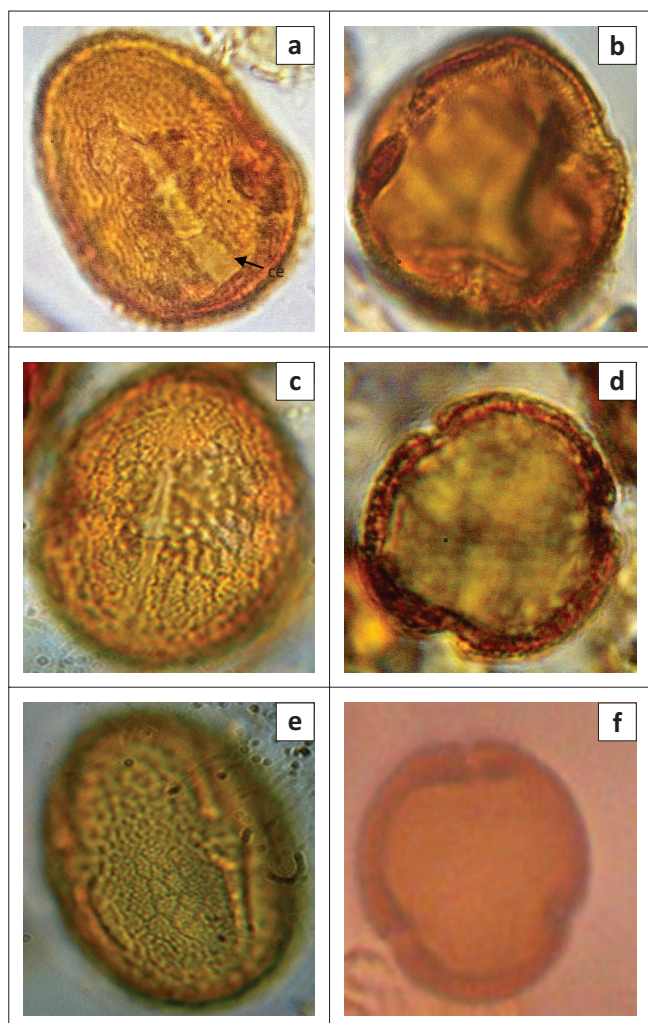
### *Desplatsia chrysochlamy*

Pollen grains were single, isopolar and subprolate; Polar view 40.1 (39–41.5) μm and Equatorial diameter 31.2 (28–35) μm, P/E ratio: 129 (Table 4). Colpi lack any visible margo; are long 35.4 (34–37.5) μm, wide (3.7 μm–8.7 μm) and have blunt and in some cases open ends (Figure 2a). Ora are la-longate 1.7 μm–2.5 μm wide and 4.5 μm–5.2 μm long. Pollen grains are three-colporate (Figure 2b); exine was comparatively thin (1.2 μm–2.0 μm); exine was coarsely reticulate; lumina are wide (1.8 μm–3.5 μm) and contain numerous bacules inside them; they are also bordered by numerous bacules forming the mural ridge.

### *Desplatsia dewevrei*

Pollen grains are single, isopolar and prolate. Polar view 37.5–(39.5)–41.2 μm; Equatorial diameter 26.2–(29.0)–32.5 μm,





(a)–(b) *Desplatsia chrysochlamy* equatorial and polar view showing open colpi end and tricolporate grain;

(c)–(d) *Desplatsia dewevrei* equatorial and polar view showing tricolporate grain;

(e)–(f) *Desplatsia subericarpa* equatorial and polar view showing tricolporate grain. Ce, Colpi end.

**FIGURE 2:** Microphotograph of the pollen grains of West African species of *Desplatsia*.

P/E ratio: 136 (Table 4). Colpi long, narrow with margo (Figure 2c). Ora la-longate, seldom lo-longate; Ora 3.5  $\mu\text{m}$ –5.0  $\mu\text{m}$  wide and 10.0  $\mu\text{m}$ –12.5  $\mu\text{m}$  long. Pollen grains three-colporate (Figure 2d); exine is 2.5  $\mu\text{m}$ –2.7  $\mu\text{m}$  thick; sexine thicker than nexine; exine was very coarsely reticulate, tectum perforated; lumina are large, (3.2  $\mu\text{m}$ –5.0  $\mu\text{m}$ ), prominent and angular or trapezoid-shaped.

### *Desplatsia subericarpa*

Pollen grains are single, isopolar and prolate. Polar view 37.5–(43.0)–47.50  $\mu\text{m}$ ; Equatorial diameter 27.5–(29.2)–31.2  $\mu\text{m}$ , P/E ratio: 147. Colpi with margo, long, narrow and taper to the poles (Figure 2e). Ora la-longate, 3.7  $\mu\text{m}$ –7.5  $\mu\text{m}$  wide and 7.5  $\mu\text{m}$ –10.3  $\mu\text{m}$  long. Pollen grains three-colporate (Figure 2f); exine is 2.5  $\mu\text{m}$ –3.0  $\mu\text{m}$  thick; sexine thicker than nexine (1  $\mu\text{m}$ –1.25  $\mu\text{m}$ ); exine is very coarsely reticulate, tectum perforated; lumina are medium sized (2.3  $\mu\text{m}$ –4.3  $\mu\text{m}$ ), prominent and angular or trapezoid-shaped with wavy mural ridges. Lumina with more or less same size at mesocolpium; lumina decrease in size towards colpi.

## Discussion

The three West African species of *Desplatsia* studied are exclusively lowland and are found in the high forest. *D. subericarpa* is an understory shrub to small tree while *D. chrysochlamy* and *D. dewevrei* are trees. The species have almost similar foliar epidermal characters with only few differences which points to the close inter-relationship among them. On the abaxial surface, epidermal cells are mostly polygonal to irregular with curved and wavy anticlinal walls. On the adaxial surface, isodiametric cell shapes occur in addition to other cell shapes in the taxa of most species except *D. dewevrei* (Figure 1e). The absence of isodiametric cell in *D. dewevrei* distinguished it from other taxa. Adedeji and Jewoola (2008), and Saheed and Illoh (2010) have shown that the varying sizes of foliar epidermal cells in plants could be characteristics and delimiting among closely related species. In this study, the epidermal cell diameter shows overlapping considerably on the abaxial surface and, hence, not taxonomically reliable. However, the lowest epidermal cell diameter on the adaxial surface of *D. dewevrei* is the characteristic of the species. The usefulness of leaf epidermal characters in solving taxonomic problems has been reported by many authors (Ayodele & Olowokudejo 2006; Kadiri & Ayodele 2003; Ogundipe & Ayodele 2000). The highest number of cell/ $\text{mm}^2$  and cell thickness on both surfaces separates *D. chrysochlamy* from the others. Variations in the epidermal cells also have been used taxonomically to include features of general epidermal cells, the stomata and trichomes (Bussoti & Grosson 1997). The hypostomatic nature of the three species of *Desplatsia* is probably an adaptation to water loss as it is an ecological advantage to survival as perennial plants.

Anisocytic and staurocytic stomata are encountered in the genus and stomata are mostly elliptic in all the species studied (Figure 1a–g). The stomatal size overlaps in *D. chrysochlamy* and *D. subericarpa*, hence, could only be used with caution. However, the largest stomatal size and highest stomatal index in *D. dewevrei* and the highest stomatal number and lowest stomatal index in *D. chrysochlamy* are of taxonomic significance in delimiting both species. *D. subericarpa* had the lowest number of stomata. Trichomes have been most employed taxonomically to compare species within a genus (Gonzales & Arbo 2004; Sonibare & Shokefun 2005; Zarre 2003). In this study, two-celled head glandular trichomes are peculiar to species in the genus. Nevertheless, the presence of three-celled head glandular trichomes and uniseriate branched trichomes as well as absence of simple unbranched trichomes in *D. chrysochlamy* separate it from the others while the presence of four-armed branched (Figure 1d) and stellate sessile trichomes distinguish *D. dewevrei* from *D. subericarpa*. The epidermal surfaces were devoid of crystals in all the species while secretory cavities were distributed throughout the epidermis on the adaxial surface. The result of the present investigation obviously shows that foliar epidermal characters could be employed to distinguish between species of *Desplatsia*.

Palynological evidence from this work shows similarity in the pollen characters of the taxa studied. The subprolate pollen shape, exine thickness of 1.5  $\mu\text{m}$  and absence of margo in the colpi and baculate tectum separated *D. chrysochlamy* (Figure 2a) from *D. dewevrei* and *D. subericarpa* which have prolate pollen shapes, colpi with margo and perforated tectum (Figure 2c and e). The usefulness of exine ornamentation patterns in the study of systematic and phylogenetic relationships involving subspecies, varieties and cultivars have been reported (Perveen et al. 2004). It must be reiterated, however, that David and Heywood (1963) and Moore et al. (1991) had opined that the shape of pollen grain is less useful taxonomically because it can vary considerably within one species and the variation may be caused by the extracting methods and embedding media used. *D. dewevrei* and *D. subericarpa* are only distinguished by the width of their lumen and ora sizes (Table 4); these same characters further separate them from *D. chrysochlamy*. The uniformity of pollen morphological characters observed in *D. dewevrei* and *D. subericarpa* is an indication of the closer inter-relationship between both species. The pollen characters obtained in this study correlate with the work of Perveen et al. (2004), which reported medium pollen size, tricolporate grains, perforate and coarsely reticulate tectum for the genus. The only deviation from Perveen et al. (2004) in this work is the occurrence of baculate tectum as against perforate tectum reported in *D. chrysochlamy*. Brunken and Muellner (2012) reported that *Desplatsia* and *Grewia* form a well-defined clade based on some morphological and anatomical correlation of molecular genetic clades. However, an additional synapomorphic analysis of the leaf epidermal and pollen grain morphology (comparable to that obtained in this present study) for some representative species of *Grewia* may be useful in making possible morphotypic discriminations among closely related genera to complement the molecular genetic phyletics. This work has provided basic information on foliar epidermal and pollen characters which could be employed in the identification of the three species of *Desplatsia* in West Africa. Based on the features observed with the light microscopy, an indented dichotomous key to the species of *Desplatsia* in West Africa is presented.

## Key to the species

1. Pollen subprolate; tectum non-perforated; exine 1.2  $\mu\text{m}$  – 1.8  $\mu\text{m}$ ; colpi margo absent; ora 2.1  $\mu\text{m}$   $\times$  4.9  $\mu\text{m}$ ; number of adaxial cells/ $\text{mm}^2$  480–600; simple unbranched trichomes absent, glandular trichome head up to three-celled and branched trichomes not more than three-armed. . . . . *D. chrysochlamy*
1. Pollen prolate; tectum perforated; exine 2.5  $\mu\text{m}$  – 3.0  $\mu\text{m}$ ; colpi margo present; ora 4.3–5.6  $\times$  8.9–11.3  $\mu\text{m}$ ; number of cells/ $\text{mm}^2$  289–430; simple unbranched trichomes present, glandular trichome head not more than two-celled and branched trichomes up to four-armed. . . . . 2
  2. Ora 4.3  $\mu\text{m}$   $\times$  11.3  $\mu\text{m}$ ; lumen 4.3  $\mu\text{m}$  wide; branched trichomes two to four-armed, stellate trichome present. . . . . *D. dewevrei*

2. Ora 5.6  $\mu\text{m}$   $\times$  8.9  $\mu\text{m}$ ; lumen 3.3  $\mu\text{m}$  wide; branched trichomes not more than two-armed, stellate trichome absent. . . . . *D. subericarpa*

## Conclusion

This study showed that the ora size, lumen width, epidermal cell and stomatal numbers obtained from both fresh and herbarium specimens of the three species of *Desplatsia* studied can be used as additional taxonomic characters to delimit species in the genus. However, a molecular study of the genus could further provide a detailed understanding of the phylogeny of the species.

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## Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

## Authors' contributions

E.O. initiated the project, and A.E. and E.A. are responsible for the project design. E.O. performed the leaf epidermal study. E.A. performed the pollen morphological study and A.E. performed herbarium morphological study and provided back ground information on the genus studied. The result, discussion, conclusion and finance was done by all the authors.

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