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Anatomical Studies of the Foliar Epidermis and Petiole of some *Lannea* Species in Jos, Plateau State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OEO designed the study, participated in the bench work and wrote the first draft of the manuscripts. Author LCE carried out field work, bench work, performed the statistical analysis. Author OAO reviewed the manuscripts. The three authors read and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Leaf epidermal morphology and petiole anatomy of seven *Lannea* species namely; *Lannea velutina, Lannea kerstingii, Lannea egregia, Lannea schimperii, Lannea acida, Lannea microcarpa,* and *Lannea edulis* in Nigeria were investigated to provide new taxonomic characters that could help in proper identification and delimitation of the taxa.
Place and Duration of Study: The study was carried out in the Department of Plant Science and Biotechnology, University of Jos, Nigeria between August 2020 and March 2021.
Methodology: Transverse sections of petioles were cut using a rotary microtome and epidermal peels were made. Staining was done using Safranin and slides observed using a light microscope.
Results: Stomatal distribution was hypostomatic except for *L. velutina* and *L. edulis* with amphistomatic distribution. Three stomata types are found; paracytic occurring in *L. velutina, L. edulis* and *L. egregia,* cyclocytic in *L. schimperii* and *L. microcarpa* and anomocytic in *L. kerstingii*

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and *L. acida.* Stomata index vary among taxa with *L. egregia* and *L. acida* having the highest (22.43%) and lowest (12.17%) respectively. The epidermal cell shape was polygonal in all the species and anticlinal wall patterns were straight to slightly curved. Unicellular/multicellular uniseriate trichomes were observed in *L. schimperii*, *L. egregia* and *L. kerstingii* distinguishing them from other species. Petiole outlines were circular to oval, epidermis was uniseriate and vascular bundles are collateral. Presence of continuous sclerenchyma rings surrounding the vascular bundles in *L. kerstingii* and *L. microcarpa* serve as a distinguishing character. Other distinguishing characters are presence of crystals, druses and phenolic idioblasts. A taxonomic key was produced using the anatomical character as an aid to the identification of the species.

Conclusion: Variations observed in the stomata types, petiole outline, petiole vasculature type, trichome type and stomata index could be employed for species identification and delimitation.

Keywords: Collateral; stomata; idioblasts; epidermis; trichome; delimitation.

1. INTRODUCTION

Anatomical data are of taxonomic value to researchers and have proven to be useful in the identification of small scraps of plants [1]. The foliar epidermis offers important taxonomic features and many taxonomic decisions have been made based on them. The epidermal characters of systematic value are stomata features, trichome types and epidermal cell complex [2]. These characters have aided in the proper understanding of the relationship among different taxa [3, 4]. The importance of petiole anatomy in understanding the relatedness within a plant group has been studied extensively and noted to be a region of consistency within the plant in which the median portion can be comparatively observed studied. Its usefulness as a complementary tool in plant taxonomy and systematics has increased recently and the petiole structures have been reported to exhibit differences within and between genera and species [5, 6].

The genus *Lannea* A.Rich, a member of the family Anacardiaceae contains about 40 species majorly trees, shrubs and under-shrubs. They are widely distributed in tropical Africa with three species extending into tropical Arabia and one species in southern Asia eastwards to China. Some *Lannea* species are used in indigenous medicine practice; the roots and bark of *Lannea* are used in the treatment of rachitic children, strained muscles and diarrhea. In Mali, *L.velutina* is used in treating chest pain, wounds, skin disease, respiratory tract diseases and gastric ulcer. The bark and root decoction of L. schimperi is used against chest pains, colds, diarrhea and dysentery in Malawi and Tanzania [7]. In Nigeria, the barks of *L. acida* is used in the treatment of hemorrhoids, dysentery and malnutrition [8]. In Ghana, the leaves of *L. acida* are mixed with those of *Mangifera indica* L. and *Azadirachta indica* A. Juss. for the treatment of malaria [9]. The plant decoction of *L. egregia* is used for treating diarrhea, epilepsy, rheumatism and gastric pains [10]. The bark, leaf and root decoction are used as ethno-veterinary medicine for blackleg, diarrhea, dysentery and fever in Ethiopia and Nigeria [11, 12]. The fruits of *L. acida* have a slightly acidic resinous, pleasant taste and are eaten raw or made into jam, juice and puddings [13]. *Lannea* species also provide timber that is used locally.

Previously, attempt has been done on the taxonomy of some species of the genus *Lannea*. AbdulRahaman [2] focused on the foliar epidermis of the species specifically the stomata complex, trichome type and epidermal cell complex while Elamin [14] focused on the wood anatomy of the genus and observed some wood anatomical characters that separated the species. Unfortunately, petiole anatomical study of the genus *Lannea* is still insufficient despite it been a morphologically diverse taxonomic group. This study therefore describes the leaf and petiole anatomy of seven *Lannea* species some of which have not been previously reported with the aim of providing additional data of taxonomic significance and using these characters for species identification and delimitation.

2. MATERIALS AND METHODS

2.1 Sample Collection

Samples of the seven *Lannea* species were collected from various locations within Jos, Plateau State. The plants were identified, authenticated and voucher specimens deposited at the Herbarium of the Federal College of Forestry, Jos, Plateau state Nigeria (Table 1).

Table 1. Voucher specimens of the studied *Lannea* species

Species name	Locality	Collection date	GPS coordinates	Voucher numbers
Lannea velutina A. Rich	Shere hills, Jos	25/08/2019	N09.93335□ E008.93505□ 1339 m	FHJ276
Lannea acida A. Rich	Shere hills, Jos	25/08/2019	N09.93414□ E008.93465□ 1348 m	FHJ280
Lannea egregia Engl. & K. Krause	Shere hills, Jos	25/08/2019	N09.92826□ E008.93186□ 1231m	FHJ283
Lannea kerstingii Engl. & K. Krause	Shere hills, Jos	25/08/2019	N09.92664□ E008.93448□ 1266m	FHJ278
Lannea microcarpa Engl. & K. Krause	Shere hills, Jos	25/08/2019	N09.93208□ E008.93509□1308 m	FHJ279
Lannea edulis (Sond.) Engl.	Shere hills, Jos	25/08/2019	N09.93405□ E008.93489□ 1332 m	FHJ281
Lannea shimperii (Hochst. Ex A. Rich.) Engl.	Dang-kang, LGA Plateau state	16/09/2019	N09.08989□ E009.76665□ 506m	FHJ284

2.2 Sample Preparation and Analysis

The epidermal peels of both the adaxial and abaxial surfaces of the leaves of each plant were made. The leaf materials were cut (2-5 cm) and soaked in concentrated trioxonitrate (v) acid (HNO_3) in a glass petri dish, covered and allowed to stand for 3 hours. The epidermises were separated with forceps, rinsed in distilled water and stained in Safranin solution. The epidermises were transferred into 50 % ethanol for 1-2 minute(s) to remove excess stains, afterwards mounted in 25 % diluted glycerine [15]. The parameters observed include; stomatal distribution, stomata type, epidermal cell shape. Anticlinal wall pattern, trichome type while the quantitative character measured are stomata length, stomata width, epidermal length and width. Stomata index was calculated using the formula of Stace [16].

Stomata Index (S.I) = S/E+S X 100

Where,

S=Stomata number per unit area

E=Epidermal cell number per unit area

For the study of the petiole anatomy of the species, transverse sections of 5-10 µm thickness from the median regions for each of the species were obtained using a rotary microtome. The sections were stained in 10 % aqueous Safranin solution, counter stained in lactophenol and mounted in diluted glycerine [17]. Specimen slides were observed using light microscopy and photomicrographs were captured under magnification of X400 and X100 using Olympus microscope with attached celestron digital camera. Petiole characters observed include petiole outline, cortex layers, vascular bundle type, petiolar vasculature type and cell inclusions (druses, crystals and phenolic idioblast). The identification and description of tissue and cell followed Fahn [18].

3. RESULTS AND DISCUSSION

Detailed foliar epidermal and petiole anatomy of the seven species studied are presented below. The qualitative and quantitative features of the epidermises and petioles are presented in Tables 2-4, accompanying photomicrographs in Plates (1-7).

3.1 Lannea Velutina

3.1.1 Foliar epidermis

The leaf is amphistomatic, with more stomata on the adaxial than the abaxial surface. On the abaxial surface, the stomata type is paracyctic, stomata index 15.74 %, mean length and width of stomata up to 1.50 µm and 0.92 µm respectively. Epidermal cells are polygonal and anticlinal walls are straight to slightly curve, mean length and width of cells up to 3.96 µm and 2.88 µm respectively (Plate 1A). However, on the adaxial surface (Plate 1B), stomata type is paracytic, stomata index 14.99 %, mean stomata number 23, mean length and width of stomata up to 1.44 µm and 0.86 µm respectively. epidermal cells are polygonal with straight to slightly curve anticlinal walls, mean length and width of cells up 4.62 µm and 2.98 µm respectively.

3.1.2 Petiole anatomy

Petiole outline is oval and epidermis is uniseriate. Collenchyma cells are oval, 13-20 layers below the epidermis and parenchyma cells are oval, 8-12 layers. Vascular bundle is collateral, 14 in number and surrounded by 3 layers of discontinuous sclerenchyma rings. The median bundle has 4 strands of xylem. Petiolar vasculature type is closed. Phenolic idioblasts are randomly distributed on the cortex and vascular bundles (Plates 1C-D).

3.2 Lannea Acida

3.2.1 Foliar epidermis

The leaf is hypostomatic, with stomata on the abaxial surface only. On the abaxial surface, the stomata type is anomocytic, stomata index 12.17 %, mean length and width of stomata up to 2.80 µm and 1.90 µm respectively. Epidermal cells are polygonal and anticlinal walls are slightly curve, mean length and width of cells up to 7.50 µm and 4.30 µm respectively (Plate 2A). However, on the adaxial surface (Plate 2B), epidermal cells are polygonal with slightly curve anticlinal walls, mean length and width of cells up 7.68 µm and 3.90 µm respectively.

3.2.2 Petiole anatomy

Petiole outline is circular and epidermis is uniseriate. Collenchyma cells are oval, 11-15 layers below the epidermis and parenchyma cells are oval to circular, 12-14 layers. Vascular bundle is collateral, 7 in number and surrounded by 2 layers of discontinuous sclerenchyma rings. The median bundle has 5 strands of xylem.

Petiolar vasculature type is closed. Druses are randomly distributed on the cortex (Plates 2C-D).

3.3 Lannea Schimperii

3.3.1 Foliar epidermis

The leaf is hypostomatic, with stomata on the abaxial surface only. On the abaxial surface, the stomata type is cyclocytic, stomata index 15.68 %, mean length and width of stomata up to 2.56 µm and 0.96 µm respectively. Unicellular uniseriate trichomes present, mean trichome length and width 21.92 µm and 1.08 µm respectively. Epidermal cells are polygonal and anticlinal walls are straight, mean length and width of cells up to 4.02 µm and 5.20 µm respectively (Plate 3A). However, on the adaxial surface (Plate 3B), epidermal cells are polygonal with straight anticlinal walls, mean length and width of cells up 3.52 µm and 2.94 µm respectively. Unicellular uniseriate trichomes present, mean trichome length and width 21.66 µm and 2.52 µm respectively.

3.3.2 Petiole anatomy

Petiole outline is oval and epidermis is uniseriate, having multicellular uniseriate trichomes. Collenchyma cells are angular, 7-8 layers below the epidermis and parenchyma cells are angular, 12-16 layers. Vascular bundle is collateral, 10 in number and surrounded by 2 layers of discontinuous sclerenchyma rings. The median bundle has 5 strands of xylem. Petiolar vasculature type is closed. Phenolic idioblasts and crystals are randomly distributed on the cortex and vascular bundles (Plates 3C-D).

3.4 Lannea Egregia

3.4.1 Foliar epidermis

The leaf is hypostomatic, with stomata on the abaxial surface only. On the abaxial surface, the stomata type is paracytic, stomata index 22.43 %, mean length and width of stomata up to 2.00 µm and 0.76 µm respectively. Unicellular uniseriate trichomes present, mean trichome length and width 16.06 µm and 0.94 µm respectively. Epidermal cells are polygonal and anticlinal walls are straight, mean length and width of cells up to 6.70 µm and 4.78 µm respectively (Plate 4A). However, on the adaxial surface (Plate 4B), epidermal cells are polygonal with straight anticlinal walls, mean length and width of cells up 6.80 µm and 4.00 µm respectively.

3.4.2 Petiole anatomy

Petiole outline is circular and epidermis is uniseriate, having unicellular uniseriate trichomes. Collenchyma cells are angular, 5-6 layers below the epidermis and parenchyma cells are angular, 10 layers. Vascular bundle is collateral, 9 in number and surrounded by 4 layers of discontinuous sclerenchyma rings. The median bundle has 4 strands of xylem. Petiolar vasculature type is open (Plates 4C-D).

3.5 Lannea Edulis

3.5.1 Foliar epidermis

The leaf is amphistomatic, with stomata on both abaxial and adaxial surfaces. On the abaxial surface, the stomata type is paracyctic, stomata index 17.59 %, mean length and width of stomata up to 1.90 µm and 0.88 µm respectively. Epidermal cells are polygonal and anticlinal walls are slightly curve, mean length and width of cells up to 6.82 µm and 4.28 µm respectively (Plate 5A). However, on the adaxial surface (Plate 5B), stomata type is paracytic, stomata index 17.52 %, mean stomata number 23, mean length and width of stomata up to 2.22 µm and 1.02 µm respectively. epidermal cells are polygonal with straight anticlinal walls, mean length and width of cells up 7.06 µm and 2.38 µm respectively.

3.5.2 Petiole anatomy

Petiole outline is circular and epidermis is uniseriate. Collenchyma cells are angular, 13-14 layers below the epidermis and parenchyma cells are angular, 6-7 layers. Vascular bundle is collateral, 15 in number and surrounded by 3 layers of discontinuous sclerenchyma rings. The median bundle has 4 strands of xylem. Petiolar vasculature type is closed. Druses are randomly distributed on the cortex (Plates 5C-D).

3.6 Lannea Microcarpa

3.6.1 Foliar epidermis

The leaf is hypostomatic, with stomata on the abaxial surface only. On the abaxial surface, the stomata type is cyclocytic, stomata index 17.09 %, mean length and width of stomata up to 2.14 µm and 0.78 µm respectively. Epidermal cells are polygonal and anticlinal walls are straight to slightly curve, mean length and width of cells up to 7.22 µm and 4.66 µm respectively (Plate 6A). However, on the adaxial surface (Plate 6B), epidermal cells are polygonal with straight to slightly curve anticlinal walls, mean length and width of cells up 10.40 µm and 7.56 µm respectively.

Table 2. Stomatal features in the studied *Lannea* species

Taxa	stomata length		Stomata width		Stomata index		Stomata type	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
Lannea velutina	1.44±0.09[a]	1.50±0.48[a]	0.86 ± 0.06[a]	0.92 ± 0.07[b]	14..99[a]	15.74[c]	Paracytic	Paracytic
Lannea acida	-	2.80±0.28[e]	-	1.90 ± 0.12[d]	-	12.17[a]	-	Anomocytic
Lannea schimperii	-	2.56±0.29[d]	-	0.96 ± 0.09[b]	-	15.68[c]	-	Cyclocytic
Lannea egregia	-	2.00±0.09[c]	-	0.76 ± 0.14[a]	-	22.43[e]	-	Paracytic
Lannea edulis	2.22±0.23[b]	1.90±0.12[b]	1.02 ± 0.11[b]	0.88 ± 0.09[b]	17.52[b]	17.59[d]	Paracytic	Paracytic
Lannea microcarpa	--	2.14±0.16[c]	-	0.78 ± 0.08[a]	-	17.09[c]	-	Cyclocytic
Lannea kerstingii	-	1.76±0.08[a]	-	1.16 ± 0.07[c]	-	13.29[b]	-	Anomocytic

**Measurements= Mean±SE*

Mean values with the same letter(s) in a column are not significantly different at $p < 0.05$.

Table 3. Epidermal and trichome features in the studied *Lannea* species

Taxa	Epidermal cell shape		Anticlinal wall pattern		Trichome type	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
Lannea velutina	Polygonal	Polygonal	Straight/slightly curve	Straight/slightly curve	Absent	Absent
Lannea acida	Polygonal	Polygonal	slightly curve	slightly curve	Absent	Absent
Lannea schimperii	Polygonal	Polygonal	Straight	Straight	Unicellular uniseriate	Unicellular uniseriate
Lannea egregia	Polygonal	Polygonal	Straight	Straight	Absent	Unicellular uniseriate
Lannea edulis	Polygonal	Polygonal	Straight	slightly curve	Absent	Absent
Lannea microcarpa	Polygonal	Polygonal	Straight/slightly curve	Straight/slightly curve	Absent	Absent
Lannea kerstingii	Polygonal	Polygonal	Straight/slightly curve	Straight/slightly curve	Absent	Multicellular uniseriate

Table 4. Qualitative Anatomical Characters of the petioles of the *Lannea* species

Species	Petiole Characters								
	Petiole outline	Epidermis	Sclerenchyma ring type	Vascular bundle	PVT	Trichome type	Druses	Crystals	Phenolic idioblasts
L.microcarpa	Oval	Uniseriate	Continuous	Collateral	Closed	Absent	Present	Present	Absent
L.schimperii	Oval	Uniseriate	Discontinuous	Collateral	Closed	Multicellular uniseriate	Absent	Present	Present
L.edulis	Circular	Uniseriate	Discontinuous	Collateral	Closed	Absent	Present	Absent	Absent
L.egregia	Circular	Uniseriate	Discontinuous	Collateral	Open	Unicellular uniseriate	Absent	Absent	Absent
L.acida	Circular	Uniseriate	Discontinuous	Collateral	Closed	Absent	Present	Absent	Absent
L.velutina	Oval	Uniseriate	Discontinuous	Collateral	Closed	Absent	Absent	Absent	Present
L.kerstingii	Circular	Uniseriate	Continuous	Collateral	Closed	Multicellular uniseriate	Absent	Absent	Present

**PVT=Petiolar vasculature type*

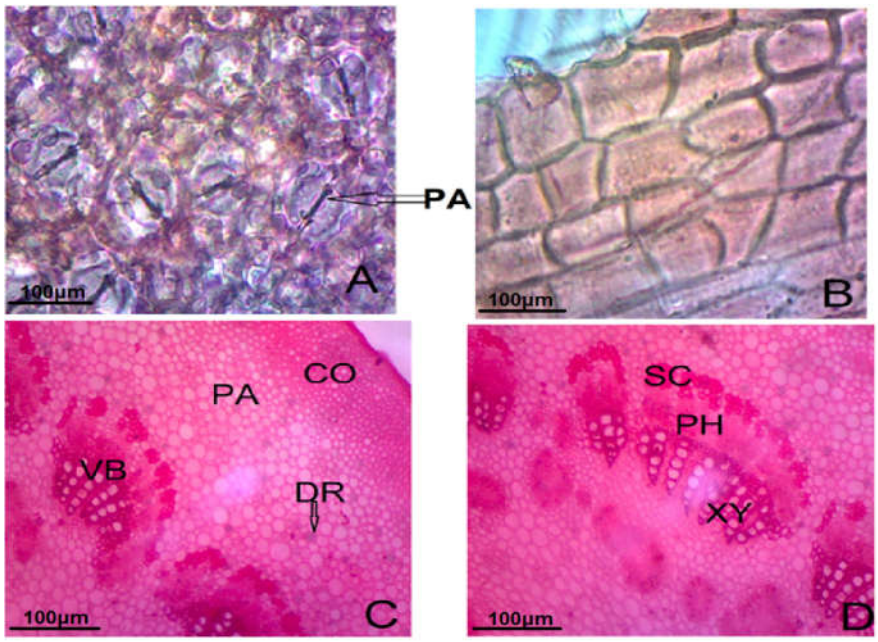

Plate 1. (A-D)-Epidermal and petiole of anatomical features *Lannea velutina*: PS-paracytic stomata, CO-collenchyma, PA-parenchyma, VB-vascular bundle, DR-druses, XY-xylem, PH-phloem, SC-sclerenchyma

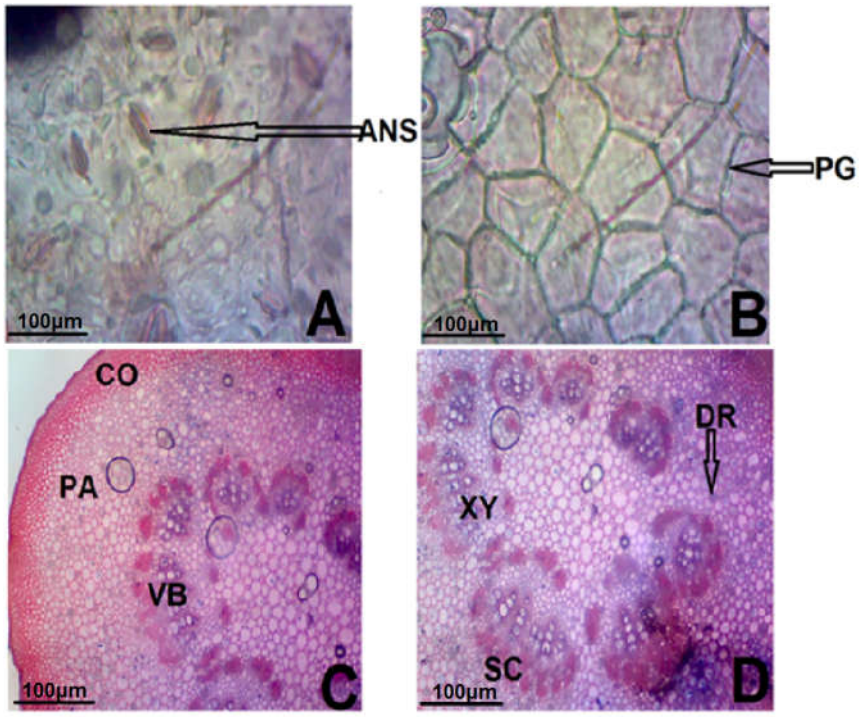

Plate 2. (A-D)-Epidermal and petiole of anatomical features *Lannea acida*: ANS-anomocytic stomata, PG-polgonal cell, CO-collenchyma, PA-parenchyma, VB-vascular bundle, DR-druses, XY-xylem, SC-sclerenchyma

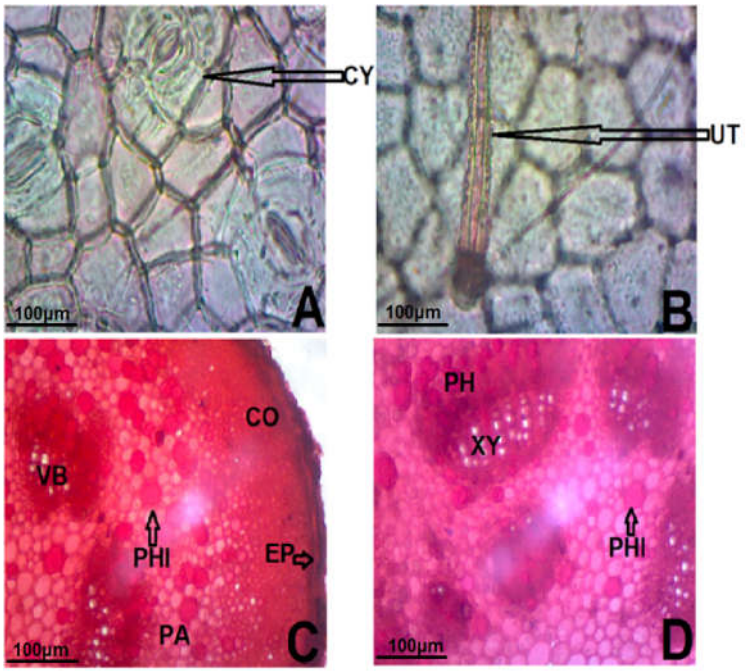

Plate 3. (A-D)-Epidermal and petiole of anatomical features *Lannea schimperii*: CY-cyclocytic stomata, Unicellular trichome, EP-epidemis, PHI-phenolic idiopblast, CO-collenchyma, PA-parenchyma, VB-vascular bundle, XY-xylem

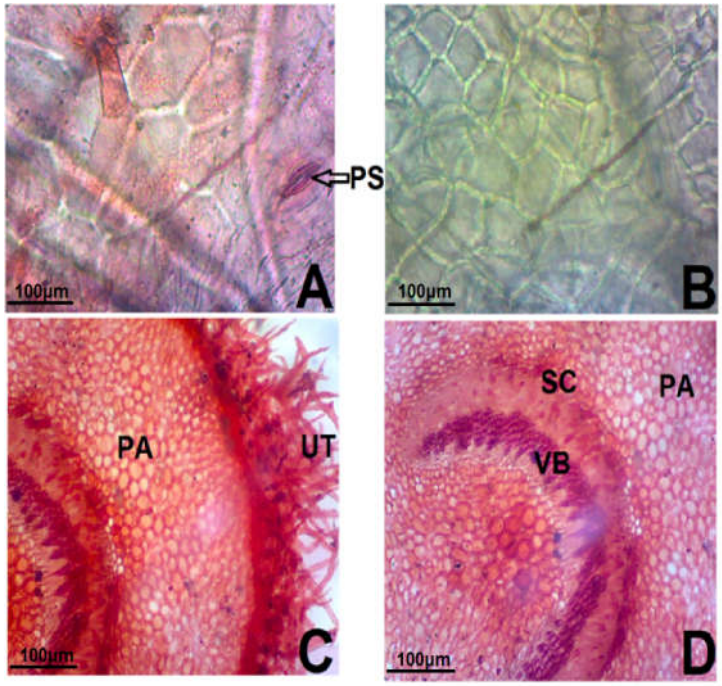

Plate 4. (A-D)-Epidermal and petiole of anatomical features *Lannea egregia*: PS-paracytic stomata, UT-Unicellular trichome, PA-parenchyma, VB-vascular bundle, SC-sclerenchyma

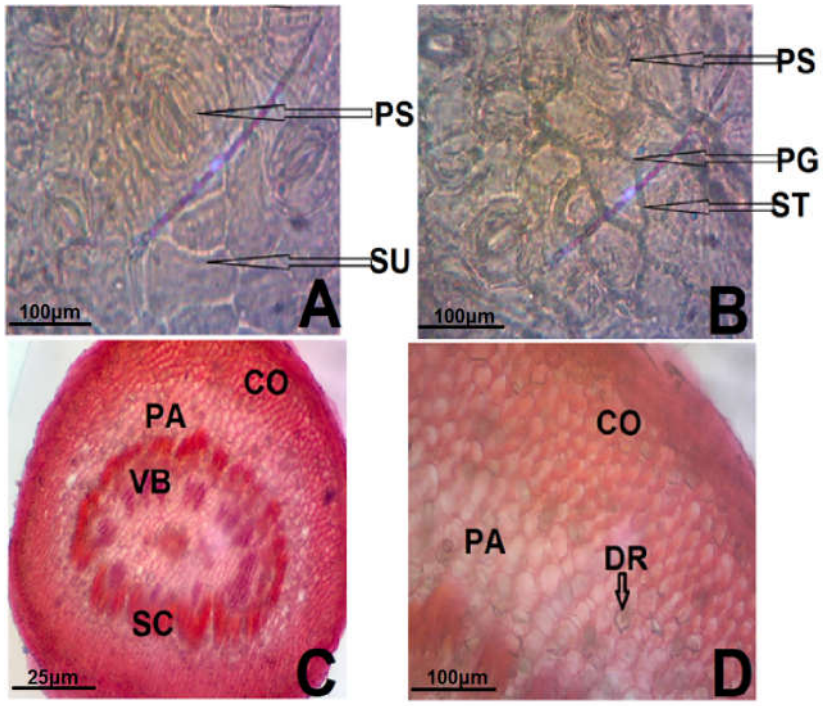

Plate 5. (A-D)-Epidermal and petiole of anatomical features *Lannea edulis*: PS-paracytic stomata, ST-straight cell wall, PG-polygonal cell, CO-collenchyma, PA-parenchyma, VB-vascular bundle, DR-druses, SU-slightly curve, SC-sclerenchyma

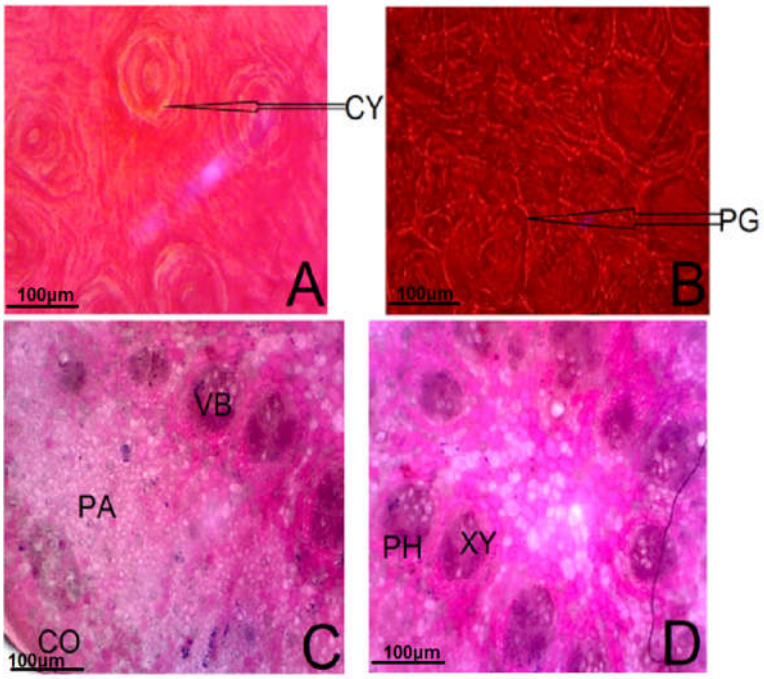

Plate 6. (A-D)-Epidermal and petiole of anatomical features *Lannea microcarpa*: CY-cyclocytic stomata, PG-polygonal cell, CO-collenchyma, PA-parenchyma, VB-vascular bundle, XY-xylem, PH-phloem

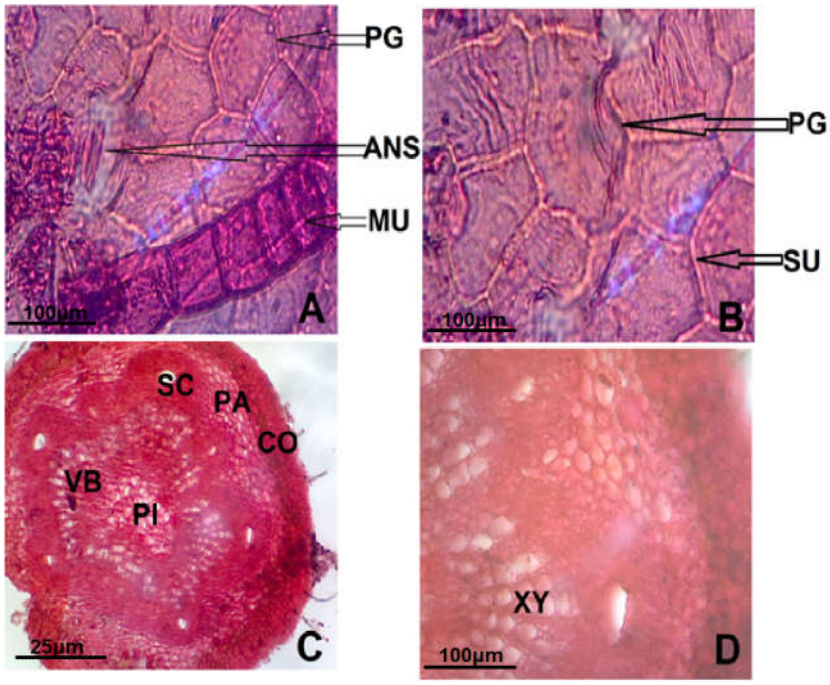

Plate 7. (A-D)-Epidermal and petiole of anatomical features *Lannea kerstingii*: ANS-anomocytic stomata, MU-Multicellular trichome, PG-polygonal cell, SU-slightly curve, PI-pith, CO-collenchyma, PA-parenchyma, VB-vascular bundle, SC-sclerenchyma, XY-xylem

3.6.2 Petiole anatomy

Petiole outline is oval and epidermis is uniseriate. Collenchyma cells are oval to angular, 9-11 layers below the epidermis and parenchyma cells are oval to angular, 9-16 layers. Vascular bundle is collateral, 16 in number and surrounded by 2 layers of continuous sclerenchyma rings. The median bundle has 6 strands of xylem. Petiolar vasculature type is closed. Druses and crystals are randomly distributed on the cortex and pith (Plates 6C-D).

3.7 Lannea Kerstingii

3.7.1 Foliar epidermis

The leaf is hypostomatic, with stomata on the abaxial surface only. On the abaxial surface, the stomata type is anomocytic, stomata index 13.29 %, mean length and width of stomata up to 1.70 µm and 1.16 µm respectively. Multicellular uniseriate trichomes present, mean trichome length and width 6.46 µm and 1.04 µm respectively. Epidermal cells are polygonal and anticlinal walls are straight to slightly curve, mean length and width of cells up to 2.96 µm and 1.60 µm respectively (Plate 7A). However, on the adaxial surface (Plate 7B), epidermal cells are polygonal with straight to slightly curve anticlinal walls, mean length and width of cells up 3.18 µm and 1.52 µm respectively.

3.7.2 Petiole anatomy

Petiole outline is circular and epidermis is uniseriate, having multicellular uniseriate trichomes. Collenchyma cells are oval, 6-8 layers below the epidermis and parenchyma cells are oval, 5-6 layers. Vascular bundle is collateral, 7 in number and surrounded by 2 layers of continuous sclerenchyma rings. The median bundle has 4 strands of xylem. Petiolar vasculature type is closed. Phenolic idioblasts randomly distributed on the cortex (Plates 7C-D).

Anatomical data has long been recognized in plant systematics and are used as taxonomic tool since variation among taxa is usually reflected in anatomical characters [19]. Many researchers including Aworinde et al. [20], Akinnubi et al. [6], Chukwuma et al. [21] opined that leaf epidermal characters such as stomata type, distribution and size, epidermal cell, presence or absence of trichomes and other cell inclusions are useful tools and have provided supplementary data of

taxonomic importance. Also, Nurui-Aimi et al. [22], Santos et al. [23] and Noraimi et al. [24] opined that petiole anatomical characters such as number, shape and arrangement of vascular bundles and petiole outline are consistent in angiosperms and could be used in plant identification and classification.

This study shows a number of important anatomical characters on the leaf surfaces and petiole sections of *Lannea* species. Although, new characters not previously reported were observed especially in the petiole anatomy, however, the foliar epidermises agreed with previous studies. Ogunkunle and Oladele [25] and AbdulRahaman and Oladele [26] reported that epidermal characters represent genetic variations and have been used to solve some taxonomic problems in some plant groups.

The presence of hypostomatic stomatal distribution on the leaf surfaces of five *Lannea* species studied is in agreement with AbdulRahaman et al. [2] who also observed hypostomatic stomatal distribution in the *Lannea* species studied. The presence of anomocytic and cyclocytic stomata types in the *Lannea* species corroborates the report of AbdulRahaman et al. [2], however the presence of paracytic stomata in *L. velutina* and *L. edulis* contradicts the work of AbdulRahaman et al. [2] who observed only cyclocytic and anomocytic stomata types in the *Lannea* species studied. Davies and Heywood [27] opined that stomatal size was too variable as a diagnostic feature, however, Adedeji and Jewoola [28] and Essiett and Akpabio [29] implied that stomatal size can occasionally be used as a distinguishing character because it shows a wider range in some species than in others and have documented its systematic relevance. Stomata size was lowest and highest in *L. velutina* and *L. acida* respectively. Furthermore, the lowest and highest stomata indices were observed in *L. acida* and *L. egregia* respectively. This study corroborates the report of Adedeji and Jewoola [28] and Essiett and Akpabio [29] indicating that stomata sizes vary and could serve as distinguishing character among the species.

The appearance of the stomata on the leaf surfaces and stomata types varied among the studied species and these could serve as distinguishing factors. Based on the stomatal complex, the studied species can be separate into four groups; *L. velutina* and *L. edulis* with amphistomatic leaf surface and paracytic stomata type differ from other species. Also, *L. Kerstingii* and *L. acida* with hypostomatic surface and anomocytic stomata type can be easily distinguished from other species studied. Similarly, *L. schimperii* and *L. microcarpa* are hypostomatic with cyclocytic stomata type are separated from other species. However, *L. egregia* is hypostomatic with paracycic stomata distinguishing it from other members of this genus.

The presence of polygonal epidermal cell shape in the *Lannea* species studied corroborates the reports of AbdulRahaman et al. [2] who also observed polygonal cell shape in the *Lannea* species, however the presence of slightly curved anticlinal walls contradicts their observation of round anticlinal walls.

Huan-Fang et al. [30] reported that the type, presence or absence, size and distribution of trichomes are important diagnostic characters in plant identification and classification. Similarly, the presence and absence of trichomes can be used in characterizing the studied *Lannea* species. The presence of unicellular and/or multicellular uniserate trichomes on the leaf surfaces of *L. Kerstingii, L. schimperii* and *L. egregia* distinguished them from *L. velutina, L. edulis, L. microcarpa*, and *L. acida* with no trichomes.

Petiole anatomy has been utilized for solving taxonomic problems and characters such as petiole outline, layers of collenchyma, sclerenchyma and parenchyma cells, arrangements and types of vascular bundles and trichome distributions have been reported by some researchers including Ogundipe and Olatunji [31] and Adedeji and Illoh [32] as useful tools in the identification and delimitation of plant taxa.

The presence of oval to circular petiole outline, one layered epidermis, parenchymatous cortex and closed to open petiolar vasculature system in the studied species is in agreement with Sharma et al. [33] and Cahyanto et al. [34] who observed these characters in the Anacardiaceae species studied.

The presence of trichome on the petioles of *L. Kerstingii, L. schimperri* and *L. egregia* distinguished them from the other species without trichomes. Furthermore, the presence of layers of continuous sclerenchyma rings surrounding the vascular bundles in *L. microcarpa* and *L. Kerstingii,* separate them from

the other species with discontinuous sclerenchyma rings surrounding the vascular bundles. Similarly, the presence of phenolic idioblasts on the parenchyma cells of *L.velutina*, *L.schimperii* and *L. kerstingii* distinguished them from other species.

An artificial key to the studied *Lannea* species using leaf epidermal and petiole anatomical characters is provided for easy species identification

1a. Amphistomatic stomatal distribution, oval petiole outline…….....2
2a. Stomata length 1.44-1.50 µm, stomata width 0.86-0.92 µm, phenolic idioblast present……***L. velutina***
2b. Stomata length 1.90-2.22 µm, stomata width 0.88-1.02 µm, phenolic idioblast absent…….....***L. edulis***
1b. Hypostomatic stomatal distribution, circular petiole outline……..……..….3
3a. Trichome present on foliar epidermis, collenchyma cells 5-8 layers.....4
4a. Multicellular trichome present, trichome length 5.6-7.4 µm, trichome width 0.60-1.60 µm.....***L. kerstingii***
4b. Unicellular trichome present, trichome length 4.00-30.00 µm, trichome width 0.60-5.00 µm ……...5
5a. Stomata type paracytic, petiolar vasculature open, sclerenchyma 8-9 layers…….***L. egregia***
5b. Stomata type cyclocytic, petiolar vasculature closed, sclerenchyma 2 layers ……..……..…..***L. schimperii***
3b. Trichome absent on foliar epidermis, collenchyma cells 9-15 layers…..……...6
6a. Sclerenchyma ring continuous, stomata type cyclocytic, crystals present…….……..***L. microcarpa***
6b. Sclerenchyma ring discontinuous, stomata type anomocytic, crystals absent ……....***L. acida***

4. CONCLUSION

Understanding the high-value taxonomic characters of the Lannea leaves is an important systematic consideration in studying the group. The leaf epidermal and petiole anatomical features are said to be taxonomically significant because of the differences that occur among the studied species. The diagnostic features used for species delimitation and identification include stomata type, stomata index, stomata size, trichome type, petiole outline, petiole vasculature type, type of sclerenchyma rings and presence of phenolic idioblasts. These characters have not been considered wholistically in the grouping of the Lannea species, and we believe our results have revealed them to be strong enough to provide useful insights on infrageneric relationship within the group.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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