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Morphological and Anatomical Studies on *Buchholzia coriacea* Engl. (Capparaceae) Endemic to West Africa

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Abstract:

Morpho-anatomical and distributional studies of *Buchholzia coriacea* Engl., an endemic species to West Africa, were conducted based on herbaria and fresh samples using physical observation and microtomy. This species is hypostomatic with anomocytic and tetracytic stomata in random distribution on the abaxial surface, and is covered by non-glandular hairs. The subsidiary cells are distinct, epidermal cells polygonal in shape, and the anticlinal walls straight or curved. Abaxial epidermal cells measured 4.139 ± 1.28 µm long and 2.21 ± 0.39 µm wide and the adaxial ones 4.52 ± 0.59 µm long, and 2.74 ± 0.34 µm wide. Guard cells are often equal in size, oval, and with abaxial stomatal index (SI) 36.36. The mesophyll comprised spongy and palisade mesophylls. The palisade parenchyma cells are arranged in rows of 2-3 layers, while the palisade parenchyma cells have 7-8 layers with many intercellular air spaces and a bundle sheath embedded in them. Sclereids and fibre cells occurred in a discontinuous ring outside the secondary phloem. *Buchholzia coriacea* exhibited a latitudinal distribution across the transitional equatorial region of Nigeria which suggests that it is confined to the tropical areas and may not thrive in drier parts. Currently, its conservation status remains unknown and has not been assessed by the IUCN. Therefore, its sustainable collection and use are of paramount importance not only to the Nigerian society, but also to the world at large mainly to face the global climate change resulting from human anthropogenic activities and also because of the medicinal properties of this species.

Keywords: Anatomy**,** *Buchholzia coriacea,* Capparaceae**,** Hypostomatic**.**

Introduction

Buchholzia (Capparaceae) comprises only two species worldwide namely *Buchholzia tholloniana* Hua (synonym: *Buchholzia macrothyrsa* Gilg) and *Buchholzia coriacea* Engl. (synonym: *Buchholzia macrophylla* Pax). *Buchholzia coriacea* is the only species occurring in West Africa (Hutchinson and Dalziel, 1954). These species have close morphological attributes and similar medicinal uses (Lemmens, 2013). *Buchholzia coriacea*is endemic to West Africa and is distributed in the rain forest zone across Nigeria, Ghana, the Central African Republic, Gabon, Congo, Angola, Liberia (Hutchinson and Dalziel, 1954; Ezekiel and Onyeoziri, 2009; Ijarotimi *et al.,* 2015).

Published reports show that much work has been carried out on many genera under this family. Aleykutty and Inamdar (1978) reported the structure, ontogeny, and taxonomic significance of trichomes and stomata in some Capparaceae. El-Ghani *et al.,* (2007) illustrated the taxonomic significance of leaf architecture in the Egyptian species of Capparaceae. Kamel *et al.,* (2009) classified the Egyptian Capparaceae based

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on morphological attributes. Sharma (1969) studied and described the brachysclerieds in *Capparis* and *Crataeva,* while Pranom (2002) described the leaf anatomy of Capparaceae (*Capparis, Cleome, Crateva,* and *Maerua*) in Thailand.

There is adequate literature on the phytochemical, medicinal, antimicrobial, and ethnobotanical uses of *Buchholzia coriacea* (Abubakar *et al.,* 2017; Izah, *et al.,* 2018). *Buchholzia coriacea* has anti-diabetes properties (Adisa, *et al.,* 2011; Okoye, *et al.,* 2012; Egwu, *et al.,* 2017; Obiudu, *et al.,* 2015; Lapshak, *et al.,* 2016), anti-plasmodial activity (Bassey and Izah, 2017), anti-trypanosomal properties (Abubakar, *et al.,* 2017; Izah, *et al.,* 2018), anti-modulatory activities (Eze, *et al.,* 2015), anti-spasmodic and anti-diarrhoea properties (Anowi, *et al.,* 2012), anti-ulcer properties and can be used as worm-expellers (Anowi, *et al.,* 2012; Erhenhi and Obadoni, 2015; Salami, *et al.,* 2017). Traditionally, the seeds of *B. coriacea* are used to treat pregnant women, and has stimulant, tonic, aphrodisiac effects (Anowi, *et al.,* 2012; Erhenhi and Obadoni, 2015). They can also be used as memory boosters (Ibrahim and Fagbohun, 2012; Nwachukwu, *et al.,* 2014), and in the treatment of malaria and fever (Titanji, *et al.,* 2008), cough, hypertension, headaches, sinusitis, and nasal congestion, and in smallpox for skin-itching (Adisa, *et al.,* 2011; Nwaichi, *et al.,* 2017). Moreover, they have effective properties in the treatment of scabies, chest pains and boils (Anowi, *et al.,* 2012; Erhenhi and Obadoni, 2015), syphilis, sinusitis, earache, smallpox, gonorrhea and convulsion in children (Ajaiyeoba, *et al.,* 2003; Nwaichi, *et al.,* 2017).

Previous reports have been done on Nigerian species dealt only with the phytochemical, medicinal, and ethnobotanical uses of this species, while reports from other countries described the morphological, anatomical, palynological, and leaf epidermal features of other taxa in Capparaceae excluding *B. coriacea*. There is no information on the leaf epidermal characters, and the anatomy of *B. coriacea*. The present study presents information on the morphology, leaf micro-morphology, and the ecological distribution of *B. coriacea* from Nigeria and compares the results with other members of Capparaceae to assess its taxonomic position.

Materials and Methods

Voucher specimens studied

The specimens used for this study were collected from the Forestry Research Institute Station Ibadan, Calabar, and Umuelechi-Asa, Abia State (Table 1). **Table 1.** Voucher specimens studied (locations, coordinate, and voucher number)

Distributional study

The information on the specimens deposited in the Forestry Herbarium Ibadan (FHI) and the University of Port Harcourt Herbarium (UPH) is used for the distributional analysis. The localities including the states of collection of the herbarium specimens are used to generate the distributional map of the species (Table 1).

Morphological Studies

The overall morphology of the leaf, flowers, fruits, and seeds of the herbarium and fresh specimens were calculated using a meter ruler and a hand lens. The photographs of the vegetative and other parts of the plant were taken and documented using Nikon D3200 digital camera.

Anatomical Studies

Fresh plant materials were collected from trees growing in the Forestry Research Institute Station Calabar, and Umuelechi Asa, Abia State. Petiole, and midrib; other leaf samples were cut and fixed immediately in Formalin-Acetic-Alcohol for twenty-four hours. After fixation, they were washed thoroughly in distilled water, dehydrated, embedded in paraffin wax after infiltration and sectioned using rotary microtome to the

Table 1. Voucher specimens studied (locations, coordinate, and voucher number)

Locality	Latitude	Longitude	Voucher No.
Ondo State	4.7712	6.7684	FHI 93581
Benin City, Edo State	6.346	5.628	
Eket District, Akwa Ibom State	4.65	7.93	
Sapoba Forest Reserve, Orhionmwon,	6.075677	5.819154	FHI 32885
Onigambari,	7.133333	3.8	
Urhonigbe Forest Reserve, Odigi, Orhionmwon,	5.938197	5.888867	
Omo Forest Reserve, Ijebu East, Nigeria	6.846962	4.371434	
Okomu Forest Reserve, Ovia South-West, Nigeria	6.312748	5.233653	FHI 101633
Aponmu, Ondo State, Nigeria	7.2405	5.0664	FHI25536
Ijebu-Igbo, Ijebu North, Nigeria	6.970306	4.000526	FHI 110096
Idanre Forest Reserve, Idanre, Nigeria	6.857701	5.10551	
Uromi, Edo State	6.708269	6.328938	
Uyo, Akwa Ibom State	5.05127	7.9335	FHI 110746
Umuelechi-Asa, Abia State			UPH/V/1458
Forestry Research Institute Station Calabar,	$5^0$13’24.40’’	$8^0$21’44.74’’	UPH/V/1457

thickness of 8-12 µm. Sections were stained with Safranin and counter stained with Alcian blue. The photographs of thirty good sections were taken and described.

Results

The results of the current research on *B. coriacea* are presented in Figures 1 to 7 and Table 1.

Ecological Distribution

The available information in the Forestry Herbarium Ibadan (FHI), University of Port Harcourt Herbarium (UPH), Nigeria and the field collections showed that this species exhibits a latitudinal distribution across the transitional equatorial region of Nigeria, extending from Oyo state in the South-West to Akwa-Ibom in the farther south (Figure 1). Most of the species cited in the herbaria were collected from the high rainforest zone of Nigeria. This pattern suggests that *B. coriacea* is confined to tropical areas and is less in the drier parts of Nigeria (Figure 1).

Morphology

A small to medium-size tree of about 4.5 to 6.2 m tall. Leaves lanceolate or elliptic, base cuneate to acute, apex acute, acuminate, 19.5–23.8–25.6 cm. long, 5.2–6.5–8.4 cm. broad, glabrous; midrib very prominent beneath; lateral nerves about 10 - 14, prominent beneath; veins very lax; petiole 2.0–7.5–13.4 cm. long, swollen for about 0.8 - 1 cm. at the apex; inflorescence axillary racemes, slightly branched, 10.2–12.5–14.6 cm. long; pedicels 0·4 – 1 cm. long; bracts 4-5, small green, hook-like; flowers bisexual, stalk about 1·5 cm. long; sepals 4, 4 – 5 × 3 – 4 mm; stamens numerous, free, 1 – 2.5 cm long, cream to yellowish, anthers brownish to blackish; fruit ellipsoid (seeds 2–3) up to 7.8 – 8 × 5-6 cm., with thick woody endocarp about 6 mm. thick; about 1.5 – 2.5 cm. diameter with flattened sides (Figure 2).

Micromorphology

Epidermal characteristics: Lamina hypostomatic with anomocytic and tetracytic stomata in random orientation (Figure 3). Subsidiary cells distinct,

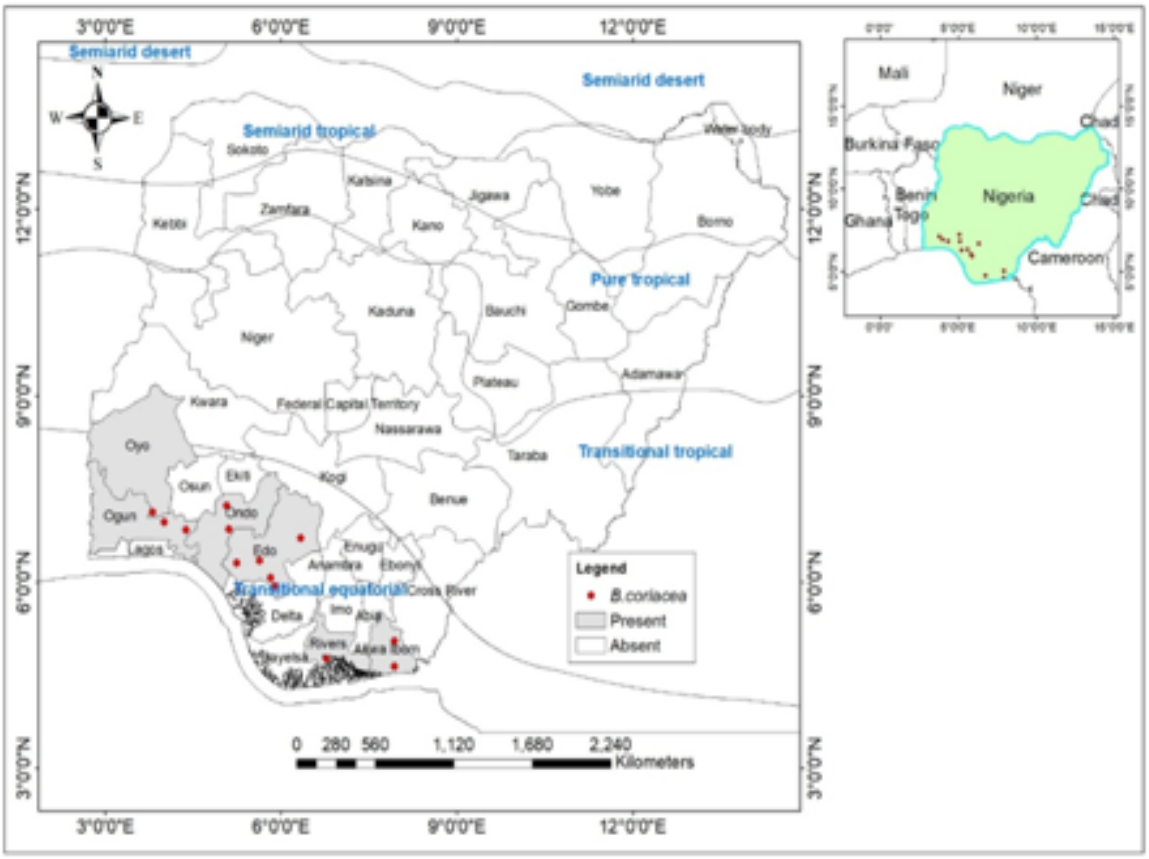


Figure 1. Ecological Distribution of *B. coriacea* in Nigeria

Figure 2. The flowers, fruit and seeds of *B. coriacea*; (A) Flower, (B) fruit, and (C and D) seed.

epidermal cells polygonal in shape, anticlinal walls straight or curved (Figures 3 and 4). Abaxial epidermal cells 4.139 ± 1.28 µm × 2.21 ± 0.39 µm while the adaxial epidermal cells are 4.52 ± 0.59 µm × 2.74 ± 0.34 µm (Table 2). Guard cells are often equal in size, oval, and abaxial stomatal index (SI) 36.36.

Leaf lamina: The transverse section of the lamina exhibits uniseriate upper and lower epidermis with barrel-shaped cells (Figure 5). The adaxial epidermis is covered with a thin cuticle 0.67 µm thick, cells are cylindrical or oval, devoid of stomata, and periclinally elongated. Abaxial epidermal cells are oval, 1.32±0.29 µm thick, and covered with 1.03 µm thick cuticle (Figure 5). The mesophyll comprised spongy and palisade mesophylls. The palisade parenchyma cells are arranged in rows of 2-3 layers, while the spongy parenchyma cells have 7-8 layers with many intercellular air spaces and a bundle sheath embedded in them.

Petiole: A T.S. of petiole has a more or less circular outline with two outwardly directed adaxial ends, and an adaxial surface convex (Figures 6A and 6B). The vascular bundles are collateral in a semi-circle arrangement formed by many distinct strands with patches of fibre on the abaxial side (Figure 6B). The cells of the epidermis are uniseriate, followed by layers of a small, oval, or round collenchymatous hypodermis layer. The ground tissue is composed of round or oval parenchymatous cells.

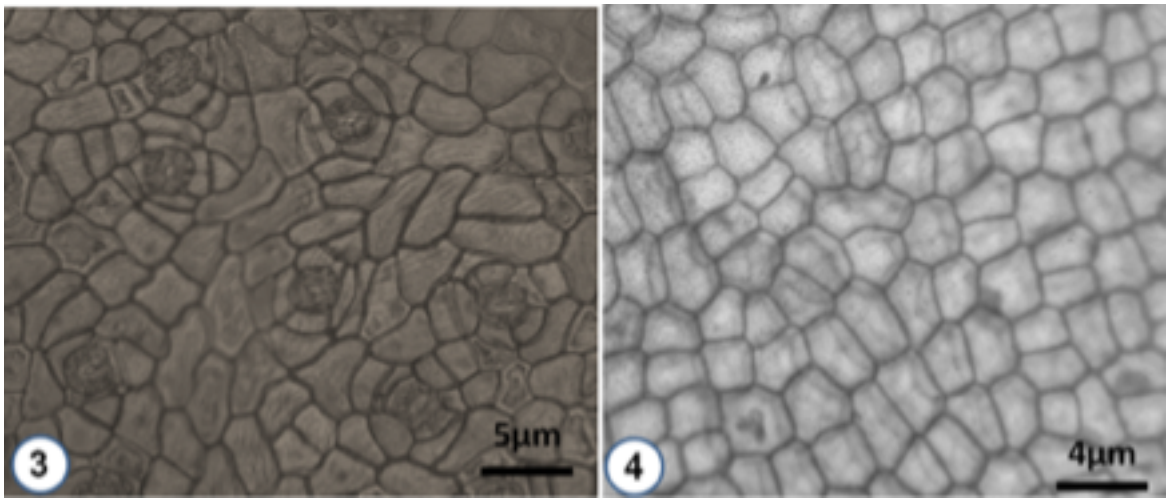


Figure 3-4. Epidermal cells, and leaf lamina of *B. coriacea.* (3) abaxial epidermis, and (4) adaxial epidermis.

Table 2. Measurement of different tissues and cells

Parameter(s)	Length (µm)		Width (µm)	
	Range	**Mean ± SD**	**Range**	**Mean ± SD**
Stomatal complex	3.83 - 6.56	5.02 ± 0.82	4.15 - 5.26	4.77 ± 0.35
Stomata size	2.37 - 3.38	2.92 ± 0.28	2.20 - 2.96	2.65 ± 0.22
Adaxial epidermal cell	3.31 – 5.58	4.52 ± 0.59	1.86 – 3.38	2.74 ± 0.34
Abaxial epidermal cell	2.22 - 6.17	4.14± 1.28	1.62 - 3.03	2.21 ± 0.39
Leaf Lamina			**Thickness (µm)**	
			Range	**Mean ± SD**
			29.86 - 31.62	30.77 ± 0.55
Adaxial epidermal cell			1.81 - 2.23	2.03 ± 0.13
Abaxial epidermal cell			0.99 – 1.78	1.32 ± 0.29
Palisade mesophyll			4.31 - 6.84	6.06 ± 0.82
Spongy mesophyll			14.11 - 20.8	17.49 ± 2.27

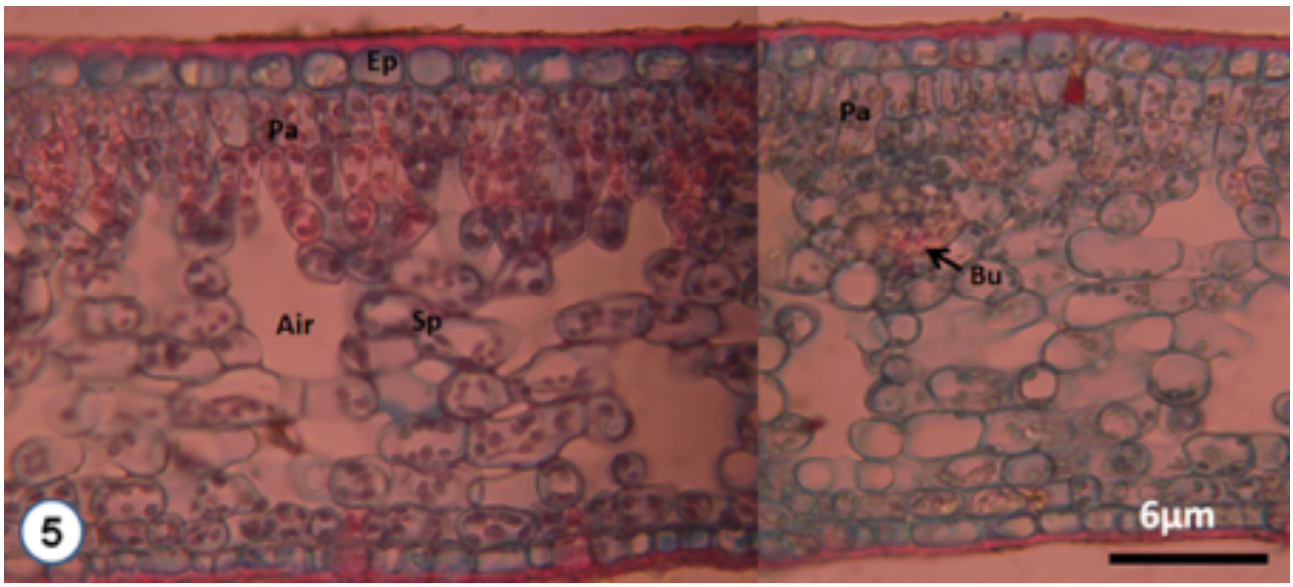
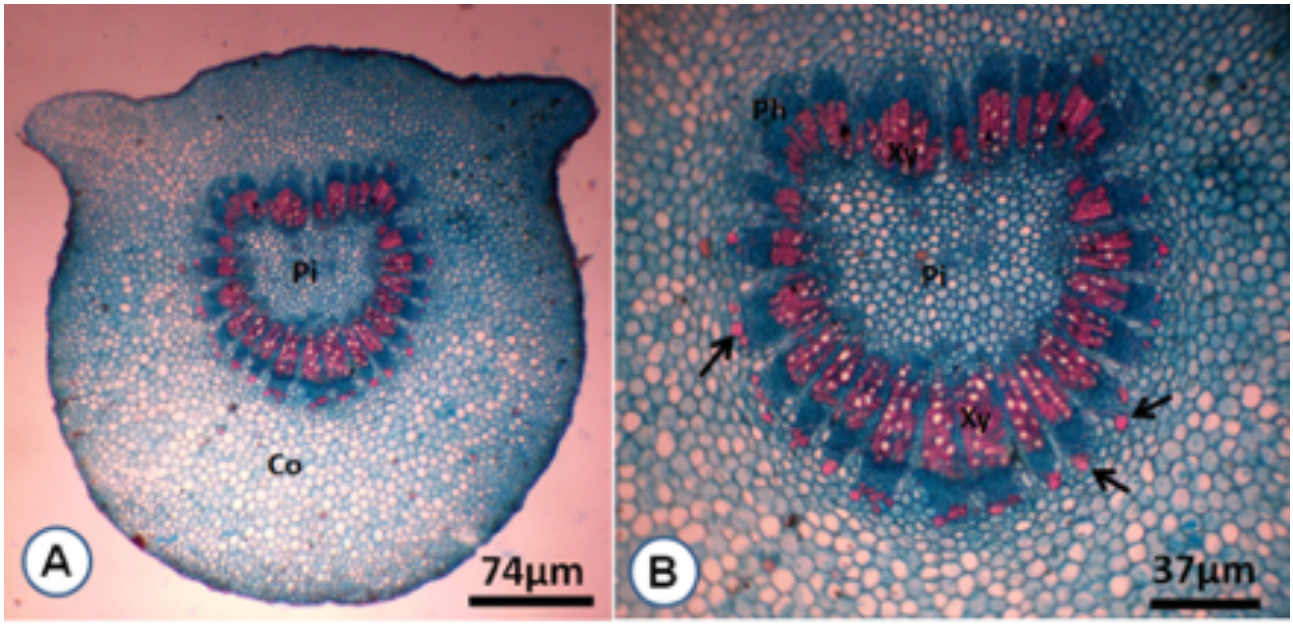


Figure 5. Transverse section (TS) of the lamina of *B. coriacea* (Pa –palisade mesophyll, Pi – pith, Sp –spongy mesophyll, Bu – bundle sheath, Air – air space, Ep – epidermis).

Transverse section of midrib: The outline of the midrib is oval to circular. The adaxial cuticle convex (Figure 7). The epidermis is uniseriate, and the ground tissue is composed of round or oval parenchymatous cells. The vascular system is arranged as a closed ellipse (Fig. 7A), vessels solitary with a continuous layer of xylem tissues and patches of fibre (Figure 7B). The collenchyma or endodermis is separated from the cortex by layers of crushed parenchymatous cells (Figure 7C) and vessels are solitary in radial pairs.

Discussion

The information gathered about the anatomy, and epidermal features makes it possible to compare *B. coriacea* with other members of Capparaceae because there is lack of data on this species endemic to Africa. However, many published works are mainly on *Capparis* L., *Cadaba* Forsk., *Boscia, Crataeva , Maerua* Forsk., *Dipterygium* Decne, *Cleome* L., *and Gynandropsis* DC. (Aleykutty and Inamdar, 1978; Okonwu *et al.,* 2017).



Figures 6. Transverse section of *B. coriacea* petiole (A) complete outline of the petiole, (B) Vascular bundle arrangement (Co- cortex parenchyma, Pi – pith, Ph – phloem, Xy- xyleme, and the arrows show patches of fibre).

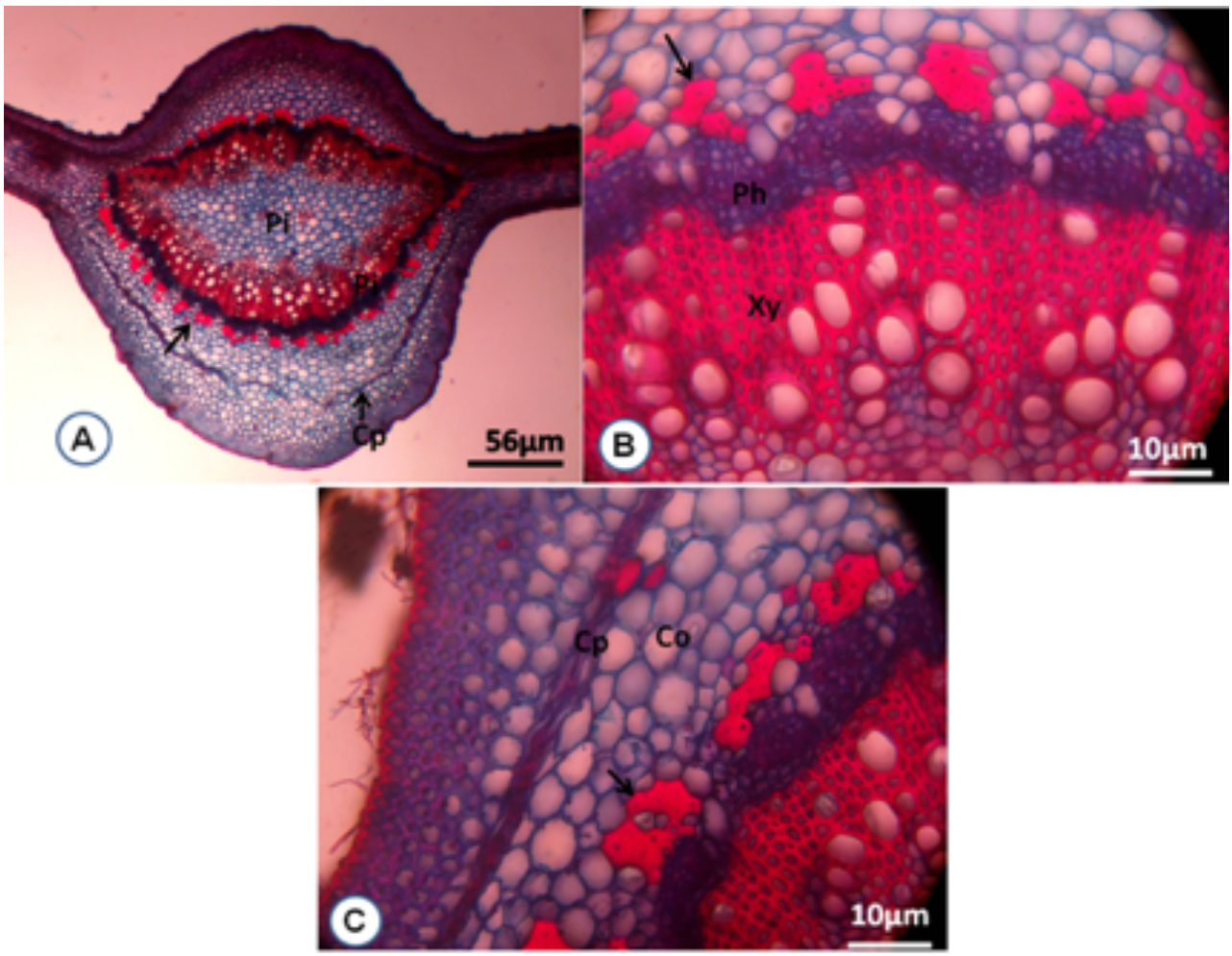


Figure 7. Transverse Section of *B. coriacea* midrib (A) complete outline of the midrib, (B) orientation of the fibre tissues, (C) cortex and collenchyma separated by crushed parenchyma (Cp- crushed parenchyma, Co – cortex, the arrows show patches of fibre cells, Ph –phloem, Xy – xylem).

The importance of the morphological and anatomical features in the systematics of angiosperm cannot be over emphasized. Also, several accounts have explained the value of epidermal characteristics in differentiating many plant families, genera, and species (Metchalfe and Chalk, 1950, 1976). In their work on the epidermal features of Capparaceae, Metcalfe and Chalk (1950, 1976) reported several types of hair namely non-glandular shaggy hairs in the *Morisonia* and *Cadaba* species, stellate hairs in *Steriphoma*, glandular hairs, branched or dendritic non-glandular hairs, capitate glandular hairs with the long or fairly long stalk in *Cleome* species, and peltate glandular or non-glandular hairs in *Atamisqea, Cadaba,* and *Capparis*. They also recorded anomocytic stomata, and papillose on the lower epidermis of the family. In the current study, the researchers observed anomocytic and tetracytic stomata in *B. coriacea*. Aleykutty and Inamdar (1978) reported cyclocytic, tricytic, staurocytic, tetracytic, anomocytic, anisocytic, paracytic stomata, and stomata with a single subsidiary cell in *Cleome*, *Capparis*, *Cadaba*, *Crataeva*, and *Maerua* from Thailand. This characteristic supports the placement of this species in this family as a distinct species.

The distribution of sclereids in the genera *Capparis* and *Crataeva* is documented (Rao, 1951; Sharma, 1969). In *Capparis*, sclereids from a more or less continuous ring outside the secondary phloem or interspersed between the sclerenchyma patches in the stem (Rao, 1951). In *C. moonii* Wight and *C. orbiculata* Wall. ex Hook. f. and Thomson sclereids are present in the leaf and have a direct relationship with the veins and

veinlets. In *Crataeva religiosa* Forst. f. the sclereid distribution is similar to *Capparis horrida* L.f. and differs from *C. grandis* L.f. and *C. sepiaria* L. The form of the sclereid is also slightly different (Sharma, 1969). In *B. coriacea,* sclereids and fibre cells occurring in a discontinuous ring outside the secondary phloem.

Ecologically, and based on the habits, members of the Capparaceae family can occur in different habitats (Zahran and Willis 1992; Abd-El-Ghani and Marei 2006; Boulos and El-Hadidi 1984; Abd-El-Ghani *et al.,* 2007). Abd-El-Ghani *et al.,* (2007) investigated the Egyptian taxa and reported that they vary considerably in their growth forms from small trees (*Boscia*) or shrubs (*Capparis*) to annual (*Gynandropsis gynandra*) or perennial herbs (*Cleome*), while the present study shows that *B. coriacea* is a small tree or shrub that grows in dryland and rainforest areas. The Egyptian taxa of Capparaceae belong to the xerophytic communities (Zahran and Willis 1992; Abd El-Ghani and Marei 2006), except for *Gynandropsis gynandra* which is common among the weed flora of the arable fields (Boulos and El-Hadidi 1984). *Buchholzia coriacea* exhibits a latitudinal distribution across the transitional equatorial region of Nigeria, extending from Oyo state in the South-West to Akwa-Ibom in the farther south. This pattern suggests that *B. coriacea* is confined to the tropical areas and may not thrive in drier parts. Currently, its conservation status remains unknown and has not been assessed by the IUCN. Therefore, its sustainable collection and use are of paramount importance not only to the Nigerian society but to the world at large especially in the face of climate change resulting from human anthropogenic activities.

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References

Abd El-Ghani MM and Marei AH. 2006. Vegetation associates of the endangered *Randoniaafricana* Coss. and its soil characteristics in an arid desert ecosystems of western Egypt. *Acta Botanica Croatica,* **65 (1):** 83-99.

Abd-El-Ghani, MMA, Kamel, W and and El-Bous, M. 2007. The leaf architecture and its taxonomic significance in Capparaceae from Egypt. *Acta Biologica Szegediensis*, **51(2):**125-136

Abubakar, A, Jigam, AA, Kabir, AY and Adefolaju, OV. 2017, Phytochemical Constituents and In Vitro Antitrypanosomal Activity of Ethanol Seed Extract of *Buchholzia Coriacea*. *J. Pure Appl. Sci*., **4:** 43-48.

Adisa, RA, Choudhary, MI and Olorunsogo, OO. 2011. Hypoglycemic activity of *Buccholzia coriacea* (Capparaceae) seeds in streptozotocin-induced diabetic rats and mice, *Exp Toxicol Pathol*, **63**:619-25 https://doi.org/10.1016/j.etp.2010.05.002 PMid:20965120

Ajaiyeoba, EO, Onocha, PA, Nwozo, SO and Sama, W. 2003. Antimicrobial and cytotoxicity evaluation of *Buchholzia coriacea* stem bark. *Fitoterapia*, **74(7-8):**706-9 https://doi.org/10.1016/S0367-326X(03)00142-4

Aleykutty, SAKM and Inamdar JA. 1978. Structure, ontogeny, and taxonomic significance of trichomes and stomata in some Capparidaceae. *Feddes Repertorium,* **89(1):**19 – 30. DOI: 10.1002/fedr.19780890104

Anowi, FC, Ike, C, Ezeokafor, E and Ebere, C. 2012. The Phytochemical, Antispamodic and Antidiarrhoea properties of the methanol extract of the leaves of *Buchholzia coriacea* family Capparaceae, *Int J Curr Pharm Res,* **4(3):** 52-58.

Bassey, SE and Izah, SC. 2017. Nigerian plants with insecticidal potentials against various stages of mosquito development, *ASIO Journal of Medical and Health Sciences Research,* **2 (1):** 07-18

Boulos, L and El-Hadidi, MN. 1984. **The Weed Flora of Egypt**, The American University of Cairo Press, Cairo.

Egwu, CO, Offor, CE and Alum, EU. 2017. Anti-diabetic effects of *Buchholzia coriacea* ethanol seed extract and vildagliptin on alloxan-induced diabetic albino rats. *International Journal of Biology, Pharmacy and Allied Sciences,* **6(6):** 1304-1314.

Erhenhi, AH and Obadoni, BO. 2015. Known medicinal and aphrodisiac plants of Urhonigbe forest reserve, Edo State. *Nigeria Journal of Medicinal Plant Studies*, **3(4):** 101-106

Eze, JI, Ekelozie, CF and Nweze, NE. 2015. Immunomodulatory Activity of the Methanolic Extract of *Buchholzia coriacea* Seeds on *Trypanosomabrucei* Brucei Infected Mice, *Global Veterinaria,* **14(4):** 582-588

Ezekiel, OO and Onyeoziri, NF. 2009. Preliminary studies on the antimicrobial properties of *Buccholzia Coriacea. African Journal of Biotechnology*, **8(3):** 472-474

Hutchinson, J and Dalziel, JM. 1954. *Flora of West Tropical Africa.* Revised by Keay, R. W. J. *Vol. I Part I.* Crown Agents for Oversea Governments and Administrations, London.

Ibrahim, TA. and Fagbohun, ED. 201). Phytochemical and Nutritive Qualities of Dried Seeds of *Buchholzia Coriacea,Greener Journal of Physical Sciences*, **2(5):** 185-191

Ijarotimi, OS, Nathaniel, FT and Faramade, OO. 2015. Determination of chemical composition,nutritional quality and anti-diabeticpotentials of raw, blanched and fermentedwonderful Kola (*B. coriacea*) seed flour. *Journal of Ham Nutrition and FoodScience*, **3(2):**1060–1067.

Izah, SC, Uhunmwangho, EJ and Eledo, BO. 2018. Medicinal potentials of *Buchholziacoriacea* (wonderful kola). *Medicinal Plant Research,* **8(5):** 27-42 (doi: 10.5376/mpr.2018.08.0005)

Kamel, MW, Abd El-Ghani, MM and El-Bous, MM. 2009. Taxonomic Study of Capparaceae from Egypt: Revisited. *The African Journal of Plant Science and Biotechnology*, **3 (1)**: 27-35.

Lapshak, LJ, Domkat, LC and Nansah, LS. 2016. The effect of aquous extract of *Buchholzia coriacea* seed and some biochemical parameters in normal and alloxan-indduced diabtetic rats, *International Journal of Biochemistry Research*, **11(1):** 1-10

Lemmens, RHMJ. 2013. *Buchholzia coriacea* Engl. *In*: Schmelzer, G.H. and Gurib-Fakim, A. (Editors). **PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale)**, Wageningen, Netherlands. Accessed 12 November 2020.

Metcalfe, CR and Chalk, L. 1950. **Anatomy of the Dicotyledons,** Vol 1 **and 2**. Oxford Univ. Press, London, UK.

Metcalfe, CR and Chalk, L. 1979. **Anatomy of the Dicotyledon, Vol. 2: Systematic Anatomy of the Leaf and Stem**. Oxford University Press, New York.

Nwachukwu, MI, Duru, MKC, Amadi, BA and Nwachukwu, IO. 2014. Comparative evaluation of phytoconstituents, antibacterial activities and proximate contents of fresh, oven dried uncooked and cooked samples of *Buchholzia coriacea* seed and their effects on hepatocellular integrity. *International Journal of Pharmaceutical Invention*, **3(6)**: 41-49

Nwaichi, EO, Osuoha, JO and Monanu, MO. 2017. Nutraceutical Potential of *Tetracarpidium conophorum* and *Buccholzia coriacea* in Diet-induced Hyperlipidemia. *Journal of Chemical Health Risks,* **7(3):** 157-170.

Obiudu, IK, Okolie, AC, Agbafor, KN, Unaegbu, ME, Engwa, GA and Obiudu, CV. 2015. Anti-Diabetic Property and Phytochemical Composition of Aqueous and Methanol Extracts of *Buchholzia coriacea* Seeds in Alloxan-Induced Diabetic Rats. *Journal of Medical Sciences,* **15:** 241-245. https://doi.org/10.3923/jms.2015.241.245

Okonwu, K, Ekeke, C and Mensah, SI. 2017. Micromorphological and Phytochemical Studies on *Cleome rutidosperma* Linn. *Journal of Advances in Biology & Biotechnology,* **11(3)**: 1-8. DOI: 10.9734/JABB/2017/31028

Okoye, TC, Akah, PA, Ilogu, CL, Ezike, AC and Onyeto, CA. 2012. Anti-diabetic Effects of Methanol Extract of the Seeds of *Buchholzia coriacea* and its Synergistic Effects with Metformin, *Asian Journal of Biomedical and Pharmaceutical Sciences*, **2(12):** 32-36

Rao, TA. 1951. Studies on foliar sclereids. A preliminary survey," *Journal of Indian Botanical Society,* **30:** 28-39.

Salami, AT, Odukanmi, OA, Faniyan, OF, Omayone, TP and Olaleye, SB. 2017. Seeds of *Buchholzia coriacea* in Diet Mitigate Ischemic Reperfusion–Induced Gastric Ulceration in Experimental Rats, *Journal of Dietary Supplements,* **15 (6):** 842-859.

Sharma, M. 1969. **A Study of Brachysclereids in two Members of *Capparidaceae***. Botany Department, Lucknow University, Lucknow

Titanji, VPK, Zofou, D and Ngemenya, MN. 2008. The Antimalarial Potential Of Medicinal Plants Used For The Treatment Of Malaria In Cameroonian Folk Medicine. *African Journal of Traditional, Complementary and Alternative Medicines*, **5(3):** 302-321.

Zahran, MA. & Willis, AJ. 1992. **The Vegetation of Egypt**. Chapman and Hall, London, UK.