



Morphological and Anatomical Studies on *Ipomoea coccinea* L. (Convolvulaceae): A New Record from Nigeria

Chimezie Ekeke^{1*}, Cornelius O. Nichodemus¹ and Chinedum A. Ogazie¹

¹Department of Plant Science and Biotechnology, Faculty of Science, University of Port Harcourt, P.M.B. 5323, Choba, Rivers State, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author CE designed the study, conducted the laboratory analysis, wrote the study protocol, conducted literature searches and wrote the first draft of the manuscript. All the authors read and approved the final manuscript.

Article Information

Editor(s):

(1) Prof. Ayona Jayadev, University of Kerala, India.

Reviewers:

(1) Ahmed Mohamed Faried, Assiut University, Egypt.

(2) Deng-Feng Xie, Sichuan University, China.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/67118>

Original Research Article

Received 10 February 2021

Accepted 16 April 2021

Published 19 May 2021

ABSTRACT

We reported the morpho-anatomy of *Ipomoea coccinea* L. a new record from Nigeria for the first time. Fresh plant materials (stem, petiole, and leaf) were fixed immediately in Formalin-Acetic-Alcohol for 24h, dehydrated, embedded in paraffin wax sectioned using rotary microtome, Sections were stained with Safranin and counterstained with Alcian blue and micro-photographed with trinocular research microscope fitted with Amscope digital camera. *Ipomoea coccinea* is twisting climber with reddish flowers; vine is up to 10 m long with alternate leaf arrangement. The leaf is amphistomatic and dorsiventral. The epidermal cells are irregular in shape with wavy anticlinal walls. The upper epidermis has only paracytic stomata while the lower epidermal surface has mainly paracytic stomata but rarely anisocytic measuring 4.36–8.7×3.9–6.24 μm. The stomata on the upper epidermis are few and mainly located close to the leaf veins. The vascular bundle in the petiole formed a semi-circle with one rib trace. The abaxial and adaxial parenchymatous cortex comprised 7–11 layer of cells with crushed parenchymatous cells below the epidermal cells. The midrib outline is circular to U-shaped with long median projection measuring about 80–90 μm. The stem has protuberances, short glandular trichome, cortex 6–8 layers, and rays in radial multiples of

*Corresponding author: E-mail: ekeke.uche@uniport.edu.ng, ekeke.uc@gmail.com;

3 – 6, a continuous thick layer of xylem, and a discontinuous ring of sclerenchymatous fibre. It has glandular peltate trichome with 5 – 6 basal cells which occurred mainly on the lower surface of the leaves but partly on the stem and upper leaf surfaces. The laticifer is found in the cortical parenchyma of the petiole, midrib, and stem while the papillose is found on the stem and the midrib. The calcium oxalate (druses) sparsely occurred in the phloem tissues in the stem. These features of the species confirm that it is member of the Convolvulaceae family.

Keywords: *Ipomoea coccinea*; Convolvulaceae; morphology; parenchymatous cells; trichome; cortex.

1. INTRODUCTION

The family Convolvulaceae is mainly cosmopolitan climbers [1], with about 58 genera and approximately 1,800 to 2,000 species in the world [2,3]. Among the genera in this family, *Ipomoea* L. is the largest genus, represented by approximately 650 to 1,000 species mainly found in tropical and warm temperate regions of the world [4–7]. In West Africa, 38 known species have been documented with 30 occurring in Nigeria [8,9]. These species are commonly found in the Southern and eastern regions of Nigeria with a few in the Northern and Savanna zones [10]. Most of the times this species is referred to as Red Morning Glory, Scarlet Starglory. Scarlet Morning Glory, Starglory, Redstar, Mexican Morning Glory, or Woolly Tidestromia [10–12]. Most *Ipomoea* species including *I. coccinea* are native to tropical America and have been introduced in much of the US and Africa (They can be found in disturbed areas along roads, stream banks, fence rows, old fields and other waste areas. Native of tropical America, often cultivated in warmer countries as an ornamental and frequently naturalized [10–13]. In the family Convolvulaceae and the genus *Ipomoea*, several scholars have carried out and documented their morphological, anatomical, and pollen features. In Nigeria, Okereke et al. [14] reported the morphology and anatomy of some members *Ipomoea*, *Hewittia*, *Evolvulus*, and *Merremia*. Folorunso [15] and Folorunso et al. [9] described the foliar micro-morphology of 15 *Ipomoea* species from South-Western Nigeria. Also, pollen and flower morphology of South-Western *Ipomoea* has been reported by Jayeola and Oladunjoye [16]. Majority of other research works concentrated on *I. batatas* (sweet potatoes). Abdel [17] described the morphology of 44 taxa belonging to 6 tribes (*Convolvuleae*, *Cuscutaeae*, *Cresseae*, *Dichondreae*, *Ipomoeaeae*, and *Merremieae*) and 10 genera in Egypt.

Despite these floristic studies and documentations in West Africa and Nigeria in

particular, information on the morphology and anatomy of *Ipomoea coccinea* is lacking. Therefore this work presents the first report on the morphological and anatomical features of *I. coccinea* from Nigeria.

2. MATERIALS AND METHODS

2.1 Plant Materials

Fresh plant materials were collected during vegetation survey from Umuogele Nvosi, Abia State. The species was authenticated at the University of Port Harcourt Herbarium (UPH) and voucher specimen (UPH/V/1456) deposited at the University of Port Harcourt Herbarium.

2.2 Morphological Study

Morphological description was conducted on twenty different plant specimens from the study area. The data were put together and documented.

2.3 Anatomical Studies

Stem, petiole, and leaf samples were cut and fixed immediately in Formalin-Acetic-Alcohol for 24h. After fixation they were washed thoroughly in distilled water, dehydrated, embedded in paraffin wax after infiltration and sectioned using rotary microtome to the thickness of 8–12 μm . Sections were stained with Safranin and counterstained with Alcian blue and micro-photographed with trinocular research microscope fitted with Amscope digital camera.

3. RESULTS

The results of our finding are presented in Figs. 1–3.

3.1 Morphology

Ipomoea coccinea is twisting climber with reddish flower, vine up to 10 m long with alternate leaf

arrangement (Fig. 1), and internode 10 – 17.4 cm. long. The leaves are ovate or three-lobed, 5 – 7.5 cm. long, 5 – 6 cm. wide, base cordate, sagittate or auriculate, and apiculate or acute (Fig. 1), and petiole purple to light green, 5.8 – 10 cm. long. Inflorescence 9.4 – 22.3 cm. long; flowers 2 – 7, red with yellow to orange throat, stalk 0.8 – 1 cm long, perianth or tube 2.4 – 3.4 cm. long, 5 sepals green, 1 – 1.5 cm. long (Fig. 1B). Young fruits 6 – 8 mm in diameter and mature ones spherical, light brown and can contain up to 4 seeds (Fig. 1C), 2 – 3 mm long, brown to black.

3.2 Distribution

This is a weed of cultivated farms, bush fallow, road sides, and dry places.

3.3 Micro-morphology

3.3.1 Epidermal characteristics

The leaf is amphistomatic and dorsiventral. The upper and lower epidermal cells are irregular in shape with wavy anticlinal walls. The lower epidermal surface has mainly paracytic stomata but rarely anisocytic (Fig. 2A) and the stomata measuring $4.36 - 8.7 \times 3.9 - 6.24 \mu\text{m}$ while upper epidermis has only paracytic stomata (Fig. 2B). The stomata on the upper epidermis are few and mainly located close to the leaf veins. The size of the lower epidermal cell is $6.05 - 7.93 \times 3.28 - 6.13 \mu\text{m}$. The average stomatal index on the upper epidermis is 4.84 while on the lower epidermis is 25. The lamina measures 18 – 22 μm thick, and comprised palisade and spongy mesophylls with bundle sheet embedded in the spongy mesophyll (2C). The palisade has a layer of elongated and cylindrical cells while the spongy cells are oval, loosely packed with intercellular spaces.

3.3.2 Transverse section of petiole

The transverse outline of the petiole is circular with wavy cuticle (Fig. 3A). The upper surface is U-shaped. The vascular bundle formed a semi-circle with one rib trace each on both sides of the semi-circle. The abaxial and adaxial parenchymatous cortex comprised 7 – 11 layer of cells with 2 – 4 layers of crushed parenchymatous cells below the epidermal cells.

3.3.3 Midrib

The midrib outline is circular to U-shaped with long projection measuring about 80 – 90 μm (Fig.

3C). The palisade cells extended to the middle of the midrib separating the projection from the upper parenchymatous cells. Upper cortex has 4 – 7 layers of cells while the lower cortex has 5 – 6 layer of cells.

3.3.4 Stem

The stem is circular with some protuberances (Figs. 3D – 3F). Epidermis 1-layer, having short glandular trichome, cortex 6 – 8 layers, rays in radial multiples of 3 – 6, a continuous thick layer of xylem (Fig. 3E), a discontinuous ring of sclerenchymatous fibre (Fig. 3F). The parenchymatous cortex contains secretory cavity and un-lignified pith.

3.3.5 Occurrence and distribution of trichome, papillose, laticifer, and calcium oxalate

Trichome type observed in this species is glandular peltate trichome with 5 – 6 basal cells. It occurred mainly on the lower surface of the leaves but partly on the stem and upper leaf surfaces (Fig. 2A). The laticifer is found in the cortical parenchyma of the petiole, midrib, and stem while the papillose is found on the stem and the midrib (Fig. 3C). The calcium oxalate (druses) sparsely occurred in the phloem tissues in the stem.

4. DISCUSSION

Anatomical, morphological, and histological data have been of a great deal in the taxonomy of members of Convolvulaceae [18-27]. *I. coccinea* differed from the two closely related Nigerian species (*I. quamoclit* and *I. hederifolia*) in that the leaves are ovate or three-lobed, with cordate, sagittate or auriculate base, and apiculate or acute apex. The petiole purple to light green, flowers are red with yellow to orange throat while in *I. quamoclit* the leaves are pinnately parted into numerous linear or filiform segments, rarely less deeply pinnately cut and in *I. hederifolia* the leaves not pinnately cut; ovate to orbicular, cordate at the base; margin entire or lobed. Though these two species have red flowers, the throat are not yellow or orange (Table 1).

Also, among the Nigerian *Ipomoea* genus, Aworinde et al. [28] reported amphistomatic leaves, paracytic and anomocytic stomata, and stomatal index of 9 – 28 were and divided them into two groups base on their epidermal features. They reported that the adaxial epidermal cells have rectangular, polygonal and irregular shape

with straight to wavy anticlinal walls and glandular trichomes. Also, they observed that the stomata are brachyparacytic and paracytic, oval or elliptic in shape. Furthermore, they stated that glandular trichomes, brachyparacytic stomata oval in shape occurred in *I. batatas* and *I. carnea*. *I. involucreta* while circular or elliptic stomata, and absence of trichome, irregular epidermal cells, and non-glandular trichomes occurred in *I. hederifolia*, *I. muricata*, *I. heterotricha* and *I. obscura*. On the other hand, Adedeji [21] and Abdulrahman & Oladele [22] reported that stomatal index is highly constant for a certain species of *Ipomoea* and can be used for species delimitation. The findings of our work on the epidermal characteristics of *I. coccinea* similar and corroborates, with these previous publications on other members of this genus [21, 29, 30].

Among the angiosperms, the presence laticifers in different parts and tissues (stem, midrib, phloem, cortex and pith) have been reported [18, 23, 31] including the Convolvulaceae [19,23,32] and particularly in *Ipomoea* [23]. In the *Ipomoea* species, the laticifers are found in phloem tissues in the midrib, the cortex and pith of the stem and the rhizome [18,31,33], *I. alba* [23], and secretory structures, and laticifers in the petiole of *I. asarifolia* [34]. In our work on *I. coccinea*, laticifers are observed in the parenchymatous cortex of the petiole, midrib, and stem.

The presence of crystals in the parenchyma of *I. asarifolia* have been reported [18], druses and laticifers in *I. pes-tigridis* collenchyma of the petiole, and cortex and pith of the stem, and discontinuous layers of fibre above the phloem [35], and bicollateral vascular bundles in the petiole and midrib of in *I. imperati* and *I. pes-*

caprae [18,31,36]. Aworinde et al. [28] showed that the petiolar transverse section or outline in *I. batatas* has an undulating wall, semi-circle to boat or winged in *I. aquatica*, angular with depression in the adaxial surface *I. asarifolia* and boat shaped in *I. involucreta*. They further reported that the cortex is divided into collenchyma and parenchyma with the presence of rib traces in *I. aquatica* and *I. involucreta* but absence in *I. asarifolia*. Also, different layers of collenchyma and number of the vascular bundle have been reported in the petiole of *I. batatas*, *I. aquatic*, *I. asarifolia*, and *I. involucreta* [28]. The collenchyma is 6-8 layers in *I. triloba* and 5-6 layers in *I. batatas*. Also, five vascular bundles arranged in a semi-circle in *I. asarifolia*, three strands of bundles at the centre of *I. batatas* arranged in an arc shape, 6-7 bundles arranged in a circular arrangement in *I. aquatica*, 6 bundles in a semi-circle in *I. triloba* and 4 isolated bundles arranged in a circular arrangement in *I. involucreta*. Our present report showed that in *I. coccinea* the vascular bundle in petiole formed a semi-circle with one rib trace each on both sides of the semi-circle, and the abaxial and adaxial parenchymatous cortex comprised 7 – 11 layers of cell. The adaxial cuticle of the midrib has long projection and the palisade cells extended to the middle of the midrib with the upper and lower cortical cell have 4-7 and 5-6 layers of cell respectively [37,38]. This species has glandular peltate trichome with 5 – 6 basal cells which occurred mainly on the lower surface of the leaves but partly on the stem and upper leaf surfaces. The laticifer is found in the cortical parenchyma of the petiole, midrib, and stem while the papillose is found on the stem and the midrib with calcium oxalate (druses) sparsely occurred in the phloem tissues in the stem.

Table 1. Morphological diagnostic features of *I. quamoclit*, *I. hederifolia* and *I. coccinea*

Species	<i>I. quamoclit</i> L.	<i>Ipomoea coccinea</i> L.	<i>I. hederifolia</i> L.
Features	Leaves pinnately parted into numerous linear or filiform segments, rarely less deeply pinnately cut. The leaves are 1–4 inches (2.5–10.2 cm) long, deeply lobed (nearly pinnate), with 9-19 lobes on each side of the leaf. Flowers red, pink or white, perianth or tube 2.5–5.1 cm long and 2.5 cm in diameter.	The leaves are ovate or three-lobed, 5 – 7.5 cm. long, 5 – 6 cm. wide, base cordate, sagittate or auriculate, and apiculate or acute, and petiole purple to light green, 5.8-10 cm. long. Inflorescence 9.4 – 22.3 cm. long; flowers brilliant red with yellow to orange throat, perianth or tube 2.4 – 3.4 cm. long.	Leaves ovate to orbicular, cordate at the base; margin entire or lobed. Flowers orange or pink – red, leaf simple, glabrous, shape hastiform, apex apiculate, base cordate, margin entire, petiole glabrous, stem fibrous.
Reference	[8,29]	Current study	[8,29,30]

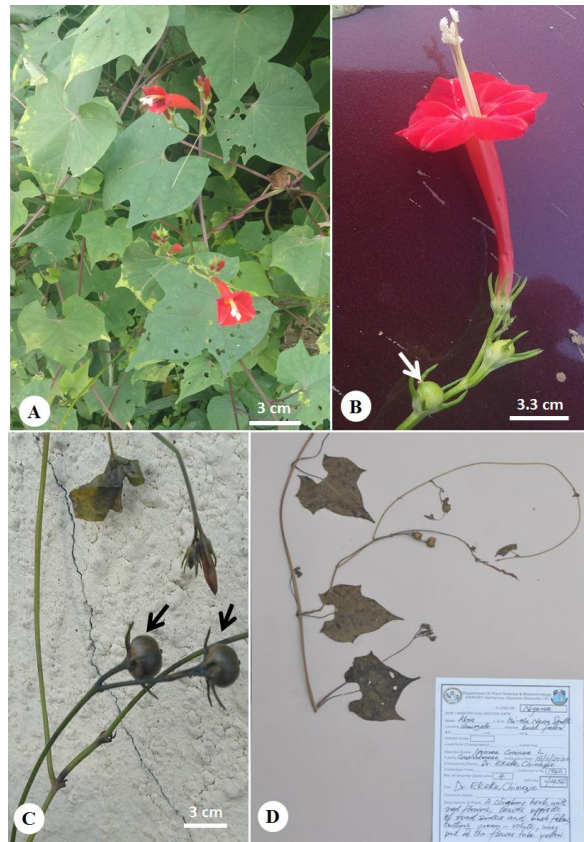


Fig. 1. Habit, flower, and fruits of *I. coccinea*: A- habit, B- flower, arrow shows fruit, C- fruits, and (D) Herbarium specimen

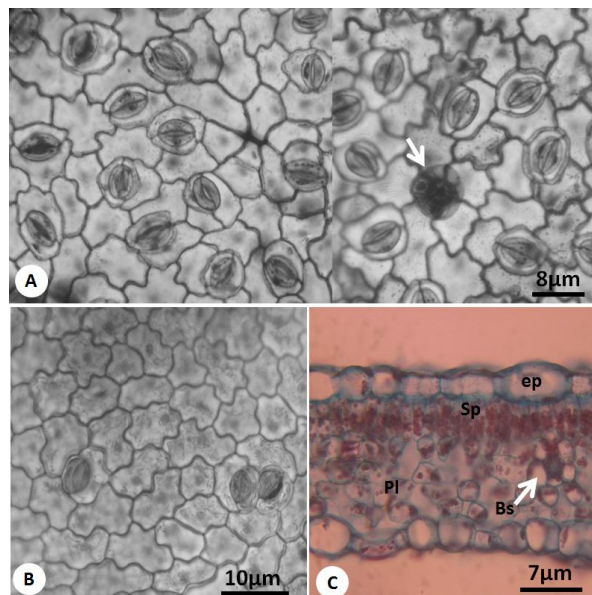


Fig. 2. Epidermal peels and leaf lamina of *I. coccinea*; (A) Adaxial surface (arrow shows glandular trichome), (B) abaxial surface, and (C) leaf lamina
PI – palisade mesophyll, Sp – spongy mesophyll, ep – epidermis, Bs – bundle sheet

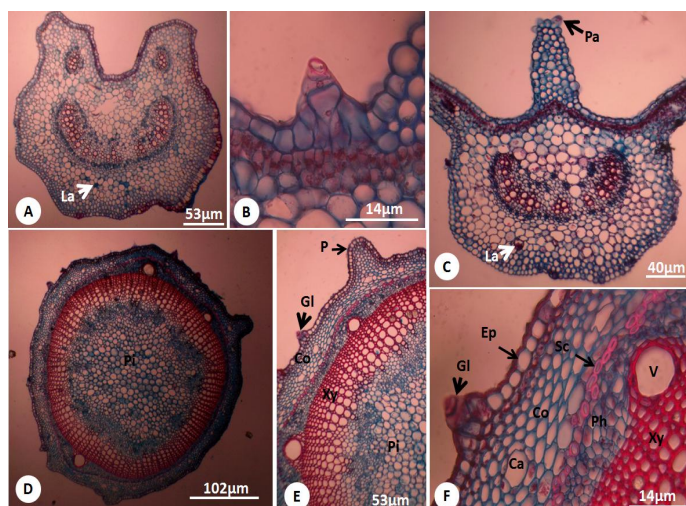


Fig. 3. Transverse sections of petiole, midrib, and stem of *I. coccinea*
Pa – papillose, *Ep*- epidermis, *Co*- cortex, *Xy*- xylem, *Ph*- phloem, *P*- projection, *Pi*- pith,
Ca- secretory cavity, *Vi*- vessel element, *Gl* – glandular trichome, and *Sc*- fibre

5. CONCLUSION

The morphological and anatomical of *I. coccinea* for Nigeria is reported for the first time. These features of the species confirm that it is member of the Convolvulaceae family.

ACKNOWLEDGEMENTS

Authors wish to thank and appreciate the Department of Plant science and Biotechnology, University of Port Harcourt for providing the laboratory equipment and assistance during this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fang RC, Staples G. Convolvulaceae In: Wu ZY, Raven PT. (ed.). Science press, Beijing, China, and Missouri Botanical Garden, St. Louis, U.S.A. Flora of China. 1995;16:271-325.
2. Staples GW, Yang SZ. Convolvulaceae In: Editorial Committee of the Flora of Taiwan, 2nd. ed., Flora of Taiwan. 1998;4:341-384.
3. Staples GW. Convolvulaceae unlimited. Available:<http://convolvulaceae.myspecies.info/> (Viewed 7 October 2011).
4. Mabberley DJ. The Plant-Book: A portable dictionary of plants their classification and uses. Third ed. Cambridge University Press, Cambridge; 2008.
5. Miller RE, Buckley TR, Manos PS. An examination of the monophyly of morning glory taxa using Bayesian phylogenetic inference. Systematic Biology. 2002;51: 740-753.
6. Manos PS, Miller RE. Phylogenetic analysis of *Ipomoea*, *Argyrea*, *Stictocardia*, and *Turbina* suggests a generalized model of morphological evolution in morning glories. –Syst. Bot. 2001;26(3):585-602.
7. Wilkin PA. Morphological cladistic analysis of the Ipomoeae (Convolvulaceae). Kew Bulletin. 1999;54:853-876.
8. Hutchinson J, Dalziel JM. Flora of West Tropical Africa. Revised by Keay, RWJ. Vol. I Part I. Crown Agents for Overseas Governments and Administrations, London; 1954.
9. Folorunso AE. Taxonomic Evaluation of Fifteen Species of *Ipomoea* L. (Convolvulaceae) from South-Western Nigeria using Foliar Micro-morphological Characters. Not Sci Biol. 2013;5(2):156-162.
10. Hutchinson J, Dalziel MJ. Flora of West Tropical Africa. Crown Agents for Overseas Governments and Administration. London. 1963;2:152-352.
11. USDA, NRCS. The PLANTS Database, Version 3.1, National Plant Data Center, Baton Rouge, LA 70874-4490 USA; 2008.

- Available:<http://plants.usda.gov/> (February 25, 2011).
12. McGregor RL. Flora of the Great Plains. Lawrence, Kansas: The University Press of Kansas; 1986.
 13. Song H. Flora of Missouri; 2006. Available:http://www.efloras.org/florataxon.aspx?flora_id=11&taxon_id=242417485
 14. Voss EG. Michigan Flora Part III: Dicots Concluded. Ann Arbor, Michigan: Cranbrook Institute of Science; 2004.
 15. Okereke CN, Iroka FC, Chukwuma MO. Assessing the morphological and taxonomic characteristics of some members of Convolvulaceae family. International Journal of Herbal Medicine. 2015;2(5):38-42.
 16. Folorunso AE, Illoh HC, Olorungbeja JA. Numerical taxonomy of some *Ipomoea* (Linn.) species in South-West Nigeria. Ife Journal of Science. 2013;15(1):63-74.
 17. Jayeola AA, Oladunjoye OR. Systematic studies in some *Ipomoea* Linn. species using pollen and flower morphology. Annals of West University of Timișoara, ser. Biology. 2012;15(2):177-187.
 18. Abdel KK. A phenetic study of Convolvulaceae from Egypt based on analysis of morphological characters. — Fl. Medit. 2008;18:65-87. ISSN: 1120-4052.
 19. Metcalfe CR, Chalk L. Anatomy of the Dicotyledons, vol. 1 Clarendon Press, Oxford; 1950.
 20. Metcalfe CR, Chalk L. Anatomy of the Dicotyledons 2nd Edition, Volume I, Oxford, Clarendon Press. 1979;40-53.
 21. Aworinde DO, Ogundairo BO, Erinoso SM, Sharaibi OJ. Foliar Epidermal and Petiole Anatomical Studies of Some Nigerian Species of *Ipomoea* (Convolvulaceae). Current Botany. 2013;4(3):55-58.
 22. Adedeji O. Leaf epidermal studies of *Emilia* Cass. (*Senecionaea*, *Asteraceae*) species in Nigeria. Bot Lithu. 2004;10(2):121-133.
 23. Abdulrahman AA, Oladele O. Anatomical basis for optimal use of water for maintenance of three xerophytic plants. Not Sci Biol. 2012;4(2):53-58.
 24. Pickard WF. Laticifers and secretory ducts: two other tube systems in plants. New Phytol. 2008;177:877–887.
 25. Akçin OE, Binzet R. The micromorphological and anatomical properties of *Onosma angustissimum* Hausskn. & Bornm. and *O. cassium* Boiss. (*Boraginaceae*). Bangladesh J Plant Taxon. 2010;17(1):1-8.
 26. Ogundipe OT, Olatunji OA. The leaf anatomy of the species of *Cochlospermum* (Cochlospermaceae) in West Africa, Feddes Reppert. 1991;102(3-4):183-187.
 27. Illoh HC. Foliar epidermis and petiole anatomy of four species of *Celosia* L. in Nigeria. Feddes Reppert. 1995;106(1-2): 15-23.
 28. Ogundare CS, Saheed SA. Foliar epidermal characters and petiole anatomy of four species of *Citrus* L. (Rutaceae) from South-Western Nigeria. Bangladesh J. Plant Taxon. 2012;19(1):25-31.
 29. Aworinde DO, Ogundairo BO, Erinoso SM, Olanloye AO. Foliar epidermal studies of some Nigerian species of *Sida* Linn. (Malvaceae). Scholarly Journal of Agricultural Science. 2012;2(2):18-22.
 30. Bolarinwa KA, Oyebanji OO, Olowokudejo JD. Comparative morphology of Leaf epidermis in the genus *Ipomoea* (Convolvulaceae) in Southern Nigeria. Annals of West University of Timișoara, ser. Biology. 2018;21(1):29-46
 31. Lowell C, Lucansky TW. Vegetative Anatomy and Morphology of *Ipomoea hederifolia* (Convolvulaceae) Bulletin of the Torrey Botanical Club. 1986;113(4):382-397, Available:<https://doi.org/10.2307/2996431>
 32. Solereder H. *Systematic anatomy of the dicotyledons*. Oxford: Clarendon Press; 1908.
 33. Metcalfe CR, Chalk L. Anatomy of the Dicotyledons: Wood Structure and Conclusion of the General Introduction. Clarendon Press, Oxford; 1983.
 34. Condon JM, Fireran BA. Distribution and organization of articulated laticifers in *Calystegia silvatica* (Convolvulaceae). Bot Gaz. 1989;150:289-302.
 35. Fabiano MM, Jamile FL, Ana ASM, Thayane PM. (2012). Secretory structures of *Ipomoea asarifolia*: anatomy and histochemistry. Brazilian Journal of Pharmacognosy. 2012;22(1):13-20.
 36. Babu K, Dharishini PM, Austin A. Studies on anatomy and phytochemical analysis of *Ipomoea pes-tigridis* L. Journal of Pharmacognosy and Phytochemistry. 2018;7(1):791-794.
 37. Arruda RCO, Viglio NSF, Barros AAM. Anatomia foliar de halófitas e psamófilas reptantes ocorrentes na Restinga de Ipitangas Saquarema, Rio de Janeiro Brasil. *Rodriguésia*. 2009; 60:333–352.

38. Shrestha S, Shrestha N, Rajbhandary S. *Ipomoea* L.(Convolvulaceae) in Nepal. Micromorphological Studies of the Genus Himalayan Biodiversity. 2017;5(1):16-23.

© 2021 Ekeke et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/67118>