NJB, Volume 35 (2), 93-104, Dec, 2022

INVESTIGATION OF SIMILARITIES BETWEEN *CLAPPERTONIA FICIFOLIA* (WILLD.) DECNE. AND *URENA LOBATA* L. BASED ON MORPHOLOGY AND DISTRIBUTION

[1]Nichodemus, C. O., [2] Konyeme. T. E. and [3]Adewale, D. B.

[1]Department of Plant Science and Biotechnology, University of Port Harcourt, Rivers State, Nigeria

[2] Department of Biological Sciences, University of Delta, Delta State, Nigeria

[3] Department of Crop Science and Horticulture, Federal University, Oye-Ekiti, Ikole-Ekiti Campus, Ekiti State, Nigeria

Correspondence: cornel4nic@gmail.com

Received 23rd November, 2022; accepted 18th December, 2022

ABSTRACT

Clappertonia ficifolia (Willd.) Decne. and *Urena lobata* L. are pantropical and indigenous African species with high socioeconomic importance, especially as sources of food and fiber. In this study, both species were investigated with respect to their shared similarities, habitat and geographical distribution. Qualitative and quantitative data on the vegetative and floral parts were recorded. Field records for various habitats and geographical distribution were made. Morphologically, both species have Malvoid leaf type, bristle fruits, simple to lobed (3-7) leaves, pubescent to tomentose vestiture with multiple branching patterns and are inhabitants of tropical evergreen forests. Both species differ in their inflorescence, fruit shape, number and metric measurements of their floral parts. *U. lobata* has secretory glands (1-3), axillary cyme to rarely solitary inflorescence, round fruits and 5 fused petals while *C. ficifolia* has no secretory gland, terminal, solitary to rarely paired inflorescence, oblong fruits, and 4 free petals and sepals. *Clappertonia ficifolia* is an indicator species for seasonally swamp forests and flowers when the forest is flooded. The similarities recorded for these species are a guide to their systematics. Although these species are found in a range of habitats and have a wide geographical distribution, their conservation is recommended.

Keywords: *Clappertonia ficifolia*; habitat; Malvoid; morphology; similarity; *Urena lobata*

https://dx.doi.org/10.4314/njbot.v35i2.1

INTRODUCTION

The circumscription of families within Malvales (i.e. Tiliaceae, Sterculiaceae, Bombacaceae and Malvaceae) has been of taxonomic concern (Bayer and Kubitzki, 2003; Perveen *et al.*, 2004). This has resulted in the transfer of several genera from one family to another (Nilsson and Robyns, 1986; Kelman 1991). To resolve this, Judd and Manchester (1997) reported that Hutchinson (1926, 1973) placed Tiliaceae, Sterculiaceae and Bombacaceae in Tiliales, leaving Malvaceae in Malvales. This classification system was further supported by Hutchinson and Dalziel (1958) using the morphological phylogenetic approach. One of their classifications reported that *Urena lobata*, a West African monotypic species, belongs to the family Malvaceae while *Clappertonia*, a ditypic genus with two species, *C. ficifolia* and *C. minor*, belongs to the family Tiliaceae. By this classification, *U. lobata* and *C. ficifolia* were placed within the orders Malvales and Tiliales, respectively.

The introduction of molecular phylogenetic studies has resolved issues of phylogenetic relationships among plants particularly in Malvaceae (Bayer *et al*., 1999; Whitlock *et al*., 2001) and improved plant classification. APG (2009, 2016) and Haston *et al.* (2009) classification system using molecular phylogenetic studies placed Malvaceae in the order Malvales and re-classified nine subfamilies within Malvaceae, thereby highlighting Tilioideae, Bombacoideae, Sterculioideae and six (6) other subfamilies within Malvaceae. This led to the current expansion of Malvaceae (the mallow family) consisting of 244 genera and 4225 species (Christenhusz and Byng, 2016) based on molecular classification.

Despite the improved classification system using molecular tools (APG 2009, 2016), a number of species within Malvaceae are still placed inappropriately and retain their former classification (Akobundu *et al*., 2016; Akunne *et al*., 2016). This could be due to a couple of reasons; first, the use of an old classification system that is based on morphology alone. Second, the continuous change in the nomenclature of species. Third, lack of updated taxonomic information. These factors have led to wrong placement (classification) of plant species in recent times. Here, morphological evidence is used to show that these species belong to the Malvaceae family irrespective of their similarities and dissimilarities that have resulted in wrong classification.

In this study, the geographical distribution of *U. lobata* and *C. ficifolia* is also examined as they are tropical species found within the rainforest region of southern Nigeria. Studies on the geographical distribution of plants, underlying their localities, habitats and ecological zones are well documented (Sulman *et al*., 2013; Awala *et al*., 2019; Stubbs *et al.*, 2020). Geographical distribution of plants refers to the distribution or arrangement of plants across different regions or localities of the globe (Martín-Bravo and Escudero, 2012). Both species are widespread and can be found in a wide range of habitats.

In plant systematics, species often possess similar features which overlap and create confusion in their taxonomy (Nichodemus and Ekeke, 2021). In this study, morphological and biogeographical characteristics that make *U. lobata* and *C. ficifolia* similar and dissimilar were investigated.

MATERIALS AND METHODS

Study area

This study was conducted at the University of Port Harcourt (4.906901° N, 6.917005° E) and three surrounding communities – Alakahia (4.885303°N, 6.925127°E), Aluu (4.919633°N, 6.915125°E) and Choba (4.891500°N, 6.906808°E) all in Rivers State, Nigeria. The study area is within the tropical rainforest vegetation in the southern part of Nigeria, and a region with abundant plant diversity.

Sample collection and identification

Matured fresh samples (vegetative and floral parts) of *U. lobata* and *C. ficifolia* were collected from the field using a collection bag and taken to the University of Port Harcourt Herbarium (UPH) for identification and characterisation. Both species occurred in groups or clusters in each habitat and were collected from June through October 2020 and 2021. The species were found in disturbed vegetation, along roadsides, swampy areas and forest fringes.

Data collection and analysis

Qualitative and quantitative data were recorded on vegetative and reproductive parts of the collected *U. lobata* and *C. ficifolia* (Table 1). A total of 12 samples from the four locations were collected. Observations were recorded on some quantitative parameters using the meter rule, Vernier caliper, hand lens, etc.

Data analysis

Mean and standard error were calculated for the samples of each species. Moreover, paired t-test statistic was employed to compare the means of the two species for the different quantitative traits, using PROC t-test in SAS (version 9.4, 2011).

Habitat and geographical distribution

Field data were documented based on physical observations for the habitat and geographical distribution of *U. lobata* and *C. ficifolia*. Information from previous literature was used to further create a comprehensive study list for *U. lobata* and *C. ficifolia*.

RESULTS

Morphology

The descriptive morphology of *U. lobata* and *C. ficifolia* is presented in Table 1. Both species are shrubby, erect, perennial and highly branched. The plant height of *C. ficifolia* is higher, but the stem girth of the two species is similar (4 – 7 cm thick). The vestiture of *U. lobata* is pubescent with green to brown pigmentation. The stem and the branches of *C. ficifolia* have either grey, brown or red pigmentation. The inflorescence of *U. lobata* has an axillary cyme but in *C. ficifolia,* it is solitary and terminal. In both species, the fruits have bristles, dry dehiscence and are dark-brown at maturity. The fruits of *U. lobata* and *C. ficifolia* are round and oblong, respectively (Table 1).

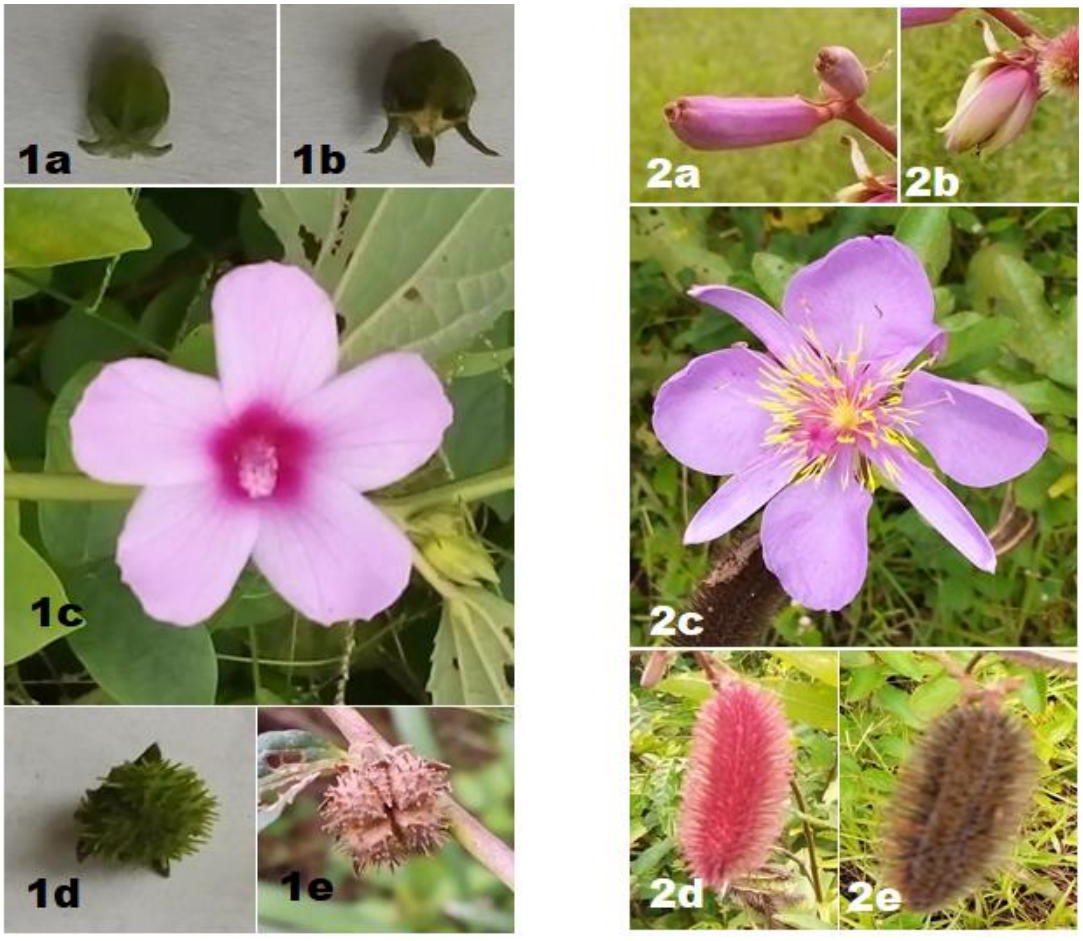
Table 1. Descriptive features of *Urena lobata* and *Clappertonia ficifolia*

Plant species **Characters**	***Urena lobata***	***Clappertonia ficifolia***
Plant height	1.2-3.7 m	3.0-5.2 m
Stem		
Vestiture	Pubescent	Short stellate-tomentose
Pigmentation	Green to brown	Grey, red to brown
Girth	4-7 cm	4-7 cm
Leaf		
Shape	Simple-lobed (3-7 not deeply lobed)	Simple-lobed (3-5) not deeply lobed
Vestiture	Tomentose	Tomentose
Apex; base; margin	Acute; cordate; dentate	Acute; round-cordate; toothed-dentate
Venation	Palmate (5-7 veins)	Palmate (5-7 veins)
Length by width	3.7-9.6 cm by 3.1-10.4 cm	3.6-10.3 cm by 2.2-7.4 cm
Abaxial pigmentation	Grey	Light green
Secretory gland	Present (1-3) towards the leaf base	Absent
Petiole		
Vestiture	Pubescent	Tomentose
Pigmentation	Green – brown	Red
Length	0.7-6.7 cm	1.2-3.4 cm.
Stipules	Present	Present
Inflorescence	Cyme (3-7) and rarely solitary, pubescent, axillary	Solitary and rarely in pairs, pubescent, terminal
Flower		
Colour; vestiture	Purple; hairy	Pink to purple; hairy
Flower nature	5 sepals united at base and 5 inner sepals, 5 fused petals. Stamen and carpel on the same flower (hermaphrodites), purple anthers are attached to the style through the filaments. Anthers contain four (4) hairy pollen sacs, sticky stigma on top of the style.	4 free sepals and petals, yellow stamen, and carpel on the same flower, white-yellow anthers arising from the base.
Measurement	Petal length (1.4-1.6 cm), sepal length (0.7-0.8 cm) and inner sepal length (0.4 cm).	Petal length – 3 cm, sepal length – 3.6 cm
Fruit		
Nature	Rough, circular, 5 chambered, covered with rigid hooked bristles and dry dehiscence	Rough, oblong, covered with spiny bristles, dry dehiscence
Fruit colour	Green and dark brown at a young stage and maturity, respectively	Reddish and dark brown at young stage and maturity, respectively
Measurement	1.0-1.2 cm by 0.6-0.8 cm	2.8-3.8 cm by 0.9-1.8 cm

Table 2: Descriptive and mean difference detection by t-test statistics of some quantitative traits of *U. lobata* and *C. ficifolia*

S/N	Variables	*U. lobata*	*C. ficifolia*	t-value	Probability	Significance
1	Leaf length (cm)	7.15±0.6	7.09±0.63	0. 08	0. 9407	Ns
2	Leaf width (cm)	7.67±0.78	5.39±0.47	2. 56	0. 0265	*
3	Petiole length(cm)	4.53±0.57	2.23±0.21	3. 62	0. 0040	**
4	Fruit length (cm)	1.07±0.02	2.92±0.03	80. 34	<0. 0001	***
5	Fruit width (cm)	0.75±0.02	1.32±0.1	5. 93	<0. 0001	***
6	Petal length (cm)	1.53±0.01	3.01±0.02	67. 79	<0. 0001	***
7	Sepal length (cm)	0.74±0.02	3.57±0.02	80. 52	<0. 0001	***

Table 2 shows the mean and the significant test for variation between the two species for three vegetative, two floral and two fruit traits. Significant ($p<0.05$) variation existed between the means of the various traits for the two species in Table 2 except for leaf length. *U. lobata* had significantly ($p\leq0.05$) higher means for leaf width (7.67 cm) and petiole length (4.53 cm) compared to *C. ficifolia.* Moreover, in the Table, the mean length of the petal (3.01 cm) and sepal (3.57 cm) and the length (2.92 cm) and width (1.32 cm) of the fruits of *C. ficifolia* were significantly ($p<0.0001$) higher than that in *U. lobata* (Table 2).



Figures 1 & 2: Floral and fruit features of *U. lobata* (1a-e) and *C. ficifolia* (2a-e), (**a-b**) flower bud (**c**) flower (**d**) young fruit (**e**) matured fruit

Figures 1 & 2 show the flower and fruit morphology of both species. Flower colour, petal orientation, number and fruit size were distinctive characteristics of *U. lobata* and *C. ficifolia*. *U. lobata* has pink flowers, 5 fused petals and round fruits while *C. ficifolia* has purple flowers, 4 free petals and sepals, and oblong fruits. The fruits of both species are dry, dehiscent and covered with bristles.

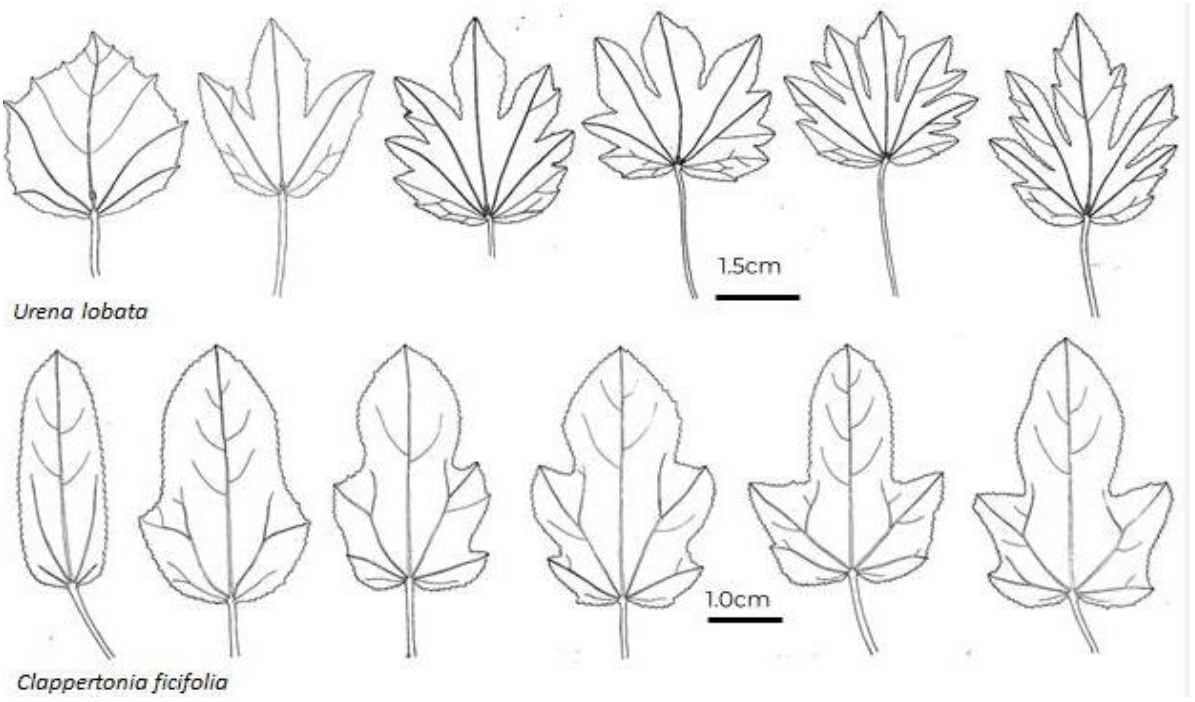


Figure 3: Morphological variations in the leaf architecture of *U. lobata* and *C. ficifolia*

From Figure 3, the leaf architecture of both species ranges from simple to lobed (3-7). Both species have palmate venation and dentate margins. Secretory glands (1-3) were observed on the abaxial layer of *U. lobata* but were absent in *C. ficifolia*.

.

Habitat and distribution

Table 3 shows that *Urena lobata* can be found in a range of habitats namely roadsides, disturbed vegetation close to forests and plain lands. It is found growing in moist tropical Africa and hence it is a pantropical species. *Clappertonia ficifolia* is a tropical species that is commonly found in southern Nigeria and occupies similar habitats such as close to water bodies, marshy places, swampy forests or forest fringes. Further information on the habitat and distribution of both species is provided in Table 3.

Table 3: Habitat and geographical distribution of the two species

Species	Habitat	Geographical distribution
Urena lobata	Grasslands, bushland, flood plains, river banks, roadsides and fallow lands (N'danikou *et al*., 2011; Akobundu *et al*., 2016). Low woody lands (Hutchinson and Dalziel, 1958). Waste grounds, coastal dunes, riparian areas, swamps, salt marshes and abandoned croplands (Langeland *et al*., 2008; Florida Exotic Pest Plant Council, 2011).	Africa – Cape Verde, Senegal, Ethiopia, Sudan, Eritrea, South Africa, DR Congo, Gambia, Togo, Ghana, Nigeria, Angola, Zambia and Madagascar (Hutchinson and Dalziel, 1958; Whitehouse *et al*., 2001; N'danikou *et al*., 2011). Asia (N'danikou *et al*., 2011). Australia, West Indies and North and South America (Broome *et al*., 2007).
Clappertonia ficifolia	Swamps, forest fringes, swampy forests and riverine (Bosch, 2011; Akobundu *et al*., 2016). Marshy (Hutchinson and Dalziel, 1958)	Tropical Africa – Cameroon, DR Congo, Nigeria, Sierra Leone, Cote d'Ivoire, Liberia and Gabon (Hutchinson and Dalziel, 1958; Bosch, 2011). Sri Lanka, Singapore, Borneo, New Guinea, Panama, southern USA (Bosch, 2011)

The distribution maps of *C. ficifolia and U. lobata* based on georeferenced occurrences from GBIF.org database are illustrated in figures 4 and 5, respectively.

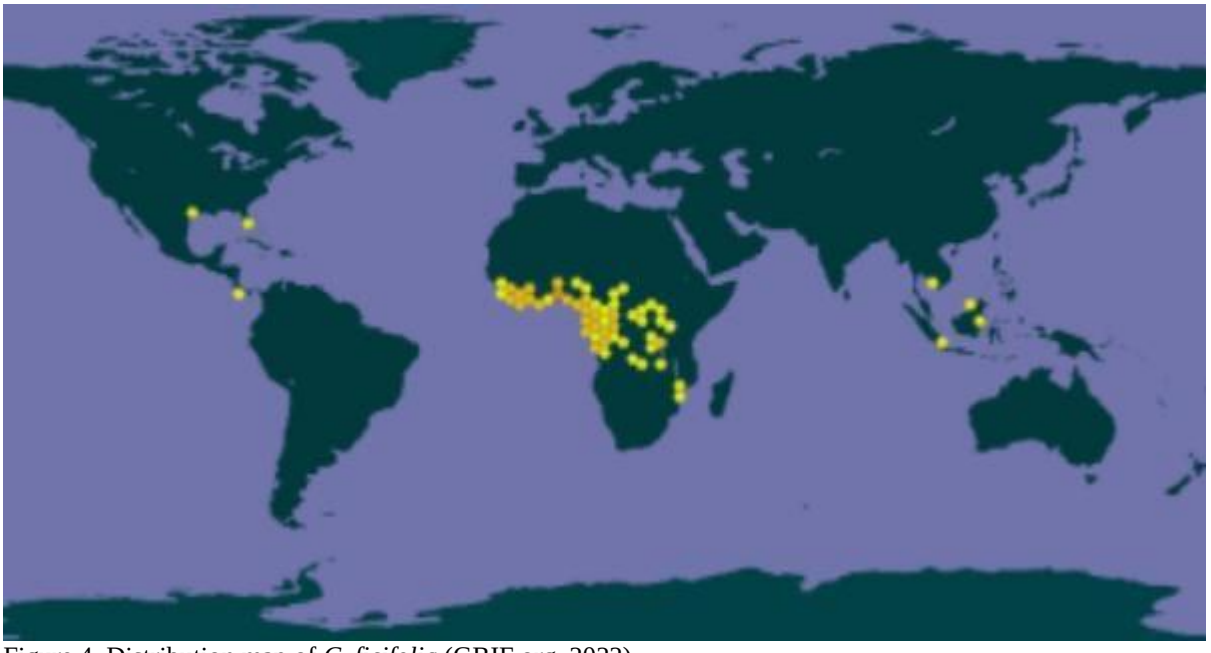


Figure 4. Distribution map of *C. ficifolia* (GBIF.org, 2022)

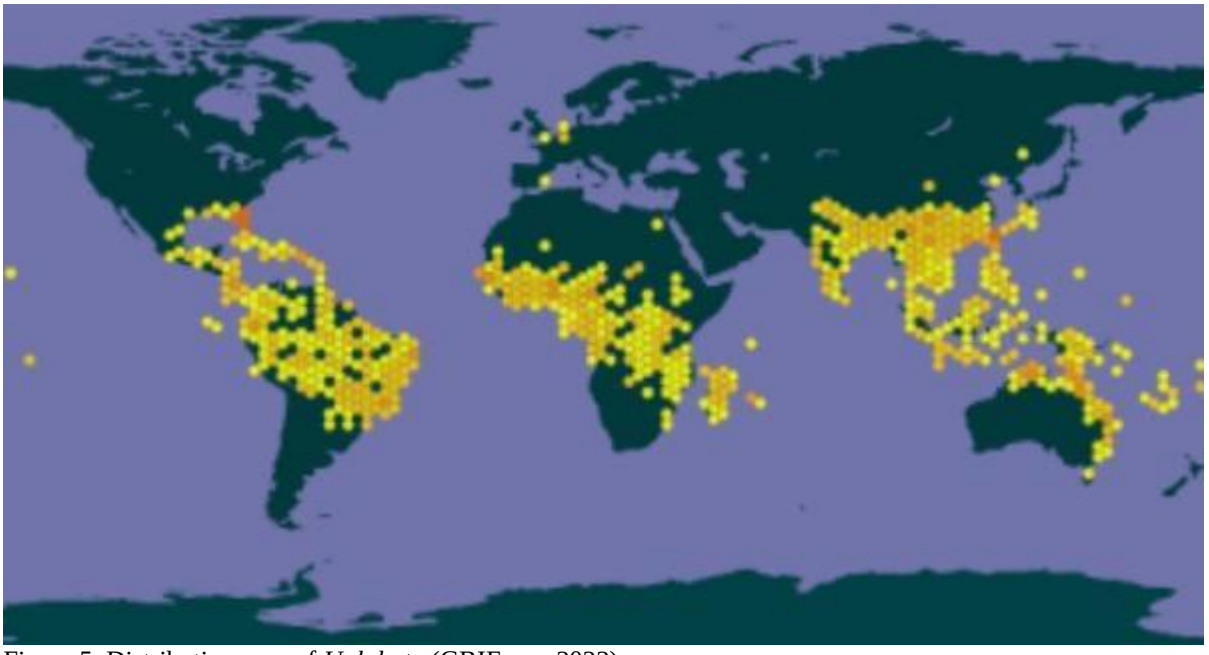


Figure 5. Distribution map of *U. lobata* (GBIF.org, 2022)

DISCUSSION

Morphology

Morphological characters have become useful tools in the identification of plant species (Nichodemus and Ekeke, 2021). Morphological similarities and differences exist among plant species at family, generic and specific epithet levels which form the basis for their taxonomy (Nichodemus and Ekeke, 2021) and binomial nomenclature designation. Though there could be some levels of overlapping characters among plant species, each possesses sole and peculiar traits vital to its identification (Stace, 1980). Species of Malvaceae are characterised by having a particular leaf serration called the Malvoid type (Mandal and Maiti, 2013) and/or palmate leaf type. This feature was evident in *U. lobata* and *C. ficifolia*, and both shared high similarities in various leaf characters like leaf shape, margin, apex, base, vestiture and venation.

About 1-3 secretory glands were present on the abaxial leaf base of *U. lobata* but absent in *C. ficifolia*. The petiole was distinctive in length, as *U. lobata* was longer than *C. ficifolia*. Features associated with the flower and fruit showed some form of similarity in colour and texture but differed in sepal and petal number, flower orientation, position, fruit size and structure. The study identified petal and sepal length, fruit length and width as very important distinguishing quantitative traits for the two species. Information arising from these supports the individual characteristics (morphology) for both species by Hutchinson and Dalziel (1958) and Akobundu *et al*. (2016) and not their family classification, as the classification system of APG (2009, 2016) proved more useful and adopted for this study. Interestingly, the distinctive characters between *U. lobata* and *C. ficifolia* are worthy morphological guides to their identification as different species irrespective of the shared characters.

Habitat and geographical distribution

Similarities as well as differences exist between the habitat and geographical distribution of *Urena lobata* and *Clappertonia ficifolia*, as reported by Langeland *et al*. (2008), Florida Exotic Pest Plant Council (2011), Bosch (2011) and Akobundu *et al.* (2016). Langeland *et al*. (2008) and Florida Exotic Pest Plant Council (2011) noted that *U. lobata* can be found in waste grounds, coastal dunes, riparian areas, swamps, salt marshes and abandoned croplands. Bosch (2011) and Akobundu *et al*. (2016) reported that *C. ficifolia* can be found in savanna, plain lands and disturbed vegetation. *Clappertonia ficifolia* is an indicator species for seasonally swamp forests and flowers when the forest is flooded.

In pollination biology, Akunne *et al*. (2016) noted that both *U. lobata* and *C. ficifolia* are nectariferous, polleniferous and entomophilous in nature. They attract similar visitors (ants) and pollinators (e.g. *Apis mellifera adansonii*). The presence of these pollinators could account for their wide occurrence and dominance in any habitat found.

The origin of diversity (centre of origin) of *U. lobata* is currently unknown due to different reports about its original distribution. It is found growing in moist tropical and subtropical regions of the world including Asia, tropical Africa, Australia, North, Central and South America, the West Indies and islands in the Pacific (Broome *et al*., 2007). Its cosmopolitan nature has made the centre of diversity for the species somewhat difficult. However, based on previous literature, Africa seems to be the centre of diversity for *U. lobata* due to some reasons. Firstly, it is a monotypic species in Africa. Secondly, it has a wide geographical distribution and occurrence in Africa. Thirdly, scanty information is available on the species, most especially the report of Hutchinson and Dalziel (1958) and N'danikou *et al*. (2011) on the geographical distribution and widespread of the monotypic species, *U. lobata* in West Africa. It is of interest that other species of *Urena* such as *U. sinuata, U. procumbens, U. grandifolia, U. chinensis, U. trilobata*, and many more are found in tropical and subtropical areas in Asia, America and Australia, and these areas are defined as their centre of diversity (Broome *et al*., 2007). In the case of *C. ficifolia*, its centre of origin is tropical Africa as reported by Hutchinson and Dalziel (1958), Whitehouse *et al*. (2001) and Bosch (2011) who noted that *C. ficifolia* could be found in Angola, Benin, Burundi, Cameroon, Central African Republic, DR Congo, Ghana, Guinea, Cote d'Ivoire, Liberia, Nigeria, Mozambique, Senegal, Sierra Leone, Sudan, Togo and Uganda. Bosch (2011) noted that it was also introduced and grown as an ornamental in Sri Lanka, Borneo, New Guinea, Panama, the southern United States and Singapore. It was introduced and distributed in tropical Asia and the Pacific regions. Hutchinson and Dalziel (1958) discovered another species of *Clappertonia* , "*C. minor*", in West Africa (Sierra Leone, Cote d'Ivoire and Liberia). These reports seem to confirm that the centre of diversity of *C. ficifolia* is tropical Africa.

Need for Conservation

Ample information is available on the economic importance of *U. lobata* and *C. ficifolia*, ranging from food (Burkill, 1997), medicine and antimicrobial (Fagbohun *et al*., 2012; Purnomo *et al.*, 2015) to fiber (Bosch, 2011; N'danikou *et al*., 2011), and other domestic purposes. The habitats occupied by these species are frequently destroyed and this poses a threat to the species niche. Therefore, there is the need to conserve these species for continuous utilisation.

Currently, increased deforestation, urbanisation, industrialisation and population have led to a global decline in biodiversity. Annually, biodiversity loss reads from hundreds of thousands to millions with little or no efforts made towards afforestation (FAO, 2011; Aliero, 2020). This calls for the conservation of both plant species and their habitats. It was observed that their habitats are constantly disturbed and threatened. For instance, *U. lobata* is found on roadsides, abandoned croplands, bushes and salt marshes. Similarly, *C. ficifolia* found in the fringe of forests and disturbed vegetation is likely to face deforestation or destruction. It is true that both species have a wide occurrence and distribution across several habitats. However, the inclusion of *U. lobata* and *C. ficifolia* and their habitats into the biodiversity conservation programme of any region would help to conserve the

species. In Nigeria, more efforts and support are needed in the conservation of indigenous plant species that are threatened due to overexploitation.

CONCLUSION

The study was borne out of observation of nearness from the shared morphology and habitat between *U. lobata* and *C. ficifolia*. The existence of several overlapping characters and variations has aided their classification as Malvaceae species. Significant variations occurred in the floral and leaf parts which form the basis for their differentiation and identification. Moreover, the habitat and geographical distribution of *U. lobata* and *C. ficifolia* showed a wide range of ecological zones in which both species could be found across the globe. Though they are ubiquitous, tropical Africa is believed to be their centre of diversity.

ACKNOWLEDGEMENT

The authors thank Jose E. Meireles for feedback and spins.

REFERENCES

Akobundu, I.O., Ekeleme, F., Agyakwa, C.W. and Ogazie, C.A. (2016). *A Handbook of West African Weeds*. Third edition, Revised and Expanded. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. pp 127-167.

Akunne, C.E., Akpan, A.U. and Ononye, B.U. (2016). A Checklist of Nectariferous and Polleniferous Plants of African Honeybees (*Apis mellifera adansonii* L.) in Awka, Nigeria. *Journal of Apiculture*, 31(4): 379-387, doi: 10.17519/apiculture.2016.11.31.4.379.

Aliero, A. A. (2020). Plants and environment for sustainable development. *Nigerian Journal of Botany*, 33(1): 1-14.

Angiosperm Phylogeny Group (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society*, 161(2): 105-121, doi:10.1111/j.1095-8339.2009.00996.x

Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society*, 181: 1–20, doi: 10.1111/boj.12385.

Awala, F.O., Ndukwu, B.C. and Agbagwa, I.O. (2019). Phytogeographical distribution and fruit diversity of *Lagenaria siceraria* species in Nigeria. *American Journal of Plant Sciences,* 10: 958 - 975, https://doi.org/10.4236/agps.2019.106069.

Bayer, C. and Kubitzki, K. (2003). Malvaceae. In: Kubitzki, K. (ed.) *The Families and Genera of Vascular Plants*, Vol. 5, Malvales, Capparales and non-betalain Caryophyllales, pp. 225-311.

Bayer, C., Fay, M.F., De Bruun, A.Y., Savolainen, V., Morton, C.M., Kubitzki, K., Alverson, W.S. and Chase, M.W. (1999). Support for an expanded family concept of Malvaceae within a recircumscribed order Malvales: a combined analysis of plastid at pB and rbcL DNA sequences. *Bot. J. Linn. Soc.*, 129: 267–303.

Bosch, C.H. (2011). *Clappertonia ficifolia* (Willd.) Decne. [Internet] Record from PROTA4U. Brink, M. & Achigan-Dako, E.G. (Editors). PROTA (Plant Resources of Tropical Africa/Ressources végétales de I'Afrique tropicale), Wageningen, Netherlands. http://www.prota4u.org/search.asp. [assessed 14th December, 2021].

Broome, R., Sabir, K. and Carrington, S. (2007). Plants of the Eastern Caribbean. Online database. Barbados: University of the West Indies. http://ecflora.cavehill.uwi.edu/index.html

Burkill, H.M. (1997). *The Useful Plants of West Tropical Africa*. 2nd Edition. Volume 4, Families M-R. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 969 p.

Christenhusz, M.J.M. and Byng, J.W. (2016). The number of known plant species in the world and their annual increase. *Phytotaxa*, 261(3): 201-217, doi:10.11646/phytotaxa.261.3.1.

Clappertonia ficifolia (Willd.) Decne. in GBIF Secretariat (2022). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei [accessed via GBIF.org on 2022-12-18].

FAO (2011). Global food losses and food waste- extent, causes and prevention. Rome, Food and Agriculture Organisation of the United Nations. [accessed 30th September, 2021].

Fagbohun, E.D., Asare, R.R. and Egbebi, A.O. (2012). Chemical composition and antimicrobial activities of *Urena lobata* L. (*Malvaceae*). *Journal of Medicinal Plants Research*, 6(12): 2256-2260, DOI: 10.5897/JMPR10.233.

Florida Exotic Pest Plant Council (2011). Florida EPPC's 2011 Invasive Plant Species List. http://www.fleppc.org/list/11list.html [assessed 30th September, 2021].

Haston, E., Richardson, J.E., Stevens, P.F., Chase, M.W. and Harris, D.J. (2009). The Linear Angiosperm Phylogeny Group (LAPG) III: a linear sequence of the families in APG III. *Botanical Journal of the Linnean Society*, 161 (2): 128-131, doi:10.1111/j.1095-8339.2009.01000.x.

Hutchinson, J. (1926). *The families of flowering plants*. Macmillan, London.

Hutchinson, J. (1973). *The families of flowering plants*. Clarendon Press, Oxford.

Hutchinson, J. and Dalziel, J.M. (1958). *Flora of West Tropical Africa*. Vol. 1 Part II. Whitefriars Press Ltd. London and Tonbridge. pp 202-256.

Judd, W.S. and Manchester, S.R. (1997). Circumscription of Malvaceae (Malvales) as determined by a preliminary cladistic analysis of morphological, anatomical, palynological and chemical characters. *Brittonia*, 49(3): 384-405.

Kelman, W.M. (1991). A revision of Fremontodendron (Sterculiaceae). *Systematic Bot*any, 16: 2-20.

Langeland, K.A., Cherry, H.M., McCormick, C.M. and Craddock Burks, K.A. (2008). *Identification and biology of nonnative plants in Florida's natural areas (2nd ed.).* Gainsville, Florida: University of Florida, IFAS Communication Services. 193 pp.

Mandal, M. and Maiti, G.G. (2013). Node-petiole anatomy and foliar architectural patterns of two Linnaean species of *Urena* Linnaeus (Malvaceae) and their taxonomic status. *Pleione*, 7(1): 59 - 65.

Martín-Bravo, S. and Escudero, M. (2012). Biogeography of Flowering Plants: A Case Study in Mignonettes (Resedaceae) and Sedges (Carex, Cyperaceae). *Global Advances in Biogeography*, 13: 257-290, Doi: 10.5772/32313.

Nichodemus, C.O. and Ekeke, C. (2021). Morpho-anatomical and histological characters in the systematics of the *Croton* species (*Crotonoideae, Euphorbiaceae*) in Southern Nigeria. *Phytologia Balcanica*, 27(2): 187-202.

Nilsson, S. and Robyns, A. (1986). Bombacaceae Kunth. *World Pollen and Spore Fl.*, 14: 1-59.

N'danikou, S., Achigan-Dako, E.G. and Oyen, L.P.A. (2011). *Urena lobata* L. [Internet] Record from PROTA4U. Brink, M. & Achigan-Dako, E.G. (Editors). PROTA (Plant Resources of Tropical Africa/Ressources végétales de I'Afrique tropicale), Wageningen, Netherlands. http://www.prota4u.org/search.asp. [Accessed 30th May 2022].

Perveen, A., Grafström, E. and El-Ghazaly, E. (2004). World Pollen and Spore Flora 23. Malvaceae Adams. P.p. Subfamilies: *Grewioideae, Tilioideae, Bromelioideae*. *Grana*, 43(3): 129-155, doi: 10.1080/00173130410000730.

Purnomo, Y., Soeatmadji, D.W., Sumitro, S.B. and Widodo, M.A. (2015). Anti-diabetic potential of *Urena lobata* leaf extract through inhibition of dipeptidyl peptidase IV activity. *Asian Pacific Journal of Tropical Biomedicine*, 5(8): 645–649 http://dx.doi.org/10.1016/j.apjtb.2015.05.014.

Stace, C.A. (1980). *Plant Taxonomy and Biosystematics*. Edward Arnold Publishers Ltd., London. pp 2-10.

Stubbs, R.L., Folk, R.A., Soltis, D.E. and Cellinese, N. (2020). Diversification in the Arctic: Biogeography and Systematics of the North American Micranthes (Saxifragaceae). *Systematic Botany*, 45(4): 802-811, https://doi.org/10.1600/036364420X16033963649282.

Sulman, J.D., Drew, B.T., Drummond, C., Hayasaka, E. and Sytsma, K.J. (2013). Systematics, Biogeography and Character Evolution of *Sparganium* (Typhaceae): Diversification of A Widespread, Aquatic Lineage 1. *American Journal of Botany*, 100(10): 2023–2039, Doi:10.3732/Ajb.1300048.

Urena lobata L. in GBIF Secretariat (2022). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei [accessed via GBIF.org on 2022-12-18].

Whitehouse, C., Cheek, M., Andrews, S. and Verdcourt, B. (2001). *Flora of Tropical East Africa – Tilaceaec & Muntingiaceae*. A.A. Balkema, Rotterdam, Netherlands. 142p.

Whitlock, B.A., Bayer, C. and Baum, D.A. (2001). Phylogenetic relationships and floral evolution of the Byttnerioideae ('Sterculiaceae' or Malvaceae s.l.) based on sequences of the chloroplast gene ndhF, *Systematic Botany*, 26: 420–437.