



Significance of stomata and hair variations within some *Bauhinia* L. species

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Abstract

Epidermal cells, hair and stomatal characters studied in the leaves of 15 Egyptian *Bauhinia* species using both light and scanning electron microscopes. Variations in epidermal shapes, periclinal and anticlinal walls investigated. Hair density, type and wall ornamentation are considerably varied between the studied taxa. Type of stomata, stomatal index and density gave valuable variations between the studied taxa. The results have been discussed according to the taxonomic opinions and support the division of the *Bauhinia* species into two subgenera with five sections. Identification key according to hair density, type and wall ornamentations beside the type of stomata has been constructed.

Keywords: bauhinia, epidermal cells, stomata, taxonomy, trichomes

Introduction

Study of the micro-morphological features in plant taxonomy gained great attention in the last decades. Stace (1965 & 1989) [19, 20], Shah and Gopal (1969), Ghose & Banerji (1981), Rao & Ramayya (1983) [12], Kotresha and Seetharam (1995) [10], and Taia (1996, 2004 & 2006) [21, 22, 23] are from the most noticeable works in this concern. The neglect of the vegetative morphological characters in the identification and grouping of taxa delayed plant taxonomy. These characters can be of help in taxonomical conclusions. From the most important micro-morphological characters are the type of stomata, epidermal cells and hair type, presence and density. Albert and Sharma (2013) [1] mentioned that the interest in leaf trichomes is based on their functions which include lowering of leaf temperature, increase in tolerance to freeze, storage of phytochemicals, protection of the inner tissues from UV radiations from sun, water retention, and a keystone in delimitation of species in taxonomic studies. Beside this interest, leaf trichomes have important role in taxonomical works. Genus *Bauhinia* L. belonging to tribe Bauhinieae, subfamily Cercidoideae, family Fabaceae as given by the Legume Phylogeny Working Group (LPWG, 2017: 68; formerly tribe Cercideae Bronn 1822: 131). This genus has been the subject of a number of taxonomical treatments in which it has been recognized either as a single genus with several subgenera or as several distinct genera (Wunderlin *et al.* 1987, Lewis & Forest 2005, Sinou *et al.* 2009 and Wunderlin 1983, 2006 & 2009) [24, 25, 26]. These taxonomical arguments about the classification of the species under this genus are according to the dissimilarities between the species. In fact the micro-morphological studies within the *Bauhinia* species are scanty, and when done they are

considering few species. Step forward to understand the relations between the Egyptian *Bauhinia* road trees, fifteen species studied in this work. Type of stomata, epidermal cells and hair characters variations investigated using both light microscope (LM) and scanning electron microscope (SEM).

Materials and Methods

Fifteen species and two forms commonly cultivated in the Egyptian roads and gardens were subjected in this study. Herbarium sheets examined from the mentioned botanical gardens in Cairo, Egypt (table 1). Leaf peels from the abaxial surfaces, at least five leaves, stained with safranin, mounted in few drops of water and glycerol on clean microscopic slides and examined carefully by 10X40x compound light microscope to observe the stomatal type, shape of epidermal cells and hair density. The stomata index (I) and density (D) were calculated by the expressions: $I (\%) = \frac{SN}{SN + EC} \times 100$ and $D (\text{stom. mm}^2) = \frac{SN}{A}$, respectively, where SN = stomata number; EC = epidermal cells number; A = area (mm²). Terminology used in the description of the morphological characters is that of Dilcher (1974).

SEM investigation

Parts of the dry leaves were stuck onto the Aluminum stubs using double cello tape. The stubs were coated with 30 nm gold in a polaron JFC-1100E coating unit, then examined and photographed under 15Kev, with JEOL JSM-IT200 SEM in the electron microscopes unit, Faculty of Science, Alexandria University, Egypt, For more detailed structures of both the stomata and hairs.

Table 1: Studied species, information of the herbarium sheets, source of materials, confirmation of nomenclature and synonyms.

No	Taxa	Collectors & date of collection	Source of materials	Confirmation of nomenclature	Synonyms
1	<i>B. acuminata</i> L.	Reham Mahdy 5/7/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources	<i>B. linnaei</i> Ali <i>B. acuminata</i> Vell.

				Program; "The Plant List entry for Bauhinia", IPNI	
2	<i>B. blackeana</i> Dunn.(hybrid)	Reham Mahdy 5/12/2021	Giza:Mazhar botanical garden	The national flowers of Hong Kong. Lau <i>et al.</i> (2005).	No
3	<i>B. forficata</i> J.H.F.	Reham Mahdy 13/9/2020	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	<i>B. candicans</i> Benth. <i>B. breviloba</i> Benth. <i>B. forficata</i> subsp. <i>forficata</i> <i>Basionym Pauletia forficata</i> (Link) A. Schmitz
4	<i>B. galpinii</i> N.E. Br.	Reham Mahdy and Al-Shaarawy 12/7/2021	Al-Abeed Agriculture Farm	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	<i>B. galpinii</i> var. <i>galpinii</i> <i>Perlebba galpinii</i> (N.E.Br.) A.Schmitz
5	<i>B. glabra</i> Jack	Reham Mahdy 12/3/2021	Giza:Mazhar botanical garden	Catalogue of life check list, The NY Bot. Gard.	<i>B.heterophylla</i> Kunth <i>Schnella glabra</i> (Jacq.) Dugand
6	<i>B. grandidieri</i> Baill	Reham Mahdy 5/7/2021	Giza:Mazhar Bot.Gard.	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	No
7	<i>B. grevei</i> Drake	Reham Mahdy 5/7/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	No
8	<i>B. hookeri</i> F. Muell.	Reham Mahdy and Al-Shaarawy 12/7/2021	Al-Abeed Agriculture Farm	IPNI-The International Plant Names Index.	<i>Lysiphyllum hookeri</i> (F.Muell.) Pedley
9	<i>B.madagascariensis</i> Desv.	Reham Mahdy 5/7/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	<i>B.commersonii</i> Scott-Elliot
10	<i>B.monandra</i> Kurz	Reham Mahdy 22/11/2020	Giza: Orman botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	No
11	<i>B. purpurea</i> L.	Reham Mahdy 7/3/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	<i>B.platyphylla</i> Zipp. ex Span. <i>B.triandra</i> Roxb. <i>B.castrata</i> Blanco
12	<i>B.roxburghiana</i> Voigh	Reham Mahdy 15/9/2021	Giza:Mazhar botanical garden	IPNI (International Plant Names Index). Govaerts (1996) World Checklist of Seed Plants.	<i>B.emarginata</i> G.Don
13	<i>B. tomentosa</i> L.	Reham Mahdy 5/7/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	No
14	<i>B. vahlii</i> Wight & Arn	Reham Mahdy 8/3/2021	Giza:Mazhar botanical garden	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	<i>B.racemosa</i> Vahl <i>Phanera vahlii</i> (Wight & Arn.) Benth.
15	<i>B.variegata</i> (L.) Benth.	Reham Mahdy 7/5/2021	Giza:Mazhar botanical garden	Plants of the world on line	<i>Phanera variegata</i> (L.) Benth.
16	<i>B.variegata</i> (L.) alba	Reham Mahdy 8/3/2021	Doki: near Russian Center	"ILDIS LegumeWeb entry for Bauhinia"; USDA, ARS, National Genetic Resources Program; "The Plant List entry for Bauhinia"	No

Results (Table 2)

1. Epidermal cells

The photomicrographs of both the light and scanning electron microscope of the studied *Bauhinia* leaf surfaces revealed that the leaves have elongated or isodiametric polygonal, tetragonal or triangular epidermal cells with straight, wavy or undulate anticlinal walls. The periclinal walls are mostly convex, as appeared from the SEM examinations (plate 2), while only few species, *B.forficata*, *B.monandra* and *B.vahlii* have flat periclinal walls (Plate 2, photos. 6,17 & 23). The secondary ornamentations of the periclinal walls were unclear due to either the dense hairs or wax depositions. In the SEM photographs, the convex epidermal cells appear as globular in *B.glabra*, *B.grevii*, *B.hookeri*, *B.hookeri* and *B.purpurea* (Plate2, Photos. 9, 13, 14, 19 & 21)

2. Trichomes

Most of the studied taxa covered by hairs in both the adaxial and abaxial leaf surfaces with different densities and types, except both *B.hookeri* and *B.roxyburghiana* they are glabrous (Table 2 and Photos. 14 & 20). The hairs are distributed on all the leaf blades, except in *B.galpinii*, *B.glabra* and *B.grevei* they are restricted on the leaf blade margins only (Plate 1, photo 4 and Plate 2, Photo 7). The

hairs are very dense in *B.acuminata*, *B.blakeana*, *B.forficata*, *B.monandra* and *B.variegata* (Plate 2, Photos.1, 3, 5, 16 & 24) and multicellular uniseriate tabular or pointed (Plate 1, Photos. 4 & 5, and Plate 2, Photos. 4, 11, 17, 19 & 21). Cavitated hairs reported in *B.forficata*, *B.madagascariensis* and *B.vahlii* (Plate 1, photo 6, Plate 2, Photos. 6, 15 & 23).

The hair walls are either smooth, or ornamented with external sculptures. These sculpture are either echinate in both *B.monandra* and *B.tomentosa*, or granulates in the two forms of *B.grevei* or scales in both *B.grandidieri* and *B.purpurea* (Plate 2, Photos. 4, 11, 17, 19, 21 & 25).

3. Stomata

The leaf surfaces are mostly covered by epicuticular wax secretions which make the stomata unclearly noticed in the SEM. For that the observations of the stomatal characters were according to light microscope investigation. The photomicrographs of the light and scanning electron microscope revealed a paracytic, anisocytic and anomocytic types of stomata. They are hypostomatic except in *B.blakeana* they are amphistomatically distributed. They are randomly arranged and mostly covered by a mass of trichomes in *B.acuminata*, *B.blakeana*, *B.forficata*, *B.galpinii*, *B.monandra*, *B.vahlii* and *B.variegata alba* (Plate 2,

photos.1,3,5,17,22 & 24). Some of the studied species of *Bauhinia*; *B. blakeana*, *B. grandidieri* and *B. purpurea*; have two types of stomata, paracytic and anisocytic. The paracytic type, the two guard cells are surrounded by two parallel epidermal cells (Plate 1, photos.2, 3 & 8). The anisocytic stomata, the two guard cells surrounded by three epidermal cells (Plate 1, photos 1& 12). The anomocytic stomata, reported in in *B.grevii*,*B.hookeri*, *B.madagascariensis* and *B.vahlii*, where the two guard cells surrounded by four epidermal cells (Plate 1, photos. 7,9,10

& 12). The stomata are mostly small and in the same plane of the epidermal cells, except in both *B.glabra* and *B.grevei*, the guard cells are sunken.

The guard cells are of small size in all the studied taxa. The stomatal index and density is relatively few, while the stomatal density gives bigger number for the division of the stomatal index over the area which is 0.1 mm (table 2). The stomata in all the studied taxa were nearly shut and the stomatal openings were very small.

Table 2: Vegetative morphological characters of the studied species examined by SEM

No.	TAXA↓ Char.→	Epidermal cells				Hairs				Stomata			
		SH	PW	AW	Or	P	D	T	W	T	P	D	I
1	<i>B.acuminata</i> L.	Is	Cv	St	Gr	Al	+++	MUP	Sm	Par	S	116.3	11.2
2	<i>B. blakeana</i> Dunn	Is	Cv	St	Gr	Al	+++	MUP	Sc	Par& Ani	S	183.2	18.1
3	<i>B.forficata</i> Link	El	Fl	St	Gr	Al	+++	MUP& Gl	Sm	Par& Ani	S	201.3	19.1
4	<i>B.galpinii</i> N.E.Br.	Is	vC	St	tS	M	+	GUM	Sm	Ani	S	173.2	16.7
5	<i>B.glabra</i> Jacq.	El	vC	Wy	Sm	Al	+	TMM	Sm	Ani	Su	129.3	13.2
6	<i>B grandidieri</i> Baill.	Is	Cv	St	Pi	Al	++	UT	Sc	Par	S	174.5	16.3
7	<i>B. grevei</i> Drake	Is	vC	St	Gr	M	+	UP	Gr	Ano	Su	110.8	10.3
		Is	Cv	St	Gr	M	+	UP	Gr	Ano	Su	165.2	14.6
8	<i>B. hookeri</i> F. Muell.	El	Cv	Wy	Sm	---	--	---	---	Ano	S	198.3	15.8
9	<i>B.madagascariensis</i> Desv.	El	Cv	Si	Sm	Al	++	Gl	Sm	Ano	S	210.8	19.8
10	<i>B.monandra</i> Kurz	El	Fl	Wy	Ec	Al	+++	UT	Ec	Ani	S	235.2	21.6
11	<i>B. purpurea</i> L.	Is	Cv	Si	Gr	Al	++	UP	Sc	Par& Ani	S	197.2	19.5
12	<i>B.roxburghiana</i> Voigt	Is	Cv	Wy	Sm	---	--	---	---	Ani	S	151.3	13.5
13	<i>B.tomentosa</i> L.	El	Cv	Wy	Gr	Al	++	UP	Ec	Par	S	191.8	18.3
14	<i>B. vahlii</i> Wight & Arn.	Is	Fl	Wy	Sm	Al	+++	MUP& Gl	Sm	Ano	S	172.3	17.9
15	<i>B.variegata</i> L.	Is	Cv	Si	Sm	Al	+++	UP	Sm	Ani	S	194.3	20.1
16	<i>B. variegata alba</i>	Is	Cv	St	Sm	Al	+++	UP	Sm	Ani	S	202.8	19.2

Abbreviations: Al=All over the surface, Ani=Anisocytic, Ano=Anomocytic, AW=Anticlinal wall, Cv=Convex, D= Density, DH=Densely hairy, Ec=echinate, El=Elongated, Fc=flakes, Fl=Flat, Gl=Globular, Gr=Granulate, I=Index, Is= Isodiametric, M=Margin, MMT= Multicellular multiserrate tabular, MMU=Multicellular multiserrate glandular, MUG=Multicellular uniseriate glandular, MUP=Multicellular uniseriate pointed, Or=Ornamentation, P=Position, Par=Paracytic, PW=Periclinal wall, S=Superficial, Sc=Scally, St=Straight, Sm=Smooth, Su=sunken, T=type, Uc=unicellular, UT= unicellular tabular, W=Wall Wy=Wavy.

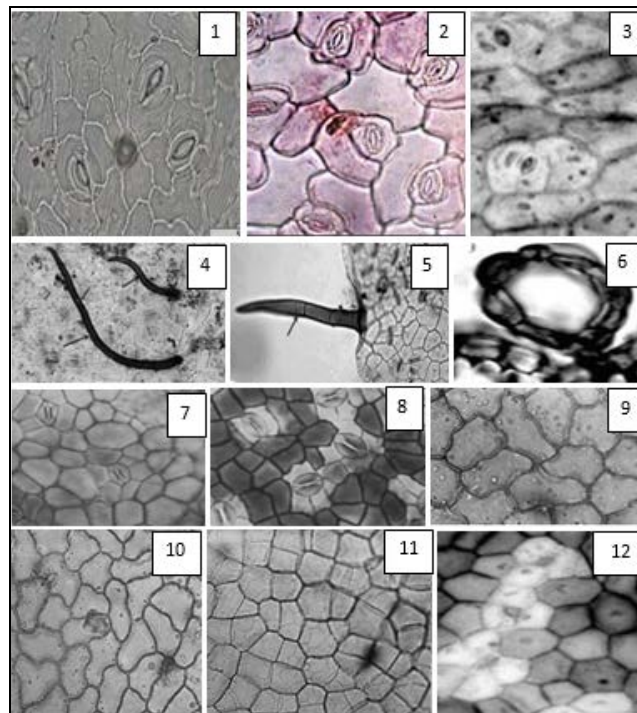


Plate 1: Light microscope photographs of leaf peels, 1*B.glabra* (anisocytic stomata & wavy pW), 2- *B.monandra* (anisocytic stomata & wavy pW), 3 & 4- *B.acuminata* (paracytic stomata & straight pW), 5-*B.forficata* (hair), 6- *B.vahlii* (Cavitated hairs), 7- *B.grevei* (anomocytic stomata & straight pW), 8- *B.purpurea* (both paracytic and anisocytic stomata & slightly sinuate pW), 9-*B.variegata* (sinuate pW), 10- *B.madagascariensis*(anomocytic stomata & sinuate pW), 11-*B.hookeri* (anomocytic stomata & straight pW), 12-*B.roxyburghiana* (anisocytic stomata & straight pW),

Identification key to the studied taxa**1. Densely hairy leaves all over the leaf blade**

- II-Unicellular pointed hairs with smooth walls----
B.variegata
II- Unicellular pointed hairs with echinate walls---
B.monandra
II-Multicellular uniserriate hairs with smooth walls only---
B.acuminata
II-Multicellular uniserriate hairs with smooth walls only---
B.Blakeana
II- Both Multicellular uniserriate hairs with smooth walls
and globular excavated hairs
III-Both paracytic and anisocytic stomata-----
B.forficata
III-Anomocytic stomata only-----*B.vahlII*

2. Hairs on the margins only

- II-Unicellular pointed hairs with granulated walls----*B.grevei*.
II-Multicellular uniserriate glandular hairs with smooth
walls ---- *B.galpinii*
II-Multicellular uniserriate tabular hairs with smooth walls--
----- *B.glabra*

3. I-Glabrous leaves

- III-Anisocytic stomata only-----*B.roxyburghiana*
III-Anomocytic stomata only-----*B.hookeri*

4. I-Moderately hairy

- II- Unicellular pointed hairs with ornamented walls
III-Both paracytic and anisocytic stomata----*B.purpurea*
III-Paracytic stomata only----- *B.tomentosa*
II-Cavitated globular hairs only-----*B.madagascariensis*

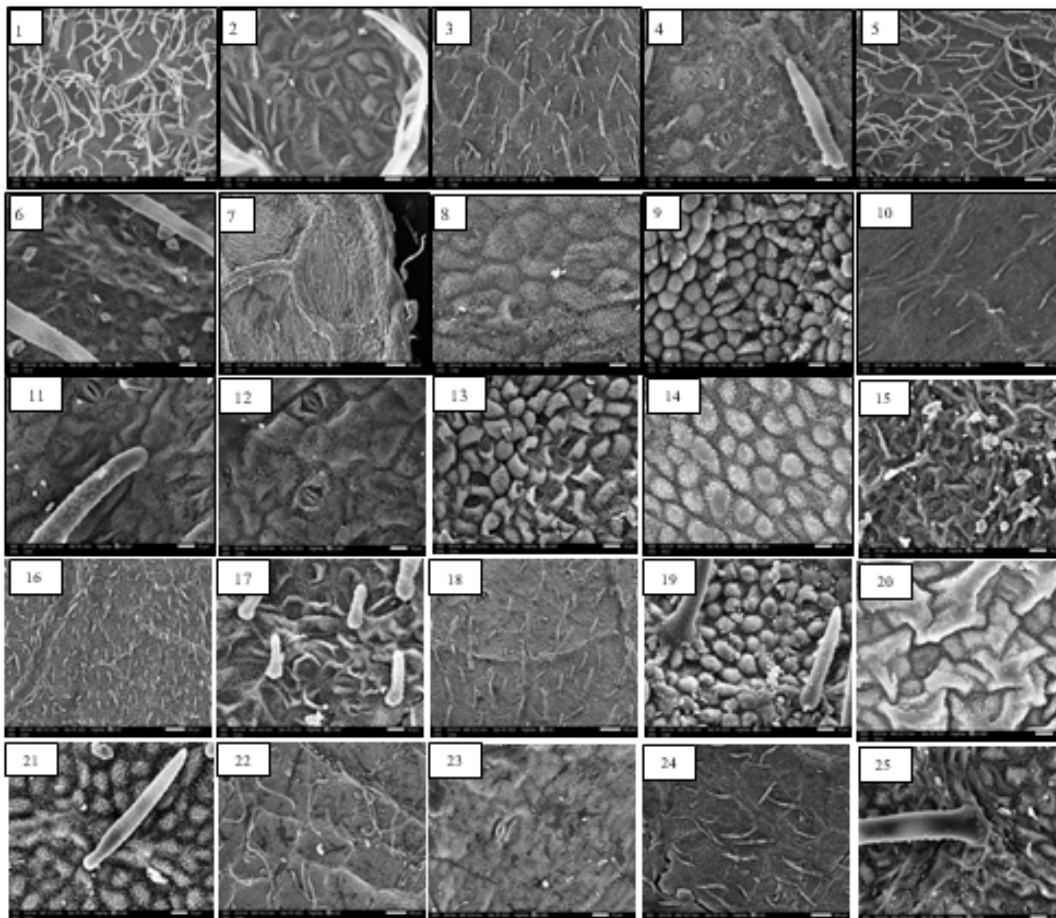


Plate 2: SEM photographs for the studied taxa, 1&2 *B. acuminata*, 3&4 *B.blakeana*, 5&6 *B.forficata*, 7&8 *B.galpinii*, 9- *B. glabra*, 10, 11 & 12 *B.grandidieri*, 13- *B. grevei*, 14- *B.hookeri*, 15- *B.madagascariensis*, 16&17 *B.monandra*, 18&19 *B.purpurea*, 20- *B. roxburghiana*, 21- *B.tomentosa*, 22&23 *B.vahlII*, 24&25 *B. variegata alba*.

Discussion

Leaf macro- and micro-morphological characters have been used in many taxonomical works and help in solving identification uncertainties. Within genus *Bauhinia*, the differentiation between the belonging species is confused and their taxonomic history and classification is long and complicated. Analyses based on morphological characters done (Wunderlin *et al.* 1987; Zhang 1995) [27] and molecular characters (Bruneau *et al.* 2001, 2008; Hao *et al.* 2003; Lewis, Forest 2005 and Sinou *et al.* 2009) [13, 18] suggest contrasting relationships within the genus. Albert and Sharma (2013) [1] indicated to the importance of using variations in frequency, types, distribution, and arrangement

of stomata in taxonomy and classification. Boodle and Fritsch (1908) [3] mentioned that the epidermal cells shape as well their walls of significance value in the classification of *Cassia* species. In this work the epidermal cells are either isodiametric, with different shapes and sizes, or longitudinally elongated. The anticlinal cell walls varied between straight, undulate and wavy. These observations confirm those obtained by Albert and Sharma (2013). Secondary sculpture on the periclinal walls can be used in distinguishing some closely related species and considered important character in taxonomical confusion (Zou *et al.* 2008). Within the majority of the studied *Bauhinia* species, the secondary sculpture of the periclinal walls lie within two

categories; smooth and granulate. Striate periclinal walls recorded in *B.galpini*, pitted walls in *B.grandidieri* and echinate walls in *B.monandra*.

From the most important character in taxonomy are those related to the trichomes (Stace, 1965 and Leelavathi & Ramayya, 1983) [12]. Hair type, density, position and wall ornamentations considered valuable in constructing the taxonomical keys. In this study the density, type and position of hairs varied greatly within the studied taxa. These variations used in constructing the identification key of the taxa. Even the lengths of the hairs varied between them, *B.acuminata* and *B.forficata* have very long hairs, while *B.monandra* has short hairs, while both *B.hookeri* and *B.roxyburghiana* have glabrous leaf surfaces. This observation coincide that obtained by Bannerje *et al.* (2002) on their study on the leguminous trees. According to hair characters, the studied taxa can be grouped under three groups; glabrous, moderately hairy and densely hairy. Under the later two groups subgroups can be obtained according to the type of hairs and hair wall characters. Cavitated globular hairs obtained in three species only *B.forficata*, *B.madagascariensis* and *B.vahlia*, this type of hairs have been reported by Marinho *et al.* (2016). Stomatal type and guard cell size have long been regarded as one of the diagnostic features for different taxa and has well been utilized by many workers to establish the groups or to eliminate the controversy about the taxonomic group (Dilcher 1974; Stace 1989; Carpenter 2005). Carlquist (1961) [14] and Praveen *et al.* (2007) pointed to the importance of stomatal characters in the delimitations between the species under the same genus. The studied taxa have three types of stomata; paracytic, anisocytic and anomocytic; in *Bauhinia*; *B.blakeana*, *B.grandidieri* and *B.purpurea*; have two types of stomata, paracytic and anisocytic. The occurrence of different types of stomata in the same species is rare, but it reported by Inamdar *et al.* (1969).

The guard cells are small and the opening is narrow in all the species. The stomatal index and density are considerably few in the leaf lamina, but near the margins they are slightly increased. This finding coordinates that obtained by Albert and Sharma (2013) [1], where they found the increase in the stomatal density near the margins of the leaves. These characters are due to the adaptation of the plants to reduce the water lost through transpiration as pointed by Dalin *et al.* (2008).

Conclusion

This study has highlighted detailed descriptive information of the micromorphological structures of *Bauhinia* species. The presence of the cavitated secretory trichomes, the stomata type, density, distribution, and epidermal cells characters could be useful in providing taxonomic information and could also serve as a database for future references of the species. The key provided can facilitate the identification of the studied taxa.

References

1. Albert S, Sharma B. Comparative Foliar micromorphological studies of some *Bauhinia* (Leguminosae) species. *Turk J Bot*,2013;37(2):276-281. doi:10.3906/bot-1201-37
2. Banerjee A, Chowdhry HR, Mandal S, Kar RK. Micromorphology of foliar epidermis of some tropical tree legumes. *Phytomorphology*,2002;1-2:49-52.
3. Boodle LA, Fritsch FE. Solereder's Systematic Anatomy of the Dicotyledons, Revised by Scott DH. Oxford: Clarendon Press, 1908, 1-2.
4. Carlquist S. Comparative Plant Anatomy. New York, USA: Holt, Rinehart and Winston, 1961.
5. Carpenter KJ. Stomatal Architecture and Evolution in Basal Angiosperms. *American Journal of Botany*,2005;92(10):1595-1615.
6. Dalin P, Ågren JA, Björkman C, Huttunen P, Kärkkäinen KK. "Leaf trichome formation and plant resistance to herbivory," in *Induced Plant Resistance to Herbivory*, A. Schaller, Ed., Springer Science+Business Media, Dordrecht, The Netherlands, 2008, 89-105.
7. Dilcher DL. Approaches to the identification of angiosperm leaf remains. *Bot. Rev*,1974;40(1):1-157.
8. Inaadar JA, Gopal VB, Chohan AJ. Development of normal and abnormal stomata in some Araliaceae. *Annals of Botany*,1969;33:67-73
9. Ghosh B, Banerji ML. Heteromorphic stomata in *Ilex L.* *Bulletin of Botanical Society of Bengal*,1981;35:113-115.
10. Kotresha K, Seetharam YN. Epidermal studies in some species of *Bauhinia L.* (Caesalpinioideae). *Phytomorphology*,1995;45:127-137.
11. Legume Phylogeny Working Group. A new subfamily classification of the Leguminosae based on a taxonomically comprehensive phylogeny. *Taxon*,2017;66:44-77. <https://doi.org/10.12705/661.3>
12. Leelavathi PM, Ramayya N. Structure, distribution and classification of plant trichomes in relation to taxonomy in *Caesalpinia*aceae. *Indian Journal of Forestry*,1983;6:43-53.
13. Lewis GP, Forest F. Cercideae. In: Lewis, G.P., Schrire, B., Mackinder, B. & Lock, M. (Eds.) *Legumes of the World*. Royal Botanic Gardens, Kew,2005:592:57-67]
14. Marinho CR, Oliveira RB, Teixeira SP. The uncommon cavitated secretory trichomes in *Bauhinia s.s.* (Fabaceae): the same roles in different organs. *Bot. J. Linn. Soc*,2016;180:104-122.
15. Parveen A, Abid R, Fatima R. Stomatal types of some dicots within flora of Karachi, Pakistan. *Pakistan Journal of Botany*,2007;39(4):1017-1023.
16. Rao Shanmukha SR, Ramayya N. Occurrence of stomatal diversity and taxonomic value of dominant and co-dominant stomatal types in the Mavales. *Feddes Repertorium*,1983;94(9-10):639-642.
17. Shah GL, Gopal BV. Development of stomata in some *Papilionaceae*. *Canadian Journal of Botany* • March • <https://doi.org/10.1139/b69-053>
18. Sinou C, Forest F, Lewis GP, Bruneau A. The genus *Bauhinia s.l.* (Leguminosae): a phylogeny based on the plastid *trnL-trnF* region. *Botany*,2009;87:947-960. <https://doi.org/10.1139/B09-065>
19. Stace CA. The Taxonomic Importance of the Leaf Surface. *Current Concept of Plant Taxonomy*. London: Academic Press, 1965.
20. Stace CA. *Plant Taxonomy and Biosystematics*. Cambridge University Press, Cambridge, 1989, 264 .
21. Taia WK. Morphological characters in the leaf of species of *Papilionoideae* (Leguminosae) in Egypt. *J. Union Arab Boil. Cairo* 5 (B), *Botany*, 1998, 137-158.
22. Taia WK. Leaf Characters Within Tribe *Trifolieae* (Family *Leguminosae*) *P.J.Bio.Sci*,2004;7(8):1463-1472.

23. Taia WK (2006). Boraginaceae: Hair variations and their significance in the systematic of the Genera .Asian Journal of Plant Sciences 5(3): 441-454.
24. Wunderlin RP. Revision of the arborescent Bauhinias (Fabaceae: Caesalpinioideae: Cercideae) native to middle America. Annals of the Missouri Botanical Garden,1983:70:95–127. <https://doi.org/10.2307/23990>.
25. Wunderlin RP. Revision of Bauhinia subgenus Bauhinia section Amaria (Cercideae: Caesalpinioideae: Fabaceae). Sida, Contributions to Botany,2006:22(1):97-122.
26. Wunderlin RP. Reorganization of the Cercideae (Fabaceae: Caesalpinioideae). Phytoneuron,2010:48:1-5.
27. Wunderlin RP, Larsen K, Larsen SS. Reorganization of the Cercideae (Fabaceae: Caesalpinioideae). Biol. Skrift,1987:28:1-40.
28. Zou P, Liao J, Zhang D. Leaf epidermal micromorphology of Cercis (Fabaceae: Caesalpinioideae). Botanical Journal of the Linnaean Society,2008:158:539-547.