Bangladesh J. Plant Taxon. **31**(1): 123-140, 2024 (June) DOI: https://doi.org/10.3329/bjpt.v29i2.74393

SYSTEMATICS AND MORPHOMETRICS OF THE SUBFAMILY BYTTNERIOIDEAE BURNETT IN BANGLADESH

SHEIKH SUNZID AHMED AND M. OLIUR RAHMAN[1]

Department of Botany, Faculty of Biological Sciences, University of Dhaka, Dhaka-1000, Bangladesh

Keywords: Byttnerioideae; Revision; Numerical Taxonomy; UPGMA; PCA.

Abstract

Taxonomic revision and morphometrics are two crucial facets for the proper identification, updating of taxa, and strengthening phenetic relationships of angiosperms. This study focused on the systematics and morphometrics of the subfamily Byttnerioideae Burnett (Family Malvaceae) for the first time in Bangladesh, revealing eight taxa under seven genera, namely *Abroma* Jacq., *Ayenia* L., *Guazuma* Mill., *Kleinhovia* L., *Melochia* L., *Theobroma* L. and *Waltheria* L. These seven genera fall into three tribes: Byttnerieae, Theobromateae, and Hermannieae. Dichotomous bracketed keys to genera and species were generated. Detailed nomenclature, diagnostic characteristics, illustrations, representative specimens, notes on distribution and uses for each species were provided. Morphometrics study was conducted employing cluster and principal components analysis (PCA). Cluster analysis revealed close relationships between Theobromateae and Hermannieae tribes compared to Byttnerieae tribe in the form of UPGMA dendrogram. Similarity matrix revealed the highest affinity between *Ayenia elegans* Ridl. and *Ayenia grandifolia* (DC.) Christenh. & Byng. In the PCA analysis, the first two principal components explained approximately 82.26% cumulative variance. PCA-derived scatter and projection plots supported the topology and inter-relationships in the cluster analysis. These findings will enhance future conservation strategies, especially for the threatened and medicinally important taxa of Byttnerioideae in Bangladesh, and support molecular phylogenetic studies of the subfamily Byttnerioideae.

Introduction

Byttnerioideae is one of the nine subfamilies of the angiosperm family Malvaceae (APG IV, 2016), consisting of 650 species belonging to 26 genera worldwide. Prior to the Angiosperm Phylogeny Group (APG) classification, members of Byttnerioideae were placed under the family Sterculiaceae (Cronquist, 1981). The 26 genera of Byttnerioideae have been incorporated under four tribes: Byttnerieae, Hermannieae, Lasiopetaleae and Theobromateae. The member taxa of Byttnerioideae inhabit predominantly in the tropical and subtropical regions (Lima *et al.*, 2019). In Bangladesh, this subfamily is consisted of 8 taxa under 7 genera and 3 tribes (Ahmed and Rahman, 2022). Byttnerioideae is distinct by its simple, lobed or compound leaves, with five petals and numerous stamens, frequently connate at the base. Fruits typically manifest as capsules or schizocarps and seeds often adorned with hairs or other appendages (Colli-Silva *et al.*, 2024). The importance of these species underscores the need for a taxonomic revision of Byttnerioideae. Such a revision is crucial in plant taxonomy, as it entails a thorough re-examination of a particular group to amend or enhance its description or diagnosis. Given that taxa often exhibit phenotypic plasticity, a taxonomic revision serves to update and refine the classification system (Baur *et al.*,

[1]Corresponding author, Email: prof.oliurrahman@gmail.com; oliur.bot@du.ac.bd

2014). In Bangladesh, no efforts have been made so far for taxonomic revision of Byttnerioideae and thereby, this process is particularly necessary to ensure accurate identification and conservation of economically and medicinally important species within this subfamily.

Morphometrics, also known as numerical taxonomy or taximetrics, is a multidisciplinary approach that integrates mathematical principles with taxonomy to analyze character states through covariances between morphological variation and other associated or causal variables (Sneath and Sokal, 1973; Bookstein, 1991). Morphological data derived from taxonomic revision provides the pedestal of morphometric analysis because the diversity in morphological characters can be classified by the numeric gaps between taxa, which reflects their evolutionary relationships as revealed by morphological changes (Otte and Endler, 1989). This integrated approach allows for a more precise and quantifiable understanding of species differences and similarities, facilitating deeper insights into the classification and interrelationships of Byttnerioideae taxa in Bangladesh. There have been limited efforts to elucidate the morphometric relationships of angiosperm taxa in Bangladesh, and to date, no studies have focused specifically on the Byttnerioideae subfamily (Rahman and Rahman, 2013; Rahman *et al.*, 2013).

An integrated approach combining taxonomic revision and morphometric analysis is critical for a detailed understanding of Byttnerioideae. Taxonomic revision ensures up-to-date classifications, while morphometrics provides detailed analysis of phenotypic variations and inter-relationships. With these integrated approaches, we aimed to enhance species identification, update classifications, and clarify morphometric relationships, thereby providing a comprehensive understanding of systematic position of Byttnerioideae in Bangladesh and supporting conservation efforts for the threatened and medicinally important species.

Materials and methods

Taxonomic revision

Twenty-five field visits were undertaken in different areas of Bangladesh to collect plant samples. These specimens were meticulously studied and identified, with confirmations made through consultation of standard literatures (Ahmed *et al*., 2009; Ashrafuzzaman and Sarwar, 2021). Additional voucher specimens of Byttnerioideae deposited at the DUSH, DACB, HCU and BFRIH were studied. To facilitate identification, taxonomic keys were generated for genera and species. Nomenclature was updated using recent standard floras and trustworthy web-based data sources (www.powo.science.kew.org; www.ipni.org). Each species is accompanied by technical descriptions, up-to-date nomenclature, phenology, representative specimens, habitat, global distribution, illustrations and uses. Voucher specimens were deposited at DUSH.

Morphometric analysis

Eight species of the Byttnerioideae used for morphometric analysis are presented in Table 1. Thirty-one characters, both qualitative and quantitative, were investigated and analyzed for morphometrics endeavor (Table 2). Both vegetative and reproductive characters were considered and coded as binary-states using NTedit v.1.2 module of NTSYSpc v.2.10e software package (Rohlf, 2012). The Similarity module was employed to construct similarity matrix using the Simple Matching coefficient. Subsequently, cluster analysis was performed using the UPGMA method through the SAHN module. Principal components analysis (PCA) was conducted employing the Ordination module and Eigen package to construct the two-dimensional scattered diagram. The Eigen package was used to generate Eigenvector and Eigenvalues. Afterwards, the Mod3D tool from the Graphics module was implemented to generate three-dimensional diagram of PCA. All analyses were conducted using the NTSYSpc v.2.10e software package (Rohlf, 2012).

Results and Discussion

Taxonomic treatment

The subfamily Byttnerioideae comprises seven genera and eight species in Bangladesh. A dichotomous bracketed key to the genera of Byttnerioideae is presented below:

1	Ovary stipitate.	*Kleinhovia*
-	Ovary sessile.	2
2	Staminodes absent.	3
-	Staminodes present.	4
3	Capsule 5-celled; styles 5, central; stigma slightly thickened; seeds winged, triangular.	*Melochia*
-	Capsule 1-celled; style 1, excentric; stigma fimbriate; seeds wingless, obovate.	*Waltheria*
4	Fruits fleshy or drupaceous; cauliflorous.	*Theobroma*
-	Fruits not fleshy; not cauliflorous.	5
5	Staminodes emarginate; fruits 5-winged.	*Abroma*
-	Staminodes acute or lanceolate; fruits wingless.	6
6	Fruits covered with stiff spines and barb; fertile stamens 5.	*Ayenia*
-	Fruits tuberculate or downy; fertile stamens 10-15.	*Guazuma*

ABROMA Jacq.

Hort. Vindob. 3: t. 1 (1776); Miquel, Fl. Ind. Bat. 1: 182 (1859) Benth. & Hook. f., Gen. Pl. 1: 224 (1862); Merrill, J. Straits Branch Roy. Asiat. Soc.: 378 (1921); Enum. Philip. Pl. 3: 48 (1923); Ridley, Fl. Mal. Pen. 1: 285 (1922).

Abroma augustum (L.) L.f., Suppl. Pl.: 341 (1781) (‘*Ambroma*’); Mast. in Hook. f., Fl. Brit. Ind. 1: 375 (1874); Prain, Beng. Pl. 1: 191 (1903); Ridl., Fl. Mal. Pen. 1: 286 (1922); Craib, Fl. Siam. Enum. 1: 179 (1925). *Theobroma augustum* L., Syst. Nat. ed. 12(2): 233 (1767). *Abroma fastuosum* Jacq., Hort. Bot. Vindob. 3: 3 (1776). *Abroma angulatum* Lam., Encycl. Metho. Botan. Par. 1(1): 126 (1783). *Abroma elongatum* Lam., Encycl. Metho. Botan. Par. 1(1): 127 (1783). *Abroma wheleri* Retz., Observ. Bot. Retzius. 5: 27 (1788). *Abroma molle* DC., Prod. Syst. Nat. Reg. Veg. 1: 485 (1824). *Abroma obliquum* C. Presl., Reliq. Haenk. 2: 143 (1835). *Abroma alatum* Blanco, Fl. Flip.: 605 (1837). *Abroma denticulatum* Miq., Pl. Jungh. 3: 288 (1854). *Abroma javanicum* Miq., Fl. Ned. Ind.1(2): 183 (1859). *Abroma sinuosum* G. Nicholson, Ill. Dict. Gard. 4: 482 (1888). **(Fig. 1A).**

Vernacular names: Devil’s Cotton (English); Ulatkambal (Bangla), Tambol (Chakma), Daiya (Garo).

A shrub, 2.5-4.5 m tall. Stem cylindrical, branchlets densely stellate, velutinous when young. Leaves simple, alternate; petiole 2.5-3.0 cm, cylindrical, glandular; stipules intrapetiolar, linear, 10 mm long, caducous; lamina cordate or ovate-cordate, occasionally 3-5 lobed, 10-25 x 9-8 cm; margin entire to slightly serrate, pinnately reticulate, 3-7 nerved, membranous, glabrescent adaxially, tomentose or densely puberulent abaxially, veins prominent, apex acute or acuminate, base cordate or obliquely cordate. Inflorescence cymose. Flowers bisexual, c. 3 cm in diameter, complete, pedunculate, peduncle 1.5 cm long; sepals 5, gamosepalous, c. 2 cm long, lanceolate, aestivation valvate; petals 5, gamopetalous, dark red, scarcely exceeding the sepals, upper lobe

oblong-ovate, lower lobe narrowed down, obtuse, aestivation valvate; stamens connate to the copular column, epipetalous; anthers extrorse, 2-celled, indefinite; ovary sessile, 5-locular; ovules indefinite. Fruit capsule, 4.5 cm long, 5 cm in diameter, obpyramidal, 5-angular, dehisce septicidally. Seeds many, rounded; albumen copious; embryo straight. *Flowering and fruiting:* June-December.

Habitat: Open, dry places of the tropical forests and often prefer the edges of forests and clearings, sometimes on the bank of watercourses. Grows well in Gardens throughout the country.

Representative specimens: **Chittagong:** Korerhat, Shonai, 1 Aug 1997, M.A. Rahman *et al.* 1633 (HCU); Hazarikhil Wildlife Sanctuary, 13 Jun 2022, Sunzid 64 (DACB). **Cox's Bazar:** Rajarkul Botanical Garden, Ramu, 17 Jan 2017, Niyamul Kabir *et al.* NK 2471 (DACB). **Dhaka:** Naya Bazar, Old Dhaka, 16 Sep 2021, Sunzid 17 (DUSH). **Dinajpur:** Jagathdal, Birganj, 27 Aug 1998, Mia *et al.* M 4380 (DACB). **Faridpur:** Goulandaghat, 1 Jul 1973, A.M. Huq 982 (DACB). **Gazipur:** Sreepur, 10 Apr 1964, M.A. Baqui 101 (DUSH). **Jamalpur:** Tulshipur, 18 Nov 2019, Kanis Fatema 1 (DACB). **Khagrachari:** Dighinala, 13 Aug 2008, Bushra *et al.* B 1003 (DACB). **Manikganj**: Taraghat, 6 Jun 1978, Soejarto *et* Rahman 4976 (DACB). **Moulvibazar:** Madhabkunda Eco Park, 28 Mar 2016, Naimur Rahman NR 129 (DACB). **Mymensingh:** Gafargaon, Bagbari, 23 Sep 2021, Sunzid 24 (DUSH). **Natore:** Khandibhita, 8 Oct 1990, M.K. Huda 6804 (BFRIH). **Nawabganj:** Rohanpur, 2 Sep 2022, Rezia *et al.* RIC 3705 (DACB). **Pabna:** Madhupur, 27 Mar 1978, Md. Hafizur Rahman 13 (DACB). **Rangamati:** Shubalong, 5 Sep 1999, M.A. Rahman *et al.* 5657 (HCU); Barkal, Aimachara forest, 7 Aug 2017, Joyanta *et al.* JCR 6302 (DACB). **Sirajganj:** *s. loc.*, 20 Apr 1994, Basak *et al.* 749 (BFRIH). **Tangail:** Takurpara, 10 Sep 1992, E Rahman *et* M.A. Rahman 63 (HCU).

*Distribution***:** Australia, Belgium, Bhutan, Cambodia, Cameroon, China, Democratic Republic of the Congo, Federative Republic of Brazil, India, Indonesia, Ivory Coast, Jamaica, Japan, Malaysia, Myanmar, Nepal, Nigeria, Philippines, Papua New Guinea, Spain, Thailand, United States of America and Viet Nam.

Uses: Traditionally, *A. augustum* is used to treat swellings, cuts, sores and bruises. An infusion with stem of *A. augustum* in cold water is effective in the treatment of gonorrhea. Different phytochemicals such as flavonoids, phenolics and alkaloids extracted from the species have been found to inhibit pancreatic lipase activity (Gupta *et al.* 2012). Strong bast fibre from the stem is used for making rope, fishing lines, twine and pouches in Philippines (Ahmed *et al.*, 2009).

AYENIA L.

Kongl. Svenska Vetensk. Acad. Handl. 17: 24 (1756); *Byttneria* Loeft., Iter. Hisp.: 313 (1758); Miquel, Fl. Ind. Bat. 1: 184 (1859); Ridley, FMP 1: 286 (1922). *Buettneria* L., Syst. Veg. ed. 13: 197 (1774); Benth. & Hook. f., Gen. Pl. 1: 225 (1867).

Key to species of *Ayenia* L.

1 Inflorescence densely stellate-pubescent; leaves finely serrate-dentate; flower buds conical. *A. elegans*

\- Inflorescence minutely puberulous; leaves entire; flower buds ovoid. *A. grandifolia*

Ayenia elegans Ridl., Skvortsovia. *Byttneria pilosa* Roxb., Fl. Ind. 2: 681 (1832); Mast. in Hook. f., Fl. Brit. Ind. 1: 377 (1874); Kurz, Fl. Burm. 1: 151 (1877); Craib, Fl. Siam. Enum. 1: 181 (1925), 'Buettneria' Prain, Beng. Pl. 1: 192 (1903). *Commersonia pilosa* (Roxb.) G. Don., Gen. Hist. 1: 524 (1831). *Byttneria pilosa* var. *pellita* Gagnep., Fl. Indo-Chine 1(5): 517 (1910);

Byttneria elegans Ridl., J. Sraits Roy. Asiat. Soc. 57: 25 (1911). *Chaetaea pilosa* (Roxb.) Adelb. in Backer, Bekn. Fl. Java 107: 11 (1944). *Ayenia indica* Christenh. & Byng, Global Fl. 4: 136 (2018). **(Fig. 1B).**

Vernacular names: Flame tree (English); Harjora Lata (Bangla); Kudi-Paing (Chakma), Choloimro-Bang (Marma), Sola Ludi (Tripura), King Kay (Murong).

A large, woody climber or scandent shrub, branchlets grooved, hispid with spreading hairs or sparsely stellate-hairs. Leaves simple, 10-18 x 6-15 cm, suborbicular, palmately lobed, cordate at the base, stellate-pilose on both surfaces, 5-7 main nerves from leaf base; petioles 2-18 cm long, shaggy tomentose. Flowers pale yellow, minute, 4-6 mm in diameter, in much-branched axillary umbellate cymes; pedicels slender; bracts and bracteoles subulate; sepals 5, cup-shaped, longer than petals, connate below, tomentose, c. 3 mm long; petals 5, 4-5 x 1-2 mm, yellow, incurved, claw concave and long strap like, limb 2-fid; stamens and staminodes united at the base by a cup-like membrane; anthers 2-lobed, lobes extrorse; ovary 5-locular; styles entire or 5-fid.. Fruit a globose capsule, 2.0-2.5 cm across, with sharp spines, septicidally 5-valved, with persistent central column. Seeds black, ellipsoid, c. 5 x 2 mm, triangular. *Flowering and fruiting:* September-February.

Habitat: Occurs in evergreen to mixed evergreen forests.

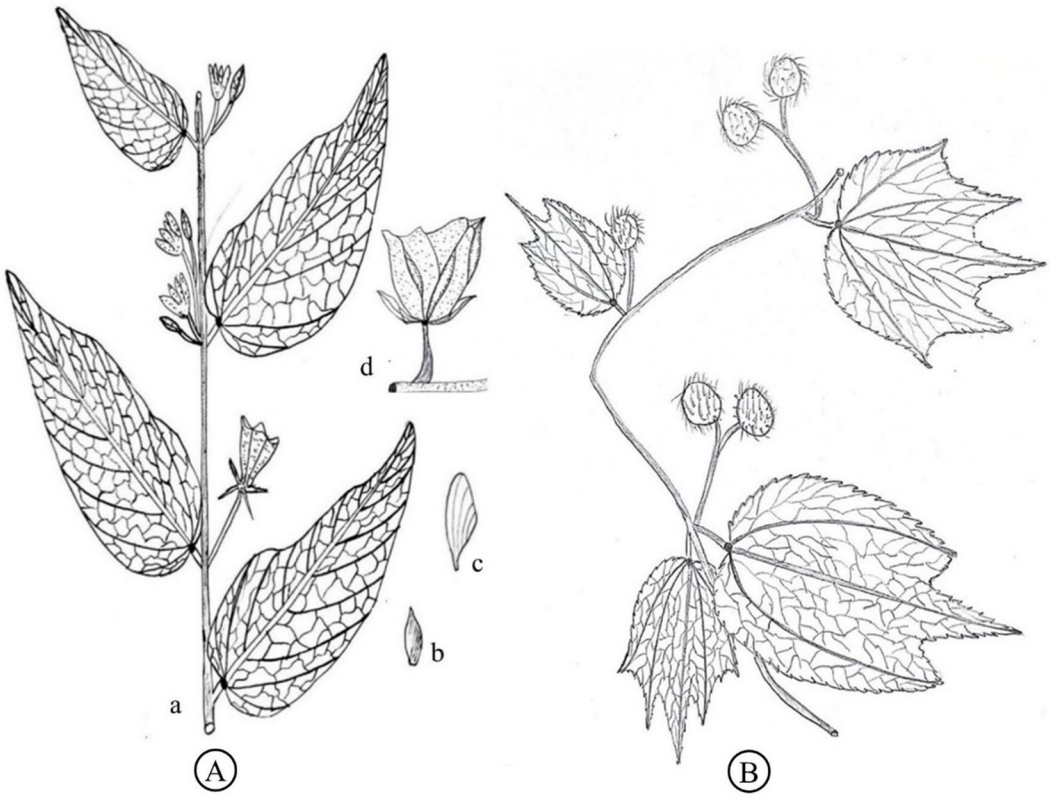

Fig. 1. A. *Abroma augustum* (L.) L.f.: a. Habit sketch, b. Sepal, c. Petal, d. Dehisced fruit; B. *Ayenia elegans* Ridl.*:* Habit sketch.

Representative specimens: **Bandarban:** Chimbuk Hill, 8 Sep 1999, M.A. Rahman *et al.* 5767 (HCU); Ruma, Bogalake, 3 Dec 2018, Khandakar Kamrul Islam KKI 3095 (DACB). **Chittagong:** Potia, 30 Oct 1975, Jahir *et al.* 127 (BFRIH); Hathazari, Sarkarhat, Kumarikhal, 23 Nov 2016, Bashkhali Eco Park, 29 Jan 2018, Md. Moniruzzaman *et* Al-Amin MA 7398 (DACB). **Cox's Bazar:** Pekua, Barbakia, 9 Feb 2017, Niyamul Kabir *et* Mehedi Hasan NK 2755 (DACB); Chakaria, Fasiakhali, 21 Nov 2017, Niyamul Kabir *et al.* NK 6444 (DACB); **Habiganj:** Satchari forest, 27 May 1999, A. M. Huq and Harun 10614 (DACB). **Khagrachari:** Hatimura, Perachara, 28 Oct 1997, M.A. Rahman *et al.* 2330 (HCU); Panchhari, Jugolchhari Reserve Forest, 2 Oct 2017, Kowser *et al.* KH 6764 (DACB). **Moulvibazar:** Kamalganj, Adampur, Dalua Chara, 12 Sep 2012, S.N. Uddin N 5027 (DACB). **Rangamati:** Kaptai, Baghaichari Reserve Forest, 8 Feb 2017, Joyanta *et al.* JCR 2803 (DACB); Sapchari, Puramon, Morongchori forest, 7 Nov 2017, Joyanta *et al.* JCR 6912 (DACB). **Sherpur:** Runctia forest, 29 Oct 1972, A.M. Huq 449 (DACB).

Distribution: Bhutan, China, India, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, Thailand and Viet Nam.

Uses: The species is traditionally applied for treating scabies, rheumatalgia, syphilis, elephantiasis, and eye infection. It possesses analgesic, thrombolytic as well as anti-diarrheal properties (Sikdar *et al.* 2022).

Ayenia grandifolia (DC.) Christenh. & Byng, Global Fl. 4: 136 (2018). *Byttneria aspera* Colebr. in Roxb., Fl. Ind. ed. Carey 2: 383 (1824); Mast. *in* Hook. f., Fl. Brit. Ind. 1: 377 (1874); Prain, Beng. Pl. 1: 191 (1903); Kanjilal *et al.*, Fl. Assam 1: 160 (1934). *Byttneria nepalensis* Turcz., Bull. Soc. Imp. Nat. Mosc. 31(1): 207 (1858). *Byttneria integrifolia* Lace, Kew Bull. 1915: 396 (1915); Craib, Fl. Siam. Enum. 1: 181 (1925). *Byttneria grandifolia* DC., Prod. 1: 486 (1824). **(Fig. 2A)**

*Vernacular names***:** Nilbhutta (Bangla).

A scandent shrub, longitudinally or spirally close furrowed on old stem, sparsely stellate hairy when young. Leaves simple, cordate, 10-18 x 5-15 cm, apex cuspidate, base cordate, margin entire, 5-7 nerved at the base; petioles 5-13 cm long, grooved, puberulous; stipules 8-12 mm long, linear-lanceolate, early caducous. Flowers reddish, minute, 4-6 mm across, in much-branched axillary umbellate cymes; pedicels slender; bracts and bracteoles subulate; sepals 5, connate below, hairy on both surfaces, lanceolate; petals 5, claw concave, limb 2-fid; stamens and staminodes united at the base by a cup-like membrane; anthers 2-lobed, lobes extrorse; ovary 5-locular; ovules 2 in each locule; styles entire or 5-fid. Capsule globose, sometimes ovoid-globose, armed, septicidally 5-valved, with persistent central column. Seeds ovate-oblong, black when mature. *Flowering and fruiting:* May-December.

Habitat: Near water course, in the hilly forest areas.

Representative specimens: **Bandarban:** Ruma, Maurchara, 25 Jan 2017, Khandakar Kamrul Islam KKI 1013 (DACB). **Chittagong:** Chunati, Baroitala, 26 Feb 1997, M.A. Rahman 814 (HCU). **Cox's Bazar:** Eidgaon, Bhomarighona, 16 May 1999, M.A. Rahman *et al.* 4904 (HCU); Ukhia, Thaing-khali, 4 May 2017, Niyamul Kabir NK 4254 (DACB). **Moulvibazar:** Kamalganj, Adampur, 19 May 2014, S.N. Uddin N 5197 (DACB). **Rangamati:** Kaptai, Sitapahar, 3 Sep 1999, M.A. Rahman *et al.* 5592 (HCU); Barkal, Choto-horina, Jaingachchara, 9 Dec 2015, Khandakar Kamrul Islam KKI 1928 (DACB). **Sylhet:** Jaintapur-Tamabil, 5 Apr 1988, Mahfuz *et al.* Mz. 33 (DACB).

*Distribution***:** Bhutan, Cambodia, China, Hong Kong, India, Lao PDR, Nepal, Thailand and Viet Nam.

Uses: A. grandifolia leaves possess anticancer property (Lalawmpuii *et al.*, 2017). Ethnic ladies of Chittagong Hill Tracts wash their hair with macerated young parts and barks (Uddin and Hassan, 2018).

GUAZUMA Mill.

Gard. Dict. Abridg. ed. 4: 2 (1754); Benth. & Hook. f., Gen. Pl. 1: 225 (1862); Mast. in Hook. f., Fl. Brit. Ind. 1: 375 (1874).

Guazuma ulmifolia Lam., Encycl. Math. Bot. 3: 52 (1789). *Theobroma guazuma* L., Sp. Pl.: 782 (1753). *Guazuma polybotrya* Cav., Icon. 3: 51 (1795). *Theobroma celtifolium* Salisb., Prodr. Strip. Chap. Allerton: 387 (1796). *Bubroma ulmifolia* (Lam.) Oken, Allg. Naturgesch. 3(2): 1204 (1841). *Guazuma parvifolia* A. Rich., Hist. Fis. Cuba, Bot. 10: 190 (1845). *Diuroglossum rufescens* Turcz., Bull. Soc. Imp. Nat. Mosc. 25 (2): 157 (1852). *Guazuma guazuma* var. *ulmifolia* (Lam.) Kuntze, Revis. Gen. Pl. 3 (2): 24 (1898). *Guazuma tomentosa* Mast. in Hook. f., Fl. Brit. Ind. 1: 375 (1874); Prain, Beng. Pl. 1: 278 (1903).
(Fig. 2B).

*Vernacular names***:** West Indian Elm (English); Juma (Bangla).

A medium-sized tree, up to 25 m long. Leaves ovate or oblong-lanceolate, 7-13 x 3-6 cm, apex acuminate, base obliquely cordate, 6-8 nerved, margin serrate, glabrescent on upper surface, pubescent on lower surface, adaxially dark green, abaxially light green; petiole 0.7-1.2 cm long. Inflorescence a panicle. Flowers yellow, flower buds globose; sepals 5, reflexed, stellately hairy; petals 5; stamens 10; anthers 2-lobed, divergent; ovary 5-celled, ovules many in each cell; style connate. Capsule woody, oblong. Seeds albuminous. *Flowering and fruiting:* January-September.

Habitat: Grows in the lowland and forests.

Fig. 2. A. *Ayenia grandifolia* (DC.) Christenh. & Byng: a. Habit sketch, b. Fruit; B. *Guazuma ulmifolia* Lam: Habit sketch.

Representative specimens: **Dhaka:** Govt. Nursery, 13 Sep 1949, S.K. Sen *s.n.* (DUSH). **Jessore:** *s. loc.*, 23 Feb 1969, S.K. Sen *s.n.* (DUSH).

Distribution: Argentina, Brazil, India, Indonesia, Mexico, Sri Lanka, United States of America and Viet Nam.

Uses: Guazuma ulmifolia is administered for treatment of diarrhea, hemorrhages, inflammatory disorders, and as a uterine contraction stimulant. Aerial portions of the plant have been demonstrated to protect the stomach from the harmful effects of NSAIDs (non-steroidal anti-inflammatory medicines), mostly through anti-inflammatory and radical-scavenging processes. Flavanocoumarins isolated from *G. ulmifolia* showed promising anti-cancer effects *in-vitro* against human monocytic leukemia cell line TPH-1 (Maldini *et al.* 2013).

KLEINHOVIA L.

Sp. Pl. (ed.2): 1365 (1763), Gen. Pl. (ed.6): 468 (1764); Benth. & Hook. f., Gen. Pl. 1: 219 (1862).

Kleinhovia hospita L., Sp. Pl.: 1365 (1763); Mast. in Hook. f., Fl. Brit. Ind. 1: 364 (1874); Gagnep. In Fl. Gen. I.-C. 1: 497 (1911); Ridl., Fl. Mal. Pen. 1: 280 (1922). *Grewia meyeniana* Walp., Nov. Actorum. Acad. Caes. Leop.-Carol. Nat. Cur. 19 (Suppl. 1): 311 (1843); *Cattimarus hospitus* (L.) Kuntze, Revis. Gen. Pl. 1: 77 (1891). **(Fig. 3A).**

Vernacular names: Guest Tree (English); Bola, Bholla (Bangla).

A small tree, up to 12 m tall. Leaves broadly ovate, 5.5-18 x 5.5-18 cm, abaxially puberulent when young, adaxially glabrous, acuminate or acute at the apex, cordate or subcordate at the base, margin entire or sparsely dentate, axils of venation and midrib sometimes with minute simple hairs, lateral veins 4-6 pairs; petiole 3.0-5.5 cm long, glabrous or with dense, minute simple hairs. Inflorescence a thyrse, up to 45 cm long. Sepals c. 6 mm long, pink; petals pink, yellow at apex; ovary globose, hairy, ovule 1 in each locule; style glabrous; stigma protruding 1-2 mm long. Capsule pyriform to globose, 5-angled, greenish pink at maturity. Seeds globose, dark brown or black. *Flowering and fruiting:* February-April.

Habitat: Occurs in hilly or montane forests.

Representative specimens: **Dhaka:** *s. loc*, 19 Dec 1945, S.K. Sen *s.n.* (DUSH); Sadarghat, 18 Sep 1949, Atul *s.n.* (DUSH). **Pabna:** Jamtoli Railway Station, 1 Mar 1980, D.K. Das *et* M.K. Alam 3491 (BFRIH).

Distribution: Africa, Australia, China, India, Indonesia, Malaysia, Philippines, Polynesia, Sri Lanka, Taiwan, Tonga and Thailand.

Uses: The species is utilized as a traditional remedy for treatment of scabies. The plant contains cyanogenic compounds that are thought to aid in the killing of lice, and extracts of leaves have showed anticancer efficacy against mice sarcomas (Arung *et al.*, 2009).

MELOCHIA L.

Sp. Pl. 1: 674 (1753); Miquel, Fl. Ind. Bat. 1: 187 (1859); Mast. in Hook. f., Fl. Brit. Ind. 1: 373 (1874). *Visenia* Houtt., Handl. Pl. Kruidk. 8: 308 (1777); *Riedleia* DC., Prodr. 1: 490 (1824); *Physodium* Presl., Rel. Haenk. 2: 150 (1835).

Melochia corchorifolia L., Sp. Pl.: 675 (1753); Schumacher, Besk. Guin. Plan.: 297 (1827); Mast. in Hook. f., Fl. Brit. Ind. 1: 374 (1874); Prain, Beng. Pl. 1: 190 (1903). *Melochia supina* L., Sp. Pl.: 675 (1753). *Melochia concatenata* L., Sp. Pl.: 675 (1753). *Melochia erecta* Burm. f., Fl. Ind.: 143 (1768). *Melochia truncata* Willd., Sp. Pl. (ed.3): 601 (1800). *Riedlea supina* (L.) DC., Prodr.

1: 491 (1824). *Melochia pauciflora* Wall., Numer. List.: 1199 (1829). *Melochia burmanni* Zoll. & Moritzi, Syst. Verz.: 27 (1846). **(Fig. 3B).**

Vernacular names: Chocolate Weed (English); Tikiokra (Bangla); Jarbo Maresh (Chakma), Bish Karali (Marma).

Herb or subshrub, up to 1 m tall. Branches yellow-brown, sparsely stellate puberulent. Leaves ovate, oblong-ovate, or lanceolate, 2.5-7.0 long and 1.0-1.3 cm across, thinly papery or membranous, basal veins 5, acute or obtuse at apex, rounded or cordate at base, margin dentate; petiole up to 2.5 cm long; stipules linear. Inflorescence a glomerule or cyme, axillary or terminal. Sepals 5, triangular, c. 2.5 mm long, villous abaxially, glabrous adaxially; petals 5, oblong, white, reddish, c. 6 mm long; stamens 5, connate at base, free above, opposite to petals; anthers extrorse; ovary densely velutinous, ovules 2 in each locule; styles 5, filiform. Capsule 5-angular, globose, villous. Seeds ovoid, brown-black, c. 2-3 mm long. *Flowering and fruiting:* March-June.

Habitat: Marshy lands and waste places.

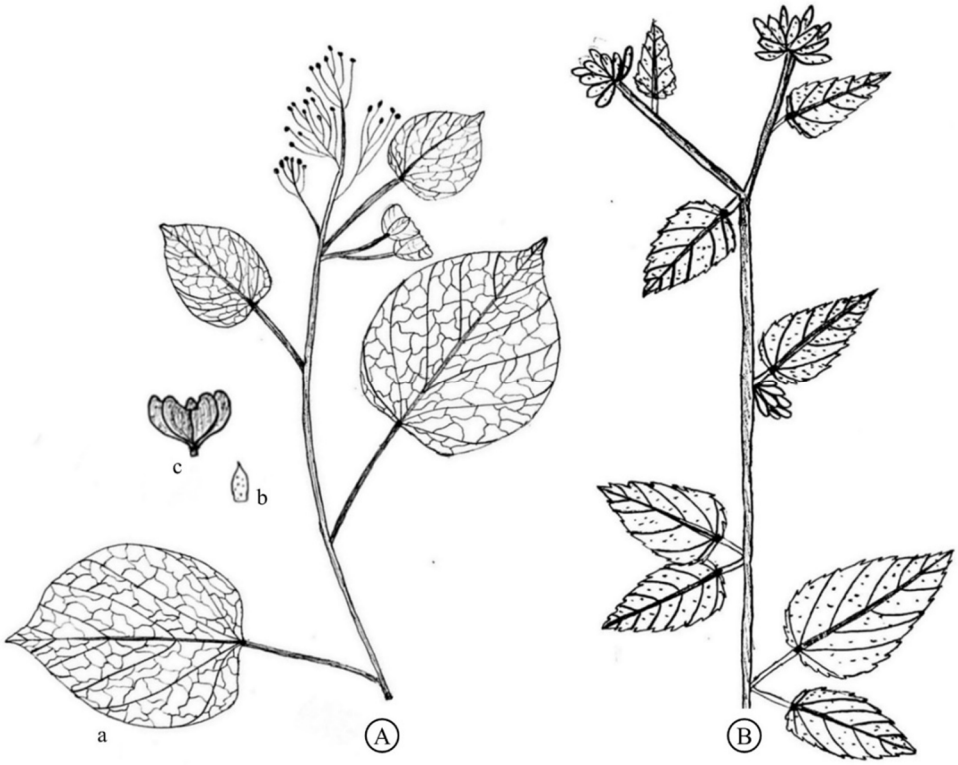

Fig. 3. A. *Kleinhovia hospita* L.: a. Habit sketch, b. Sepal, c. Fruit; B. *Melochia corchorifolia* L.: Habit sketch.

Representative specimens: **Chittagong:** Maheshkhali, 6 Mar 1978, M.S. Khan K. 482 (DACB); Ichanagar Beribadh, 9 Sep 1987, D.K. Das 6105 (BFRIH). **Cox's Bazar:** Chakaria, Fasiakhali, 26 Sep 2017, Niyamul Kabir *et al.* NK 5241 (DACB). **Cumilla:** Lalmai, 9 Aug 1988, Mahfuz *et* A.H. Huq MZ 239 (DACB). **Dhaka:** Sher-E-Bangla Agricultural University compound, 20 Sep 2021, Sunzid 23 (DUSH). **Faridpur:** Roypur, 22 Oct 1961, Amjed Ali Khan 20 (DUSH). **Kushtia:** Meherpur, Baradi, 10.6.1974, M.S. Khan *et* A.M. Huq K. 3889 (DACB). **Moulvibazar:**

Kamalganj, Adampur forest beat, 20 Sep 2011, S.N. Uddin N. 4701 (DACB). **Mymensingh:** Mymensingh University Campus, 19 Sep 1980, Mia *et al.* M. 404 (DACB). **Narayanganj:** Araihazar, 24 Sep 2021, Sunzid 31 (DUSH). **Natore:** Gurudashpur, Chalon Beel, 20 Sep 1996, M.S. Khan & H. Rashid K. 9598 (DACB). **Nawabganj:** Naehal Para, 5 Sep 2002, Rezia *et al.* RIC 3916 (DACB). **Patuakhali:** Kuakata, Kolapara, 5 Jan 1980, Khan *et al.* K. 5953 (DACB). **Rajshahi:** Mirzapur, 27 Oct 1989, Mia *et al.* M. 2394 (DACB). **Rangamati:** *s. loc.*, 6 Jun 1969, M.S. Khan K. 1766 (DUSH). **Rangpur:** Chalahazzi, 17 Oct 1976, Huq *et al.* H. 2746 (DACB). **Sylhet:** Salutikar, 27 Apr 1968, Sudhangshu 97 (DUSH); Tamabil to Joyantapur, 9 Oct 1979, Khan *et* Mia K. 5665 (DACB). **Tangail:** Mirzapur, 20 Sep 2001, Harun *et* Rahman SH 620 (DACB).

*Distribution***:** Africa, Australia, Cameroon, Cambodia, China, Congo, Gambia, Ghana, Guinea, India, Indonesia, Japan, Kenya, Lao PDR, Madagascar, Malaysia, Myanmar, Nepal, Nigeria, Philippines, Polynesia, Sudan, Taiwan, Tanzania, Thailand, Uganda, United States of America and Viet Nam.

Uses: Fruits are administered for treating several ailments including dysentery, abdominal swelling and small pox. The species is reported to possess antioxidant potential (Rao *et al.* 2013, Mamatha *et al.* 2018).

THEOBROMA L.

Sp. Pl. 2: 782 (1753); Sesse & Moc. *ex* DC., Prodr. 1: 484 (1824); Karst., Linnaea 28: 447 (1856). *Cacao* Gaertn, Fruct. Sem. Pl. 2: 190 (1791).

Theobroma cacao L., Sp. Pl: 782 (1753); Wallpers *et* Muller, Ann. Bot. System. 7: 430 (1848). *Cacao sativa* Aubl., Hist. Pl. Guiane 2: 689 (1775). *Theobroma integerrima* Stokes, Bot. Mat. Med. 4: 83 (1812). *Theobroma leiocarpum* Bernoulli, Denkschr. Schweiz. Naturf. Ges. 24 (3): 6 (1871). *Cacao theobroma* Tussac, Fl. Antill. 1: t. 13 (1881). *Theobroma kalagua* De Wild., Bull. Herb. Boissier 7: 957 (1899). *Theobroma sapidum* Pittier, Bol. Soc. Venez. Ci. Nat. 1: 183 (1932). **(Fig. 4A).**

Vernacular names: Cacao (English); Coco (Bangla).

An evergreen tree, up to 20 m tall. Bark thick, dark gray-brown. Leaves narrowly ovate to obovate-elliptic, 20-30 x 7-10 cm, glabrous or sparsely stellate on both surfaces, long acuminate at apex, rounded to shallowly cordate at base, texture coriaceous or chartaceous; stipules 5-14 x 0.5-1.5 mm, subulate, pubescent or puberulous, caducous. Inflorescence cymose. Flowers c. 18 mm in diam.; pedicels c. 12 mm long; sepals narrowly lanceolate, pink; petals 5, yellowish, reflexed; staminodes linear; ovary obovoid, 5-locular; ovules 14-16 in each locule; style cylindrical. Fruits sub-baccate, globose to fusiform, acute. Seeds 20-40, ovoid, ellipsoid, amygdaloid. *Flowering and fruiting:* April-December.

Habitat: The plant thrives in the understory of tropical rainforests that are evergreen. It grows in bunches along river banks, wherein roots are frequently soaked throughout the year. Planted in gardens as well.

Representative specimens: **Dhaka:** Dhaka University Botanical Garden, 30 Nov 2021, Sunzid 41 (DUSH).

Distribution: Bolivia, Brazil, Cameroon, Fiji, Haiti, Ivory Coast, India, Lao PDR, Mexico, Nigeria, Pakistan, Peru, Sri Lanka and Viet Nam.

Uses: Cocoa is economically significant as used in various industries, including confectionery, food and beverage, and, more recently, pharmaceuticals and cosmetics. It is used for the treatment of cardiovascular problems (Rusconi and Conti, 2010).

WALTHERIA L.

Sp. Pl. 2: 673 (1753); Gen. Pl. ed. 5: 304 (1754); Benth. & Hook. f., Gen. Pl.: 224 (1862); Mast. in Hook. f., Fl. Brit. Ind. 1: 374 (1874); Prain, Beng. Pl. 1 (Reprint): 190 (1963).

Waltheria indica L., Sp. Pl.: 673 (1753); Wight & Arn., Prodr. 1: 67 (1834); Mast. in Hook. f., Fl. Brit. Ind. 1: 374 (1874); Prain, Beng. Pl. 1: 190 (1903). *Waltheria americana* L., Sp. Pl.: 673 (1753). *Waltheria angustifolia* L., Syst. Nat. ed. 10: 1140 (1759). *Waltheria elliptica* Cav., Mon. Cl. Diss. Dec. 6: 316, t. 171, 2 (1788). *Waltheria guineensis* K. Schum, Kongl. Dansk. Selsk. Math. Afhandl. 4: 69 (1829). *Waltheria dentosa* A. Grey, Smithsonian Contr. Knowl. 5(6): 24 (1853). *Waltheria makinoi* Hayata, Enum. Pl. Formosa 61: 5 (1906). (**Fig. 4B).**

Vernacular names: Sleepy morning (English); Khar Dudhi, Khar Dudha (Bangla).

Erect herb or undershrub, up to 1 m tall. Branchlets pubescent and terete. Leaves simple, 2.5-6.5 x 1.5-4.5 cm, ovate, elliptic-ovate, base shallowly cordate to rounded, apex acute to rounded, serrate-dentate, stellate-pubescent on both surfaces. Inflorescences cymose, axillary, capitate, peduncles up to 4 cm long. Flowers with epicalyx, lobes narrowly lanceolate, up to 5 mm long; sepals 5, triangular, c. 2.5-4.5 mm long; petals yellow, spathulate, c, 4 mm long, apex truncate, veined; stamens 5; staminal cup c. 2 mm long, subconical; ovary sessile, unilocular, puberulent; styles obliquely inserted, fimbriate at the apex; stigmas penicillate. Capsules obovoid, c. 3 mm long, hairy. Seeds smooth, obovate, very tiny. *Flowering and fruiting:* April-December.

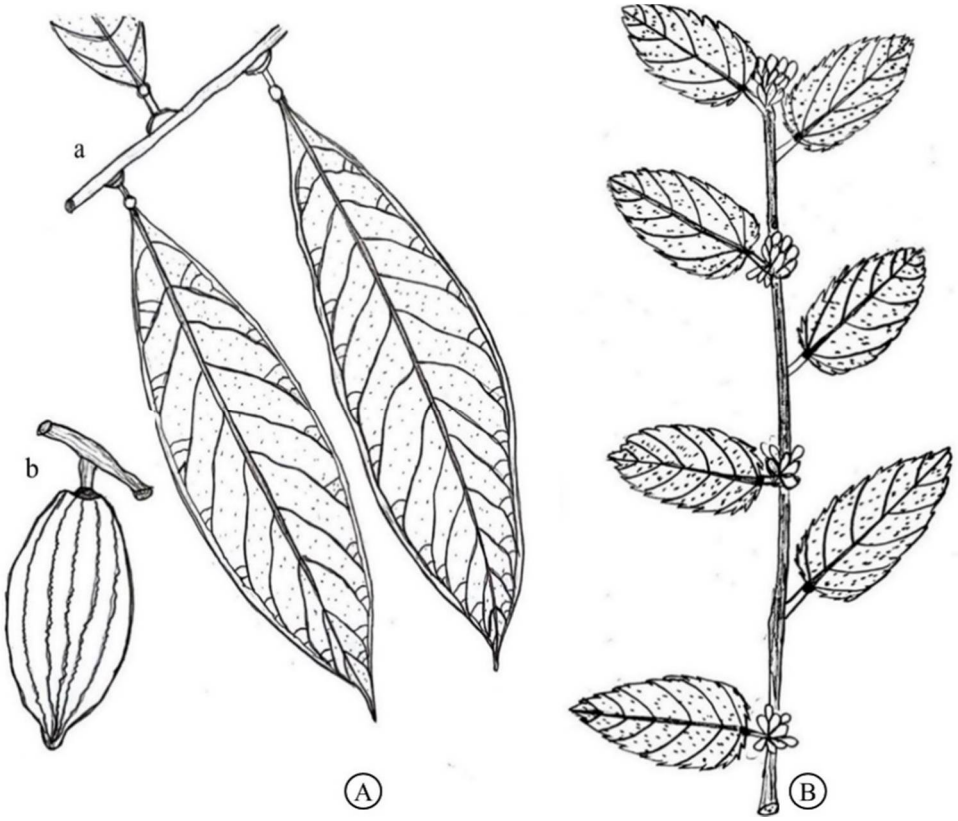

Fig. 4. A. *Theobroma cacao* L.: a. Habit sketch, b. Fruit; B. *Waltheria indica* L.: Habit sketch.

Habitat: Occurs mostly in waste places as a weed, and sometimes is grown as ornamentals.

Representative specimens: **Dhaka:** *s. loc*., 17 Sep 1949, S.K. Sen & H. Singh *s.n.* (DUSH); Nakhalpara, 20 Jul 1969, M.M.R. Bhuiyan *s.n.* (DUSH).

Distribution: Argentina, Brazil, Cambodia, Haiti, Honduras, India, Mexico, Pakistan, Sri Lanka, Taiwan, Tanzania, Tonga, Thailand, Uganda, USA, Viet Nam, Yemen, Zambia and Zimbabwe.

Uses: The species is valued for its medicinal properties, and administered for sore throat, cough inflammation and asthma. The species is also ethnomedicinally important, and used for rheumatism, diarrhea and infertility (Zongo *et al*., 2013; Chitra *et al*., 2022).

Morphometric analysis

The morphometric analysis of eight taxa within the subfamily Byttnerioideae (Table 1) yielded insights into their inter-relationships. Thirty-one characters, both qualitative and quantitative, were investigated to infer inter-relationships among the taxa employed. The characters and character states of the taxa studied are presented in Table 2. To corroborate systematic position of the member taxa of Byttnerioideae, a combinatory approach was undertaken with cluster analysis (CA) and principal components analysis (PCA), revealing agreeable and congruent results among the member taxa.

Table 1. List of taxa of Byttnerioideae used in the morphometrics endeavor.

No.	Taxa	Code	Vouchers
1	*Abroma augustum* (L.) L.f.	Aba	Chittagong: Rangapani, 30 Oct 1978, Huq *et al.* H. 4005 (DACB). Dhaka: Naya Bazar, Old Dhaka, 16 Sep 2021, Sunzid 17 (DUSH).
2	*Ayenia elegans* Ridl.	Aye	Habiganj: Satchari forest, 27 May 1999, A. M. Huq and Harun 10614 (DACB). Sylhet: Lawachara forest, 19 Jan 1965, M.S. Khan 467 (DUSH).
3	*Ayenia grandifolia* (DC.) Christenh. & Byng	Ayg	Bandarban: Ruma, Maurchara, 25 Jan 2017, Khandakar Kamrul Islam KKI 1013 (DACB). Rangamati: Bilaichari, 26 Jul 1999, S.B. Uddin 5193 (HCU).
4	*Guazuma ulmifolia* Lam.	Guu	Jessore: *s. loc.*, 23 Feb 1969, S.K. Sen *s.n.* (DUSH).
5	*Kleinhovia hospita* L.	Klh	Dhaka: *s. loc*, 19 Dec 1945, S.K. Sen *s.n.* (DUSH). Pabna: Jamtoli Railway Station, 1 Mar 1980, D.K. Das *et* M.K. Alam 3491 (BFRIH).
6	*Melochia corchorifolia* L.	Mec	Dhaka: Sher-E-Bangla Agricultural University compound, 20 Sep 2021, Sunzid 23 (DUSH).
7	*Theobroma cacao* L.	Thc	Dhaka: Dhaka University Botanical Garden, 30 Nov 2021, Sunzid 41 (DUSH).
8	*Waltheria indica* L.	Wai	Dhaka: Nakhalpara, 20 Jul 1969, M.M.R. Bhuiyan *s.n.* (DUSH).

Cluster analysis revealed distinct groupings among the eight species within the Byttnerioideae, as shown in the UPGMA dendrogram. The studied species were grouped into two major clusters: major cluster 1 and major cluster 2 (Fig. 5). The major cluster 1 included all the members of the tribe Byttnerieae, namely *A. augustum*, *A. elegans*, *A. grandifolia*, and *Kleinhovia hospita.* In major cluster 2, four species from two tribes, Theobromateae and Hermannieae were grouped together, forming two subclusters within the second major cluster. *G. ulmifolia* was

accompanied by *T. cacao* in the first subcluster, while *M. corchorifolia* was grouped with *W. indica* in the second subcluster of the major cluster 2. The similarity matrix indicated the highest affinity (0.935) between *A. elegans* and *A. grandifolia* (Table 3).

Table 2. Characters and binary states employed in the morphometric study.

No.	Characters	Character states
1	Habit	Trees or shrubs (1), Herbs or climbers (0).
2	Leaf type	Compound (1), Simple (0).
3	Leaf lobe	Present (1), Absent (0).
4	Leaf attachment	Alternate (1), Opposite or crowded (0).
5	Leaf margin	Entire (1), Denticulate or serrulate (0).
6	Leaf venation	Pinnately reticulate (1), Palmately reticulate (0).
7	Leaf texture	Membranous (1), Subcoriaceous (0).
8	Shape of lamina	Cordate or suborbicular or ovate or obovate (1), Elliptic or lanceolate or linear-lanceolate (0).
9	Leaf apex	Acute or acuminate (1), Obtuse or cuspidate (0).
10	Leaf base	Cordate or obliquely rounded or rounded (1), Cuneate or acute or obtuse (0).
11	Petiole length	< 2.0 cm (1), 2.0-40.0 cm (0).
12	Petiole surface	Glabrous (1), Hairy (0).
13	Leaf surface	Glabrous (1), Hairy (0).
14	Inflorescence	Axillary (1), Terminal (0).
15	Flower sexuality	Unisexual (1), Bisexual (0).
16	Flower type	Regular (1), Irregular (0).
17	Floral symmetry	Actinomorphic (1), Zygomorphic (0).
18	Petal	Present (1), Absent (0).
19	Staminodes	Present (1), Absent (0).
20	Number of stamens	10-15 (1), 5 (0).
21	Androgynophore	Present (1), Absent or very short (0).
22	Flower	Complete (1), Incomplete (0).
23	Stipules	Linear or lanceolate (1), Ovate or subulate or fimbriate (0).
24	Ovary shape	Oblong or globose (1), Ovoid or obovoid (0).
25	Ovary hair	Present (1), Absent (0).
26	Ovary type	Stipitate (1), Sessile (0).
27	Carpels	United (1), Free (0).
28	Fruits	Capsule or drupe (1), Follicle or samara (0).
29	Seeds	Winged (1), Wingless (0).
30	Seed shape	Oblong or ovoid (1), Elliptic or globose (0).
31	Number of seeds	1-10 (1), > 10 (0).

On the contrary, the lowest morphological affinity (0.516) was observed between *M. corchorifolia* and *K. hospita* (Fig. 5). The UPGMA-based cluster analysis was applied to *Acacia senegal* to understand its morphometric relationships in Uganda (Mulumba and Kakudidi, 2010). Similarly, this procedure was used to reveal morphological relationships of *Salvia fruticosa* in Greece (Bertsouklis *et al.*, 2021). These studies validate our choice of using UPGMA for this morphometric investigation, reinforcing its effectiveness in analyzing and understanding the morphological similarities and variations within Byttnerioideae.

Table 3. Similarity matrix of eight taxa of Byttnerioideae based on simple matching coefficient.

Species	Aba	Ayg	Aye	Guu	Klh	Mec	Thc	Wai
Aba	1							
Ayg	0.806	1						
Aye	0.806	0.935	1					
Guu	0.677	0.612	0.677	1				
Klh	0.741	0.677	0.677	0.612	1			
Mec	0.580	0.645	0.709	0.774	0.516	1		
Thc	0.709	0.580	0.580	0.774	0.580	0.677	1	
Wai	0.612	0.741	0.741	0.741	0.548	0.903	0.580	1

Aba: *Abroma augustum*, Aye: *Ayenia elegans*, Ayg: *Ayenia grandifolia*, Guu: *Guazuma ulmifolia*, Klh: *Kleinhovia hospita*, Mec: *Melochia corchorifolia*, Thc: *Theobroma cacao*, Wai: *Waltheria indica*.

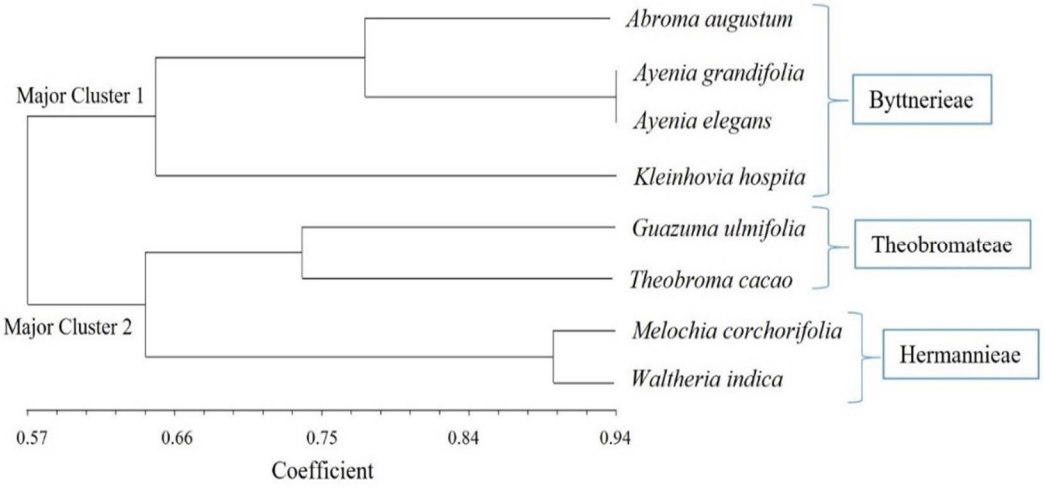

Fig. 5. UPGMA tree showing inter-relationships among the Byttnerioideae taxa based on Simple matching coefficient.

The study employing the scatter diagram representing two-dimensional plot resulted in two major clusters, wherein the first major cluster consisted of four taxa belonging to the tribe Byttnerieae (Fig. 6). The second major cluster comprised another four species belonging to the tribes Theobromateae and Hermannieae.

Principal components analysis (PCA) revealed groupings of the species consistent with the findings of cluster analysis (Fig. 7). The 3d-plot corroborated the findings of the scatter diagram with identification of the two major clusters. Similar to scatter plot, the first major cluster represented Byttnerieae and the second one showcased Theobromateae and Hermannieae (Fig. 7). In the PCA, the first five components displayed eigenvalues of greater than 1 and their contribution rates were found to be 72.71%, 9.54%, 7.60%, 4.21% and 2.41%, respectively. The cumulative contribution rate was 96.50% for the first five components (Table 4). When the PCA is used to replace the information provided by the original characters, the contribution rate might show the validity of the replacement. Usually, the cumulative contribution rate should be greater than 70% in order to accurately reflect how things appear on the surface (Mulumba and Kakudidi,

2010). PCA, by reducing the dimensionality and noise of multivariate data, enables the adjustment of univariate trait models to specific principal components. It operates by analyzing a data table consisting of observations described by multiple inter-correlated dependent variables. This revolutionary method extracts essential information from the data table and represents it as a series of new orthogonal variables. Additionally, PCA illustrates the similarity patterns of the data and variables by presenting them as points on maps (Uyeda *et al*., 2015).

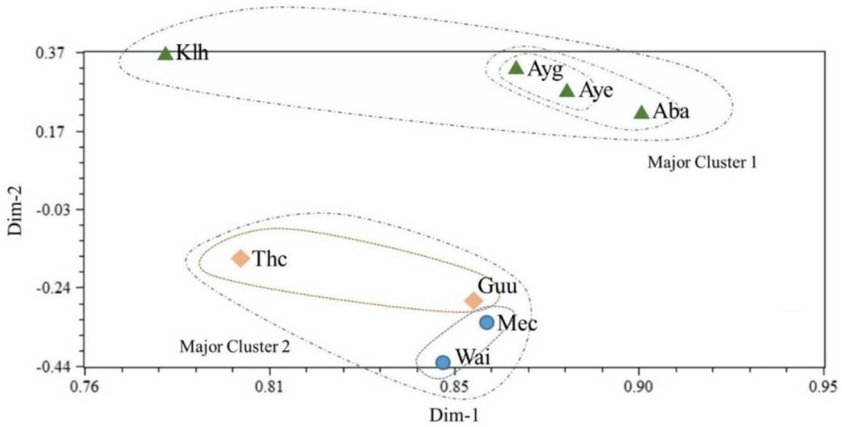

Fig. 6. Scatter diagram showing the relationships of the taxa within the Byttnerioideae. Aba: *Abroma augustum*, Aye: *Ayenia elegans*, Ayg: *Ayenia grandifolia*, Guu: *Guazuma ulmifolia*, Klh: *Kleinhovia hospita*, Mec: *Melochia corchorifolia*, Thc: *Theobroma cacao*, Wai: *Waltheria indica*.

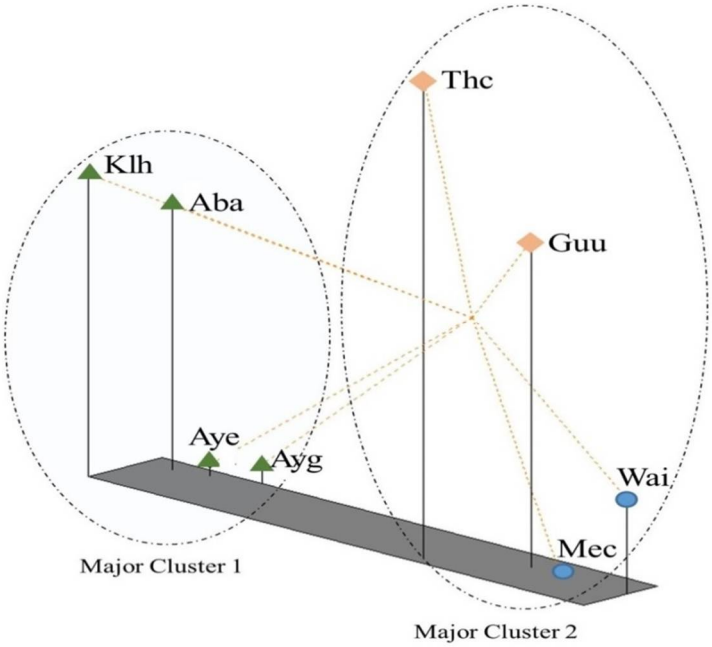

Fig. 7. PCA analysis with 3D vector projection plot using the first two principal components showing major clustering patterns in Byttnerioideae. Aba: *Abroma augustum*, Aye: *Ayenia elegans*, Ayg: *Ayenia grandifolia*, Guu: *Guazuma ulmifolia*, Klh: *Kleinhovia hospita*, Mec: *Melochia corchorifolia*, Thc: *Theobroma cacao*, Wai: *Waltheria indica*.

CA can provide a hierarchical classification of entities using similarity or dissimilarity matrix. This efficacious technique helps to characterize and compare communities (assemblages) of organisms in varied habitats on a geographical and temporal scale. Some properties of clustering include high scalability, high dimensionality, algorithm usability with multiple data types and interpretability. Different methods are employed for clustering, such as partitioning, hierarchical, density-based, grid-based and constraint-based strategies (Kettenring, 2006). In a previous study, the UPGMA results were compared with PCA outcomes to understand the morphometrics of *Tibouchina hatschbachii* and *T. marumbiensis*, showing consistent findings between the UPGMA and PCA (Maia and Goldenberg, 2019). Another study combined these techniques to understand species delimitation in *Argyreia* using leaf anatomical characters, revealing a new species, *Argyreia gyrobracteata* Traiperm & Chitchak (Chitchak *et al*., 2018). In our study, the coherence of UPGMA and PCA, therefore, strengthens the inter-relationships of the three tribes of Byttnerioideae.

Table 4. Eigen value and percentage of Eigen value explained by components.

Components	Eigen value	Percentage of Eigen value (%)	Cumulative percentage (%)
1	5.81	72.71	72.71
2	0.76	9.54	82.26
3	0.60	7.60	89.86
4	0.33	4.21	94.08
5	0.19	2.41	96.50
6	0.14	1.83	98.34
7	0.09	1.26	99.60
8	0.03	0.40	100.00

The current morphometric findings, along with a comprehensive taxonomic revision of Byttnerioideae, provide essential insights for future conservation strategies and phylogenetic studies. By analyzing morphometric data and revising taxonomic classifications, the study clarifies species boundaries and inter-relationships, enhancing our understanding of species diversity and evolution. This combined approach guides conservationists in prioritizing species and habitats for protection based on unique morphological traits and environmental adaptations, particularly for the economically and medicinally important taxa. The coherence between UPGMA and PCA techniques ensures robust, reproducible results, offering a reliable foundation for future studies. These findings will serve as a crucial resource for constructing accurate phylogenetic trees and developing effective conservation strategies, ensuring the sustainable management of Byttnerioideae species in Bangladesh.

References

Ahmed, S.S. and Rahman, M.O. 2022. Taxonomic revision of the subfamily Sterculioideae Beilschm. in Bangladesh. Bangladesh J. Plant Taxon. **29**(2): 373-401.

Ahmed, Z.U., Hassan, M.A., Begum, Z.N.T., Khondker, M., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A. and Haque, E.U. (Eds.). 2009. Encyclopedia of Flora and Fauna of Bangladesh, Vol. **10**. Angiosperm: Dicotyledons (Ranunculaceae-Zygophyllaceae). Asiatic Society of Bangladesh, Dhaka. pp. 328-351.

APG IV. Chase, M.W., Christenhusz, M.J., Fay, M.F., Byng, J.W., Judd *et al.* 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Bot. J. Linn. Soc. **181**(1): 1-20.

Arung, E.T., Kusuma, I.W., Purwatiningsih, S., Roh, S.S., Yang, C.H., Jeon, S., Kim, Y., Sukaton, E., Susilo, J., Astuti, Y., Wicaksono, B.D., Sandra, F., Shimizu, K. and Kondo, R. 2009. Antioxidant activity and cytotoxicity of the traditional Indonesian medicine Tahongai (*Kleinhovia hospita* L.) extract. J. Acu. Merid. Stud. **2**(4): 306-308.

Ashrafuzzaman, M. and Sarwar, A.G. 2021. Species diversity of Sterculiaceae at Bangladesh Agricultural University Botanical Garden and their ethnobotanical uses. Asian J. Res. Bot. **5**(4): 1-8.

Baur, H., Kranz-Baltensperger, Y.V.O.N.N.E., Cruaud, A., Rasplus, J.Y., Timokhov, A.V. and Gokhman, V.E. 2014. Morphometric analysis and taxonomic revision of *Anisopteromalus* Ruschka (Hymenoptera: Chalcidoidea: Pteromalidae) – an integrative approach. Syst. Entomol. **39**(4): 691-709.

Bertsouklis, K.F., Martini, A.N., Vlachou, G., Dariotis, E. and Papafotiou, M. 2021. A first approach on morphometrics studies of *Salvia fruticosa* found in Greece. ISHS Acta Hortic. 1327: 97-102.

Bookstein, F.L. 1991. Morphometric tools for landmark data: Geometry and biology. Cambridge University Press.

Chitchak, N., Traiperm, P., Staples, G., Rattanakrajang, P. and Sumanon, P. 2018. Species delimitation of some *Argyreia* (Convolvulaceae) using phenetic analyses: Insights from leaf anatomical data reveal a new species. Botany **96**(4): 217-233.

Chitra, M., Venkatalakshmi, K., Sivakumar, P., Arulselvi, S., Ishwariya, S. and Velayutham, A. 2022. Nutritional and therapeutic potential of *Waltheria indica* linn: A review. Pharm. Innov. **11**(4): 9777-983.

Colli-Silva, M., Richardson, J.E., Bossa-Castro, A.M. and Pirani, J.R. 2024. Phylogenetic evidence reshapes the taxonomy of Cacao and its allies (*Theobroma* and *Herrania*; Malvaceae, Byttnerioideae). Brittonia: 1-9.

Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press., New York.

Gupta N., Ganeshpurkar, A., Jatav, N., Bansal, D. and Dubey, N. 2012. *In vitro* prevention of chick pancreatic lipase activity by *Abroma augusta* extract. Asian Pac. J. Trop. Biomed. **2**(2): S712-S715.

Kettenring, J.R. 2006. The practice of cluster analysis. J. Classif. **23**(1): 3-30.

Lalawmpuii, R., Lalhriatpuii, T.C. and Ghosh, S.K. 2017. In vitro anticancer activity of *Callicarpa arborea* and *Buettneria aspera* Colebr., a traditional medicinal plant from Mizoram, Northeast India. Eur. J. Biomed. Pharm. Sci. **4**(3):362-367.

Lima, J.B., Bovini, M.G. and Conceição, A.D.S. 2019. Bombacoideae, Byttnerioideae, Grewioideae and Helicterioideae (Malvaceae *s.l.*) in the Raso da Catarina Ecoregion, Bahia, Brazil. Biota Neotrop. **19**: e20180569.

Maia, F.R. and Goldenberg, R. 2019. Morphometric analysis and the distinction between *Tibouchina hatschbachii* and *T. marumbiensis*: Morphological differentiation driven from the past. Plant Syst. Evol. **305**(2): 169-180.

Maldini, M., Di, M.S., Montoro, P., Darra, E., Mariotto, S., Bifulco, G., Pizza, C. and Piacente, S. 2013. Flavanocoumarins from *Guazuma ulmifolia* bark and evaluation of their affinity for STAT1. Phytochem. **86**: 64-71.

Mamatha, B.S., Palaksha, M.N., Gnanasekaran, D., Senthilkumar, G.P. and Tamizmani, T. 2018. *Melochia corchorifolia* L: A review. World J. Pharm. Res. **7**(19): 482-491.

Mulumba, J.W. and Kakudidi, E. 2010. Numerical taxonomic study of *Acacia senegal* (Fabaceae) in the cattle corridor of Uganda. S. Afr. J. Bot. **76**(2): 272-278.

Otte, D. and Endler, J.A. 1989. Speciation and its consequences. Sinauer Associates. Sunderland, Massachusetts. pp. 28-59.

Rahman, M.O., Rahman, M.Z. and Begum, A. 2013. Numerical taxonomy of the genus *Senna* Mill. from Bangladesh. Bangladesh J. Plant Taxon. **20**(1), 77-83.

Rahman, M.Z. and Rahman, M.O. 2013. Morphometric analysis of *Desmodium* Desv. in Bangladesh. Bangladesh J. Bot. **41**(2): 143-148.

Rao, B.G., Rao, Y.V. and Rao, T.M. 2013. Hepatoprotective and antioxidant capacity of *Melochia corchorifolia* extracts. Asian Pac. J. Trop. Med. **6**(7): 537-543.

Rohlf, F.J. 2012. NTSYSpc: Numerical Taxonomy System. Exeter Software, Version 2.

Rusconi, M. and Conti, A. 2010. *Theobroma cacao* L., The Food of the Gods: A scientific approach beyond myths and claims. Pharmacol. Res. **61**(1): 5-13.

Sikder, L., Khan, M., Smrity, S.Z., Islam, M.T. and Khan, S.A. 2022. Phytochemical and pharmacological investigation of the ethanol extract of *Byttneria pilosa* Roxb. Clin. Phytosci. **8**(1): 1-8.

Sneath, P.H.A. and Sokal, R.R. 1973. Numerical Taxonomy, Freeman and Company, San Francisco, USA, 573 pp.

Uddin, S.N. and Hassan, M.A. 2018. Vascular Flora of Chittagong and the Chittagong Hill Tracts, Vol **2**. Bangladesh National Herbarium, Dhaka.

Uyeda, J.C., Caetano, D.S. and Pennell, M.W. 2015. Comparative analysis of principal components can be misleading. Syst. Biol. **64**(4): 677-689.

Zongo, F., Ribuot, C., Boumendjel, A. and Guissou, I. 2013. Botany, traditional uses, phytochemistry and pharmacology of *Waltheria indica* L. (syn. *Waltheria americana*): A review. J. Ethnopharmacol. **148**(1): 14-26.

(Manuscript received on 30 December, 2023; revised on 2 June, 2024)