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continued on the back inside cover

**Cover: The critically endangered *Lilium polyphyllum* in watercolour and acrylics. © Aishwarya S Kumar.**

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# Comparative morphological and ethnobotanical assessment of certain taxa of genus *Glochidion* (Phyllanthaceae) from Assam, India

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**Abstract:** The genus *Glochidion*, a member of the family Phyllanthaceae, primarily comprises shrub or tree species. It stands out from other genera due to distinctive reproductive features, including prolonged styles in flowers and fruits, apiculate anthers, and lobed and unlobed capsules. This study aimed to compare the morphological characteristics of nine taxa in Assam to facilitate identification and assess ethnobotanical knowledge. Ethnobotanical information was gathered by interviewing the local community, and a taxonomic key was provided for accurate identification. Morphological data underwent principal component analysis (PCA) and cluster analysis using PAST for validation. The comparison revealed distinct characteristics in both vegetative and reproductive traits among *Glochidion* members. Reproductive features, such as inflorescence, style, ovary, and capsules, were key factors for differentiation and identification. PCA and cluster analysis demonstrated correlation and variation among the taxa, contributing significantly to their demarcation. Ethnobotanical studies indicated the genus's potential medicinal properties, supported by both primary and secondary information.

**Keywords:** Angiosperms, cluster analysis, ethnobotany, PCA, Phyllanthoideae, taxonomy, UPGMA.

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**Author contributions:** PB has collected, done photography, identified, carried out the morphological analysis of the specimen, performed the PCA and cluster analysis and drafted the manuscript. SB contributed to the present study's design, supervised the work and revised the manuscript. The final manuscript was examined and approved by both the authors.

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## INTRODUCTION

Northeastern India, including Assam, has a wide variety of vegetation due to its topographic and climatic diversity. It is one of the most diverse regions in the world (Dutta & Dutta 2005; Mao & Roy 2016; Bhattacharyya et al. 2020). The people of Assam have employed a number of plants to treat a wide range of ailments since ancient times (Kanjilal et al. 1940; Bhattacharya et al. 1991). There are many medicinal plants in the area that are well-known to ethnic communities, and Assam is regarded as one of the ecological hot spots in the world (Myers et al. 2000; Asati & Yadav 2004; Saikia et al. 2006).

The species of *Glochidion* J.R.Forst. & G.Forst. have been used by local people in different places in the world and have immense value in the field of medicine (Lai et al. 2004; Xiao et al. 2008; Bajpai et al. 2016; Chakrabarty & Balakrishnan 2018). Some important biological and pharmacological activities, including the anticancer, antioxidant, and antimicrobial activities of a few members of *Glochidion* have been reported by many workers (Azam et al. 2012; Rathod & Rajurkar 2017). The people of India mainly rely on medicinal plants and are well-known for ethnobotanical knowledge (Maikhuri & Gangwar 1993; Prakash et al. 2008). Therefore, it was felt worth exploring the genus *Glochidion* in Assam for its current taxonomy and to assess its ethnomedicinal uses.

The genus *Glochidion* J.R.Forst. & G.Forst. is a member of the family Phyllanthaceae which is native to northern Australia, Polynesia, southern Asia, and tropical Asia (Chakrabarty & Balakrishnan 2018). The members of the genus are either shrubs or trees, monoecious, pubescent, or glabrous with drooping branches. They are mostly found in evergreen, moist deciduous, tropical, primary and secondary forests, sal forests, hilly areas, and some swampy areas. There are over 320 species worldwide; about 22 species, and eight varieties in India (Balakrishnan & Chakrabarty 2007; Balakrishnan et al. 2012; Chakrabarty & Balakrishnan 2018; Brahma & Baruah 2023). Kanjilal et al. (1940) designated 16 species from erstwhile Assam in 'Flora of Assam'. At present 12 species and four varieties of the genus are found in Assam (Chakrabarty & Balakrishnan 2018). Traditionally, *Glochidion* was placed in Euphorbiaceae (Bentham & Hooker 1862–1883; Hutchinson 1973). Later, Hoffmann et al. (2006) discovered that the genus *Glochidion* sensu lato includes *Breynia* J.R.Frost & G.Forst., *Flueggea* Willd. and *Margaritaria* L.f., which are all allied to *Phyllanthus* as members of the tribe Phyllantheae and, therefore, belong to the segregate family Phyllanthaceae, and this was later ascertained by Chase et al. (2016) on the molecular basis. The absence of latex and the bi-ovulate ovary distinguish the family Phyllanthaceae from Euphorbiaceae (Chakrabarty & Balakrishnan 2018).

Earlier in some floras, *G. ellipticum* used to be referred to as *G. assamicum*, a synonym of *G. ellipticum*; *G. velutinum*, i.e., synonym of *G. heyneanum*; *G. hirsutum* or *G. tomentosum*, i.e., synonym of *G. zeylanicum* var. *tomentosum;* and *G. arborescens*, i.e., synonym of *G. zeylanicum* var. *arborescens* (Hooker 1890; Kanjilal et al. 1940). According to recent literature and taxonomy data, the taxa *G. ellipticum*, *G. heyneanum*, *G. zeylanicum* var. *tomentosum*, *G. zeylanicum* var. *arborescens* are the accepted names (Chakrabarty & Balakrishnan 2018; WFO 2023).

The present study aimed to resolve the taxonomic identity of certain members of the genus *Glochidion* based on their morphology. The principal component analysis (PCA) and cluster analysis were carried out to authenticate the morphological evaluation of the taxa studied. All the relevant ethnobotanical information about the *Glochidion* taxa collected from Assam was documented based on primary sources that could yield potential information in the field of medical research.

## MATERIALS AND METHODS

### Sample collection, Identification, and Ethnobotanical assessment

Field surveys were conducted in the diverse forest areas in Assam from December 2019 to January 2023. Before conducting the field survey, approval was taken from Assam State Biodiversity Board (ASBB) and PCCF Wildlife Warden, Panjabari, Assam. *Glochidion* specimens were collected randomly from various locations in Assam, India (Table 1). During the field, collected specimens were taken in an airtight poly bag for further morphological examination and photographs of the specimens were taken using a Realme XT 64 MP mobile camera phone. Garmin GPS etrex 10 was used to record and identify precise latitudes and longitudes of the area of the specimen. In the lab, both vegetative and reproductive characteristics of freshly collected specimens were examined carefully under a Biocraft 20X simple microscope and a Leica EZ4W stereo microscope.

After a critical analysis of the character, identification was made with the help of some authentic literature (Hooker 1890; Kanjilal et al. 1940; Borthakur et al. 2018; Chakrabarty & Balakrishnan 2018), online taxonomic databases (e-Floras 2008; The Plant List 2013; GBIF

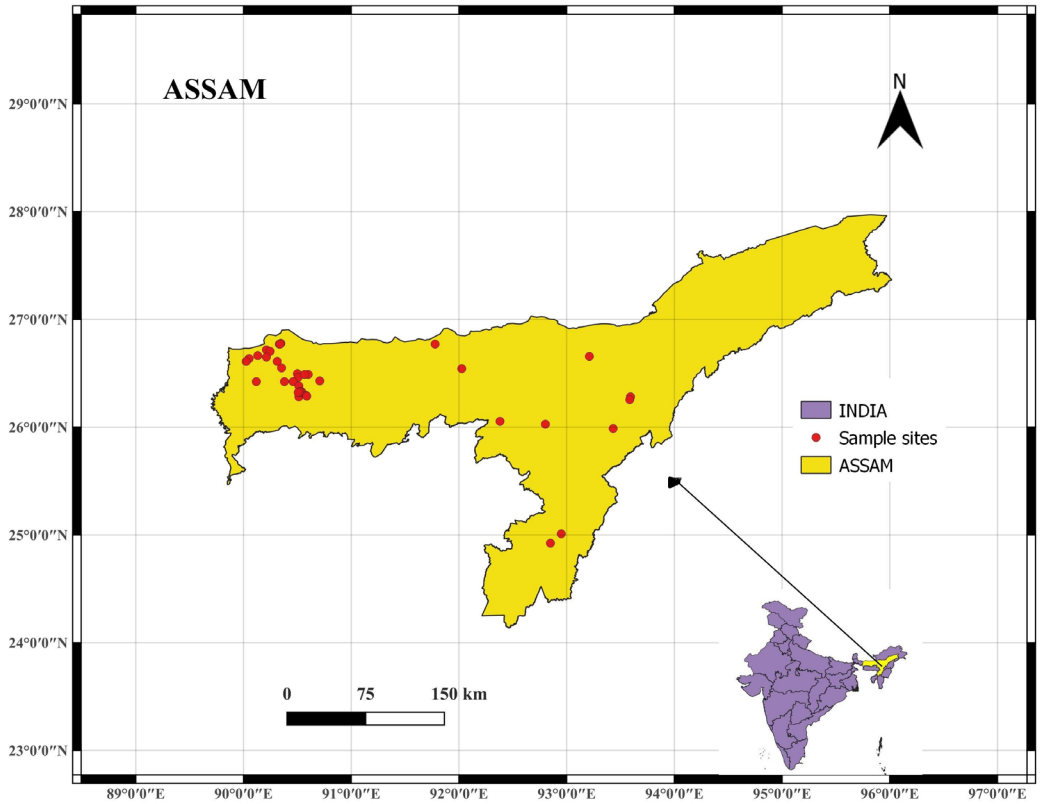


Figure 1. Distribution map of collected taxa from different places in Assam.

2021; POWO 2023) and also with the help of India herbaria (ASSAM, ARUN, and CAL) and digital herbaria (A, MO, NY) (acronyms following Thiers 2018). After reviewing pertinent literature, the threat status of the collected plant taxa was also determined (IUCN 2022). During identification, accepted scientific names and the synonyms of the collected taxa were also checked and confirmed through online databases such as IPNI, POWO, and The WFO Plant List (IPNI 2023; POWO 2023; WFO 2023). The dominant characters that played a key role in the identification of the specimen were their reproductive characters. The list of the collected specimens with their locality, accession number, GPS coordinates, and distribution map were procured (Table 1; Figure 1). The distribution map was created with QGIS 3.26.3 version software.

Ethnobotanical information of all collected taxa was made by the scrutiny of literature as well as communication with some local people and traditional healers in the study area. In addition to documenting the traditional uses and parts utilized for the specimen, we recorded their vernacular names, mode of preparation, application, and route of administration, as outlined in Table 5.

**Herbarium preparation and deposition**

Herbarium preparations adhered to the established techniques outlined by Jain & Rao (1977), while poisoning procedures followed the methods specified by Clark (1986). Authenticated and verified herbarium specimens for each collected taxon were deposited at the Botanical Survey of India (BSI) in Shillong, Meghalaya.

**PCA and Cluster analysis**

Fifteen morphological characters (Table 3) were analyzed based on using principal component analysis (PCA) and cluster analysis (Hammer et al. 2001). Multivariate PCA and hierarchical cluster analysis were assessed using the software PAST 4.06b version.

## RESULTS

***Glochidion*: Morphological diagnosis**

Monoecious and rarely dioecious; primarily of shrubs or trees; pubescent or glabrous; droopingly branched. Leaves simple, alternate, usually asymmetrical at the base, entire, petiolate, stipulate. The inflorescence is usually axillary, supra-axillary, or pedunculate, with few to many flowers. Staminate flowers are mostly long

**Table 1. List of recorded taxa in the studied area with their locality, accession number, and GPS coordinates.**

| Taxa | Locality | Accession No. | GPS coordinates |
|---|---|---|---|
| *Glochidion ellipticum* Wight | Kokrajhar District, Assam | 98605 | 26.4947°N, 90.4319°E |
| *G. heyneanum* (Wight & Arn.) Wight | Kokrajhar District, Assam | 98606 | 26.6236°N, 90.4061°E |
| *G. lanceolarium* (Roxb.) Voigt | Chakrashila Wildlife sanctuary, Kokrajhar District, Assam | 98608 | 26.4236°N, 90.4963°E |
| *G. multiloculare* (Rottler ex Willd.) Voigt | Kokrajhar District, Assam | 98604 | 26.7338°N, 90.4308°E |
| *G. multiloculare* var. *pubescens* Chakrab. & M.Gangop. | Orang National Park, Udalguri District, Assam | 98610 | 26.7858°N, 92.3305°E |
| *G. sphaerogynum* (Mull.Arg.) Kurz | Chakrashila Wildlife Sanctuary, Kokrajhar District, Assam | 98609 | 26.2902°N, 90.3747°E |
| *G. zeylanicum* var. *arborescens* (Blume) Chakrab. & M.Gangop. | Ultapani Forest Range, Kokrajhar District, Assam | 98603 | 26.8002°N, 90.3466°E |
| *G. zeylanicum* var. *tomentosum* Trimen. | Ultapani Forest Range, Kokrajhar District, Assam | 98607 | 26.7722°N, 90.4158°E |
| *G. zeylanicum* (Gaertn.) A.Juss | Nokpakghat, Karbi Anglong District, Assam | 98611 | 26.3838°N, 93.2061°E |

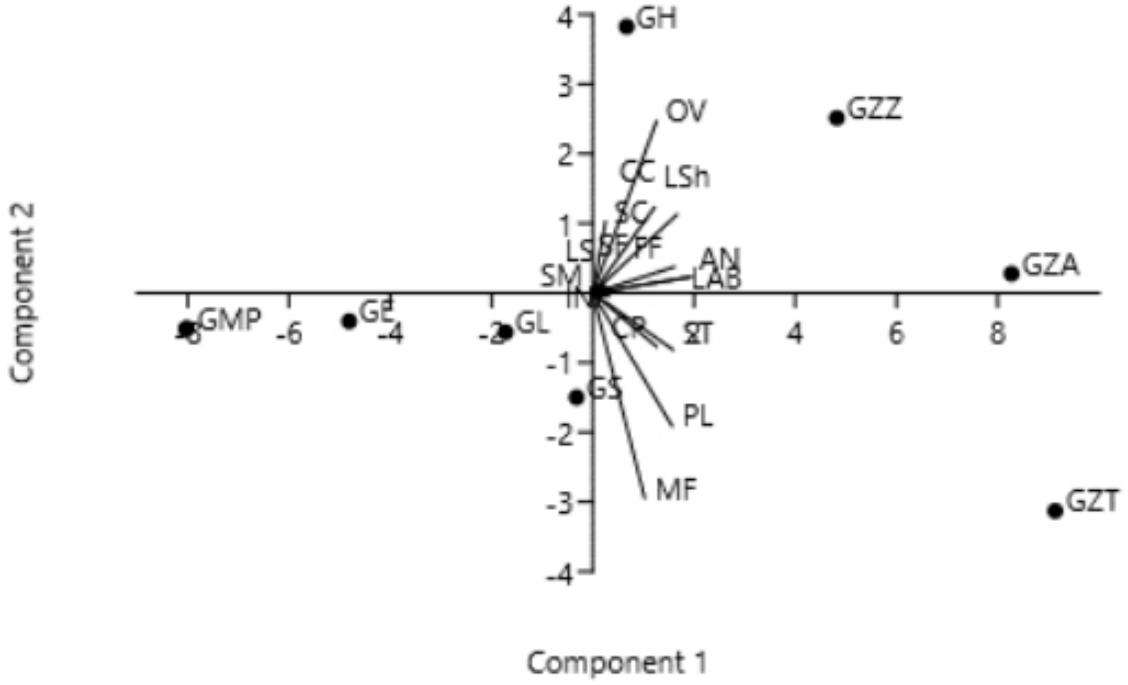


**Figure 2. Multivariate Principal Component Analysis (PCA) of different members of *Glochidion* based on morphological characteristics.**

pedicellate, with sepals 3–6, free, but no petals or disc. Anthers are present, 3–12, connective, pistillode absent. Pistillate flowers shortly pedicellate or sessile; sepals 3–6, free to connate; petals or disc absent; staminodes absent. Ovary 3–14 locular, biovulate locules; styles usually connate into a column, conical, or globose. Capsular pedicellate or sessile with a style column at the apex, depressed, subglobose, unlobed, and deeply or conspicuously lobed; pubescent or glabrous, green, white, or creamy to reddish. Seeds are usually 3–14, compressed, hemispherical with an arillate coat.

**Review on the ethnobotanical knowledge of members of *Glochidion* in India**

Some ethnobotanical uses of members of the genus *Glochidion* were mentioned by earlier workers. These are given below-

The paste of *Glochidion tomentosum* Dalz. is used externally in wounds by the tribes of Eastern Ghat, India (Reddy et al. 2006). The Chiru tribe of Manipur, India, consumed young leaves of *G. multiloculare* (Rottler ex. Willd.) Voigt and cooked them as an enjoyable curry and used them against stomach disorders (Rajkumari et

**Table 2. Comparative morphological characters of certain species of genus *Glochidion* collected from different localities of Assam.**

| Characters | *G. ellipticum* | *G. heyneanum* | *G. lanceolarium* | *G. multiloculare* var. *multiloculare* | *G. multiloculare* var. *pubescens* | *G. sphaerogynum* | *G. zeylanicum* var. *arborescens* | *G. zeylanicum* var. *tomentosum* | *G. zeylanicum* var. *zeylanicum* |
|---|---|---|---|---|---|---|---|---|---|
| Leaf shape | Elliptic to lanceolate, oblong to obovate | Ovate to elliptic, obovate | Lanceolate to oblanceolate, elliptic | Oblong to lanceolate, elliptic to oblanceolate | Oblong to lanceolate, elliptic to oblanceolate | Oblong to elliptic, falcate | Ovate to elliptic | Ovate to elliptic, cordate | Ovate to elliptic, cordate |
| Leaf apex & and base | Apiculate, caudate, acuminate at apex, obtuse at base | Acute, apiculate at apex, obtuse or rounded at base | Apiculate, acuminate, or acute at apex, obtuse or rounded at base | Acute, apiculate, or retuse at apex, obtuse or rounded at base | Acute, apiculate, or retuse at apex, obtuse or rounded at base | Acuminate at apex, attenuate at base | Acute, acuminate at apex, obtuse or rounded at base | Obcordate, acute at apex, obtuse, truncate, asymmetric at base | Acute, apiculate at apex, cordate, asymmetric, truncate at base |
| Leaf surface | Glabrous on both surfaces | Pubescent on both surfaces and densely pubescent beneath | Glabrous on both surfaces | Glabrous on both surfaces at mature and pubescent at young | Pubescent on both surfaces and densely pubescent beneath | Glabrous on both surfaces | Densely pubescent on both surfaces | Densely pubescent on both surfaces | Glabrous on both surfaces |
| Petiole length | 0.4–1 cm long | 0.1–0.5 cm long | 0.6–1 cm long | 0.1–0.5 cm long | 0.1–0.5 cm long | 0.9–1 cm long | 0.3–0.5 cm long | 0.5–0.7 cm long | 0.1–0.8 cm long |
| Inflorescence | Axillary | Axillary | Axillary | Axillary | Axillary | Axillary | Supra-axillary, pedunculate, rarely axillary | Supra-axillary, pedunculate, rarely axillary | Supra-axillary, pedunculate, rarely axillary |
| Male flower | Pedicellate, 0.5–1.7 cm long | Pedicellate, 0.5–1 cm long | Pedicillate, 0.9–2 cm long | Pedicellate, 0.5–1 cm long | Pedicellate, 0.5–1 cm long | Pedicellate, 0.5–1.8 cm long | Pedicellate, 0.5–0.7 cm long | Pedicellate, 0.7–1.8 cm long | Pedicellate, 0.5–1 cm long |
| Sepal | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Anther | 4–5 | 3–4 | 4–6 | 5–12 | 5–12 | 3–5 | 5–7 | 5–8 | 3–8 |
| Female flower | Pedicellate, 0.1–0.5 cm long | Pedicellate, 0.1–0.6 cm long | Sessile, 0.06–0.09 cm long | Pedicellate, 0.3–0.5 cm long | Pedicellate, 0.3–0.5 cm long | Pedicellate, 0.3–0.5 cm long | Pedicellate, 0.4–0.6 cm long | Pedicellate, 0.4–1 cm long | Pedicellate, 0.1–0.9 cm long |
| Sepal | 6 | 6 | 6 | 6–12 | 6–12 | 6 | 6 | 6 | 6 |
| Style | Columnar, conical | Columnar | Columnar | Conical, subglobose | Conical, subglobose | Discoid | Columnar, persistent | Columnar, subconical | Free |
| Ovary | Subglobose, 3–6 locular | Depressed, subglobose, 4–5 locular | Depressed, subglobose, 5–8 locular | Depressed, 5-12 locular | Depressed, 5-12 locular | Depressed, 4–12 locular | Subglobose, 4–6 locular | Depressed, Subglobose, 5–8 locular | Depressed, Subglobose, 4–8 locular |
| Capsule | Pubescent, pedicellate, shallowly lobed | Pubescent, pedicellate, conspicuously lobed | Sparsely pubescent, sessile, shallowly lobed to deeply lobed | Pubescent, pedicellate, conspicuously lobed | Pubescent, pedicellate, conspicuously lobed | Glabrous, pedicellate, ambiguously lobed | Densely pubescent, pedicellate, obviously unlobed | Densely pubescent, pedicellate, ambiguously lobed | Glabrous, pedicellate, ambiguously lobed |
| Capsule color | Light green to creamy, whitish | Green to yellow-green | Light green, creamy to reddish | Green | Green | Green | Light green, yellow green to reddish | Light green, yellow green to reddish | Light green, yellow green to reddish |
| Seed color | Yellow green to red | Yellow green to orange | Yellow green to red | Green to red | Green to red | Green to orange | Yellow green to red | Yellow green to red | Yellow green to red |

**Table 3. Character state of morphological characteristics of different members of *Glochidion* used in cluster analysis.**

| Taxa | LSh | LAB | LS | PL | INF | MF | SM | AN | FF | SF | ST | OV | CP | CC | SC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| H | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 4 | 3 | 1 | 2 | 4 | 2 | 3 | 3 |
| L | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 |
| M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MP | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| S | 3 | 3 | 2 | 3 | 0 | 3 | 0 | 3 | 0 | 1 | 3 | 3 | 3 | 0 | 2 |
| ZA | 6 | 6 | 1 | 5 | 1 | 4 | 0 | 6 | 5 | 1 | 5 | 6 | 4 | 4 | 1 |
| ZT | 5 | 7 | 1 | 6 | 1 | 5 | 0 | 7 | 6 | 1 | 6 | 2 | 5 | 4 | 1 |
| ZZ | 5 | 5 | 2 | 4 | 1 | 0 | 0 | 5 | 4 | 1 | 4 | 5 | 3 | 4 | 1 |

E—*G. ellipticum* | H—*G. heyneanum* | L—*G. lanceolarium* | M—*G. multiloculare* var. *multiloculare* | MP—*G. multiloculare* var. *pubescens* | S—*G. sphaerogynum* | ZA—*G. zeylanicum* var. *arborescens* | ZT—*G. zeylanicum* var. *tomentosum* | ZZ—*G. zeylanicum* var. *zeylanicum* | LSh—Leaf shape | LAB—Leaf apex & base | LS—Leaf surface | PL—Petiole length | INF— Inflorescense | MF—Male flower | SM—Sepal of male flower | AN—Anther | FF—Female flower | SF—Sepal of female flower | ST—Style | OV—Ovary | CP—Capsule | CC—Capsule color | SC—Seed color

**Character states: Leaf Shape:** Oblong to lanceolate, elliptic to oblanceolate = 0; Elliptic to lanceolate, oblong to obovate = 1; Lanceolate to oblanceolate, elliptic = 2; Oblong to elliptic, falcate = 3; Ovate to elliptic, obovate = 4; Ovate to elliptic, cordate = 5; Ovate to elliptic = 6; **Leaf apex & base:** Acute, apiculate or retuse at apex, obtuse or rounded at base = 0; Apiculate, caudate, acuminate at apex, obtuse at base = 1; Apiculate, acuminate or acute at apex, obtuse or rounded at base = 2; Acuminate at apex, attenuate at base = 3; Acute, apiculate at apex, obtuse or rounded at base = 4; Acute, apiculate at apex, cordate, asymmetric, truncate at base = 5; Acute, acuminate at apex, obtuse or rounded at base = 6; Obcordate, acute at apex, obtuse, truncate, asymmetric at base = 7; **Leaf surface:** Glabrous on both surfaces at mature and pubescent at young = 0; Pubescent on both surfaces and densely pubescent beneath = 1; Glabrous on both surfaces = 2; **Petiole length:** 0.1–0.5 cm long = 0; 0.4–1 cm long = 1; 0.6–1 cm long = 2; 0.9–1 cm long = 3; 0.1–0.8 cm long = 4; 0.3–0.5 cm long = 5; 0.5–0.7 cm long = 6; **Inflorescence:** Axillary = 0; Supra-axillary, pedunculate, rarely axillary = 1; **Male flower:** Pedicellate, 0.5–1 cm long = 0; Pedicellate, 0.5–1.7 cm long = 1; Pedicillate, 0.9–2 cm long = 2; Pedicellate, 0.5–1.8 cm long = 3; Pedicellate, 0.5–0.7 cm long = 4; Pedicellate, 0.7–1.8 cm long = 5; **Sepal of male flower:** 6 = 0; **Anther:** 5–12 = 0; 4–5 = 1; 4–6 = 2; 3–5 = 3; 3–4 = 4; 3–8 = 5; 5–7 = 6; 5–8 = 7; **Female flower:** Pedicellate, 0.3–0.5 cm long = 0; Pedicellate, 0.1–0.5 cm long = 1; Sessile, 0.06–0.09 cm long = 2; Pedicellate, 0.1–0.6 cm long = 3; Pedicellate, 0.1–0.9 cm long = 4; Pedicellate, 0.4–0.6 cm long = 5; Pedicellate, 0.4–1 cm long = 6; **Sepal of female flower:** 6–12 = 0; 6 = 1; **Style:** Conical, subglobose = 0; Columnar, conical =1; Columnar = 2; Discoid = 3; Free = 4; Columnar, persistent = 5; Columnar, subconical = 6; **Ovary:** Depressed, 5–12 locular = 0; Subglobose, 3–6 locular = 1; Depressed, subglobose, 5–8 locular = 2; Depressed, 4–12 locular = 3; Depressed, subglobose, 4–5 locular = 4; Depressed, Subglobose, 4–8 locular = 5; Subglobose, 4–6 locular = 6; **Capsule:** Pubescent, pedicellate, conspicuously lobed = 0; Pubescent, pedicellate, shallowly lobed = 1; Sparsely pubescent, sessile, shallowly lobed to deeply lobed = 2; Glabrous, pedicellate, ambiguously lobed =3; Densely pubescent, pedicellate, obviously unlobed =4; Densely pubescent, pedicellate, ambiguously lobed; **Capsule color:** Green = 0; Light green to creamy, whitish = 1; Light green, creamy to reddish = 2; Green to yellow green = 3; Light green, yellow green to reddish = 4; **Seed color:** Green to red = 0; Yellow green to red = 1; Green to orange = 2; Yellow green to orange = 3

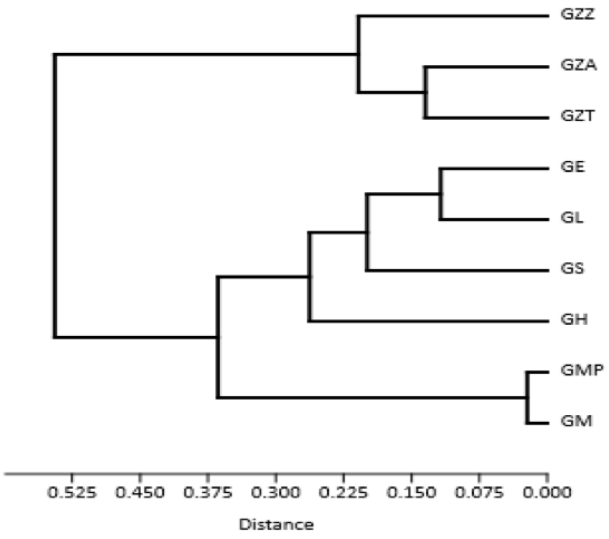


**Figure 3. Paired group (UPGMA) dendrogram using hierarchical cluster analysis of different members of genus *Glochidion* based on their morphological characteristics.**

**Table 4. Principal component analysis (PCA) based on morphological characteristics of different members of *Glochidion*.**

| PC | Eigenvalue | % variance |
|---|---|---|
| 1 | 41.3263 | 83.254 |
| 2 | 4.25921 | 8.5804 |
| 3 | 2.02297 | 4.0754 |

al. 2013). The bark of *G. multiloculare* is used for skin diseases and wounds (Bajpai et al. 2016). Roots of *G. multiloculare* are used in snake bites (Brahma et al. 2002). The fruit and stem of *G. heyneanum* (Wight & Arn.) Wight is used in diabetes, fever, and bone fracture (Kumar et al. 2019). Roots of *G. heyneanum* are used in snake bites (Bajpai et al. 2016). Barks and leaves of *G. zeylanicum* (Gaertn.) A.Juss. are used in snake bites and stomach ulcers, and tender shoots are applied to itches (Das et al. 2013; Chakrabarty & Balakrishnan 2018; Kumar et al. 2019). Branches and leaves of *G. sphaerogynum* (Mull. Arg.) Kurz. are used in influenza and eczema (Lalrinkimi & Lallianthanga 2019). Fruits of *G. daltonii* (Mull.Arg.) Kurz. is used in cough and dysentery, and the bark of *G. ellipticum* Wight is used in inflammation (Bajpai et al.

**Table 5. Enumeration of ethnobotanical knowledge of *Glochidion* in Assam.**

| Botanical name | Vernacular names | Parts used | Mode of preparation | Application | Route of administration |
|---|---|---|---|---|---|
| *Glochidion multiloculare* (Rottler ex Willd.) Voigt | Thakha Biphang or thakha mala (Bodo), Gorumora, Dolpoduli (Assamese) | Leaves, barks, Roots | - A small number of leaves are ground into a paste.<br>- A small amount of bark is taken and ground into a paste.<br>- 3–4 roots are taken to make a paste. | - Fracture and body swelling<br>- Skin diseases and wounds<br>- Snake bite | - External<br>- External<br>- External |
| *G. ellipticum* Wight | Thakha Biphang or thakha mala (Bodo), Panimadhuri (Assamese), Latimaowa (Nepali) | Bark, stem branches, and roots | - A small amount of bark is removed and ground into a paste, which is then administered to the diseased area.<br>- A paste is made by crushing the stem and applying it to the swelling area.<br>- Roots are ground into a paste. | - Body swelling, Skin problem<br>- Body swelling<br>- Snake bite | - External<br>- External<br>- External |
| *G. sphaerogynum* (Mull.Arg.) Kurz. | Thakha Biphang or thakha mala (Bodo), Panimadhuri (Assamese), Boljakru (Garo) | Young branches and leaves | Young branches and leaves are ground into a paste and blended with a small amount of water. | - Skin diseases<br>- Branches are used as firewood also. | - External |

2016). The paste made from the seeds of *G. ellipticum* is used as an antiallergic (Babu 1995). The bark of *G. lanceolarium* (Roxb.) Voigt is used in stomach diseases and is used as an anti-itch drug, oil made from seeds is also used as a source of light (Chanda et al. 2007; Bajpai et al. 2016; Chakrabarty & Balakrishnan 2018). The seeds of *G. calocarpum* Kuna are applied externally for skin diseases, and leaves are used orally to cure fever (Elanchezhian et al. 2007). According to Lalfakzuala et al. (2007), fruits of *G. arborescens* are used as wild edible fruits that are consumed by the local people of Mizoram. The fruits of *G. khasicum* (Mull.Arg.) Hook.f. are also edible and consumed by the tribal people of the Khasi hills in Meghalaya (Chakrabarty & Balakrishnan 2018).

## DISCUSSION

The comparative morphological characteristics of certain species of the genus *Glochidion* showed many similarities and distinctive characteristics, which can be helpful for the identification and classification of the taxa (Table 2). Some of the major distinctive characteristics were leaf morphology, petiole length, and reproductive structures, i.e., inflorescences, male and female flowers, anthers, style, ovary, and capsule. The presence or absence of hairs on stems, leaves, inflorescence, and capsules also significantly differentiates the taxa. *G. multiloculare* var. *pubescens* an endemic variety of Assam showed nearly identical habit, vegetative and reproductive characteristics, with the exception of a glabrous plant body in *G. multiloculare* var. *multiloculare* (Chakrabarty & Balakrishnan 2018). The other major distinctive characteristics of both the taxa are that solitary or individual flowers and fruits occur in each axil in *G. multiloculare* var. *pubescens* while multiple flowers and fruits in each axil of the plant body have been observed in *G. multiloculare* var. *multiloculare*. The variety *G. zeylanicum* var. *tomentosum* presented almost the same character as *G. zeylanicum* var. *zeylanicum*, with the major difference being its hairy or tomentose character. *G. heyneanum* showed puberulous habits on the stems and leaves. In some taxa, leaves were asymmetric or symmetric at the base.

The majority of taxa exhibited axillary inflorescence while *G. zeylanicum* var. *zeylanicum, G. zeylanicum* var. *tomentosum* and *G. zeylanicum* var. *arborescens* showed supra-axillary or pedunculate and rarely axillary inflorescence. Male flowers of the taxa revealed remarkably similar traits, but the number of anthers separated them. Female flowers presented different characteristics from male flowers. The peduncles of all the female flowers were shorter than the male flowers. The number of locules in the ovary varied by taxon, and style characters also played a key role. The shape, size, color, locules, and hairy habit of the capsule were distinguished among taxa, which showed taxonomic significance. Some taxa like *G. zeylanicum* var. *zeylanicum* and their varieties, were easily identified with their unlobed and ambiguously lobed capsule. *G. multiloculare* and *G. sphaerogynum* exhibited deeply or conspicuously lobed capsules while *G. ellipticum* presented a superficially lobed capsule. The capsule of *G. lanceolarium* was sessile, i.e., the fruit without the stalk or it lacked a pedicel, which distinguished it from other taxa. When dried, most of the leaves of the members were curled at the margin. While *Glochidion* and *Epicephala* moths were mutualists (Kato et al.

2003), most *Glochidion* leaves and drooping branches were found in insect-damaging conditions. As a result, some easily detectable characters for taxa identification could exist.

Based on morphological data, both PCA and cluster analysis were analyzed (Table 3–4 & Figure 2–3). The first PCA variance was 83.254% with an eigenvalue of 41.3263 followed by the second PCA variance of 8.5804% with an eigenvalue of 4.25921. The line connected to PC1 and PC2 makes up 91.8344% of the total variance and is a good sign of the variability of the initial data. PC1 represented the variation of the taxa based on the characters such as leaf shape (LSh), leaf apex and base (LAB), anther (AN), female flower (FF), sepal of the female flower (SF), ovary (OV), capsule color (CC), seed color (SC) and PC2 represented the characters such as leaf surface (LS), petiole length (PL), inflorescence (INF), male flower (MF), sepal of male flower (SM), style (ST), capsule (CP). In PC1, five taxa were observed i.e., *G. ellipticum* (GE), *G. lanceolarium* (GL), *G. multiloculare* var. *pubescens* (GMP), *G. sphaerogynum* (GS), and *G. zeylanicum* var. *tomentosum* (GZT). PC2 denoted a total of four taxa, viz., *G. heyneanum* (GH), *G. multiloculare* var. *multiloculare* (GM), *G. zeylanicum* var. *arborescens* (GZA), and *G. zeylanicum* var. *zeylanicum* (GZZ). From cluster analysis the tree revealed that *G. multiloculare* var. *multiloculare* (GM) and *G. multiloculare* var. *pubescens* (GMP) as cluster 1, *G. heyneanum* (GH) as cluster 2, *G. sphaerogynum* (GS) as cluster 3, *G. ellipticum* (GE) and *G. lanceolarium* (GL) as cluster 4, *G. zeylanicum* var. *arborescens* (GZA), and *G. zeylanicum* var. *tomentosum* (GZT) as cluster 5, *G. zeylanicum* var. *zeylanicum* (GZZ) as cluster 6. Taxa present in the same cluster specified more correlation than the taxa present in the different clusters.

The ethnobotanical study revealed that some members of the genus *Glochidion* were traditionally used to cure different diseases (Table 5) in Assam. Among the uses, the most frequent are skin diseases, fractures, body swelling, and snake bites.

## CONCLUSION

The study revealed that there are similarities and differences among the members of the genus *Glochidion* which are more reliable for grouping and classifying the taxa. Documentation of ethnobotanical evidence signifies the importance of the genus. Both primary and secondary sources of the ethnobotanical knowledge showed the members have medicinally important properties and almost all parts, i.e., leaves, bark, and roots, have been used by the local people for the treatment of various diseases in India including Assam. This study summarized that both taxonomical study and conservation of ethnobotanical knowledge are of great significance, with the ability to stimulate subsequent biological investigation. Moreover, PCA and cluster analysis also validated the data on comparative morphological traits that showed correlation and variation among the analyzed species.

**Key to the species and varieties based on vegetative and reproductive characters**

1. Inflorescence axillary ..... 2
1. Inflorescence axillary to supra-axillary ..... 6

2. Capsules shortly pedicellate ..... 3
2. Capsules sessile ..... *G. lanceolarium*

3. Leaves curl upwards with a margin when dry ..... *G. sphaerogynum*
3. Leaves do not curl upwards with a margin when dry ..... 4

4. Plant part glabrous except the reproductive organs ..... *G. multiloculare* var. *multiloculare*
4. Plant parts all pubescent ..... *G. multiloculare* var. *pubescens*

5. Capsules 3–6 locular; green to white creamy ..... *G. ellipticum*
5. Capsules 4–5 locular; yellowish-green ..... *G. heyneanum*

6. Fruits obscurely lobed ..... 7
6. Capsules unlobed ..... *G. zeylanicum* var. *arborescens*

7. Plants entirely glabrous ..... *G. zeylanicum* var. *zeylanicum*
7. Plant parts all pubescent ..... *G. zeylanicum* var. *tomentosum*


Image 1. Morphological characters: A—*Glochidion multiloculare* var. *multiloculare* | B—*G. ellipticum* | C—*G. heyneanum* | D—*G. lanceolarium* | E—*G. sphaerogynum* | F—*G. multiloculare* var. *pubescens* | G—*G. zeylanicum* var. *zeylanicum* | H—*G. zeylanicum* var. *arborescens* | I—*G. zeylanicum* var. *tomentosum*. © Priyanka Brahma.

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