CHAPTER 2

REVIEW OF LITERATURE

2.1. International scenario

Many members of the genus *Glochidion* J.R. Forst. & G.Forst. exhibited substantial research on taxonomy, ethnobotany, and phytochemical study and showed significant values in the field of taxonomy, ethnobotany, and phytochemical analysis.

2.1.1. Review of Taxonomy

Forster & Forster (1776) first established the genus *Glochidion* in 'Characteres Generum Plantarum'. Airy Shaw (1972) described 22 species from Siam in the book 'The Euphorbiaceae of Siam', and some species are now treated as synonyms namely *G. hypoleucum* (synonym of *G. lutescens* Blume), *G. perakense* (synonym of *G. zeylanicum*), *G. hongkongense* (synonym of *G. zeylanicum*). Taxonomic work was done by Li & Gilbert (2008) in '*Flora of China*'. They described a total of 28 species of the genus.

Yao & Zhang (2015) gave taxonomic notes on 2 species of the genus *Glochidion* viz., *G. acuminatum* Mull.Arg. and *G. triandrum* (Blanco) C.B. Rob. They claimed *Glochidion* is a challenging genus and its inclusive taxonomic treatments are still absent. Yao et al. (2018) described the genus with a taxonomic account from the Indo-China Peninsula. They observed *G. anamiticum* (Kuntze) Kuntze ex Merrill and *G. annamense* Beille were formerly thought to be somewhat similar in habit to *G. eriocarpum*, but their investigations revealed that it may be appropriate to treat these two species as different species. Yao et al. (2018) recorded a new species from Myanmar named *G. shanense* Gang Yao & Shixiao Luo. The study revealed that the species resembles *G. ellipticum* Wight morphologically but can be differentiated later by having pubescent branches, lengthier pedicels, uniseriate and female flowers with narrow triangular sepals, 4–5 locular ovules, and cylindrical persistent style on capsules. Yao et al. (2020) conducted a thorough taxonomic review of the genus *Glochidion* J.R. Forst. & G.Forst. from Taiwan, China based on field studies and the analysis of herbarium samples.

2.1.2. Review of Phytochemistry

Many chemical substances have been isolated from several parts of the genus. It shows the genus has potential medicinal value. The genus contains many phytochemical

constituents. They are mainly rich in flavonoids, terpenoids, glycoside, steroids, phenolic compounds, and almost all types of phytochemical constituents like steroids, triterpenoids, tannins, saponins, alkaloids, resins, anthraquinone, reducing sugar, phlorotannins, carbohydrates have also been reported in some species. Various biological activities like antioxidant, antibacterial, antidiabetic, anti-inflammatory, analgesic, antiurolithiatic, antimicrobial, antibiofilm, antitumor, and cytotoxic activities also have been studied from some species of the genus *Glochidion*. In the leaves of *G. zeylanicum* (Gaertn.) A. Juss, lignan and neolignan derivatives and megastigmane glucosides have been isolated (Otsuka et al., 2000, 2003). The stem bark of *G. zeylanicum* showed anti-tumor activity (Tanaka et al., 2004). Cytotoxic activity has been found in the roots and stem wood of *G. sphaerogynum* (Puapairoj et al., 2005). From the rhizome of *G. coccineum*, some sesquiterpenoid glycosides, sesquiterpenoid lactone, phyllaemblic acid, and methyl ester were isolated (Xiao et al., 2007, 2008b). Kiem et al. (2009) evaluated cytotoxic activity in the aerial parts of *G. eriocarpum*. Machana et al. (2011) estimated cytotoxic and apoptotic effects on the HepG2 cell line from *G. daltonii*. Four main compounds of triterpenes, namely glochidonol, glochidiol, glochidone, luperol, and two steroids namely daucosterol and stigmasterol were reported in the extract of aerial parts of *G. multiloculare* (Rottler ex Willd.) Voigt (Hasan et al., 2012). Azam et al. (2012) investigated that the bark of *G. multiloculare* (Rottler ex Willd.) Voigt possesses antibacterial, antioxidant activity and strong cytotoxic activities. Nhiem et al. (2012) evaluated the anticancer activity from aerial parts of *G. eriocarpum* on human cancer cell lines. Kabir et al. (2013) examined antimicrobial and cytotoxic activities in the stem bark of *G. multiloculare*. Antioxidant activities have been found in the leaves of *G. hypoleucum* (Anantachoke et al., 2014). Ali et al. (2014) investigated sedative activity in the leaves of *G. multiloculare*. From the roots of *G. puberum* antibacterial activity has been studied (Liu et al., 2014). Kabir et al. (2015) analysed the stem bark of *G. multiloculare* and found that the plant possesses antitumor, analgesic, and anti-inflammatory activities. Thu et al. (2015) evaluated the cytotoxic activity of *G. glomerutum*. Hasan et al. (2016) revealed the cytotoxic potentiality of different extracts of *G. velutinum* wight. by BSLA (Brine Shrimp lethality bioassay) methods. Are et al. (2016) studied hypoglycemic and antidiabetic activity from the leaves of *G. velutinum* in type 2 diabetic rats. Anti-inflammatory activity has been extracted from *G. daltonii* (Junlatat & Sripanidkulchai, 2016). Thang et al. (2017) evaluated the cytotoxic activities of *G. hirsutum*. Deb et al. (2019) published a review work on a medicinally known plant species *G. velutinum* Wight. They reported the plant having significant

phytoconstituents as well as pharmacological activities. Benny et al. (2019) also reported that the whole parts of the plant *G. velutinum* Wight have medicinal value. Kabir et al. (2021) isolated triterpenoids from the stem bark of *G. lanceolarium* namely Epilupeol, Glochidonol, Glochidone and they possess strong anti-proliferative activity against tumor cell lines. Shah et al. (2022) evaluated the phytochemical profile of *G. velutinum* and its cytotoxic activity against prostate cancer and breast cancer based on LC-MS/MS metabolomics analysis. They concluded that *G. velutinum* extract has a remarkable number of polyphenols, flavonoids, fatty acids, terpenoids, coumarins, and sugars and has cytotoxic effects molecules against prostate and breast cancer cells i.e., the plant has anticancer potential. Tian et al. (2023) investigated the stems and twigs of *G. puberum* that exhibited Glochidpurnoids A and B, coumaroyl or feruloyl oleananes, triterpenoids and the species also have high cytotoxic activity.

2.2. National scenario

2.2.1. Review of Taxonomy

Voigt (1841) was the first to record the genus *Glochidion* from the Indian subcontinent in 'Hortus Suburbanus Calcuttensis'. He described only 6 species from the genus. Taxonomic study on *Glochidion* in India can be traced back to the book '*The Flora of British India*' (Hooker, 1890). He described 59 species, of which 21 are found to occur in North East India. Balakrishnan et al. (2012) described 22 species and 13 varieties in '*Flora of India*'. Kanjilal et al. (1940) carried out major taxonomic work in Assam where they described 16 species of the genus from erstwhile Assam in the book '*Flora of Assam*' namely *G. multiloculare, G. coccineum, G. lanceolarium, G. zeylanicum, G. oblatum, G. thomsonii, G. heyneanum, G. acuminatum, G. daltoni, G. khasicum, G. sphaerogynum, G. assamicum* (synonym of *G. ellipticum*), *G. hirsutum* (accepted name is *G. zeylanicum* var. *tomentosum*), *G. arborescens* (accepted name is *G. zeylanicum* var. *arborescens*). The rest of the 2 species are now treated as synonyms i.e., *G. velutinum* (accepted name is *G. heyneanum*) and *G. gamblei* (accepted name is *G. daltonii*). Preetha S.S. (2007) performed some floristic work in Kerala state and identified six different species and two varieties of *Glochidion* namely *G. bourdillonii* Gamble, *G. candolleanum* (Wight & Arn.) Chakrab. & M. Gangop., *G. ellipticum* Wight, *G. heyneanum* (Wight & Arn.) Wight, *G. hohenackeri* Bedd., *G. hohenackeri* var. *johnstonei* (Hook.f.) Chakrab. & M. Gangop., *G. zeylanicum* A. Juss., *G. zeylanicum* var. *tomentosum* (Daiz.) Chakrab. & M. Gangop. A new endemic species *G. tirupathiense* from the Seshachalam biosphere reserve, Andhra Pradesh, India

has been discovered (Rasingam et al., 2014). Later the specimen was accepted as one of the varieties of *G. heyneanum* (Chakrabarty & Balakrishnan, 2018).

The anatomical work of a few members of *Glochidion* has been carried out in India. Thakur & Patil (2011, 2014) studied foliar epidermal work on two species viz., *G. neilgherrense* Wight, *G. hohenackeri* Bedd. Stomata were mostly anomocytic and randomly distributed in both species and their stomatal index vary from one another. Thakur & Patil (2011) studied petiolar anatomy in the species *G. hohenackeri* Bedd. The petiole almost has a circular shape to it. Small, barrel-shaped epidermal cells with thick cuticles are followed by 2 to 3 layers of collenchyma and a continuous ring of vascular tissue. Conjunctive tissue, phloem cells, and certain collenchyma cells all contain tannin. A study of the leaf architecture of the species *G. hohenackeri* Bedd. was conducted by Tadavi & Bhadane (2014).

2.2.2. Review of Phytochemistry

Srivastava & Kulshreshtha (1988) isolated triterpenoids, triterpene glycosides and various compounds from *G. heyneanum*. Sunkara et al. (2009) mentioned the occurrence of antioxidant activity and cytotoxic activity in *G. zeylanicum* (Gaertn.) A. Juss leaf extract. Sandhya et al. (2010) gave an updated review of the genus *Glochidion* which revealed different chemical constituents in plants having different medicinal values. Sharma et al. (2010) studied the root extract of *G. zeylanicum* using the disc paper method. The study has been carried out for antibacterial and antifungal activities against various organisms. Sharma et al. (2011) revealed that the root extract of *G. zeylanicum* has potential anticancer activity on human cancer cell lines. The extract exhibited outstanding therapeutic value against the cancer cell line. Mallikarjuna (2012) studied in vitro morphogenesis, phytochemistry, and bioactivity of a medicinal plant *G. velutinum*. This study revealed the occurrence of some secondary metabolites in *G. velutinum* which has important medicinal value. Rao et al. (2013) found anti-diabetic activity in *G. velutinum*. They found that the plant was closer to the common sedative drug diazepam. Jawarkar (2015) worked on the phytochemical investigation and pharmacological screening of *G. ellipticum* and revealed that leaves, stem bark, and roots of *G. ellipticum* have potential cytotoxic secondary metabolites and bioactivity compounds. Also, a high amount of anticancer activity has been observed in *G. ellipticum* (Jawarkar & Mohite, 2016). Jawarkar & Kane (2017) investigated phytochemical and anthelmintic properties on the

leaves of *G. ellipticum* L. which showed the presence of diterpenoids, flavonoids, steroids, tannins, and resins in the species. This study revealed that the leaf extract of *G. ellipticum* L. not only verified immobilization but also instigated the decease of worms, especially at a high concentration amount and produced anthelmintic activities. Rathod & Rajurkar (2017) estimated phytochemical screening on the species *G. ellipticum* L. which exhibited maximum antioxidant and anti-inflammatory activities. The cytotoxic and antiproliferative activity of *G. ellipticum* by using human cancer cell lines MCF-7 and assayed by MTT has been reported and it showed the maximum activity towards MCF-7 cell line (Rathod & Rajurkar, 2017). Anthelmintic activity has also been detected from the *G. ellipticum* (Jawarkar & Kane, 2017). Duangjan et al. (2019) evaluated leaf extracts of *G. zeylanicum* for their antioxidant and anti-aging properties in *C. elegens* using GLC-MS, LC-MS, and RP-HPLC. Antibacterial and antibiofilm activity was present in the leaves of *G. lanceolarium* (Mohanta et al., 2020). Vinayaka et al. (2022) evaluated the phytochemical analysis of *G. ellipticum* leaves. The result revealed the existence of antioxidant activity as well as the occurrence of flavonoids, saponins, terpenoids, and tannins.

2.3. Review of Ethnobotany

Some ethnobotanical information has been gathered on the genus *Glochidion* by earlier workers. It showed the genus has been potentially used by indigenous people around the world for many purposes.

Ye et al. (2021) mentioned important uses of some *Glochidion* species in the book 'Common Chinese Materia Medica Volume 3' 'Medicinal Angiosperms of Euphorbiaceae'. He revealed the use of *G. eriocarpum* in relieving etching and the treatment of dysentery, exfoliative dermatitis, skin eczema, etc. Leaves, branches, and roots of *G. lanceolarium* are used as remedies to cure diseases in China. Leaves and stems of this species are used to heal wound damage, gum disease, and oral ulceration, and roots are applied to cure jaundice. The function of this plant is to disperse blood stasis and eliminate inflammation. *G. puberum* is used to treat fever, throat pain, malaria, stomach ache, diarrhea, injury, and menstrual cramps. Wiart (2021) mentioned different uses of *Glochidion* in the book 'Medicinal Plants in the Asia Pacific for Zoonotic Pandemics, Volume 2 Family Zygophyllaceae to Salvadoraceae'. He mentioned that *G. obscurum* (local name: dulang dulang) is traditionally used in Malaysia to treat diarrhea and in Indonesia (local name: Ki pare lalaki) the species is used for dysentery and after childbirth.

In Indonesia, *G. rubrum* (local name: Dempul) is used to treat cough. In Papua New Guinea, *G. submolle* (local name: Hin) is used to treat toothache. In Bangladesh, *G. multiloculare* (local name: Kudurpala) is used to treat diarrhea.

Reddy et al. (2006) worked on ethnobotanical work on endemic plants of the eastern Ghats, India. They described ethnobotanical uses of a total of 28 endemic plant species used by the tribes of Eastern Ghat, India. Among them, he described one species from *Glochidion* i.e., *G. tomentosum*. According to them, the paste of the species is applied externally in wounds. Elanchezhian et al. (2007) worked on the ethnobotany of the primitive tribe of the Great Nicobar Island. They mentioned the species, *G. calocarpum* Kuna, as having medicinal value. The leaves are consumed orally to treat fever while the seeds are applied topically to treat skin problems. Tribes of Mizoram consumed the fruits of *G. arborescens* (Lalfakzuala et al., 2007). According to Chanda et al. (2007), traditional healers of Sikkim Himalayas, India, used the bark of *G. lanceolarium* as juice to cure stomach diseases. Rajkumari et al. (2013) investigated the ethnobotanical study of wild edible medicinal plants in Manipur, India. They mentioned a total of 69 wild species. Among them, one *Glochidion* species i.e., *G. multiloculare* has been mentioned. According to them, young leaves of this species were cooked as delicious curry to cure intestinal disorders. Leaves and barks of *G. zeylanicum* are used in stomach ulcers and snake bites respectively (Das et al., 2013). Stem branches and fruits of *G. heyneanum* are used in the treatment of diabetes, fever, cold, and bone fractures (Savithramma et al., 2014). Bajpai et al. (2016) worked on ethnomedicinal practices of tree species in the Himalayan region of India. They described a total of 50 families. Out of these, 5 species from the genus *Glochidion* have been reported. *G. daltonii* fruits are used for cough, fever, and dysentery. *G. ellipticum* bark is used in inflammation. Roots of medicinal plant species *G. heyneanum* is used in snake bites. *G. lanceolarium* bark is used in abdominal illnesses and also serve as an antipruritic to relieve itches. The bark of *G. multiloculare* is used for skin diseases and wounds. Chakrabarty & Balakrishnan (2018) mentioned that tribal people of Khasi Hills in Meghalaya consumed the fruits of *G. khasicum*. Kumar et al. (2019) described traditional practices of medicinal plants in ethnic groups of South India. They mentioned two species of *Glochidion*, namely *G. heyneanum* and *G. zeylanicum* which are medicinally important. Lalrinkimi & Lallianthanga (2019) documented tree species of Mizoram, India with their ethnomedicinal values. They described *G. sphaerogynum* as a medicinal species. Branches and leaves of this species are used in influenza and eczema.