

Taxonomic studies on the genus *Leea* L. (Vitaceae) in India

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University of Calicut in partial fulfillment of the requirements for
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DOCTOR OF PHILOSOPHY IN BOTANY

by

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CERTIFICATE

This is to certify that the thesis entitled **Taxonomic studies on the genus *Leea* L. (Vitaceae) in India**, submitted to the University of Calicut by Ms. **Amrutha A.**, in partial fulfillment of the award of the degree of Doctor of Philosophy in Botany is a bona fide record of the research work carried out by her under my supervision and guidance. No part of the present work has formed the basis for the award of any other degree or diploma previously.

Calicut University
Date: 13.02.2024

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DECLARATION

I hereby declare that the work presented in the thesis entitled **Taxonomic studies on the genus *Leea* L. (Vitaceae) in India** is based on the original work done by me under the guidance of **Dr. A.K. Pradeep** and has not been included in any other thesis submitted previously for the award of any degree. The contents of the thesis are undergone plagiarism check using iThenticate software at C.H.M.K. Library, University of Calicut, and the similarity index found within the permissible limit. I also declare that the thesis is free from AI generated contents.

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Despite the difficulties, here I am

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ABSTRACT

The present study deals with the taxonomic revision of the genus *Leea* L. (Vitaceae) in India. This tropical genus comprises 38 species worldwide restricted to the Indo-Malayan region extending to Australia and some parts of Africa and Madagascar. This study recognized 17 species in India with two endemics, mainly distributed in Northeast India, Peninsular India and Andaman and Nicobar Islands. The genus *Leea* was earlier recognized at the rank of family, but now included under the subfamily Leeoideae Burmeister of Vitaceae according to the APG system of classification. They are mostly shrubs, trees or creeping herbs, and some species possess prickles on their stems. *Leea* is distinguished by the presence of a conspicuous petiolar stipule, well-developed floral disc, syngeneceous stamens, one ovule in each locule and ruminant endosperm. A combined approach of morphology, anatomy, micromorphology and molecular data were used since for species delimitation in this genus is often quite challenging. An illustrated taxonomic account of the genus has been made and a taxonomic key was also prepared. Two new species have been described from the study area and three names, *Leea sundaica* Miq., *Leea latifolia* Wall. ex Kurz, *Leea trifoliata* M.A.Lawson were reinstated from *Leea indica* (Burm.f.) Merr., *Leea macrophylla* Roxb. ex Hornem., and *Leea compactiflora* Kurz respectively. *Leea talbotii* King ex Talbot was reduced into the synonymy of *Leea setuligera* C.B.Clarke and *Leea aequata* var. *villosissima* Hochr. was synonymized under *Leea aequata* L. Lectotypification of 41 names were also carried out. The conservation status of all the species was assessed according to the IUCN criteria (Version 15.1, 2022). Among the 17 species, eight species were assessed as Endangered (EN), two species as critically endangered (CR) and seven species as Least Concern (LC). Ex-situ conservations of 50 accessions of 15 species were maintained in Calicut University Botanical Garden (CUBG).

The foliar anatomical study of *Leea* in India was also carried out, and the leaf anatomy of most of these species has never been described before. The result showed that, among the anatomical characters, the number of palisade parenchyma, the thickness of leaves, shapes of adaxial and abaxial surfaces of midrib and rachis, number of vascular bundles in the midrib, types of stomata, outlines of anticlinal walls of epidermal cells, presence of hypodermis, and accessory vascular bundles in the midrib region provide additional information for delimitation of species. An identification key using anatomical characters was also provided to distinguish the species.

The seeds in *Leea* were studied through both light microscopy (LM) and scanning electron microscopy (SEM) to facilitate the identification of species based on seed characters. The seeds are wedge-shaped, triangular in cross-section, endosperm is ruminant with a long or linear dorsal chalaza. Seed coat ornamentation varied among species based on SEM analysis.

The palynological studies showed the pollen grains in *Leea* were stenopalynous and consist of trizonocolporate radially symmetrical isopolar pollen grains. Most of the species have microreticulate exine ornamentation except in two spiny species, *Leea angulata* Korth. ex Miq. and *Leea adwivedica* K.Kumar, where it was foveolate type.

This is the first phylogenetic study on Indian *Leea*. The present molecular study based on nrITS showed that the tropical genus *Leea* is monophyletic and resolved into four major clades in both maximum-likelihood and Bayesian analysis. The clade I consisted of a single species *L. asiatica* (L.) Ridsdale, having the free stamens. clade II consisted of species with prominent bracts, clade III consisted of species having prominent persistent bracts and the rest of the Indian species were nested in clade IV, which was further resolved into four subclades (a-c). The current work also supports the resurrection of the three species, *L. latifolia*, *L. trifoliata*, and *L. sundaica* and also support the establishment of new species in this genus.

പ്രബന്ധ സംഗ്രഹം

മുന്തിരിയും ചങ്ങലംപരണ്ടയും ഉൾപ്പെടുന്ന വൈറ്റേസി സസ്യകുടുംബത്തിലെ കുറ്റിച്ചെടിയാലായി വളരുന്ന 'ലിയ' എന്ന ജനുസിന്റെ വർഗ്ഗീകരണ പഠനമാണ് നടത്തിയിട്ടുള്ളത്. ഇന്ത്യയിൽ ഈ ജനുസ്സിൽ പെടുന്ന വിഭിന്ന ഇനങ്ങളുടെ വൈവിധ്യത്തെക്കുറിച്ചും, വളരുന്ന ചുറ്റുപാടുകളെക്കുറിച്ചും ഓരോ ഇനങ്ങളുടെയും ബാഹ്യ-ആന്തരിക സ്വഭാവ വ്യതിയാനങ്ങളെക്കുറിച്ചും, വിതരണ രീതികളെക്കുറിച്ചുമുള്ള സമഗ്രമായ ഈ പഠനത്തിൽ ഇവയുടെ ശാസ്ത്രീയ നാമകരണത്തിലെ ന്യൂനതകൾ അന്തർദ്ദേശീയ സസ്യനാമകരണ നിയമാവലിയിലെ വകുപ്പുകൾ അനുസരിച്ച് നിർണ്ണയിക്കുകയും ക്രമീകരിക്കുകയും ചെയ്തിട്ടുണ്ട്. ലോകത്താകമാനമായി 38 ഇനങ്ങൾ ഉള്ള ഈ ഉഷ്ണമേഖലാ ജനുസ് പ്രധാനമായും ഇൻഡോ-മലയൻ മേഖലകളിൽ വ്യാപിച്ചു കിടക്കുന്നു. കൂടാതെ ഇവയുടെ രണ്ടിനങ്ങൾ ആഫ്രിക്കയിലും കാണപ്പെടുന്നുണ്ട്. ഇന്ത്യയിൽ 17 ഇനങ്ങൾ ഉള്ള ഈ ജനുസിന്റെ വൈവിധ്യം വടക്കു കിഴക്കൻ ഇന്ത്യയിലും പശ്ചിമഘട്ടത്തിലും ആൻഡമാൻ നിക്കോബാർ ദ്വീപുകളിലുമായി പരിമിതപ്പെട്ടിരിക്കുന്നു. ഇവയിൽ ആൻഡമാൻ നിക്കോബാർ ദ്വീപുകളിൽ കണ്ടുവരുന്ന രണ്ടിനങ്ങൾ ലോകത്ത് ഇന്ത്യയിൽ മാത്രം കാണപ്പെടുന്നവയാണ്. വൈറ്റേസിയയിലെ മറ്റു ചെടികളിൽ നിന്നു വ്യത്യസ്തമായി ഇവയ്ക്ക് പ്രകടമായ പീറ്റിയോളാർ സ്റ്റിപ്പ്യൂൾ, പരസ്പരം സംയോജിച്ചുള്ള പരാഗകേസരങ്ങൾ എന്നിവ ഉണ്ട്. ഈ പഠനത്തിൽ മിസോറാമിൽ നിന്നും രണ്ട് പുതിയ ഇനങ്ങളെ ശാസ്ത്ര ലോകത്തിനു പരിചയപ്പെടുത്തുകയും മൂന്ന് ഇനങ്ങളുടെ ഇപ്പോഴത്തെ നില പുനരവലോകനം ചെയ്യുകയും ചെയ്തിട്ടുണ്ട്. ഈ പ്രബന്ധത്തിൽ ഇന്ത്യയിലെ മൊത്തം ലിയ ഇനങ്ങളുടെ പാരീഡമിതിക പ്രശ്നങ്ങൾ വിശദമായി പഠിച്ച്, ഇന്റർനാഷണൽ യൂണിയൻ ഫോർ കൺസർവേഷൻ ഓഫ് നേച്ചർ അനുശാസിക്കുന്ന സംരക്ഷണ സൂചികയെ അടിസ്ഥാനപ്പെടുത്തി തരംതിരിക്കുകയും ചെയ്തിട്ടുണ്ട്. ഇവയിൽ 8 എണ്ണം വംശനാശ ഭീഷണി നേരിടുന്ന വിഭാഗത്തിലും 2 എണ്ണം ഗുരുതരമായി വംശനാശ ഭീഷണി നേരിടുന്ന വിഭാഗത്തിലും വരുന്നതാണെന്ന് വിലയിരുത്തിയിട്ടുണ്ട്.

ഈ പഠനത്തിനു പുറമെ ഇന്ത്യയിൽ നിന്നുള്ള ലിയ ചെടികളുടെ ആന്തരിക ഘടനയെ കുറിച്ച് വിശദമായ പഠനം നടത്തുകയും അവ ഓരോ ഇനങ്ങളെയും വേർതിരിക്കുന്നതിന് ഉപകാരപ്പെടുന്നതാണെന്നും കണ്ടെത്തിയിട്ടുണ്ട്. ഇവയുടെ വിത്തുകളെക്കുറിച്ചും പരാഗരേണുക്കളെക്കുറിച്ചും വിശദമായ പഠനം നടത്തുകയും അവയുടെ പ്രാധാന്യം മനസ്സിലാക്കുകയും ചെയ്തിട്ടുണ്ട്. ഇത് കൂടാതെ ഐടിഎസ് സീക്വൻസ് വച്ച് നടത്തിയ ഫൈലോജനെറ്റിക് പഠനത്തിൽ ഇന്ത്യയിലെ ലിയ ഇനങ്ങൾ നാല് വിഭാഗമായി തിരിഞ്ഞിട്ടുണ്ട്. ഈ പഠനം ലിയ ഇനങ്ങളുടെ വർഗ്ഗീകരണത്തിനും പുതുതായി കണ്ടുപിടിച്ച സസ്യങ്ങളുടെ നിലനില്പിനെ സാധൂകരിക്കുകയും ചെയ്യുന്നുണ്ട്.

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Man has lived in harmony with nature since ancient times, and as a result, he started looking for plants. Humans have been hunting plants for essentials for eons, and the knowledge of plants is closely tied to human civilization history. Throughout our shared evolutionary history, there has been a complicated relationship between humans and plants. As a systemic life support, plants contribute greatly to the survival of all other living creatures on the planet, as well as providing food, medicines, and other resources. It improves our environment by making it more attractive, which enriches our lives and improves our wellbeing. Domestication of plants is one of the most important processes in human history. His unrelenting pursuit aided in the development of agriculture, and it is still going strong in the twenty-first century. Humans have endeavored to gather knowledge about plants since ancient times. In India itself, there are in-depth accounts on plants and their uses in Vedic as well as other ancient literature such as *Charaka* and *Susrutha Samhitas* (Nair, 1998). In order to preserve and secure the future of plants and build an ecological civilization, we must further our understanding of plant biodiversity.

Angiosperms or flowering plants are a diverse and species-rich clade and are found in terrestrial habitats, as well as both freshwater and saltwater habitats. The angiosperms dominate Earth's surface and constitute approximately 3,25,000 species (Antonelli *et al.*, 2020). According to the most recent classification (APG IV), there are 64 orders and 416 families of angiosperms. They are recognized as one of the most powerful terrestrial radiations in more recent geological history. Darwin's theory of progressive evolution could not account for the geologically abrupt appearance of a variety of angiosperm fossils, which led him to refer to the phenomenon as an "abominable mystery".

Classification is a process that humans have engaged in since the ancient period and that comes naturally and instinctively to them. The earliest human effort has been aimed at classifying objects around him. Davis and Heywood (1963) begin their book entitled *Principles of Angiosperm Taxonomy* with a quote from A. Tindell Hopwood which reads "The urge to classify is a fundamental human

instinct, like the predisposition to sin, it accompanies us into the world at birth and stays with us to the end". We all classify things, even when we are not conscious of it. The first human endeavor was to categorize living and non-living things. The usefulness of plants served as the basis for classification. The subsequent phase involved grouping valuable plants into different categories, including those for food, medicine, and other uses. The science that deals with classification is Taxonomy.

Taxonomy so far as it is concerned with variation in organisms and their classification, deals with characters (Davis & Heywood, *l.c.*). The science of taxonomy is based mainly on similarities and dissimilarities among organisms. Botanical classification involves the assembling of plants into taxonomic groups on the basis of their relationship (Davis & Heywood, *l.c.*). This classification of plants dates back to Theophrastus, the father of Botany, who classified plants based on their habit. Earlier taxonomists distinguished groups on the basis of some selected characters. They were unaware of the interrelationships among plants. But, with the acceptance of Darwin's ideas, classification is also looking to incorporate the ideas of evolution. Darwin's evolutionary theory proposed that species represent lineages and that species within a genus have evolutionary relationships with each other. Hence, the classification has since evolved into the phylogenetic system, which uses evolutionary relationships of entities.

Taxonomic research is becoming an increasingly attractive topic through the applications of scientific principles and practices. A correct taxonomic identification is the first step in any plant research. Specifically, it can only be achieved by studying taxonomic groups thoroughly. However, people continue to view taxonomy as a challenging endeavor due to the overlapping characters in many groups. The taxonomy of the genus *Leea* of the family Vitaceae is also difficult due to similar vegetative and floral characters shared by its members.

Vitaceae Juss. are a medium-sized plant family mainly distributed in the tropical and temperate zones, with two subfamilies, Leeoideae Burmeister and Vitoideae Eaton. The Leeoideae is monogeneric and comprises the genus *Leea* and Vitoideae constituting 950 species under 16 genera (Wen *et al.*, 2018). The family is well known economically for grapes, wine, and raisins and is ecologically

important since the majority of species are climbers in tropical and temperate forests (Wen, 2013). Members of the Vitaceae family possess unique morphology, particularly in the case of their tendrils, peculiar axile placentation with partially fused septa in a bi-carpellate gynoecium, pearl glands, and distinctive seed characters (Süssenguth, 1953; Wen, 2007a; Gerrath & Posluszny, 2007; Chen & Manchester, 2011; Trias-Blasi *et al.*, 2012; Ickert-Bond *et al.*, 2014; Zhang *et al.*, 2016). The phylogeny of the Vitaceae family has drawn interest from numerous teams of researchers (Ingrouille *et al.*, 2002; Rossetto *et al.*, 2002, 2007; Soejima & Wen, 2006; Ren *et al.*, 2011; Trias-Blasi *et al.*, 2012; Wen *et al.*, 2013) in recent years.

Leea L., a small group of non-viny shrubs to trees comes under the grape family Vitaceae. It comprises 38 species worldwide (Amrutha & Pradeep, 2023). The genus is found entirely in the old-world tropics, mainly restricted in the Indo-Malayan region extended to Northern and Eastern Australia and some parts of Africa and Madagascar with the highest extent of species diversity in the Malay Peninsula. Malaysia has largest number of species and endemism with 25 endemic species. (Ridsdale, 1974, 1976; Lok *et al.*, 2011). A total of 17 species are recognized in India, including 2 endemic species that are mainly found in northeast India, peninsular India, and the Andaman and Nicobar Islands. This tropical genus was named after James Lee, an English botanist and nurseryman. *Leea* has previously been recognised at the family rank (Ridsdale, 1974, 1976; Wen, 2007a, 2007b), but is now accepted as a subfamily Leeoideae Burmeister of Vitaceae according to the APG system of classification (APG III, 2009; APG IV, 2016). Their morphological range includes subshrub to shrubs, trees, and some species with prickles on stems (*L. angulata* Korth. ex Miq., *L. adwivedica* K.Kumar, *L. spinea* Desc., and *L. aculeata* Blume ex Spreng.). *Leea* is distinguished by its petiolar stipule, well-developed floral disc, presence of pearl glands, syngeneacious stamens, occurrence of a single ovule within each ovary locule, and ruminant endosperm. The genus is renowned for being taxonomically difficult since similar vegetative and floral characters and almost similar habitat preferences among its species make identification at the species level often difficult.

The inclusion of this genus in the family Vitaceae is still a point of contention. Some authors still consider *Leea* in its own family Leeaceae L. (Ridsdale,

1974, 1976; Wen, 2007a) due to the shrubby to tree habit, absence of tendrils, presence of petiolar stipules, development of a complex floral disc attached to a polypetalous corolla, the locules of the ovary each having one ovule as well as the palynological characters. The inclusion of *Leea* under the family Vitaceae is justified based on its seed and embryo characters as well as the occurrence of pearl glands on the vegetative organs. However, it has also been argued that *Leea* as comprising the subfamily Leeoideae within Vitaceae (Burmeister, 1837; Gilg, 1897; Gilg & Brandt, 1911); this concept was supported in the recent APG system of classification (APG III, 2009; APG IV, 2016).

The infrageneric classification of *Leea* has been problematic. Different classifications were proposed based on various morphological characters. Based on the pinnation of leaves, Lawson (1875) divided the genus into three sections without assigning any names. Section I consists of a single species having simple leaves. Species having pinnate leaves are constituted in section II and 2–3 pinnate-leaved plants come under section III. Section III was again grouped into two based on the vestiture of leaves *viz.*, glabrous and pubescent. Clarke (1881) divided the genus into two series, namely "*Rubriflorae*" and "*Viridiflorae*" based on flower colour. Each series is further divided into sections mainly based on the pinnation of leaves. Burt (1935) attempted to classify the genus based on the number of petals, *viz.*, 4-merous, and 5-merous.

Phylogenetic analysis has revealed that the genus *Leea* is monophyletic. However, some complex species such as *L. indica* (Burm.f.) Merr. and *L. guineensis* G.Don has emerged as polyphyletic. The phylogenetic studies, based on the molecular and morphological evidence by Molina *et al.* (2013) resolved four main clades (Clade I–IV). Morphological character analysis showed that clade I was the early separating clade, and it has free stamens which is considered as primitive. Prickle-bearing species are included in clade II, the sister group to clade III, which comprises species that have moderately larger flowers. Clade IV is sister to clade II and III and four subclades have been identified within clade IV. The dating analysis revealed that *Leea* originated in Indochina during the Late Cretaceous period (65–86.19 Mya). The species were later dispersed throughout tropical Australia, Madagascar, South-East (SE) Asia, Africa, and India. The Neogene period witnessed a significant increase in species diversity.

Area of Study

India, (Fig. 1) located in the northeastern hemisphere is one among the 17 mega-biodiversity countries and the seventh largest country in the world, harboring 7–8% of plants and animal species. It is located between 8°4' to 37°6' N latitude and 68°7' to 97°25' E longitude. The length of the country from north to south is 3214 km and the average width is 2933 km from east to west with a 7516.66 km coastline. It has a land boundary measuring 15200 km. The south is bounded by the Indian Ocean, the Arabian Sea to the west, and the Bay of Bengal to the east. Northern frontiers of the country are borders with China, Bhutan and Nepal, north-west with Pakistan and the east with Bangladesh and Myanmar. India has been politically divided into 28 states and 8 union territories for administrative convenience.

India shares 4 of the 36 biodiversity hotspots recognized worldwide. They are the Himalayas, the Western Ghats, the Indo-Burma region and the Sundaland.

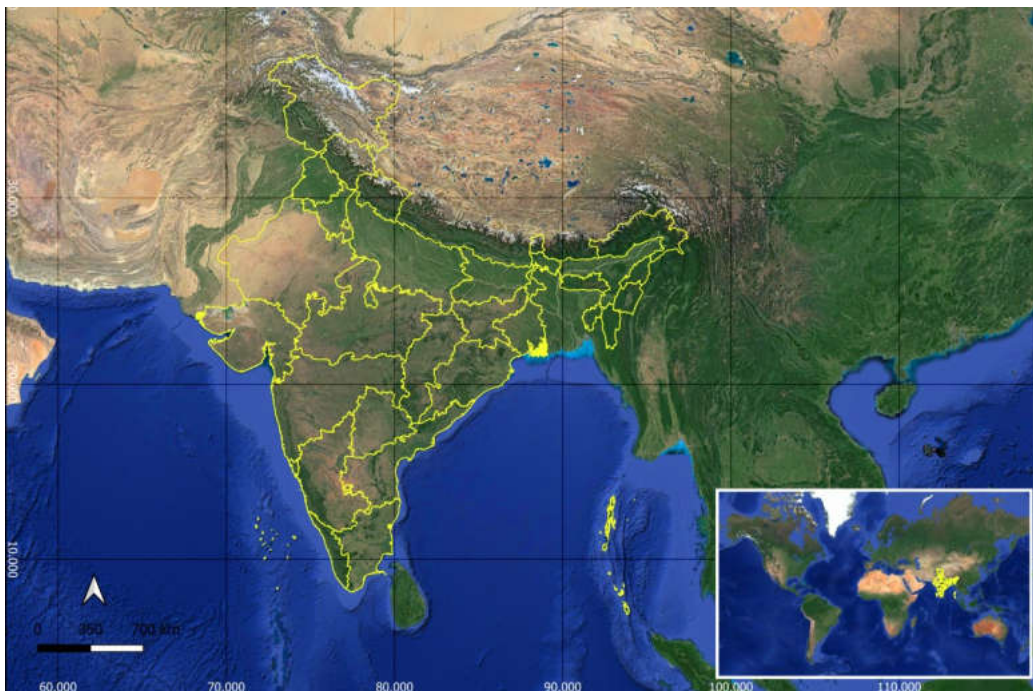


Fig. 1. Map of India, the study area (drawn using QGIS version 3.24.3).

1. Biogeographic Regions

Biogeography is the scientific study of the distribution of organisms and ecosystems throughout geological time and space. Biological communities and

living species often exhibit regular variances due to geographic gradients of elevation, isolation, latitude, and habitats. A biogeographic region is essentially a geographic area where plants and animals are dispersed with consistent or shared characteristics. According to biogeographical characteristics, there are 10 biogeographic regions or zones in India (Rodgers *et al.*, 2002), (Fig. 2) which are further subdivided into 25 biogeographic provinces.

1.1. Trans-Himalayan Region

Trans Himalayan zone comprises the high altitude, cold and arid mountain regions of Ladakh, Jammu & Kashmir, North Sikkim, Lahual and Spiti areas of Himachal Pradesh. The extensive region of Trans-Himalayan comprises bare rock and glaciers. This zone contains only sparse alpine steppe vegetation.

1.2. The Himalayan zone

The world's youngest mountain ranges are found in the Himalayas. This zone has three biogeographical provinces namely, West, Central and East Himalayas. Eastern Himalaya is predominated by tropical rain forests whereas dense subtropical and alpine forests are more common in the western and central parts of the Himalayas.

1.3. Indian Desert zone

The Indian desert zone includes two biogeographic provinces *i.e.*, The Thar deserts and the Rann of Kutch. The Thar is the largest and includes parts of Rajasthan, Haryana, and Punjab, moreover adjoining Pakistan. The climate reflects a very hot and dry summer while the winter is cold and arid. The Great Rann of Kutch is a salt marsh situated in the Kutch district of Gujarat.

1.4. Semi-Arid zone

This area represents a transition between the desert and denser forests of the Western Ghats. Thorny forests make up the native vegetation. This area is distinguished by varying levels of vegetation, patches of exposed soil, and a persistent soil-water deficit.

1.5. The Western Ghats

The Western Ghats, a major biodiversity zone in India extends from the South tip of the Peninsula northward about 1600 km to the mouth of the river Tapi. It is one among the 36 biodiversity hotspots of the world and harbours a high level of endemic species. This mountain range is one of the eight "hottest hotspots" of biological diversity in the world. The primary forms of vegetation include sholas, savannas, scrub jungles, moist deciduous forests, and tropical evergreen forests.

1.6. Deccan Plateau

The Deccan Plateau, which occupies 42% of India's total land area, is the country's largest biogeographic region. It is a semi-arid comprising of deciduous forests, thorn forests and degraded scrubland.

1.7. Gangetic Plains

The Gangetic plain is topographically homogenous for a hundred kilometers. The Gangetic Plain covers Eastern Rajasthan, Uttar Pradesh, Bihar and West Bengal. Secondary forest patches are the major diversity of this area.

1.7. Northeast India

This region represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographical regions as well as being a meeting point of the Himalayan Mountains and Peninsular India. The North-East is thus the biogeographical 'gateway' for much of India's fauna and flora.

1.8. Coastal region

About 2.5 per cent of India's land area is made up of coastal regions, which are inhabited by marine Angiosperm pastures, mud flats, coral reefs, and sandy beaches. Backwater is the characteristic feature of the Coast.

1.9. Islands

Andaman and Nicobar Islands and the Lakshadweep are the two major Archipelagos of India. Lakshadweep, a Union territory is a group of Islands in the Arabian Sea. It is an archipelago comprising 36 islands that span 32 squares kilometers. The Andaman and Nicobar Islands are a pair of island groups situated on the southeast coast of the Bay of Bengal. Both Andaman Island and Nicobar Island are separated by a ten-degree channel which is 150 km wide. The highest point is 2418 feet (737 meters) at Saddle Peak (Andaman). There are 325 islands in

the Andaman group and only 247 in the Nicobar group. The Andaman Islands harbours mostly epiphytic, moist deciduous or wet evergreen forest type of vegetation. Central and Southern Islands of the Nicobar Islands are dominated by evergreen forests.

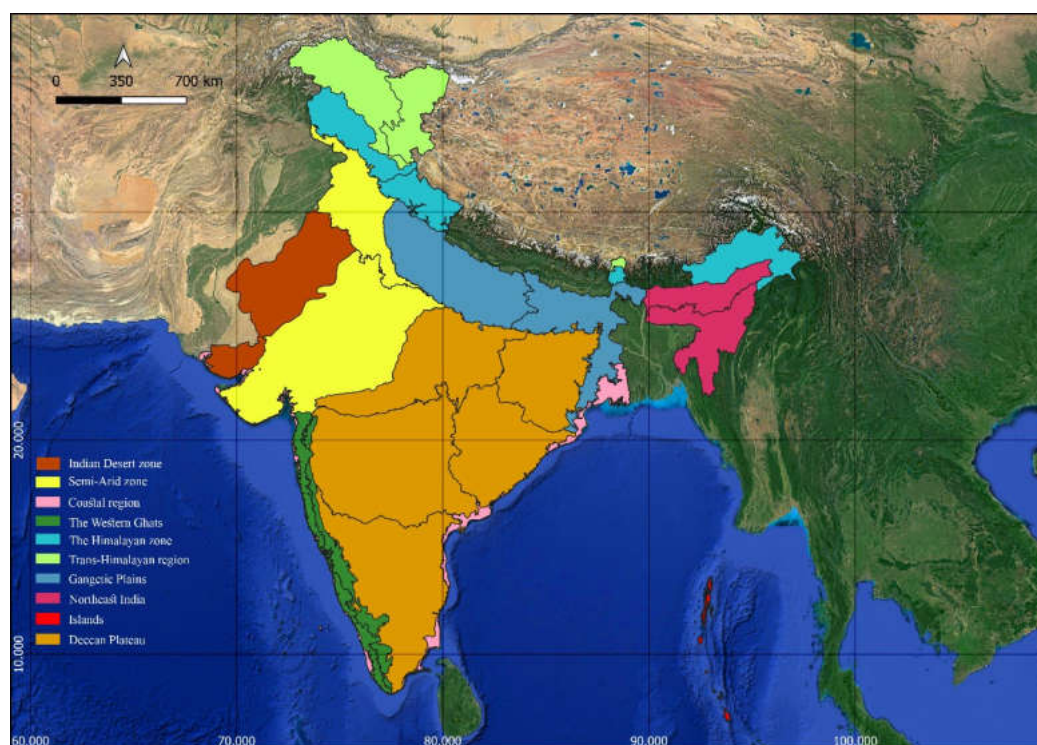


Fig. 2. Map of India showing Biogeographic zones (drawn using QGIS version 3.24.3).

2. Climate

Climate is the term used to refer to the average of the weather over a longer period. The climate in India varies depending on the wind, temperature and rainfall. The climate of India can be generally categorised as tropical monsoon type. The northeast monsoon and the southwest monsoon are two seasonal winds that affect the climate of India. In the country, the majority of the annual rainfall is brought about by the southwest monsoon. Four official seasons are recognized by the Indian Meteorological Department (IMD): 1. winter, which lasts from December to early April; 2. summer, also known as the pre-monsoon season (April to July in north-western India); 3. monsoon, also known as the wet season (June to September); and 4. post-monsoon, which lasts from October to December.

3. Rain falls

The precipitation in India is irregular over the year. The annual rainfall is 118 cm according to the annual data from the meteorological department. There are four regions in India based on the amount of rainfall. *viz.*, Region of very heavy rainfall, region of heavy rainfalls, Region of Moderate rainfall and Regions of scanty rainfall. The region with over 300 cm of rain is categorized as region of very heavy rainfall. It comprises the west coast, Assam, Bengal, and the southern part of the Eastern Himalayas. The highest rainfall in India and the world is recognized as Mawsynram village in Meghalaya. The region of heavy rainfall constitutes a location with 200–300 cm of rainfall. The regions such as the middle Ganga Valley, the Western Ghats, the east part of Maharashtra, Madhya Pradesh and Odisha are included in this zone. Region of Moderate rainfall experiences 100 to 200 cm. This includes the upper Ganga valley, East Rajasthan and Punjab, and South of Deccan. The scanty rainfall region receives less than 50 cm of rainfall. The northern parts of Kashmir, the western part of Rajasthan, and the south of Punjab come under this category.

4. Vegetation

The geological factors that regulate the growth of the vegetation in India are the temperature, rainfall, topology and soil. Based on this, natural vegetation can be categorized into six types. This includes Tropical rainforests, Tropical deciduous forests, Shrubs and Thorn forests, Desert vegetation, Mangrove forests, Mountain forests and grasslands. Areas with yearly precipitation over 200 centimeters are habitats to tropical rainforests. The forests are dense and comprised of tall trees. This forest type is mostly seen in the lower slopes of the Himalayas, the Andaman and Nicobar Islands, the western part of the Western Ghats, and certain areas of Assam and Odisha. The tropical deciduous forests are monsoon forests and usually occur in regions with an annual rainfall of between 70 and 200 cm. These forests are located in the northeastern states, on the eastern slopes of the Western Ghats, Jharkhand, West Odisha, Chhattisgarh, and along the foothills of the Himalayan mountains. The majority of shrubs and thorn forests can be found in regions with

prolonged dry seasons and the usual annual rainfall is less than 75 cm. It is mainly found in semi-arid regions of Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Southwestern Punjab, and Western Haryana, the leeward side of Western Ghats, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Desert vegetation is found in the region where the annual rainfall is less than 25 cm. They occurred in Rajasthan, Kutch and Saurashtra, southwestern Punjab and parts of the Deccan. Mangrove forests can be found in coastal regions that are frequently inundated by sea tides. They are abundant on the coastlines of the Andaman Islands and Sundarbans, as well as in the deltas of the Ganga, Mahanadhi, Godavari, Krishna, and Kaveri. Grasslands are regions in which vegetation is dominated by grasses, sedges and rushes. In India, it spans across north India some regions of Gujarat and some regions of the Western Ghats.

Relevance of the study

Leea is a taxonomically difficult genus with similar vegetative and floral characters shown by its members. The information on the taxonomy and floral biology of the genus is very limited. The only significant work on the genus is Ridsdale's (1974, 1976) revision of Leeaceae. Rather than an in-depth field exploration, it relies mostly on herbarium materials especially for the Indian taxa. As a result, variations and habitat preferences of each taxon cannot be determined with certainty. Lawson (1875) reported 15 species in India, of these 10 species occur in South India. C.B. Clarke (1881) in the revision of the genus *Leea* in India reported 29 species under two series. But in the revision of the family Leeaceae, Ridsdale (1974), synonymized most of the species recognized by Clarke, reducing the number of species to eleven. He had identified many species complex, and synonymized most of the names by earlier authors, mainly in the case of widely distributed morpho- species, *L. indica* and *L. guineensis*. Most of the red-flowered taxa are synonymized under *L. guineensis*, whereas greenish-white flowered taxa are placed under *L. indica*. Ridsdale (1974) opined that *L. macrophylla* Roxb. ex Hornem. is a highly polymorphic species with respect to the nature of leaves, consequently, he reduced a number of species published by earlier authors into synonymy of *L. macrophylla* and commended that "In some taxa such as *L.*

macrophylla, it might be possible to identify subspecific taxa, if more information becomes available and the species has been well investigated in the field". Ridsdale himself recommended that a complete field visit and ecological and population study be required for the proper delimitation of these taxonomically difficult taxa. Hence, all these characters need to be studied in detail examining natural populations in the wild and also specimens available in different herbaria. Hence, combined approaches of morphology, anatomy, micromorphology and molecular data would be of much relevance in circumscribing the species and for determining the taxonomic boundary within the complex. Admittedly, Ridsdale's study of Indian species is based solely on herbarium specimens available at Kew. Therefore, it is imperative that the genus should be subjected to a thorough examination based on extensive field studies.

An infrageneric classification of *Leea* was proposed by C.B. Clarke (*l.c.*) based on the flower colour and pinnation of leaves, but it was not accepted by subsequent authors (Ridsdale, 1974; Naithani, 2000) for various reasons. So, currently there is no sectional classification available in this genus. In this scenario, we attempt to examine the usefulness of morphological, molecular, and anatomical data in further classification of the genus *Leea*.

The genus is still having considerable and complex nomenclatural issues due to the lack of comprehensive treatments. Although the genus has undergone a worldwide revision (Ridsdale, 1974), the type designation for all the taxa has not yet been accomplished.

Extensive exploration all over India including Andaman and Nicobar Islands resulted in the discovery of some new taxa in the genus. Besides, the live collections gathered from different regions of the country during the proposed work will certainly form a useful addition to Calicut University Botanical Garden.

Moreover, the inclusion of *Leea* in the family Vitaceae is still a point of contention. The majority of the recent workers not included *Leea* in Vitaceae, instead preferred to keep it under the monogeneric family Leeaceae (Ridsdale, 1974, 1976; Wen, 2007a). But, according to the recent APG system of classification, it

is treated under the subfamily Leeoideae of Vitaceae. In this scenario, a comprehensive study on the genus *Leea* using morphological, molecular, anatomical and palynological data is significant as it contribute in helping to find the position of the genus in the tree of life.

Even though molecular phylogenetic studies on the genus have been conducted in other countries, India has yet to make a similar endeavour. Hence, a detailed study based on live collections using molecular data will be helpful in unravelling the relationships of species within this genus in India, which will also aid in reconstructing the biogeographic history and diversification of the genus across the Old World tropics.

Objectives

1. Extensive exploration all over India to study diversity, to understand habitat requirements and to collect all taxa belonging to the genus *Leea*.
2. Identification of all collected specimens and elucidation of taxonomic and nomenclatural problems in consultations with relevant type specimens and taxonomic literature.
3. To prepare detailed taxonomic descriptions, illustrations, and photomicrographs of each species.
4. Establishment and maintenance of live collection at Calicut University Botanical Garden for further studies and for the preparation of herbarium specimens for future reference.
5. To study the molecular phylogeny of *Leea*.
6. To study the anatomical and epidermal characters of *Leea*.
7. The status of each species will be assessed using IUCN criteria.

Taxonomy

Historical perspective of *Leea*: A brief glimpse

Leea L. is a challenging genus for taxonomists since its species have similar ecological preferences and a resemblance in its vegetative and floral characteristics. The taxonomic status of *Leea* is heavily debated, and species delimitation within it is incredibly difficult.

The history of *Leea* dates back to at least over a century when a specimen of *Leea* was described by Van Rheede (1679) in his botanical treatise *Hortus Malabaricus*. Rheede was the Governor of the Dutch province in Malabar. He published an extensive work on the Flora of the Malabar Coast, which involved numerous local physicians and collaborators. In this treatise, he referred to the present *Leea asiatica* (L.) Ridsdale as 'Nalugu' (2:80, t. 26, 1679). 'Nalugu' was most likely the first *Leea* mentioned before Linnaeus, the founder of modern taxonomy, who published the genus *Leea* in 1767. However, Rumphius (1743) illustration and description of two species, *Frutex aquosus femina* and *Frutex aquosus mas*, in his *Herbarium amboinense* remained uninterpreted for over a period of fifteen decades. It was Merrill (1917) who interpreted both the names as *L. aequata* L. and *L. aculeata* respectively. Meanwhile, Adanson (1763), a French botanist who devised a natural system of classification, established a genus *Nalagu* based upon the plate in Rheede's *Hortus Malabaricus* (H.M. 2. T. 26) in his monumental work *Familles Des Plantes*. These three works constitute the noteworthy pre-Linnaean account on this genus. The genus *Leea* was first proposed by Van Royen, but it was formally published by Linnaeus (1767) and described two species, viz., *L. aequata* and *L. crispa* L. in his most important work *Mantissa Plantarum*. This tropical plant genus was named in honour of James Lee (1717-1795), an accomplished natural historian and proprietor of the Vineyard Nursery at Hammersmith, London. The earliest name, according to the rule of priority, is *Nalagu* Adanson. However, Dandy (1969) submitted a proposal to conserve the name *Leea* over the name *Nalugu*, a name

which has been overlooked since its publication. Hence, the Nomenclature Committee approved the conservation of the name *Leea* for its long and persistent use in taxonomic literature (McVaugh, 1970).

The origin of the family Leeaceae traces back to the Swiss botanist A.P. de Candolle (1824), who made significant contributions to the development of higher plant classification. He split the family Ampelideae into two tribes, Viniferae and 'Leeaceae' in his most important work, *Prodromus Systematis Naturalis Regni Vegetabilis*. Thereafter, Dumortier (1829) recognized Leeaceae as a family in his *Analyse Des Familles Des Plantes*. Actually, he removed the de Candolle tribe "Leeaceae" and established a new family rank with two genera, *Leea* L. and *Lasianthera* P.Beauv. Later on, in 1837, Burmeister treated *Leea* under the subfamily Leeoideae ['Leeaceae'] of the family Ampelideae (Vitaceae).

Since the description of *Leea* by Linnaeus, many species have been described by various authors (Roxburgh, 1824; Blume, 1825; Miquel, 1859, 1863; Kurz, 1873, 1875; Elmer, 1905; Merrill, 1905; Ridsdale, 1974, 1976). Blume (1825), a German-Dutch botanist, reported seven species in his *Flora van Nederlandsch Indie*. Among these, five were newly described species. The entry of Miquel, a Dutch botanist, made significant changes in the concept of the genus. A number of new species were discovered as a result of his exploration to the Malay Archipelago. In 1859, he treated 13 species, with four new species, viz., *L. sundaica* Miq., *L. polyphylla* Miq., *L. sumatrana* Miq. and *L. ancolana* Miq. under the family Leeaceae. Later in 1860, Miquel described three more species, *L. biserrata* Miq., *L. palembanica* Miq. and *L. fuliginosa* Miq. in his *Flora van Nederlandsch Indie*. In 1863, he provided a detailed account of the genus *Leea* in his *Annales Musei Botanici*. In this treatment, he retained *L. sundaica* as a distinct species and reduced his *L. palembanica* into synonymy. Along with this, he altered the rank of his *L. fuliginosa*, *L. biserrata*, *L. polyphylla*, *L. ancolana* and *L. sumatrana* to a variety. In addition, he recognised five more varieties. There were a total of 12 species and 12 varieties that he identified. Subsequently, an elaborate account of species occurring in Burma was given by Kurz (1873). His treatment relies much on the notching pattern of the lobes of the staminal tube (floral disc). This study comprises 14 species with one new variety, and it also provides an elaborate key by taking the characters such as habit of the

plant, pinnation of leaves, flower colour, vestiture of inflorescence, shape and size of bracts, and seed characters.

The first half of the 20th century witnessed more accounts of the genus in floristic works, mainly from the Malay Archipelago. Gagnepain (1910) added two species into the genus and attempted to classify the Asian *Leea*. Merrill (1905, 1915 & 1922) appeared on the scene as a potential contributor to the genus. Based on specimens collected by Ramos and Edano and Ramose and Pascasio from different parts of the Philippines, he published a number of species in *Leea*. With increased botanical exploration, Elmer also added more species from the same country. Burt (1935) published a new species, *L. tetramera* B.L. Burt collected by W.H. Waterhouse from Malaysia. He suggested including this species under a new section characterised by 4-merous flowers. He was a critic of Clarke's classification and considered the primary division of a genus into two sections based on flower colour was not taxonomically reliable.

The genus *Leea* in Madagascar has been intensively studied by Descoings (1959, 1967). Little was known on the diversity of *Leea* in Madagascar until Descoings published new species and infraspecific taxa. In 1959, he described six new forma and one variety of the red-flowered *L. guineensis*. Besides, in 1967, he carried out a detailed study of the family in Madagascar and Comoros, recognising two species and one variety [*L. spinea* Desc., *L. guineensis* & *L. guineensis* var. *cuspidifera* (Baker) Desc.] along with six forma.

In India, a number of authors from various regions have contributed to the taxonomy of this genus. It was Scottish botanist William Roxburgh who treated the genus for the first time in India. He listed six species in his *Hortus Bengalensis* (1814), but all the names were *nomen nudum*. Later, he published a detailed description of each species in his *Flora Indica or Descriptions of Indian Plants* (1824, 1832) and validated the names. This noteworthy work included the treatment of seven species along with the addition of three new species. The 'Wallich Catalogue,' a numerical listing of the dried plant specimens in the East India Company's Museum, was brought together by Wallich (1828–1849). He catalogued 14 species of *Leea*, eight of which were newly described. Later, in 1839, Robert Wight made a coloured illustration of a red flowered *Leea* and named it *Leea*

staphylea Roxb. in his hand-coloured, two-volume work, *Illustrations of Indian Botany*. Later, Ridsdale (1974) noticed that the name was incorrectly used because Roxburgh's *L. staphylea* is a species with greenish-white flowers. As a result, he synonymized *L. staphylea sensu* Wight (*non.* Roxb.) under *L. wightii* C.B. Clarke, which in turn is a synonym of *L. guineensis*.

The First comprehensive treatment on the genus *Leea* in India was made by the British Botanist M.A. Lawson (1875). He critically examined the genus and recorded 15 species, including five new species in the Hooker's *Flora of British India*. He was the first to propose an infrageneric classification of the genus. The classification was solely based on the pinnation of leaves and divided the genus into three sections without assigning any names. Section I consists of a single species having simple leaves. Species having pinnate leaves were placed in section II, and 2-3 pinnate-leaved plants under section III. Section III was again grouped into two, based on the vestiture of leaves, *viz.*, glabrous *vs.* pubescent.

It is difficult to overestimate C.B. Clarke's contribution to Indian *Leea*. In the *Journal of Botany*, Clarke (1881), for the first time carried out the revision of the genus *Leea* in India and listed 29 species, with six new species and one new variety. After Lawson's infrageneric classification in 1875, an elaborative classification of the genus was made by Clarke in this revision. He classified all the species into two series: the red-flowered "Rubriflorae" and the green-flowered "Viridiflorae". Each series was further divided into sections mainly based on the pinnation of leaves, the nature of primary nerves, and habit. He has never felt entirely satisfied with Lawson's classification since it was primarily based on the pinnation of leaves.

There were many large and small publications on the genus in Peninsular India. Gamble's contribution to South Indian plants cannot be neglected. In his classic work, the *Flora of the Presidency of Madras*, Gamble (1918) listed eleven species of *Leea* under Vitaceae. While preparing the *Flora of Bombay Presidency and Sind*, Talbot (1909) enumerated seven species, with one new species, *L. talbotii* King ex Talbot. Later, Amrutha and Pradeep (2023) recently found this species as conspecific with *L. setuligera* and reduced it into the synonymy.

The foundation of the genus comes mainly, however, from the work of Ridsdale. In 1974, C.E. Ridsdale a botanist, who worked at the Royal Botanical

Garden, Kew, published his magnificent revision on the genus *Leea*. He synonymised many taxa, and the number of species was reduced to 34 and also provided a diagnostic key, description, distribution, and notes for each species. It can be considered as the only elaborate work on the genus *Leea* during the last five decades. Furthermore, this study did not follow any of the previously proposed infrageneric classifications since he believed that the groups recognized were not natural. Moreover, he recognised that *L. indica* and *L. guineensis* were two complex species and synonymized most of the species of the earlier workers under these names. He also considered *L. macrophylla* to be a highly polymorphic species in terms of leaf nature but admitted a scope for recognizing subspecific taxa after extensive field studies. The identification and delimitation of the species are still based on this worldwide revision of the genus *Leea* (1974), as well as a revision of the Malayan *Leea* in 1976. Soon after his revision, in 1980, he realised that the plate of Rheede's '*Nalugu*' (1679) was the basis for the Linnaean name *Phytolacca asiatica* published in 1753. As a result, Ridsdale (1980) came up with a new combination, *L. asiatica* (L.) Ridsdale. As well, he found that the Linnaean name, *L. crispa* described in 1767 was conspecific with *L. asiatica*, which was therefore reduced to a synonym, since *L. asiatica* has priority over *L. crispa*.

Only scattered publications are there after Ridsdale. Mathew and Umadevi (1992), Kumar (2000), Naithani (2000), Wen (2007a), Lok *et al.* (2011) and Dapar (2020) contributed to the taxonomy of *Leea*. Mathew and Umadevi (1992) reinstated *L. robusta* Roxb. from the synonymy of *L. macrophylla*. Additionally, they reduced *L. venkobarrowii* Gamble, into the synonymy of *L. robusta*. Soon after, Li (1996) described a new species, *Leea glabra*, from China. Later, during an exploration in search of endemic plants of the North Andaman Islands, Kumar (2000) published a new spiny species, *L. adwivedica* characterized by spiny stem, glabrous petiole and lamina, and pubescent calyx and corolla. In the same year, by accepting the broad concept of Ridsdale, Naithani (2000) treated the genus in the *Flora of India* and enumerated 11 species. He accepted treating *L. macrophylla* in a broad sense (*s.l.*) and did not consider *L. robusta* as an accepted name. In 2007, in the *Flora of China*, Chen and Wen studied the family Leeaceae and recognised 10 species. In this treatment, they reinstated the name *L. longifolia* Merr., a name synonymized by

Ridsdale under *L. indica*. Wen (2007a) in Kubitzky, *The Families and Genera of Vascular Plants*, dealt with the family Leeaceae. According to her, Leeaceae and Vitaceae are two closely related families. The genus *Leea* in Singapore was studied by Lok *et al.* in 2011. Dapar (2020) gave a note on the species *L. manillensis* Walp., a name Ridsdale synonymized under *L. guineensis*. Besides these, he has transferred 16 synonyms of *L. guineensis* to *L. manillensis*.

Regional floristic studies: An overview

Aside from the classic publications on *Leea* mentioned above, many authors have included the genus in regional or state floras, which can aid in determining the distribution and phenology of each species. Table 1 below includes a list of some of the noteworthy contributions on the taxonomy of the genus in India.

Table 1. List of Indian Flora's dealt with *Leea*

Name of the work	Authors	<i>Leea</i> species dealt	Year of publication
<i>The Bombay Flora, or, short descriptions of all the indigenous plants hitherto discovered in or near the Bombay Presidency together with a supplement of introduced and naturalised species</i>	Nicholas A. Dalzell & Alexander Gibson	2	1861
<i>Hand-book of Indian Flora; being a guide to all the flowering plants hitherto described as indigenous to the continent of India</i>	Colonel Heber Drury	6	1864
<i>Bengal plants: A list of the phanerogams, ferns and fern-allies indigenous to, or commonly cultivated in, the Lower provinces and Chittagong, with definitions of the natural orders and genera, and keys to the genera and species</i>	David Prain	9	1903
<i>Flora of the upper Gangetic plain, and of the adjacent Siwalik and Sub-Himalayan tracts</i>	J.F. Duthie	5	1903
<i>The Flora of the Presidency of Bombay</i>	Theodore Cooke	8	1903
<i>Indian trees: an account of trees, shrubs, woody climbers, bamboos, and palms indigenous or commonly</i>	Dietrich Brandis	13	1906

<i>cultivated in the British Indian empire</i>			
<i>A forest Flora of Chota Nagpur including Gangpur and the Santal-Parganahs</i>	H.H. Haines	7	1910
<i>A forest Flora of Andaman Islands</i>	C.E. Parkinson	4	1923
<i>Botany of Bihar and Orissa</i>	H.H. Haines	8	1925
<i>Flora of Assam</i>	U.N. Kanjilal & A. Das	12	1936
<i>Flora of Khandala</i>	H. Santapau	4	1967
<i>The Flora of Eastern Himalaya</i>	H. Hara	6	1966
<i>Flora of Tripura state</i>	D.B. Deb	7	1981
<i>Flora of Banswara Rajasthan</i>	V. Singh	2	1983
<i>Flora of Bilaspur District</i>	G. Panigrahi & S.K. Murti	3	1984
<i>Flora of Murshidabad district, West Bengal, India</i>	D.N. Guha Bakshi	1	1984
<i>Flora of Himachal Pradesh</i>	H.J. Chowdhery & M. Wadhwa	1	1984
<i>Flora of Pachmarhi & Bori reserves</i>	A.K. Mukherjee	2	1984
<i>Flora of Karnataka Analysis</i>	B.D. Sharma, N.P. Singh, R.S. Raghavan & U.R. Deshpande	7	1984
<i>Forest Flora of Meghalaya</i>	K. Haridasan & R.R. Rao	6	1985
<i>Flora of Goa, Diu, Daman, Dadra and Nagarhaveli</i>	R.S. Rao		1985
<i>Flora of Courtallum</i>	K.K.N. Nair & M.P. Nair	1	1987
<i>Flora of Rajasthan</i>	B.V. Shetty & V. Singh	2	1987
<i>Flora of Silent Valley</i>	K.S. Manilal	2	1988
<i>Flora of Cannanore</i>	V.S. Ramachandran & V.J. Nair	3	1988
<i>Flora of Sindhudurg</i>	B.G. Kulkarni		1988
<i>Flora of Akola District, Maharashtra</i>	S.Y. Kamble & S.G. Pradhan	1	1988
<i>Flora of Saurashtra</i>	P.V. Bole & J.M. Pathak	1	1988
<i>Flora of Eastern Karnataka</i>	N.P. Singh	1	1988
<i>Flora of Palghat District</i>	E. Vajravelu	2	1990
<i>Flora of Savantwadi, Maharashtra, India</i>	S.M. Almeida	5	1990
<i>Flora of Nallamalais</i>	J.L. Ellis	3	1990
<i>Flora of Nasik District</i>	P. Lakshminarasimhan & B.D. Sharma	2	1991
<i>An Excursion Flora of central Tamil Nadu, India</i>	K.M. Matthew	1	1991
<i>Flora of Yavatmal District</i>	S. Karthikeyan &	2	1993

	Anand Kumar		
<i>Flora of Raigad District</i>	M.J. Kothari & S. Moorthy	4	1993
<i>Flora of Madhya Pradesh</i>	K.K. Khanna D.M. Verma, N.P. Balakrishnan & R.D. Dixit	5	1993
<i>Flora of Bankura District</i>	M.N. Sanyal	1	1994
<i>Flora of Thiruvananthapuram, Kerala</i>	M. Mohanan & A.N. Henry	1	1994
<i>Flora of Orissa</i>	H.O. Saxena & Brahmam	5	1994
<i>Flora of Mahabaleshwar and adjoining, Maharashtra</i>	S.D. Deshpande, B.D. Sharma & M.P. Nayar	2	1995
<i>Flora of Jabalpur</i>	M. Oommachan & J.L. Shrivastava	1	1996
<i>A contribution to the Flora of Namdapha, Arunachal Pradesh</i>	A.S. Chauhan	5	1996
<i>Materials for the Flora of Arunachal Pradesh</i>	P.K. Hajra, D.M. Verma & G.S. Giri	6	1996
<i>Flora of Nilambur</i>	V.V. Sivarajan & Philip Mathew	6	1996
<i>Flora of Trombay</i>	V. Abraham	2	1997
<i>Flora of West Bengal</i>	R.N. Banerjee	7	1997
<i>Flora of Great Nicobar Island</i>	B.K. Sinha	3	1999
<i>Flora of Andaman & Nicobar Islands</i>	P.K. Hajra, P.S.N. Rao & V. Mudgal	7	1999
<i>Flora of Maharashtra state</i>	S. Moorthy N.P. Singh & S. Karthikeyan	8	2000
<i>Flora of Manipur</i>	Singh, N.P., A.S. Chauhan & M.S. Mondal	6	2000
<i>Flora of Hazaribagh District</i>	N.D. Paria & S.P. Chattopadhyay		2000
<i>Supplement to the Flora of Madhya Pradesh</i>	K.K. Khanna, A. Kumar, R.D. Dixit & N.P. Singh	1	2001
<i>Flora of Palamau District</i>	T.K. Sarma & A.K. Sarkar		2002
<i>Flora of Jammu & Kashmir</i>	R. Mathur		2002
<i>Flora of Kolhapur District</i>	S.R. Yadav & M.M. Sardesai	5	2002
<i>Flora of Mizoram</i>	N.P. Singh, , K.P. Singh & D.K. Singh	6	2002
<i>Flora of Agasthyamala</i>	N. Mohanan & N. Sivadasan	1	2002

<i>Biodiversity Documentation of Kerala Part 6: Flowering Plants</i>	N. Sasidharan	6	2004
<i>Flora of Kerala</i>	W. Arisdason , K.M. Reema & P. Daniel	5	2005
<i>Flora of Sanjay Gandhi National Park</i>	S.G. Pradhan & B.D. Sharma	4	2005
<i>Flora of Pathanamthitta (Western Ghats, Kerala, India)</i>	N. Anil Kumar, M. Sivadasan & N. Ravi	2	2005
<i>Flora of Chamba District (Himachal Pradesh)</i>	H. Singh & M. Sharma	1	2006
<i>Flora of Alappuzha District</i>	C.N. Sunil & M. Sivadasan	2	2009
<i>Flora of Anshi National Park, Western Ghat- Karnataka</i>	Sachin A. Punekar & P. Lakshminarasimhan	2	2011
<i>Flora of Rajiv Gandhi National Park</i>	R. Manikandan & P. Lakshminarasimhan	1	2013
<i>Flora of Sri Venkateswara National Park, Andhra Pradesh</i>	J.H.F. Benjamin & G.V.S. Murthy	1	2013
<i>Flora of Lower Subansiri District, Arunachal Pradesh (India)</i>	G.D. Pal	5	2013
<i>Flora of South Kanara</i>	K.G. Bhat	3	2014
<i>Flora of Uttar Pradesh</i>	B.K. Shukla	5	2016
<i>Flora of Kurung Kumey District, Arunachal Pradesh</i>	S.S. Dash & P. Singh	4	2017
<i>Flora of Campbell Bay National Park, Great Nicobar, India</i>	J. Jayanthi	3	2017
<i>Angiosperm diversity of Mahatma Gandhi Marine National Park, South Andaman, India</i>	K. Karthigeyan	3	2017
<i>Flora of Uttarakhand</i>	P.K. Pusalkar & S.K. Srivastava	5	2018
<i>Flora of Central & North Tamil Nadu</i>	S. John Britto	1	2019
<i>Flora of North Andaman Islands</i>	M.Y. Kamble	2	2020
<i>Flora of Udaipur Wildlife Sanctuary, West Champaran, Bihar, India</i>	O.N. Mourya, A. Kumar & S. Sachan	1	2021
<i>Flora of Little Andaman Island, India</i>	L. Rasingam & P.G. Divakar	3	2021

Anatomy

The anatomical structure is most likely to provide evidence concerning the interrelationship of larger groups, such as families, or help to establish the real affinities of genera of uncertain taxonomic status (Metcalf & Chalk, 1957). Applications of anatomical characters in plant classification date back to the Bureau

(1864), which for the first time used them for the delimitation of the taxa at various levels within the family Bignoniaceae (Sivarajan, 1991). Anatomical features of the vegetative and floral parts of plants have been effectively used to solve taxonomic problems and deduce evolutionary relationships. Most of the anatomical studies in *Leea* were done by Najmaddin *et al.* (2011a&b, 2013, & 2014). They used anatomical data to compare the species of *Leea* with other members of Vitaceae to assess the anatomical differences for the delimitation of these closely related families.

Adkinson (1913) carried out a comparative wood anatomy of *Leea* and other climbing members of the Vitaceae. His findings show that erect members like *Leea* retain a more primitive character than the climbing members. In the wood of *Leea*, numerous broad rays separate narrow fibrovascular bundles. Vessels in *Leea* are smaller compared to climbing members where the vessels are larger, a special adaptation to the climbing habit. After carrying out a careful investigation, he concluded that the living representatives of the family were most primitive in the genus *Leea*.

Metcalf and Chalk (1957) found out that raphides and mucilage cells were one of the characteristic features of this family, and druses were generally large in *Leea*, and often it appeared as dots. Watari (1951), Wen (2007b), and Prakash and Dayal (1963) reported the occurrence of raphides in the woods of some species of *Leea*. The author also conducted a detailed anatomy of wood and found that vessels were smaller in *Leea* than in the climbing members of Vitaceae, as opined by Adkinson. An extensive study of the pearl glands showed that its interior consists of large polygonal cells, surrounded by an epidermis perforated by a stoma, as reported by Solereder (1908). The relationship of the wood of *Leea* with Dilleneaceae was suggested by Hess (1936).

A group of researchers (Najmaddin *et al.*, 2011a&b, 2013, 2014) from Malaysia had undertaken comparative anatomical studies on *Leea* and other members of Vitaceae. Najmaddin *et al.* (2011a) carried out a comparative study on the anatomy of stem and leaf of *L. indica* with *Cayratia mollissima* (Wall.) Gagnep. and *Pterisanthes caudigera* (Griff.) Planch. They placed *Leea* in its own family, the

Leeaceae, and used anatomical and morphological evidence to differentiate it from Vitaceae. Their analysis revealed that there were differences between the species in terms of the outline in c.s. of the stem, the leaf margin, the midrib, and the petiole. The authors had noticed the presence of druses in the leaves and stems of all the species of *Leea*, while raphides were present in the lamina. They also observed that *L. indica* does not contain trichomes or starch grains. Najmaddin *et al.* (2011b) compared *L. aequata* with *Cissus repens* Thwaites and *Cayratia japonica* (Thunb.) Gagnep. The result confirms the earlier reports of differences in the shape of the stem, petiole, midrib, and lamina margin. Furthermore, they noticed that, as mentioned by Adkinson (1913), Metcalfe and Chalk (1957), and Wen (2007b), the vessels in Leeaceae were smaller than those in Vitaceae. Druses and raphide crystals can be seen in the lamina of all the three species. The epidermal cells were reported to be polygonal, and the anticlinal walls were described as being straight and arched. The authors (Najmaddin *et al.*, 2013) further compared the anatomy of four species of Vitaceae and two species of Leeaceae (*L. indica* & *L. rubra* Blume). The result was in corroboration with the earlier findings. Najmaddin (2014) further investigated the anatomy and palynology of the Vitaceae and Leeaceae by comparing three species, namely *Cissus quadrangularis* L., *Cayratia geniculata* (Blume) Gagnep., and the spiny species *L. angulata*. It was noted that *L. angulata* has an anomocytic type of stomata.

Cytology

Cytological data is considered more relevant than other taxonomic evidence. Chromosome cytology has been an important element in determining relationships and inferring phylogeny of angiosperms (Raven, 1975).

Shetty and Raman (1960) were the pioneers in contributing information about the chromosome number of the genus *Leea*. They reported the chromosome number of four species of the *Leea* for the first time and also disclosed the polyploidy in this genus. The somatic chromosome number of *Leea edgeworthii* Santapau was 48, while the diploid number in the other three species, *L. indica*, *L. robusta*, and *L. macrophylla* were 24. Here, the authors concur with Shetty (1959) that

polyploidy has played a significant role in the speciation of Vitaceae. Subsequently, Vatsala (1960) examined the chromosomes in Ampelideae and revealed that the diploid chromosome number of *Leea sambucina* Willd. (= *L. indica*) is 22, a deviation from earlier workers. Later, in 1980, Patil *et al.* carried out an investigation on chromosome number in the family Vitaceae. They included five species of *Leea*, among these, the chromosome numbers of two taxa were first reported. Karkamkar *et al.* (2010) performed cytological studies of Vitaceae, including 16 species of *Leea*, and indicated that the diploid chromosome number is $2n = 24$ and 48. She also noted tetraploidy in four species and opined that, with respect of chromosome number, *Leea* show a close affinity with the genus *Cissus* L.

As part of the collection of chromosome numbers of tropical species, Mangenot and Mangenot (1962) reported that the diploid chromosome number of *L. guineensis* is 24. Subsequently, Raven (1975) presented a broad assessment of chromosome numbers in the angiosperms according to the phylogenetic system of Cronquist. In this work, he reported that the basic chromosome number of the monogeneric family Leeaceae is 12, with one report of $n = 11$, and one of $n = 10$. By cytological evidence, he had suggested the inclusion of the family Leeaceae into Thorne's Santaliflorae.

Developmental biology/ Embryology

It is usually recognised that floral characteristics have been most frequently used in the classification of angiosperms. It is frequently required to explore the development of an organism, organ, or character in order to ensure its accurate interpretation and ultimately its complete application in taxonomy (Stace, 1989).

Seed development with reference to rumination of endosperm in Vitaceae was studied by Periasamy (1962). They assert that compared to the other Vitaceae members, *Leea* seeds exhibit the greatest perichalazal growth. The similarities between *Leea* and Annonaceae in terms of ruminations in the endosperm and perichalazal development also led him to conclude that this was a primitive genus in the family.

The floral morphology and embryology of *L. sambucina* (= *L. indica*) were studied by Nair and Nambisan (1957). Subsequently, Nair (1968) examined the floral morphology and embryology of two other species of *Leea*, viz., *L. robusta* and *L. edgeworthii*. Their result showed that the sepals of these species receive a single trace, but the traces of petals and stamens were conjoint. They also reported the occurrence of false septa and showed that due to this, the ovary appears as six locular with anatropous, bitegmic, and crassinucellate ovules. They also found the occurrence of ruminant endosperm in *Leea*. Besides, they checked the affinity of *Leea* with Vitaceae, Sapotaceae, Meliaceae, and Sterculiaceae since there have been reports on the affinity of *Leea* with these families. The result revealed that *Leea* showed close relationships with Vitaceae and no relationships with Meliaceae and Sapotaceae. The genus is probably related to Sterculiaceae. Nair also suggested treating *Leea* in a separate family, Leeaceae.

A group of researchers, including Gerrath *et al.* (1990), Lacroix (1990), and Wilson *et al.* (2006) from Canada presented meticulous studies of the morphological and developmental anatomy of several species of Vitaceae. The floral development of *L. guineensis* was thoroughly studied by Gerrath *et al.* (1990), and the results were compared with those of Vitaceae s.s. Initiation of the gynoecium, development of the petal-stamen primordia, and initiation of the sepals were consistent in these two families. However, the number of septa in the ovary differs between the two; three septa were initiated in the Leeaceae, whereas two in Vitaceae. The authors also reported the occurrence of secondary septa in Leeaceae which previous authors (Nair & Nambisan, 1957; Nair, 1968) identified as false septa. Other major findings of their work include the origin of the floral disc, which was previously identified as a staminodial tube. According to them, the origin of this structure in both families was identical, from the base of the gynoecial wall, alternately with the stamens. But in Leeaceae, this structure continues its development to become much more elaborate. Gerrath *et al.* (1990) concluded that the floral development of *L. guineensis* and some members of the Vitaceae were similar and the mature flowers show differences due to the variation in timing and degree of development. The presence of laterally connivent anthers, secondary septa in the ovary and the

elaboration of the floral disc of *L. guineensis* is a derived character not shared with Vitaceae. Hence, according to the authors, these two can be considered closely related families.

Using SEM analysis, the early ontogeny of the compound leaves and stipules was studied by Lacroix *et al.* (1990). As per their result, the majority of the shoot apical meristem is taken by the leaf primordium during initiation. At the base of the leaf primordium, continuous meristematic areas that were subsequently identified as stipules, develop and surround the apical meristem. Besides, he discovered that lateral traces that supply the leaf were the source of the vascular supply to the stipules.

Gerrath and Lacroix (1997) investigated the heteroblastic sequence and leaf formation in *L. guineensis*. The authors found that the development of the leaves that were started at subsequent nodes gets progressively more complicated. Simple forms of leaves were seen at the first four nodes, followed by compound forms at subsequent nodes. The most typical progression of leaf morphologies is simple, trifoliolate to pinnate, bipinnate, and tripinnate. Simple leaves in the succession had a very distinct developmental morphology from compound leaves. The primordia of simple leaves often have a central concave shape and a distinctive folded appearance, but those of compound leaves have three distinct types of breaches and were structurally more complex. In addition, they added intricacy to the leaves, which can be seen as a reiteration of the basic element.

Primary vascular architecture in Vitaceae was studied by Gerrath *et al.* (2001). Vitaceous shoots were classified into five patterns, *viz.*, pattern 1, with spiral phyllotaxy and terminal inflorescences; pattern 2, with tendrils at two of three nodes and having axillary buds restricted to the leaf axil of the leaf at the tendril less node; pattern 3, with tendrils at two of three nodes and axillary buds present at the tendril less node and the upper tendril node; pattern 4, tendrils at two of the three nodes and having axillary buds present at each node and; and pattern 5, with axillary buds and tendrils present at each node. Later, Wilson *et al.* (2006), a team from the same laboratory, examined the vegetative and floral

development of *Cyphostemma* Planch. and found that pattern 1 is the basal and it is the only pattern found in Leeaceae. Furthermore, they reported that shoot apical meristem is more noticeable in *C. juttae* (Dinter & Gilg) Desc. and *C. mappia* (Lam.) Galet and does not exhibit fluctuation in size as in the case of *L. guineensis*. Eventually, Gerrath and Posluszny (2007) evaluated the relationship between the distinctive shoot architecture pattern in Vitaceae and the usual monopodial and sympodial growth. According to their results, species exhibiting the pattern 1 model showed sympodial growth, pattern 2, 3, and 4 showed monopodial growth, and pattern 5 showed either monopodial or sympodial growth depending on the species. They also reported that pattern 1 model corresponds to Chamberlain's architectural model of Halle' *et al.* (1978).

Ickert-Bond *et al.* (2014) executed a study of the gynoecial structure of the order Vitales, and their findings were interpreted in the context of evolutionary comparisons of placentation types across all angiosperms. Their findings demonstrated that the syncarpous ovary was bicarpellate in the Vitaceae and tricarpetate in the Leeaceae. The synascidate zone is formed by the congenital fusion of carpels. The gynoecium of Leeaceae considerably varies from that of Vitaceae in that it contains secondary septa and an incompletely trilocular ovary. The ancestral character reconstruction using ML across 640 angiosperm taxa revealed that marginal placentation is the ancestral condition, but that of the Super Rosid is axile, with basal placentation presumed to be evolved inside the clade.

An investigation was conducted by Gerrath *et al.* (2017) to look at the morphology and development of inflorescences in the basal Rosid lineage, Vitales. They discovered that the terminal inflorescence of *Leea* sometimes seemed to be leaf-opposed due to the continued shoot growth of the axillary bud at a node below. Among Angiosperms, this type of inflorescence pattern is common. In *Leea*, the inflorescence type is consistently thyrsoid with raceme branching on the central axis, succeeded by cymose branching and resulting in a sequence of dichasia. They came to the conclusion that the origin of the inflorescence and tendril in Vitaceae s.s. were unique features, but there is no distinctiveness in the growth of inflorescence in Leeaceae.

Floral biology

The floral biology of *Leea* has only been the subject of a few studies. Ridsdale (1976) noted that greenish-white flowered species were visited by short-tongued bees and sylphids. According to him, since there is no disc, either honey was created by the receptacular tissue or insects were attracted by the conspicuous glandular tissue on the connective.

Another notable contribution came from Molina (2009), who conducted a study on the floral biology of three morphospecies in their natural habitat in the Philippine forests. Her research revealed that the two morphospecies of the white-flowered *L. indica* may be more prone to geitonogamous selfing than the red-flowered morphospecies *L. guineensis*, which limits selfing through synchronised dichogamy, in which male and female flowers were temporally separated in the same inflorescence. She observed the presence of wasps, butterflies, beetles, bugs, and spiders in *Leea*, in addition to bees and flies. She also observed that *L. guineensis* got more than twice as many visits as either type of *L. indica*.

According to Lok *et al.* (2011), ants, bees, wasps, and a variety of butterflies, such as *Eurema hecabe contubernalis*, *Eurema simulatrix tecmessa*, and *Ilambrix salsala salsala*, commonly visit the blooms. He also pointed out that, primarily Bulbul, were responsible for the fruit and seed dispersion in *L. indica*.

Shahida and Pradeep (2020) made some preliminary observations on the pollination biology of *L. indica*. The key features of this species include dichogamy, a short flower life span, and in the arrangement of sex organs. They also noted the proterandrous conditions in *Leea* that had already been reported by Gerrath *et al.* (1990). Their studies revealed the presence of seven species of bees, fifteen species of butterflies, five fly species, five beetle species, six ant species, five wasp species, spiders, and millipedes as flower visitors. They also believed that characteristics such as dichogamy and protandry made this plant an excellent model for studying plant-pollinator interaction and evolution.

Molecular Phylogeny

In addition to being used to recreate the development of life on Earth, phylogenetic inferences also give evidence of climatic and geological changes. The last 15 years have seen a fairly constant progression in phylogenetic studies on the Vitaceae, which has given important insights into the generic delimitations, generic and infra-familial classifications, and biogeographic diversification of the family (Wen *et al.*, 2018). A significant addition to the evolutionary research of the Vitaceae has been made by various authors (Rossetto *et al.*, 2001, 2002, 2007; Ingrouille *et al.*, 2002; Soejima & Wen, 2006; Ren *et al.*, 2011; Trias-Blasi *et al.*, 2012; Molina *et al.*, 2013; Wen *et al.*, 2013; Zhang *et al.*, 2016).

Ingrouille *et al.* (2002) performed a phylogenetic analysis of the plastid *rbcl* DNA sequence for 20 species of Vitaceae including *Leea*. Their primary findings include, Leeaceae were sister to Vitaceae s.s., as well as the fact that *Ampelopsis* Michx., *Rhoicissus* Planch., *Clematicissus* Planch., *Cissus*, and *Ampelocissus* form a set of sister clades to other Vitaceae that progressively branch out from one another. *Cayratia* Juss. ex Guill., *Tetrastigma* Planch., *Parthenocissus* Planch., *Cyphostemma*, and *Vitis* all form a clade in the shortest trees, and *Ampelopsis* is paraphyletic to all other species of Vitaceae. Additionally, they compared the phylogenetic tree with the pattern of floral and vegetative morphology and ontogeny within the family. There is a strong correlation with hypothesised floral and vegetative ontogenetic patterns, with *Leea* and *Ampelopsis* ancestral, *Cissus* and *Ampelocissus* intermediate, and *Vitis* most derived.

Later, Soejima and Wen (2006) performed a substantial phylogenetic study that was embraced by a majority of the subsequent authors (Wen *et al.*, 2007; Ren *et al.*, 2011 *etc.*). Using the three chloroplast markers (*trnL-F* spacer, *atpB-rbcL* spacer, and the *rps16* intron) and adopting members of the Leeaceae, Rhamnaceae, and Dilleneaceae as the outgroups, they performed a phylogenetic analysis of 12 genera and 79 species of Vitaceae. The combined phylogenetic data supports three major clades: (1) the *Ampelopsis-Rhoicissus-Parthenocissus-Vitis-Nothocissus-Pterisanthes-Ampelocissus* clade; (2) the core *Cissus* clade (except the South American *Cissus*

striata complex); and (3) the *Cayratia-Tetrastigma-Cyphostemma* clade. Their findings also demonstrate the sister relationship of *Leea* with Vitaceae.

In continuation with this, Wen *et al.* (2007) conducted a phylogenetic study of 105 nuclear Vitaceae *GAI1* sequences. The *GAI1* data provided significant support for the three major clades that Soejima and Wen (2006) had previously identified.

The phylogeny of the Australian Vitaceae was constructed by Rossetto *et al.* (2007) using nuclear internal transcribed spacer and plastid *trnL-F* sequences. Their findings supported the paraphyly of *Cayratia* and indicated a strong sister relationship between *Clematicissus* and a clade of two South American *Cissus*, *Cissus tweediana* Planch. and *Cissus striata* Ruiz & Pav.

Ren *et al.* (2011) reconstructed the phylogeny of Vitaceae by sampling 114 accessions of Vitaceae using three noncoding plastid markers: *trnC-petN*, *trnH-psbA*, and *trnL-F*. Six taxa of *Leea* were selected as the outgroup. *Ampelocissus*, *Vitis*, *Nothocissus* (Miq.) Latiff, *Pterisanthes* Blume, *Parthenocissus*, and *Yua* C.C.Li were among the six 5-merous taxa that form a well-supported clade. A clade that includes *Ampelopsis*, *Rhoicissus*, and the *Cissus striata* complex is formed as a sister clade to all the other taxa in the Vitaceae. It has been determined that the *Cayratia-Tetrastigma-Cyphostemma* clade, which includes species with 4-merous flowers, is sister to the core *Cissus* clade. The phylogenetic tree showed that species of *Leea* were grouped into a single clade, showing the monophyly of this genus.

Using parsimony and Bayesian analyses of four plastid DNA sequence regions (*trnL* intron, *trnL-trnF* spacer, *atpB-rbcL* spacer, and *rps16* intron), Trias-Blasi *et al.* (2012) examined the phylogenetic relationships of 34 species from 11 genera of Vitaceae. They selected the species of *Dillenia* L. and *Leea* as outgroups. Vitaceae was monophyletic, and the clade *Cayratia-Cyphostemma-Tetrastigma*, *Ampelopsis-Cissus striata-Rhoicissus*, and *Nothocissus-Pterisanthes* were among the best-supported at the infrafamilial level. As per their findings, *Cyphostemma*, *Tetrastigma*, and *Vitis* were monophyletic, while *Ampelopsis*, *Cayratia* were paraphyletic and *Cissus* was polyphyletic. Further evidence from the ancestral

character reconstruction demonstrates that hermaphroditic sexuality, leaf opposite inflorescence, and 5-numerous flowers were ancestral character states in the family.

Only significant work on the phylogeny of *Leea* was done by Molina *et al.* (2013). They reconstructed the phylogenetic tree of *Leea* with Parsimony and Bayesian methods using nuclear ribosomal sequences to assess species circumscription, morphological evolution, and biogeography. They sampled ninety accessions from twenty-two *Leea* species and used 5 species from Dilleniaceae and one from Saxifragaceae as outgroups. Their studies showed that *Leea* is monophyletic with four major clades in both parsimony and Bayesian tree. However, the topology differs in major clades. In parsimony analysis, clade II is recovered as a sister to clade III, whereas it is shown as part of a trichotomy with clade III and clade IV in Bayesian analysis. Morphological character analysis showed that clade one is the earliest diverging clade, having plesiomorphic free stamens. Prickle-bearing species were included in clade II, which is sister to clade III, which includes species with comparatively larger flowers. Clade IV is sister to Clade II and III and was resolved into four subclades. The dating analysis was also performed and showed that the ancestor of vitals originated during the early Cretaceous period. *Leea* originated in Indochina in the Late Cretaceous (65-86.19 Mya). The species were later distributed to India, Africa, Madagascar, South-East (SE) Asia and tropical Australia. Major species diversification occurred in the Neogene period.

The diversity and evolution of Vitaceae in the Philippines were studied by Wen *et al.* (2013). This study enumerates the taxonomy of Vitaceae and evaluates the assembly of taxa of Vitaceae in the Philippines using five chloroplast DNA markers. The authors chose seven different species of *Leea* to represent an outgroup since they believe Vitaceae and Leeaceae to be two distinct families. Up on the evaluation of the phylogenetic tree, it is clear that *Leea* is monophyletic and sister to the rest of the members of Vitaceae.

Cabelin *et al.* (2015) tested the DNA barcoding efficiency of cpDNA barcodes in selected species of *Leea*. They observed that though some species of *Leea*

are economically important and due to their overlapping vegetative characters, there is a chance for adulteration and misidentification. So, the use of nucleic acid analysis has provided more dependable techniques for revealing plant-based adulterants. In their study, four cpDNA barcodes, namely *matK*, *rbcL*, *trnH-psbA*, and *trnL-F*, were tested for their efficiency as a single locus barcode. Their result showed that compared with other barcodes examined, *matK* provided to be most universal, having the best discriminatory and authentication power.

Recently, Wen *et al.* (2018) suggested a new tribal classification of the Vitaceae based on phylogenetic and morphological characteristics. In accordance with the five main clades discovered during the phylogenetic analysis of the family, they divided Vitaceae into five tribes: Ampelopsideae J.Wen & Z.L.Nie, Cisseae Rchb., Cayratieae J.Wen & L.M.Lu, Parthenocisseae J.Wen & Z.D. Chen, and Viteae Dumort. She also summarised that the phylogenetic and phylogenomic analyses of sequence data from all three genomes have so far supported five major clades within Vitaceae: (i) the clade of *Ampelopsis*, *Nekemias*, the African *Rhoicissus*, and *Clematicissus*; (ii) the *Cissus* clade; (iii) the clade of *Cayratia*, *Cyphostemma*, *Tetrastigma*, *Causonis*, *Pseudocayratia*, and the "Afrocayratia" clade; (iv) the clade of *Parthenocissus* and *Yua*; and (v) the grape genus *Vitis* and its close tropical relatives *Ampelocissus*, *Pterisanthes*, and *Nothocissus* (Miq.) Latiff, with *Nothocissus* and *Pterisanthes* nested within *Ampelocissus*.

Recent phylogenomic analyses of 417 nuclear genes from transcriptome data by Wen *et al.* (2013) and chloroplast and mitochondrial phylogenomic data (Zhang *et al.*, 2016) have helped to unravel the deep phylogeny of the grape family.

Phytochemistry

Leea has been employed in traditional medicine since a long. Plant-based systems continue to be crucial to healthcare. A reference to the use of this plant in India can be traced back to *Hortus Malabaricus* (Rheede, 1690). Many species of *Leea* were known to be traditionally used to cure a variety of illnesses, and many of them contain a number of bioactive compounds that may have significant

pharmacological properties. Considerable work has been carried out to unravel the phytochemical constituents of *Leea* species by various authors.

1.1. Traditional medicine

The leaves of *L. guineensis* were used to cure toothache, rheumatism, skin ulcers, vertigo, epileptic fits, and paralysis (Burkill, 1985; Irvine, 1961; Mshana *et al.*, 2000; Eric *et al.*, 2011). Besides, the roots and seeds were used as a purgative (Irvine, 1961; Eric *et al.*, 2011). Choudhary *et al.* (2008) found that *L. macrophylla* is used in the treatment of cancer, dysentery, body aches, and sexual debility. It was Rajith and Ramachandran (2010) who reported the use of crushed leaves and roots of *L. indica* in the treatment of intestinal problems. According to Shanmugam *et al.* (2011), *L. indica* root extract is used in Tamil Nadu to treat dysentery. Mohammad *et al.* (2012) stated that *L. indica* is used for the treatment of diabetes by the Kensiu Tribe of Malaysia. Bais (2013) found that the leaves and roots of *L. indica* were used to treat diabetes, cardiac diseases, and various other ailments such as fever, headache, dizziness, soreness, eczema, sprain, leprosy, bone fracture, body pain, muscle spasm, diarrhoea, and dysentery.

According to Kadchumsang *et al.* (2014), the stem and root of *L. rubra* have been utilised in traditional Lanna medicine for Mahoog. Bose *et al.* (2015) stated that the root paste of *L. indica* is used to treat bone fractures among tribal people of the Jalpaiguri district of West Bengal, India. Deepa *et al.* (2017) noted that the root of *L. indica* is used in diarrhoea, dysentery, hyperdipsia, ulcers and skin diseases. According to Kekuda *et al.* (2018), *L. indica* is used to treat ailments such as fever, bone fracture, diarrhoea, dysentery, body aches, headaches, malaria, rheumatism, asthma, and gastric ulcer. Kil *et al.* (2019) noted that *L. asiatica* is used to treat bone fractures, liver disorders, physical wounds, skin diseases, and worm infections. Tun *et al.* (2019) found that some species were used as traditional folk medicines. For example, the roots of *L. asiatica* were used to treat icteric hepatitis in China, the roots of *L. macrophylla* were used in medication for guinea worm in Myanmar, and the leaves of *L. guineensis* are used against cancer in Guinea.

1.2. Bioactive compounds

Since many *Leea* species were employed in traditional medicine and have a wide range of phytochemical properties, they contain a variety of chemical compounds. Through hydro distillation Op de Beck *et al.* (2000) isolated the volatile constituent from *L. guineensis* wood and leaves and their composition was analysed by GC-MS analysis. They were able to recognise a total of 69 compounds. Three hydrophilic flavonoids, quercetin-3,3'-sulphate-3-O-L-rhamnopyranoside, quercetin-3,3'-disulphate, and quercetin-3,3',4'-trisulphate, were discovered by Op de Beck *et al.* (2003) from the leaves of *L. guineensis*. In addition, he discovered the presence of quercetin, mearnsitrin, quercitrin, gallic acid, and ethyl gallate.

A study conducted by Srinivasan *et al.* (2008) identified twenty-three known chemical compounds in the leaves of *L. indica* including eleven hydrocarbons, phthalic acid, palmitic acid, 1-eicosanol, solanesol, farnesol, three phthalic acid esters, gallic acid, lupeol, and ursolic acid. The presence of gallic acid in the leaves of *L. indica* was identified for the first time, and he came to the conclusion that the antioxidant activity reported for the leaves of *L. indica* is mainly due to the presence of gallic acid. The essential oil obtained from the flowers of *L. indica* was evaluated by Srinivasan *et al.* (2009) and found to be composed of more than 95% phthalic acid esters. It was found that di-isobutylphthalate, di-n-butylphthalate, di-isobutylphthalate, n-butylisobutylphthalate, and butylisohexylphthalate were major constituents, while monobutyl carbontrithioate is a trace constituent. Through a bioassay-guided technique, Wong *et al.* (2012) identified two cytotoxic cycloartane triterpenoid glycosides from *L. indica*, namely mollic acid-L-arabinoside (MAA) and mollic acid-D-xyloside (MAX).

Ajiboye *et al.* (2014) examined the composition, minerals, fatty acid, and amino acid profiles of *L. guineensis* seeds. According to them the seeds of *L. guineensis* contain ash, crude protein, crude fibre, and fibre. The findings also indicate that *L. guineensis* seeds are a good source of dietary nutrients, including potassium, phosphorus, magnesium, manganese, and copper. The fatty acid profile of the seeds showed that linoleic, oleic, and palmitic acids were present in higher

concentrations in the seed lipids. Threonine, valine, isoleucine, leucine, tyrosine, phenylalanine, and histidine were the seven amino acids that present in seeds. The phytochemical evaluation performed by Joshi *et al.* (2016) showed the presence of phenolics, tannins, flavonoids, steroids, and alkaloids in the ethanolic extract of *L. macrophylla*. While the hexane fraction showed solely the presence of steroids, the chloroform fraction showed the presence of steroids and flavonoids.

The existence of a variety of phytochemical elements was revealed by Ghagane *et al.* (2017) through a preliminary screening of *L. indica* leaf extracts (chloroform, ethyl acetate, methanol, ethanol, and aqueous). Mahmud *et al.* (2017) demonstrated the presence of two triterpenoid, oleanolic acid, 7-, 28-olean and a sterol, stigmasterol, in the crude ethanolic extract of *L. macrophylla* roots. A phytochemical constituent of aerial parts of *L. asiatica* was isolated by Kil *et al.* (2019). They succeeded in identifying 24 compounds, including a novel phenolic glucoside, seven triterpenoids, eight flavonoids, two phenolic glycosides, four diglycosidic compounds, and two miscellaneous compounds. Furthermore, they used spectroscopic techniques including 1D-and 2D-NMR and ESI-Q-TOF-MS to elucidate the structures of these compounds. An alcoholic extract of *L. macrophylla* leaves was refined by Malik and Upadhyay (2020) and found to contain alkaloids, phenolic compounds, and steroids. Seed extracts were subjected to phytochemical screening, which identified a variety of phytoconstituents, including phenolic chemicals, saponins, and glycosides.

1.3. Pharmacological activities

1.3.1. Antimalarial

Using a suppressive antimalarial test, Sulistyaningsiha *et al.* (2017) showed that the methanolic extract of *L. indica* leaves had antimalarial properties in a malaria-induced mice model.

1.3.2. Antidiarrheal

The antidiarrheal effect of ethanolic extracts of *L. aequata* was proven by Bulbul *et al.* (2022). Small intestinal transit models and castor oil-induced diarrhoea were used to study this property.

1.3.3. Anti-inflammatory

Malik and Upadhyay (2020) discovered that the methanolic extract of *L. macrophylla* leaves had anti-inflammatory activities both in vivo and in vitro. Inhibitory action in the production of inflammatory mediators was revealed in the in vitro studies whereas carrageenan induced paw edema and cotton pellet granuloma technique were revealed the in-vivo studies.

1.3.4. Antibacterial

Strong antibacterial action against *Escherichia coli* and *Salmonella typhimurium*, as well as moderate activity against *Bacillus subtilis*, *Bacillus cereus*, and *Staphylococcus aureus*, was demonstrated by the essential oil of *L. indica* flowers (Srinivasan *et al.*, 2009). Antibacterial activities of hexane, ethylacetate and ethanol extracts of *L. rubra* roots and stems were carried out by Kadchumsang *et al.* (2014). According to their findings, ethylacetate extract of *L. rubra* root showed the highest antibacterial activity against gram-positive bacteria. In order to determine the antibacterial activity of ethanolic extract of *L. macrophylla* root tubers, Joshi *et al.* (2016) tested it against a few Gram-positive and Gram-negative bacteria. Gram-positive bacteria have the most activity as compared to gram-negative bacteria. Malik and Upadhyay (2020) tested the ethanolic extracts of *L. macrophylla* for antibacterial and antifungal activity against different pathogenic bacteria and fungi. The result showed a mild to moderate zone of inhibition against different microbes such as *Aspergillus niger*, *Blastomyces dermatidis*, *Candida albicans*, *Pityrosporum ovale*, *Trichophyton* sp., *Microsporum* sp. and *Cryptococcus neoformans* were strongly inhibited.

1.3.5. Antifungal

Studies by Srinivasan *et al.* (2009) revealed that essential oil from *L. indica* had a considerable antifungal effect on *Penicillium notatum*, a moderate effect on *Aspergillus niger* and *Fusarium monelliformae*. The activity is possibly due to the high concentration of phthalates in these plants.

1.3.6. Antioxidant

The in vivo antioxidant activity of the *L. guineensis* aqueous methanolic extract was demonstrated by Pieme *et al.* (2008). The outcome showed that the

concentration of glutathione and the activity of CAT and SOD greatly increased, while the level of MDA significantly decreased. Kadchumsang *et al.* (2014) used the 2,2'-azino-bis (3-ethyl-benzthiazoline-6-sulfonic acid) (ABTS), free radical scavenging test, 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay, and ferric reducing antioxidant power (FRAP) assay to assess the antioxidant properties of hexane, ethylacetate, and ethanol extracts of *L. rubra* roots and stems. Based on data from their investigation, it can be concluded that the root ethanolic extract had the highest antioxidant activity when tested using the ABTS, DPPH, and FRAP methods. The antioxidant and neuroprotective effects of *L. macrophylla* methanol root extracts were checked by Ferdousy *et al.* (2016). The use of this plant in the reduction of oxidative stress associated with neurodegeneration has become evident by this study. Invitro antioxidant activity of ethanolic extract of *L. macrophylla* root tubers was reported by Joshi *et al.* (2016). Again, Mahmud *et al.* (2017) described the antioxidant activity of the roots of *L. macrophylla* through the DPPH free radical scavenging assay, the superoxide radical scavenging assay, and the ethyl acetate soluble fraction of ethanolic extract. By using the FRAP, PM, and DPPH assays, Ghagane *et al.* (2017) investigated the total antioxidant capacity of methanol, ethanol, and aqueous extracts of *L. indica*. The results of the experiments showed that the extracts were probably capable of scavenging free radicals, with methanol extract having the highest antioxidant capacity. Antioxidant activity of different fractions of crude extract of *L. macrophylla* was found by Malik and Upadhyay (2020) through y 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging effect, FeCl₃ reducing effect, superoxide scavenging effect, and iron chelating effect.

1.3.7. Anticancer

Anticancer activity of *L. indica* leaf extracts on human prostate cancer cell lines were confirmed by Ghagane *et al.* (2017). Aquous methanolic extract of *L. guineensis* exhibits significant antitumor effects on bearing carcinomatous cells (Pieme *et al.*, 2008).

1.3.8. Anti-urolithiatic effect

According to Nizami *et al.* (2012), the entire *L. macrophylla* ethanol extract has an antilithiatic activity. The findings of this study showed highly promising

antiurolithiatic activity with preventive and therapeutic treatments. The antiurolithiatic effect of whole *L. macrophylla* ethanolic extracts were also proven by Malik and Upadhyay (2020).

1.3.9. Cytotoxicity

According to studies by Wong *et al.* (2012), the mollic acids-L-arabinoside (MAA) and -D-xyloside (MAX) of *L. indica* leaves have a cytotoxic effect on CaSki cervical carcinoma cells. Their research revealed that the cytotoxicity of MAA was associated with a decrease in PCNA expression, an arrest of the cell cycle's S and G2/M phases, and the induction of hypodiploid cells. Malik and Upadhyay (2020) used a brine shrimp lethality experiment to examine the cytotoxicity of *L. macrophylla* roots.

1.3.10. Hepatoprotective

Different fractions of crude extract of *L. macrophylla* were evaluated by Malik and Upadhyay (2020) for CCl₄-induced acute liver injury in rats and hepatic protection activity was determined.

In addition to these, it has been demonstrated that many species exhibit a wide range of phytochemical properties, including antihelmintic, wound healing, antipyretic, anticonvulsant, and thrombolytic activities.

Palynology and Seed morphology

1.1. Palynology

Palynological characters have offered a variety of features that have been useful in deducing plant phylogenetic relationships (Simpson, 2019). Palynological traits have proven to be quite useful in taxonomic delimitations. Only a few studies have been done on the pollen grains of *Leea*. Erdtman (1962) found that the pollen grains of *L. aequata* were spheroidal. It was Nair (1968) who reported the pollen grains of *Leea robusta* and *L. edgeworthii* were tricolporate and they shed at a 3-celled stage. Following that, Gerrath *et al.* (1990) noted that the pollen grains of *L. guineensis* were triangular in shape and tricolporate.

Later, Najmaddin (2014) conducted comparative palynological studies on members of the Vitaceae [*Cissus quadrangularis* L. & *Cayratia geniculata* (Blume) Gagnep.] and Leeaceae (*L. angulata*). She observed that pollen grains in *L. angulata* were tricolporate and had a triangular shape in equatorial view, in contrast to pollen grains in Vitaceae s.s., which were tricolpate and have a prolate shape.

Nair *et al.* (2018) investigated the pollen morphology of ten accessions representing five species of *Leea* from Kerala. They observed that pollen grains of *Leea* were stenopalynous and the features of pollen that appeared to be highly conserved in this genus were 3-colporate, prolate-spheroidal to sub-prolate, and medium-sized with microreticulate exine ornamentation. They also discovered the close kin of pollen grains of *Leea* and other members of the Vitaceae. Using palynological data, they came to the consensus that *Leea* belongs to a subfamily of the Vitaceae, as suggested by the APG system of classification.

Cartaxo-Pinto *et al.* (2021) examined the pollen morphology of members of the Ampelopsidae, Cayratieae, and Parthenocisseae tribes in order to evaluate the relationships between the five tribes using multivariate analysis and using previously known evolutionary concepts to reconstruct the evolution of pollen characteristics. Results showed that pollen grains in Vitaceae were medium (25–50 μ m) in size, isopolar, tricolporate, and subprolate to prolate. Their findings demonstrate that the micro reticulate ornamentation seen in members of the Vitaceae is a plesiomorphic trait shared with the sister group Leeaceae. Finally, they concluded that it was difficult to separate Vitaceae tribes based on the characteristics of pollen.

1.2. Seed morphology

Seed morphology has long been utilized in the taxonomy of Vitaceae (Planchon, 1887; Süssenguth, 1953), and its importance for the diagnosis of Vitaceae has been confirmed by molecular investigations (Soejima & Wen, 2006; Ren *et al.*, 2011). Seeds with paired ventral infold and a dorsal chalaza is diagnostic of the order Vitales (Chen & Manchester, 2007, 2011; Manchester *et al.*, 2013).

Compared to other genera, *Leea* has extremely few works on their seed morphology. To facilitate the identification of genera based on the morphology of the seed of Vitaceae, Chen and Manchester (2011) studied 252 extant seeds representing 15 genera. A dorsal chalaza knot and two ventral infolds are two distinguishing features that make seeds of the Vitaceae easier to recognize. They found that *Leea* usually has six-seeded fruits, and the seeds were laterally compressed. Their ventral infolds and rugae were covered by sclereids on the surface. The Y-shaped dorsal infold and a pair of longitudinally arranged rugae were unique features of the genus. The longitudinal rugae of *Leea* can be unbranched, branched, or extensively branched, and the endotesta were poorly developed. In Principal Component Analysis (PCA), *Leea* came together with *Cissus* and *Cyphostemma*.

Paleobotany

Paleobotanical data is used to reconstruct the temporal and spatial evolution of plant species. It is also used as a reference point in phylogenetic research to calculate the times at which various taxa differentiate. This genus has three fossils that have been described by various authors (Watari, 1951; Prakash & Dayal, 1963; Manchester *et al.*, 2012).

Watari (*l.c.*) described a silicified fossil wood, *Leea eojaponica* Watari, from the Lower Miocene of Simane, Japan. Later, Prakash and Dayal (1963) reported another new fossil wood, *Leeoxylon multiseriatum* U. Prakash, Ramesh Dayal, from the Deccan Intertrappean series at Mahurzari near Nagpur, Maharashtra, dated from the early Tertiary, most likely the Eocene. They believed that the combination of scalariform intervacular pitting and notably broad rays was crucial to their identification but recognised 13 additional dicotyledonous families that were known to have those characteristics. A thorough anatomical comparison between each of those families and the fossil showed that *Leea* of the Vitales shared the most similarities than other families. They also carried out a comparison of this fossil with *L. eojaponica* and found that, despite certain similarities between the two, the vessel size, the presence or absence of raphides, and the parenchyma thickness differed between two.

A fossil seed called *Carpolithus olssonii* E.W. Berry from the Paleogene of Western Peru was reported by Berry in 1927. But Manchester *et al.* (2012) found that it belonged to *Leea* and assigned a new name, *Leea olssonii* (Berry) Manchester, Chen & Lott. The presence of a lateral infold that resembles a slit on both lateral faces and which is absent in other Vitales, led the scientists to conclude that the specimen was *Leea*. They assert that the discovery of *L. olssonii* seeds from the Oligocene of Peru is biogeographically intriguing because it indicates existence of *Leea* species in South America, as the genus is only restricted to the Old-World tropics.

Manchester *et al.* (2013) discovered a new vitaceous fruit containing seed, *Indovitis chitaleyae* from Late Cretaceous Deccan Intertrappean beds of many sites in central India, characterized by two ventral infolds, dorsal surface smooth with small, elliptical chalazal knot confined to central portion. They found that the fossils belong to one of the 5-petaled groups of the Vitaceae. This new fossil record disproves the earlier fossil account of this family, which dates back to the Paleocene, by showing that they were present in India during the Late Cretaceous (Maastrichtian), roughly 10–15 million years before the tectonic collision of India with Eurasia. Additionally, the authors postulated the position of *Indovitis* in the phylogenetic tree of Vitaceae, either on the stem of the *Ampelopsis-Clematicissus-Rhoicissus* clade or on the stem of the *Vitis-Ampelocissus* clade. The author's claim that the fossil evidence for Leeaceae in the Indian Cretaceous by Prakash and Dayal (1963) remains ambiguous because the authors did not identify any diagnostic characteristics that supported their conclusion. According to them, *Leea eojaonica* represents the family's oldest known Asian record, which dates to the Miocene of Japan.

General morphology of *Leea* L.

An overview of the morphology of the genus *Leea* is presented in this chapter. This is based on the live specimens gathered from different regions of India, including the Andaman and Nicobar Islands. Besides, a large number of specimens available at different herbaria were also studied.

Vegetative morphology**Habit**

The genus is most commonly represented by shrubs or subshrubs, with a height of 0.5–2.5 meters. However, some species attain a height of 15 m and are more like small trees. *Leea* is predominantly found in forest margins, but some are confined to the understory of primary rainforests.

Roots

As they are dicotyledonous plants, they have a taproot system. However, some species also exhibit adventitious roots (Fig. 4A & B). Furthermore, certain species develop tuberous roots (*L. setuligera*, *L. mizoramensis* etc.; Fig. 4C). In some species with tuberous roots, the aerial shoots die off after every growing season and are regenerated from the rootstock during the next monsoon.

Stems

The stems of *Leea* are prickled or unarmed. It consists of a number of nodes separated by internodes. Nodes may be swollen in some species. The stem can be terete or furrowed or sometimes crispately winged (*L. asiatica*); branched or unbranched. The colour varies from green, purple or brown. The indumentum varied among species and seems to be lost as the stem becomes woody at age. The vegetative shoot of *Leea* develops monopodially.

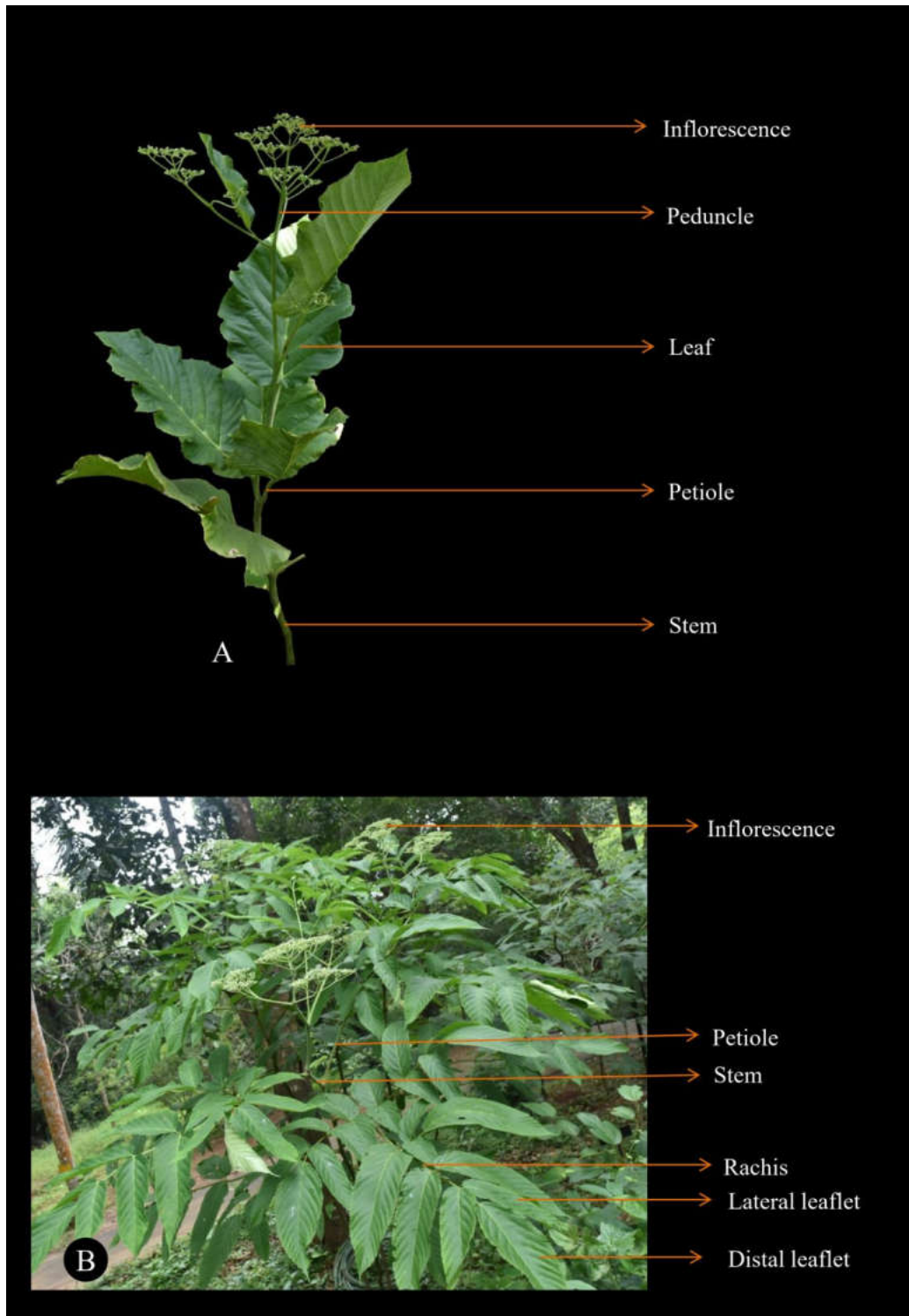


Fig 3. General morphology of *Leea*: **A.** *Leea macrophylla* Roxb. ex Hornem., flowering twig; **B.** *Leea robusta* Roxb., habit.



Fig 4. Root modifications in *Leea*: **A & B.** Adventitious roots; **C.** Tuberous root

Leaves

Species of *Leea* show diversity in terms of leaves. A wide range of variation is evident in pinnation, size, shape, and vestiture. Leaves are usually alternate. Although leaves of *Leea* are often stereotyped as being pinnately compound, some are simple (*L. macrophylla*) or trifoliolate (*L. trifoliata* M.A.Lawson, *L. grandifolia* Kurz). The pinnation of leaves varies from one to three pinnates depending on the species, (Fig. 6; Fig. 5J-L) and lower leaves are frequently less divided than the upper ones. It is common for seedlings of *Leea* to have a variable sequence of heteroblastic leaves (Fig 5A-E). The sequence of leaves covers an extremely broad spectrum of morphologies. The juvenile stage of pinnately compound-leaved species bears simple leaves at the first four nodes, followed by compound trifoliolate, pinnate and finally highly complex multi-pinnate leaves. In some species, partially pinnate leaves are also seen (Fig. 5F-H). The main part of the leaflets constitutes the lamina and petiole. In most cases, petioles are bulged at the base. The leaves surfaces are glabrous or variously hairy. The indumentum is distributed solely on the lower surfaces of leaflets or on both surfaces, and it can also occasionally be found in between two nerves.

Pearl glands

One of the distinctive features of Vitaceae is the presence of pearl glands, which are primarily found on leaves, stems, and inflorescence (Fig. 7 C-F). They are small, lustrous pearl-like or brown-coloured structures produced from the epidermis of leaves, petioles and shoots. These structures were observed on the



Fig. 5. A-E. Leaf heteroblasty in *Leea*; F-H. Partially pinnate leaves; I. Simple leaf; J-L. Pinnation types.

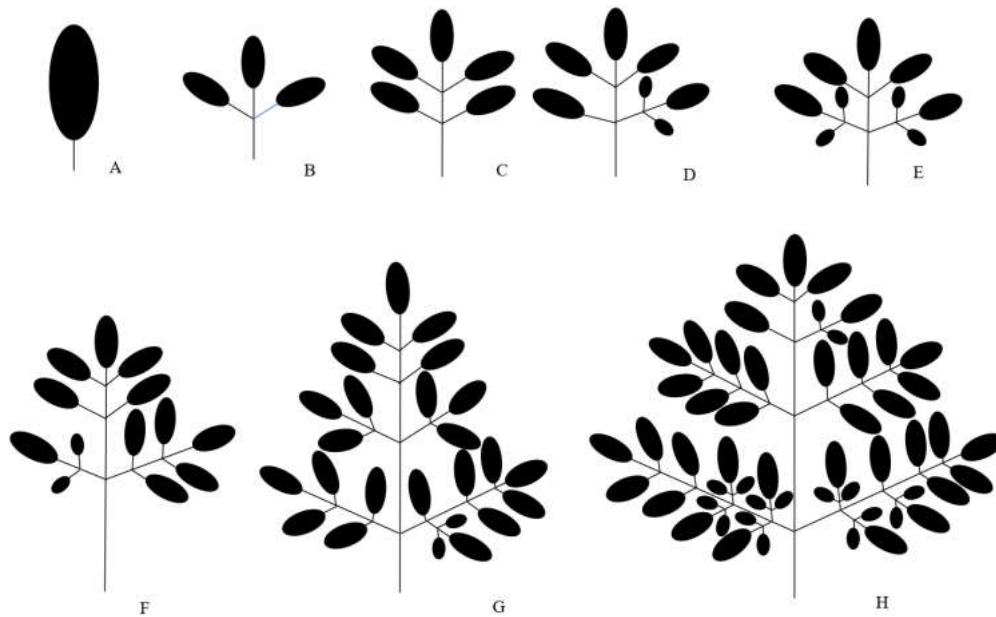


Fig. 6. Leaf pinnation pattern in *Leea*.

stem axis, being restricted to the primary growth stage, including the inflorescence axis. Pearl bodies are heterogeneous in origin and differ in morphology and development. In most cases, they are rapidly caducous and have been lost in the drying procedure. In contrast, pearl bodies in *L. aequata* are persistent, mostly confined to the lower surfaces of leaves. Plant pearl glands function as food for ants, thereby sustaining beneficial ants in the plant (Penzig, 1892).

Petiolar stipules

The presence of a petiolar stipule is a unique feature of *Leea*, which makes it stand out from other members of Vitaceae. Stipules are well developed in *Leea*, sheathing the petiole margins. There is a wide range of variation in shape (Fig. 8E) from narrowly winged (Fig. 8A) to oblong-obovate (Fig. 8B) and they are either caducous or persistent. The stipule encloses the young leaf and shoots apex as well as the young inflorescence (Fig. 8C & D). As the stipules reach maturity, the enclosed shoot tip and inflorescence continue to grow and eventually emerge from its protective enclosure. After the emergence of the young shoot, it may remain as a winged structure or soon dropping off, leaving a triangular scar on the petiole, and the cycle is repeated.

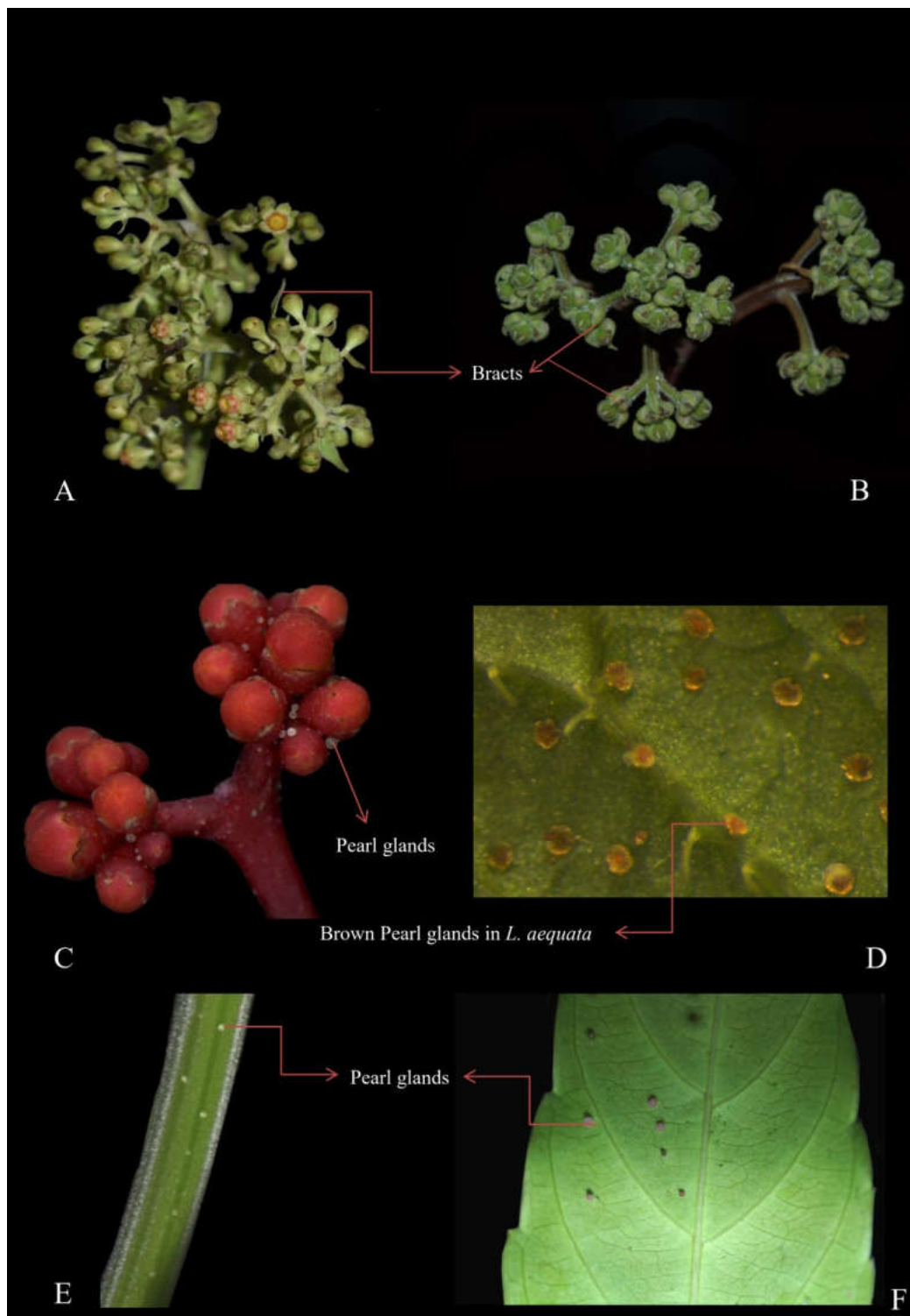


Fig. 7. A-F. *Leea*: A & B. Portion of inflorescence showing bracts; C-F. Pearl glands

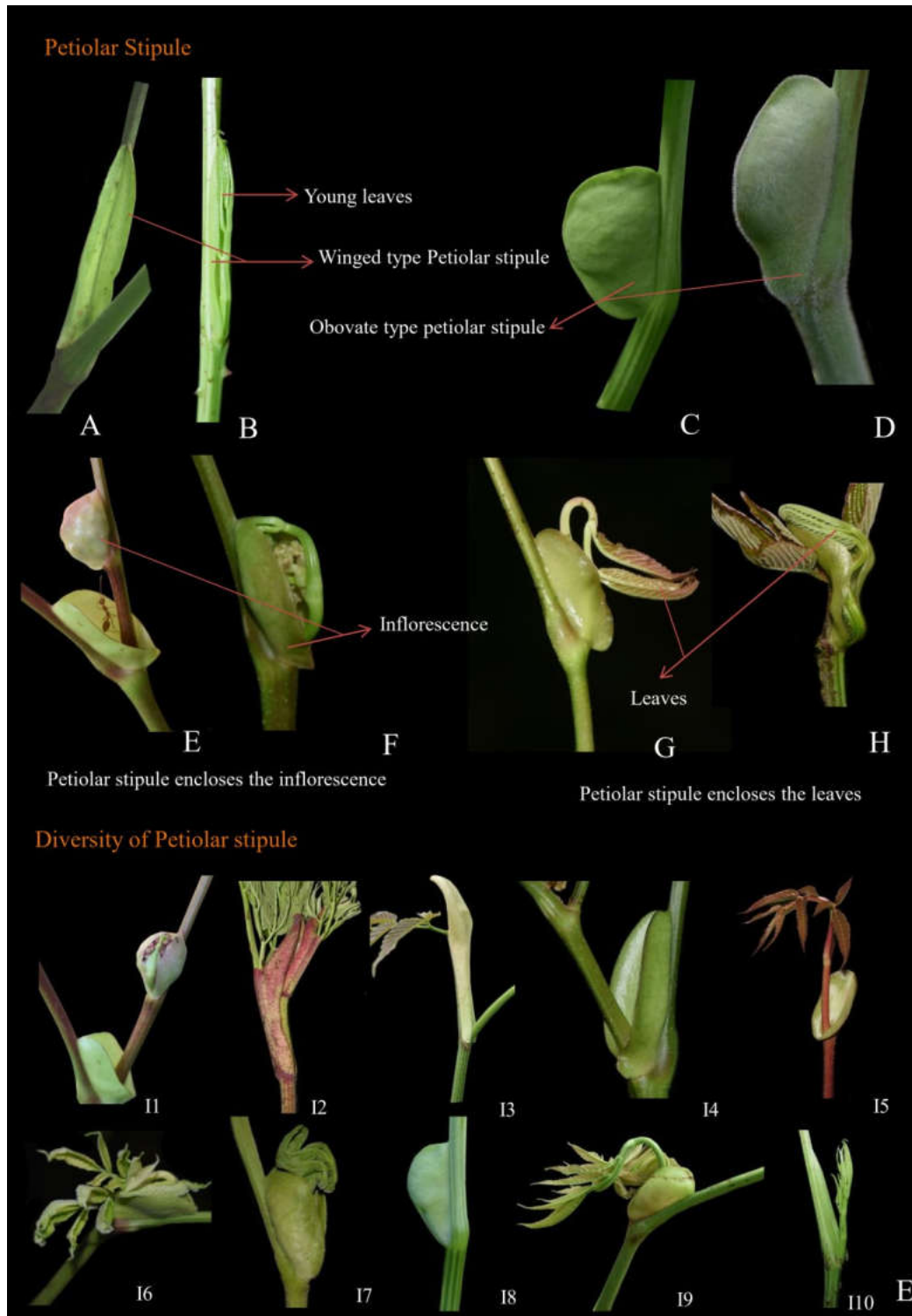


Fig. 8. Petiolar stipules in *Leea*: *L. angulata* (A, B, I10); *L. macrophylla* (C & I8); *L. robusta* (D, I6 & I7); *L. guineensis* (E, F, G, I1, I4 & I5); *L. asiatica* (H, I2 & I3); *L. indica* (I9).



Fig. 9. A & B. Inflorescence [Two portions of the inflorescence: main arm (ma); lateral arm (la)]; C & D. Infructescence.

Reproductive morphology

Inflorescence

Inflorescence is a leaf-opposed cyme which is terminal in position (Fig. 9A & B). In some instances, a second inflorescence forms from the axillary bud of the leaf below. The inflorescence is many-flowered, and the flower clusters are formed by successive orders of cymose branching, resulting in a series of dichasia. Inflorescences have two major arms: the main arm is the portion of the inflorescence formed on the main shoot, and the lateral arm inflorescence forms on the first-order inflorescence branch (Gerrath *et al.*, 1990; Lacroix *et al.*, 1990).

In most species, the cyme is dichasial and rarely some species exhibit umbellate cyme. Both condensed and lax inflorescences can be seen in *Leea*. Generally, condensation occurs with a reduction of dichotomous branching and suppression of all lateral branching (Gerrath *et al.*, 1990). In most cases, the

inflorescence is with a peduncle, which is terete or furrowed. The inflorescence bears bracts at various nodes (Fig. 7A & B), mostly small deltoid triangular structures, but in a few cases, they are conspicuous and well-developed.

Flowers

Flowers are bisexual, 4 or 5-merous, pedicellate, and actinomorphic (Fig. 10). Bracts are triangular, persistent or early caducous. Calyx campanulate with triangular lobes and glandular tips; Corolla lobes are four or five, apically often hooded, connate at base. There is a well-developed floral disc attached to the polypetalous corolla. The floral disc continues beyond the insertion, thus separating it into an upper free part and a lower free part. Species of *Leea* differ in the length of the lower and upper free parts, as well as the pattern of notching on the upper free part of the floral disc. As a composite structure, the corolla tube is composed of the corolla and the floral disc. In the descriptions, the measurements of the upper and lower parts of the floral disc are given. Additionally, we measured the length of the 'corolla tube + floral disc', which is the length from the base of the combined corolla tube to the tip of the lobes of the upper part of the floral disc. In most species, the lower half of the floral disc appears to be a short collar, but it can extend all the way to the ovary in certain species. In the upper part of the floral disc, there are four to five lobes separated by sinuses through which the filaments pass. Stamens four or five, antipetalous, alternating with the lobes of the floral disc, syngeneious except in one species, where they are free. Filaments extend over to the floral disc through the sinuses. The anthers are dorsifixed. The connective is well-developed on the dorsal side of the anthers and is purple-black. Anthers are attached to the filaments through connective tissue, introrse, and dehiscing by longitudinal slits. The detachments of stamens are unique in *Leea*. As the anthers are syngeneious, they detach as a unit. This is possible due to the outward and backward movements of the filaments, which gradually lift the anthers and pull them out of the floral disc. The anthers gradually move upwards and face outwards on the floral disc, appearing as star-shaped structures (Fig. 11C). The unit then moves out of the floral disc and detaches from the flower (Fig. 11). Carpels or pistils are differentiated into ovary, style and stigma. The ovary is superior, mostly tricarpellate with a secondary septum, 4–6 locular, globose with one ovule per locule, style short, entire and slender; stigma round (Fig. 10).

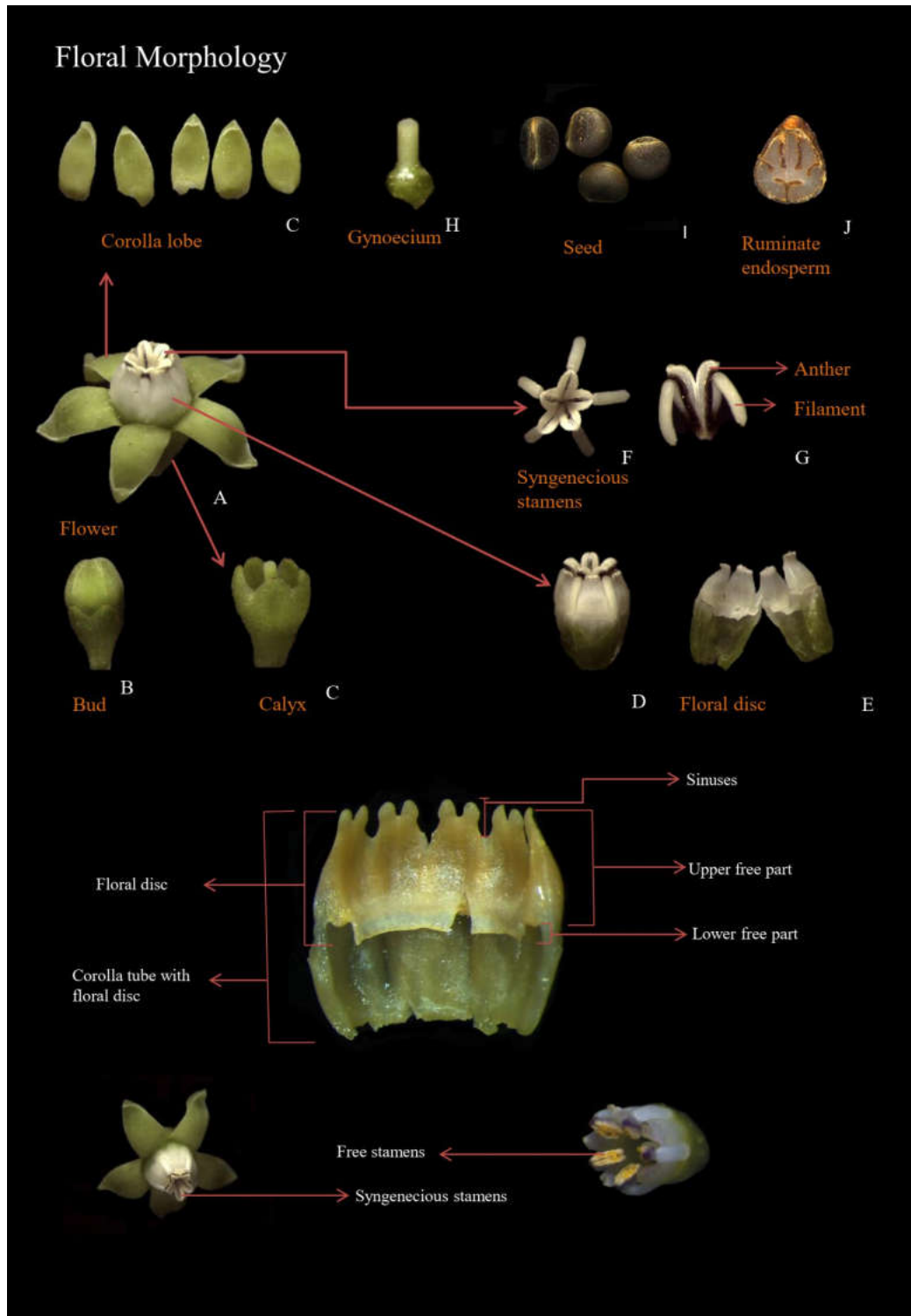


Fig. 10. Floral morphology of *Leea*.



Fig. 11. Different stages of anther dehiscence.

Fruits and Seeds

Fruits are subglobose, fleshy, 4 or 6 seeded berries (Fig. 9C & D). It may be green, yellow or red, and at maturity, all turn into black. Seeds are endotestal and wedge-shaped. The seeds have a ruminated endosperm, which usually has roughly five ingrowths: one along the median plane, two from the raphe, and one at each lateral face.

Taxonomy is the science of identifying, naming and classifying plants and all other organisms (Manilal, 1998). The word taxonomy was coined by Swiss botanist A.P. de Candolle in 1813 as a combination of two Greek words, '*taxis*', meaning arrangement, and '*nomos*', meaning law, in his book *Theorie Elementaire de la Botanique*. The term taxonomy is often employed synonymously with the term systematics. Simpson (2010) defined systematics as the "scientific study of the kinds and diversity of organisms and of any and all relationships between them".

It is imperative that any plant research begins with accurate taxonomic identification. It can only be achieved through a comprehensive study of taxonomic groups. The present study deals with the taxonomic revision of the genus *Leea* in India.

The tropical genus *Leea* comprises 38 species (Amrutha & Pradeep, 2023) worldwide, distributed entirely in the old-world tropics, mainly restricted in the Indo-Malayan region extended to Northern and Eastern Australia and some parts of Africa and Madagascar. The highest species richness and endemism can be found in Malaysia with 25 endemics. (Ridsdale, 1974, 1976; Lok *et al.*, 2011). In India, the genus is known to have 17 species with two endemics, mainly distributed in Northeast India, Peninsular India and Andaman and Nicobar Islands (Amrutha & Pradeep, 2023). *Leea* was earlier recognised at the rank of family (Ridsdale, 1974, 1976; Wen, 2007a, 2007b), but is now accepted under the subfamily Leeoideae Burmeister of Vitaceae according to the APG system of classification (APG III, 2009; APG IV, 2016). Their morphological range includes shrubs, trees, creeping herbs and some species with prickles on stems. *Leea* is distinguished by the presence of a petiolar stipule, well-developed floral disc, syngenechious stamens, one ovule in each locule and ruminant endosperm. The genus is renowned for being taxonomically difficult due to similar vegetative and floral characters, and almost identical habitat preferences which often make the identification at the species level very difficult.

C.B. Clarke (1881) in his revision of the genus *Leea* in India reported 29 species under two series (*Rubriflorae* and *Viridiflorae*). One of the significant work on the genus after Clarke is Ridsdale's (1976) revision of Leeaceae. It is an exhaustive work consulting collection of *Leea* available in almost all the herbaria. He synonymized most of the species recognized by Clarke, reducing the number of species to eleven. Subsequently, B.D. Naithani (2000) treated the genus in *Flora of India*.

Leea is often placed in its own family, Leeaceae based on the development of a complex staminodial tube attached to a polypetalous corolla, the locules of the ovary each having one ovule. Palynological studies also support its segregation from Vitaceae. Characteristics of seeds and embryos, as well as the presence of pearl glands on the vegetative organs, point to a close relationship with the Vitaceae (Ridsdale, 1976).

Classification of the genus *Leea*: A glimpse

A few authors (Clarke, 1881; Lawson, 1875) have attempted an infrageneric classification of the genus *Leea*. The British Botanist M.A. Lawson (1875) proposed the first infrageneric classification of the genus in India. This classification was solely based on the pinnation of leaves and divided the genus into three sections without assigning any names. Section I consisted of a single species having simple leaves. Species having pinnate leaves were placed in section II, and 2-3 pinnate-leaved plants under section III. Section III was again grouped sub-grouped into two, based on the vestiture of leaves, *viz.*, glabrous and pubescent.

Later, in 1881, Clarke provided, an elaborative classification of the genus in the revision of the Indian species of *Leea*. He classified all the species into two series: the red-flowered "*Rubriflorae*" and the green-flowered "*Viridiflorae*". Each series was further divided into sections mainly based on the pinnation of leaves, the nature of primary nerves, and habit. He has never felt entirely satisfied with Lawson's classification since it was primarily based on the pinnation of leaves. An overview of the classification of Clarke is demonstrated in the figure (Fig. 12).

Burt (1935) suggested the genus might be subdivided into 4-merous flowered groups and 6-merous flowered. He was a critic of Clarke's classification

and considered the primary division of a genus into two sections based on flower colour was not taxonomically reliable. Ridsdale (1974) noted the occurrence of both 4-merous and 5-merous flowers on the same plant of *L. tetramera* B.L.Burt.

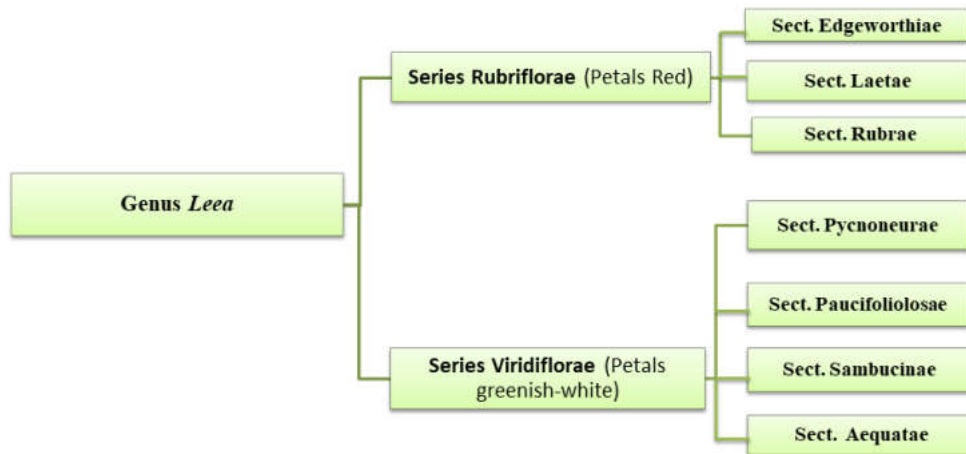


Fig 12. An overview of C.B.Clarke's classification.

While revising the genus *Leea* of the world, Ridsdale (1974) did not follow any classification by the previous authors. In his view, dividing the genus into two sections based on flower colour is unsatisfactory, and the colour of the flower in herbarium specimens is often difficult to determine if it was not recorded by the collector. Our observations of polymorphism in flower colour in *Leea* confirm the findings of Ridsdale. The green-flowered species never showed variation and never exhibited red or creamy flowers. However, red-coloured species showed creamy to different shades of red.

The high morphological variability and overlapping characteristics of this plant make sectional treatment extremely challenging. The present treatment did not follow any of the infrageneric classifications and the species are arranged alphabetically.

Systematic position: An Overview

The inclusion of *Leea* in the family Vitaceae is still up for debate and the genus has had a chequered history. It has long been debatable whether *Leea* belongs

in the monogeneric family Leeaceae (Planchon, 1887; Nair, 1968; Ridsdale, 1974, 1976; Latiff, 2001; Wen, 2007a, b) or in the family Vitaceae (APG II, 2003; APG III, 2009; Ingrouille *et al.*, 2002). The family assignment of *Leea* has been controversial since long, being included in Vitaceae or placed into its own monotypic family, Leeaceae.

The family Leeaceae was first established by Dumortier in 1829 in his *Analyse Des Familles Des Plantes*. He removed De Candolle (1824) tribe 'Leeaceae' and assigned a new family rank. The taxonomists who support the inclusion of *Leea* in Leeaceae are Planchon (1887) Cronquist (1981) and Ridsdale (1974, 1976). However, most of the earlier classical taxonomists followed the placement of *Leea* under Ampelideae (Vitaceae). Bentham and Hooker (1862) placed *Leea* under Ampelideae along with *Vitis* L. under the order Celastrales. Subsequently, in the *Flora of British India*, M.A. Lawson (1875) also treated *Leea* under Ampelideae. He included three genera: *Leea* L., *Vitis* L., and *Pterisanthes* Blume. The majority of the subsequent taxonomists, including Clarke, Kurz, King, Miquel, Blume, and Gamble, followed the successors. It has been segregated in a separate subfamily Leeoideae ['Leeaceae'], by Burmeister (1837), where he included two genera, *Leea* L. and *Lasianthera* P.Beauv. But the majority of the succeeding authors did not agree with Burmeister's perspective, except Gilg (1897), who followed Burmeister's classification in Engler's *Die Natürlichen Pflanzenfamilien*. In 1974, Ridsdale published a revision of the family Leeaceae, recognising this to be a distinct family. Following this work, subsequent authors (Singh *et al.*, 2000; Mourya *et al.*, 2021 *etc.*) adopted Ridsdale's treatment. Later, the Angiosperm Phylogeny Group (APG III, APG IV) placed the genus *Leea* in the subfamily Leeoideae of Vitaceae.

It has been controversial for a while where the genus Leeaceae belongs on the tree of life. De Jussieu (1789) considered it as a genus within the Sapotaceae. When discussing the relationships of the Leeaceae, Süssenguth (1953) proposed links with the Sterculiaceae (Buettnerieae). Vitaceae and Leeaceae (the Vitales) were once classified as either member of the Rhamnales (*e.g.*, Kirchheimer, 1939; Cronquist, 1981, 1988). Takhtajan (1997) recognised the order Vitales as consisting of Vitaceae and Leeaceae. Results from rbcL sequencing indicated that the Vitaceae-Leeaceae clade was sister to the Dilleniaceae (Chase *et al.*, 1993). Whereas based on

three-gene (*atpB*, *rbcL*, and 18S) analysis, Soltis *et al.* (2000) placed Vitaceae sister to the rest of the Rosids.

Additionally, the position of Vitales in the tree of life has been ambiguous up until this point. Vitales is an early-diverging lineage in the Rosids (Moore *et al.*, 2010; Ickert-Bond *et al.*, 2014; Zeng *et al.*, 2017; Zhang *et al.*, 2016; Wen *et al.*, 2018). The difficulty in assessing Vitales's phylogenetic position based on morphology was primarily due to the limited understanding of the morphology of the clade, as well as its numerous derived or unique character states (Ickert-Bond, 2014). APG II (2003) added Vitaceae to the Rosids but left it unassigned to an order. In APG IV (2016), Vitales is treated as sister to the Fabids+Malvids (Rosids I+II).

Materials and Methods

Literature survey

Information on taxa under investigation was gathered from a variety of sources, including institutional and university libraries, as well as from information retrieval systems. Important institutional libraries, mainly different regional centres of the Botanical Survey of India (BSI) were consulted while conducting the herbarium visits. The literature retrieval systems of New York Botanical Garden (<http://www.biodiversityheritagelibrary.org>), Missouri Botanical Garden Libraries (<http://www.botanicus.org> and <http://www.tropicos.org>); information from online libraries such as JSTOR (<https://www.jstor.org>), Hathi Trust Digital Library (<http://www.hathitrust.org>), Internet archive (www.archives.com) and Wallich catalogue (<http://wallich.rbge.info>) of Royal Botanic Garden, Edinburgh etc. were utilized.

Herbarium consultation

Various herbaria including AHMA, ARUN, ASSAM, BSHC, BSI, BSID, CAL, CALI, MH, PBL, RHT and TBGT (Acronyms as per Thiers, 2024 continuously updated) were consulted. Additionally, online databases of the different herbaria, A, BM, BR, G, GH, K, L, MICH, MO, NY, P, SING, U and US were accessed in order to obtain the digital images of type specimens and to understand their variation throughout their range of distribution. A list of herbaria consulted, and its details were given in Appendix. Barcodes of sheets were incorporated wherever available, and the specimens or images examined were denoted by an exclamation mark (!).

Specimen collection

Materials for the current study were gathered through extensive field trips in various parts of India, including the Andaman and Nicobar Islands during 2017–2023 (Figs. 13–16). Areas having a high diversity of *Leea* species, such as Northeast India and Andaman and Nicobar Islands were given priority. Live specimens of 16 out of 17 species were collected. Primary information on the collected species was directly recorded in the field note. Attempts were made to study each species in its natural habitat and also under cultivation. Habitat preferences of each species were recorded and ecological information such as associated taxa were also recorded. For a better understanding of the variation pattern, more populations of each taxon were collected from different phytogeographical areas. During field trips, 3–4 accessions of each specimen were collected and processed for the herbarium and laboratory studies. Besides, those materials in the vegetative stage were collected separately with roots for growing in Calicut University Botanical Garden (CUBG).



Fig. 13. Glimpses from the field explorations to different parts of India, including Andaman & Nicobar Islands.



Fig. 14. Areas explored: **A.** Tumbung Basti, Umrangso, Assam; **B.** Namdapha National Park, Arunachal Pradesh; **C.** Torna Fort, Maharashtra; **D.** Sessa Village, Arunachal Pradesh; **E.** Saddle Peak, North Andaman; **F.** Korigad, Maharashtra; **G.** Kaas Plateau, Maharashtra.

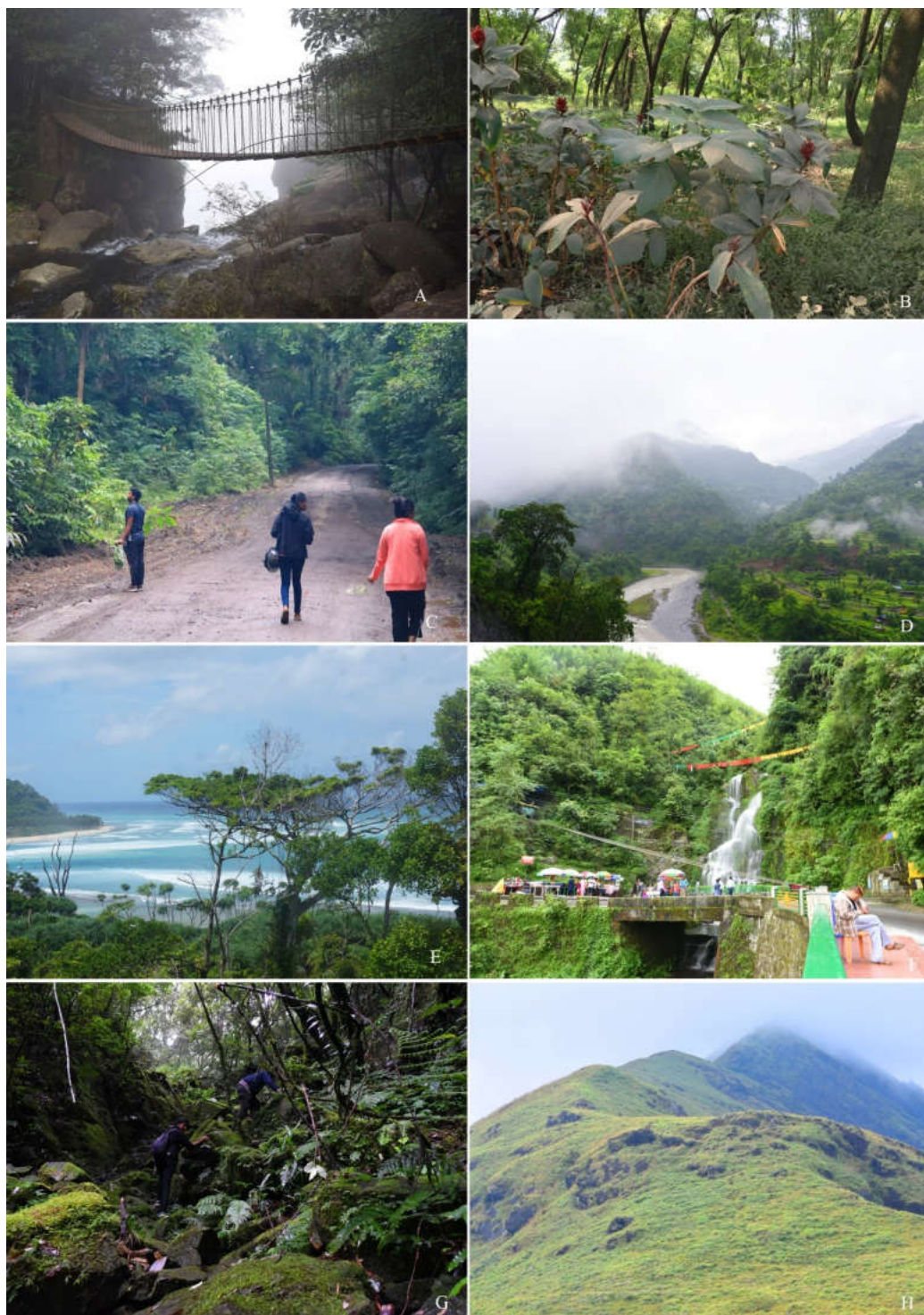


Fig. 15. Areas explored: **A.** Kakkayam, Kerala; **B.** Aarey Colony, Mumbai, Maharashtra; **C.** Ferrargunj, South Andaman; **D.** Sikkim; **E.** Galathea, Nicobar; **F.** Bakthang Waterfalls, Sikkim; **G.** Cherrapunji, Meghalaya; **H.** Chembra, Kerala.



Fig. 16. Areas explored: **A.** Nadugani Ghat, Kerala; **B.** Mud Volcano, Diglipur, Andaman; **C.** Phamrong falls, Sikkim; **D.** Farkawn, Mizoram; **E.** Thenmala, Kerala; **F.** Sialsuk, Mizoram.

Herbarium preparation

Collected specimens were cut into appropriate sizes and treated with 15–20% formaldehyde solution and sealed in polythene bags. Herbaria were prepared following the wet method (De Vogel, 1987; Forman & Bridson, 1998). Specimens were dried using the oven and wet sheets were changed with dry ones as frequently as possible. Dried specimens were mounted on handmade (24 × 42 cm) herbarium sheets, and labels (14.5 × 11 cm) containing all the relevant information were affixed. All the specimens collected were deposited at Calicut University Herbarium (CALI).

Plant identification

Identification has been done by using the key provided in various floras and the revision of Leeaceae by Ridsdale (1974, 1976). Moreover, consultation of protologues and type specimens helped to confirm the identity of each taxon. Whenever live specimens were not available, authentic collections placed at different herbaria were consulted.

Citations and Nomenclature

The correct name was provided for each taxon followed the International Plant Name Index (<http://www.ipni.org>) and POWO (<https://powo.science.kew.org/>). The author citations were provided based on Brummitt and Powell (1992). the accepted name was followed by direct reference to basionym if any, and their types. The nomenclatural problems including the typification were solved by referring Shenzhen Code (Turland *et al.*, 2018). A detailed nomenclatural note was provided for every typification, and new synonyms were justified with detailed notes.

Preparation of description

A separate data sheet for the genus *Leea* was prepared. It includes information about habit, habitat, vegetative characters and reproductive characters. The data sheet was printed to record the characters unique to *Leea*, to keep uniformity in writing descriptions and to avoid overlooking certain characters. A

detailed description of each taxon was prepared. All the specimens were examined through M80 stereomicroscope (Leica, Mannheim, Germany), Luxeo 4Z stereomicroscope (Labomed, USA) and colour photomicrographs were taken using M80 Stereomicroscope (Leica, Mannheim, Germany) attached with a Leica MC 190 HD camera with Leica Application Suite Version 4.12. The field photographs were captured using a D3400 and Nikon D750 cameras (Nikon, Japan). A large number of materials from different populations in the field and under cultivation in CUBG helped to note the extent of variation. For the preparation of the description, the terminology by Ridsdale (1974, 1976), Stearn (1983), Simpson (2010), Harris and Harris (1995), and Kew Plant Glossary (Beentje, 2016) was followed.

Preparation of Photo plates and illustrations

A detailed colour photo plate and illustration for each species were prepared to show its characters and the variation pattern of each part of the plant. Photo plates were prepared using Adobe Photoshop CS Version 8.0. Illustrations of each taxon were prepared with a scale using Camera Lucida attached to M80 stereomicroscope. Micro-tip pen (Rotring variant) equipped with 0.1 and 0.2 points were used for the preparation of the illustration.

Preparation of distribution map

The geographic coordinate of each species was noted in the field during exploration trips. Additionally, distribution details from the herbarium specimens available at various Indian herbaria were noted. Distribution data were compiled, and the distribution map was prepared by using the software QGIS version 3.24.3 (QGIS, 2022).

Conservation assessment

The threat to each species was thoroughly investigated during the field visits. The Extant of Occurrence (EOO) and Area of Occupancy (AOO) were computed by Geocat (<http://geocat.kew.org/>) and the Conservation assessment was done using IUCN Standards and Petitions Committee (Version 15.1, 2022).

Conservations of germplasm

More than 50 accessions were conserved in the special conservatory for *Leea* in Calicut University Botanical Garden (CUBG). It helped for further analysis of each taxon and to understand the variations. Collected specimens, either in the form of stem twigs, rooted plants or tubers were used for propagation. All the specimens collected were properly labelled with metallic T-labels having clear indication of name, locality, collection number, and date of collection to aid future studies.

Presentation of data

The systematic parts begin with the treatments of the genus. This begins with correct name, reference to protologue, homotypic synonyms, indication of type followed by citation of other synonyms, detailed description, phenology, distribution, etymology and relevant notes. This was followed by a detailed key for each species. Species were arranged based on alphabetic order. Each species was provided with a detailed description and followed by phenology, habitat and ecology, and distribution. The information about the cited specimens was provided. The herbarium acronym was given in parenthesis along with the barcode if available.

Systematic treatment

Leea L. *nom. cons.*

Leea L. Syst. Nat. ed. 12. 627. 1767, Mant. Pl. 17. 1767, *nom. cons.*; Roxb., Fl. Ind. (Carey & Wall. ed.), 2: 465. 1824; DC., Prodr. I. 635. 1824; Spreng., Syst. Veg. 1: 670. 1825; Blume, Bijdr. Fl. Ned. Ind. 4: 195. 1825; Miq., Fl. Ned. Ind. 1. 2: 609. 1859; Miq., Fl. Ned. Ind., Eerste Bijv. 3: 519. 1861; Benth. & Hook., Gen. Pl. I. 388. 1862; Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 95. 1863; M.A. Lawson in Hook.f. (ed.), Fl. Brit. India 1: 664. 1875; Kurz, J. Asiat. Soc. Bengal 44(2): 177. 1875, Forest Fl. Burma 1: 278. 1877; C.B. Clarke in Trimen's J. Bot. 19: 100. 1881; T. Cooke, Fl. Bombay 1: 258. 1903; Ridl., Fl. Malay Penins. 1: 483. 1922; Ridsdale, Blumea 22: 74. 1974, Fl. Males., Ser. 1, Spermat. 7: 755. 1976; B.D. Naithani in Singh *et al.* (eds.), Fl. India 5: 2000. *Type: Leea aequata* L. (*typ. cons.*)

Nalagu Adans., Fam. Pl. 2: 445. 1763, *nom. rej.* *Type: Hort. Malab. 2. t. 26. [=L. asiatica* (L.) Ridsdale].

Aquilicia L., Mant. Pl. 2: 211. 1771, *nom. rej. superfl.* *Type: A. sambucina* L. [=L. *indica* (Burm.f.) Merr.].

Blakwellia Scop., Intr. Hist. Nat.: 326. 1777, *nom. superfl.* *Type: Nalugu. Hort. Malab. 2. t. 26. [=L. asiatica* (L.) Ridsdale].

Sansovinia Scop., Intr. Hist. Nat.: 228. 1777. *Type: Staphylea indica* Burm.f. [=L. *indica* (Burm.f.) Merr.].

Otillis Gaertn., Fruct. Sem. Pl. 1: 275. 1788. *Type: Otillis zeylanica* Gaertn. [=L. *indica* (Burm.f.) Merr.].

Perennial, subshrubs to trees sometimes straggling; roots tuberous or non-tuberous occasionally with adventitious and stilt roots. Stems erect, stout, jointed, with or without branching; internodes terete, furrowed or crisped, purple or green; nodes sometimes swollen. Pearl glands globose, more on inflorescences, white, brown or pink, early caducous or persistent. Leaves alternate, simple, trifoliate, or 1–3 pinnate, imparipinnate; petioles base bulged sometimes sheathing the stem, glabrous, brown or purple; petiolar stipule a narrow wing, oblong-obovate or falcate, either caducous or persistent, glabrous or hispid; stipular scars triangular; rachis terete or furrowed or channelled on the upper side, glabrous or hairy, purple or green. Leaflets opposite, pubescent or glabrous, base cordate-obtuse or rounded,

Systematic treatment

sometimes unequal, margins sharply serrate, crenate or doubly serrate occasionally sub-entire towards base, apex acute-acuminate; petiolules occasionally sessile; secondary veins 3 or 5 nerved at base, veins mostly raised on abaxial side. Inflorescence a leaf-opposed cyme, terminal, many flowered, condensed or lax; peduncles channelled or terete, pubescent or glabrous, green, red or creamy. Flowers bisexual, actinomorphic, 4 or 5-merous, greenish white, red, creamish pink or with brownish tinge. Pedicels slender, pubescent or glabrous. Bracts prominent or inconspicuous, caducous or persistent, creamish, brown or green. Calyx campanulate, 4 or 5-lobed, lobes glandular at apex, apex acuminate or acute, green, red or creamish; corolla lobes 5, apex acute-rounded, hooded, basal portion choripetalous, margin entire, glabrous, creamish, red or green; floral disc white, brownish, white with pinkish at apex, floral disc inserted in to the corolla at a line of attachment dividing the floral tube into an upper and lower part; upper free part consisted of 4 or 5 thickened lobes connate to each other by a thinner tissues which form sinuses over which the filaments pass, lobes notched, retuse or apiculate at apex; sinuses deep or shallow; lower free part forming a collar, sometimes extending as far as the ovary. Stamens 5, syngeneceous and rarely free; filaments glabrous, white; anthers 2-locular, introrse, dehisces longitudinally by single slit, occasionally by two slits, purple on backside, creamish on margin. Ovary globose, superior, one ovule in each locule, placentation axile; style slender, entire, glabrous; stigma round. Fruit a berry, round or depressed globose, green, red or yellow when young turning black at maturity, 4 (-6) seeded. Seeds wedge-shaped, triangular in cross-section, endosperm ruminant.

Distribution: Distributed entirely in the old-world tropics, mainly restricted in the Indo-Malayan region extended to northern and eastern Australia and some parts of Africa and Madagascar.

Habitat: Most of the species prefer moist shady places along the forest margins. Some are confined along the freshwater streams and very occasionally can be seen in the beach forest in sandy soil.

Flowering & fruiting: May–December.

Etymology: Linnaeus named the genus as '*Leea*' in honour of James Lee (1717–1795), an accomplished natural historian and proprietor of the Vineyard Nursery at Hammersmith, London.

Key to the Indian species of *Leea*

1. Leaves simple *L. macrophylla*
1. Leaves pinnate or trifoliolate 2
2. Stems spined 3
2. Stems not spined 4
3. Pearl glands pink; lower part of floral disc 0.5–0.7 mm long; fruits greyish when young *L. angulata*
3. Pearl glands white; lower part of floral disc 1.3–1.5 mm long; fruits greenish when young *L. adwivedica*
4. Anthers distinct and split through two longitudinal slit; secondary veins close and parallel *L. asiatica*
4. Anthers syngeneis and split through one longitudinal slit; secondary veins distant 5
5. Petiolar stipules a narrow wing, persistent 6
5. Petiolar stipules oblong to ovate, early caducous 7
6. Inflorescence with conspicuous bracts, persistent 8
6. Inflorescence with inconspicuous bracts, early caducous 9
7. Flowers greenish white 10
7. Flowers red, creamy or yellow 11
8. Leaves pinnate; bracts broadly ovate; inflorescence >5 cm long *L. compactiflora*
8. Leaves trifoliolate sometimes with two rudimentary leaves at base, bracts lanceolate-linear, inflorescence <5 cm long *L. trifoliata*
9. Leaves mostly petioluled; peduncles <12 cm long; flowers creamish pink, lower free part of the floral disc 1.3–1.5 mm long; fruits usually 4-seeded... *L. setuligera*
9. Leaves mostly sessile; peduncles >12 cm, flowers red, lower free part of the floral disc c. 0.25 mm long; fruits usually 6-seeded *L. alata*

10. Lower surface of leaves with brown pearl glands; fruits red when young.
..... *L. aequata*
10. Lower surface of leaves without brown pearl glands; fruits green when young
..... **12**
11. Roots non-tuberos; stems and petioles terete; rachis channelled on upper
surface; pedicels short or nearly absent, glabrous *L. guineensis*
11. Roots tuberos; stems and petioles furrowed; rachis furrowed on upper
surface; pedicels 0.5–1.8 mm long, hairy **13**
12. Leaves trifoliolate or 1-pinnate; distal leaflets >15 cm broad **14**
12. Leaves 1–3 pinnate, distal leaflets <15 cm broad **15**
13. Inflorescence condensed; pedicels 0.9–1.8 mm long, hairy
..... *L. mizoramensis*
13. Inflorescence lax; pedicels ≤0.9 mm long, glabrous *L. tamdilensis*
14. Leaflets truncate, round or obtuse at base; lower surface of the leaflets
glabrous; inflorescence <12 cm long; peduncles <6 cm long; calyx glabrous;
sinuses of the floral disc shallow, 0.6–0.7 mm long *L. grandifolia*
14. Leaflets cordate at base; lower surface of the leaflets puberulous; inflorescence
>12 cm long, peduncles >6 cm long, calyx hairy, sinuses of the floral disc deep,
1.5–1.9 mm long *L. latifolia*
15. Roots tuberos; leaves hispid on upper surface of the leaflets; upper free part
of floral disc acuminate; sinuses of the floral disc deep, 1.3–1.5 mm long
..... *L. robusta*
15. Roots non-tuberos, leaves glabrous on upper surface, upper part of floral disc
notched or retuse; sinuses of the floral disc shallow, 0.3–0.9 mm long **16**
16. Leaflets glabrous on both surfaces; stems and inflorescence glabrous; upper
free part of the floral disc notched; seeds 3.13–3.42 mm broad
..... *L. indica*
16. Leaflets ferruginous hairy on lower surfaces; stems and inflorescence
ferruginously hairy; upper free part of the floral disc retuse; seeds 2.61–3.02
mm broad *L. sundaica*

1. *Leea adwivedica* K.Kumar, Rheede 10(2): 103. 2000. *Type*: INDIA, **Andaman Islands**, North Andaman, Dumar Nullah, 23 Sept 1990, *Krishna Kumar* 0338 (holotype: CAL barcode CAL0000024229!; *isotype*: Herbarium, Botany Department, Jawaharlal Nehru Rajakeeya Mahavidyalaya, Port Blair). **Fig. 17, 19 & 20**

Leea angulata auct. non Korth. ex Miq.: M.Y.Kamble, Fl. North Andaman Isl. 43. 2020.

Trees, c. 15 m high; roots non-tuberous, with stilt roots. Stems erect, stout, prickled, branched; internodes furrowed, prickled, green; nodes swollen. Pearl glands globose, white. Leaves alternate, 1 (-2) pinnate, imparipinnate; petioles 3.5–7.5 cm long, swollen at base, sheathing the stem at base, furrowed, prickled, green; petiolar stipules a narrow wing, as long as or $\frac{3}{4}$ th of the length of petiole, persistent, 3.5–6 × 0.3–0.5 mm, glabrous, green; stipular scar triangular; rachis 10.5–22 cm long, channelled on upper side, prickled, green. Leaflets opposite, narrowly to widely ovate or elliptic, distal leaflets: lamina 9–14 × 3.5–5.8 cm; lateral leaflets: lamina 8–17 × 2.5–6 cm; green above and pale green beneath, base sometimes oblique, cuneate or obtuse or round, margins serrate, apex long acuminate; petiolules: central 2–3.5 cm long, channelled on upper side, glabrous, green, lateral 0.2–1.2 cm long, channelled on upper side, glabrous, green; secondary veins 6–12 pairs, 3-nerved at base, veins prominent on both surfaces, glabrous. Inflorescence a leaf-opposed terminal dichasial



Fig. 17. Type of *Leea adwivedica* K.Kumar [Krishna Kumar 0338 (CAL barcode CAL0000024229)] © Botanical Survey of India, Kolkata.

cyme, 6–13 cm long, branched, many flowered, lax; peduncles 2–7 cm long, furrowed, glabrous, green. Bracts 0.6–0.9 mm long, spirally arranged, apex acuminate, green. Flowers 5.6–6.5 mm long, numerous, actinomorphic, greenish-white. Pedicel slender, 1.3–2 mm long, hairy. Calyx campanulate, 4–4.7 × 2.8–3.1 mm, lobes 5, 0.4–0.5 × 1–1.5 mm, apex obtuse, glabrous, green. Corolla lobes 5, ovate, 3–3.5 × 1.5–1.7 mm, apex acute and hooded, margins entire, glabrous, green; corolla tube with floral disc 3.7–4 × 2.3–2.7 mm, white. Floral disc tubular, 3.1–3.3 mm long, white when young yellowish at maturity; upper free parts 1.7–2 mm long, notched; sinuses shallow, 0.3–0.4 mm long; lower free parts 1.3–1.5 mm long, extending merely as long as the length of corolla tube. Stamens 5, syngeneceous;

Systematic treatment

filaments 1.4–1.5 mm long, glabrous, white; anthers 1.5–1.7 mm long, dorsifixed, dehisce longitudinally, brownish on back. Ovary depressed globose with 5–6 coherent reniform segments, 0.8–1.1 mm long, superior, 6-loculed; ovule one in each locule, placentation axile; style 1.3–2.3 mm long, slender, glabrous; stigma convex. Fruits berry, globose. Seeds 6, more or less obconic, $6.61\text{--}6.85$ (6.76 ± 0.07) $\times$ $5.32\text{--}5.57$ (5.47 ± 0.07) mm, brownish-black when mature.

Flowering & fruiting: June–November.

Habitat: Typically, this species can be found in interior forests and beside freshwater streams. They grow in association with *Cycas* sp. (Cycadaceae), *Mussaenda* sp. (Rubiaceae) etc.

Distribution: This species is endemic to the Andaman Islands of India. It is distributed in South Andaman (Havelock Island), Middle Andaman (CFO Nallah, Betapur) and North Andaman (Foot Hills of Saddle Peak, Near Lamiya Bay); Fig. 18.



Fig. 18. Distribution of *Leea adwivedica* K.Kumar in India (drawn using QGIS version 3.24.3).



Fig. 19. *Leea adwivedica* K.Kumar: **A.** Habit; **B.** Stem; **C.** Petiolar stipules; **D.** Inflorescence; **E.** Flower bud; **F.** Flower; **G.** Corolla lobe; **H.** Calyx; **I.** Corolla tube with floral disc; **J.** Corolla tube with floral disc split open; **K.** Stamens; **L.** Pistil; **M.** Seeds.

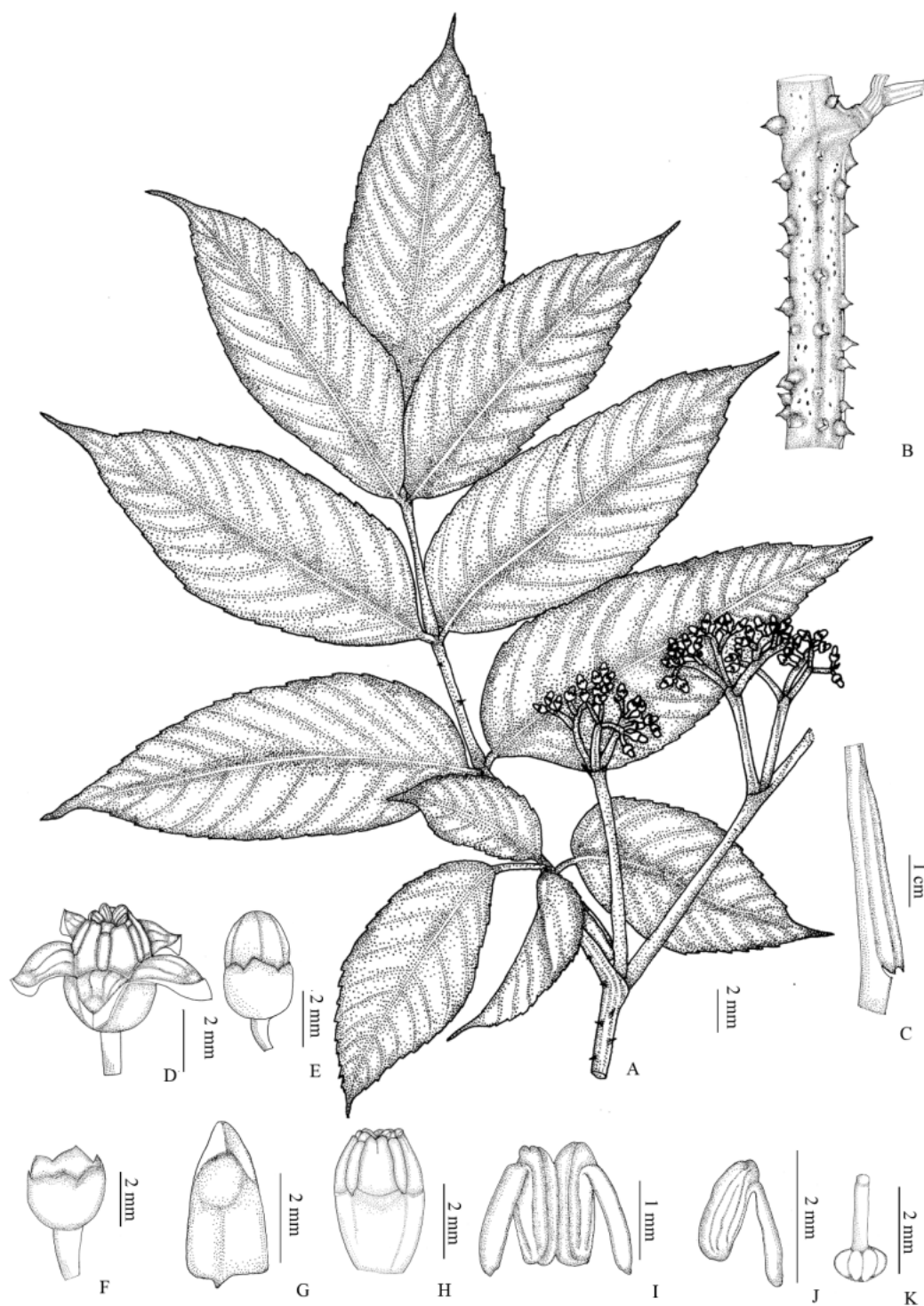


Fig. 20. *Leea advivedica* K.Kumar: **A.** A twig with inflorescence; **B.** Stem; **C.** Petiolar stipule; **D.** Flower; **E.** Flower bud; **F.** Calyx; **G.** Corolla lobe; **H.** Corolla tube with floral disc; **I & J.** Stamens; **K.** Pistil (drawn by Amrutha A. from Amrutha 164053).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, North and Middle Andaman district, CFO Nallah, Crocodile bridge, 10 July 2019, *Amrutha* 164053 (CALI); Narcondam Island Wildlife Sanctuary, 03 Mar 2011, *M.Y. Kamble* 29032 (PBL barcode PBL0000028597); Near Durgapur, 28 Nov 1976, *N.P. Balakrishnan & N.C. Nair* 4707 (CAL); Paget Island Wildlife Sanctuary, 11 Mar 2012, *M.Y. Kamble* 30556 (PBL barcode PBL0000029425, PBL0000029426); *Ibid.*, 08 Dec 2012, *M.Y. Kamble* 30766 (PBL barcode PBL0000029839, PBL0000029840); Saddle Peak, foot Hill, Along the Lamiya Bay, 07 July 2019, *Amrutha* 164027 (CALI); Sinduri Nullah, 18 June 1998, *Krishna Kumar* 0019 B (CAL barcode CAL0000024231).

Notes: While describing this species, the author pointed out that branches and branchlets are unarmed except for the young sprouts which have deep red prickles. Our observation showed that the branches and branchlets are also prickled. Moreover, the protologue states staminal filaments are absent in this species, whereas it is present in our observations. Most of the *Leea* species have syngeneious stamens and filaments extending over to the floral disc through the sinuses. It is likely that this feature might have been overlooked by the author while describing *L. adwivedica*.

2. *Leea aequata* L., Mant. Pl. 124. 1767, Syst. Nat. ed. 12. 2. 1767; DC., Prod. 1: 635. 824; Spreng., Syst. Veg. 1: 670. 1825; G.Don, Gen. His. 1: 713. 1831; Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 98. 1863; Kurz, J. Asiat. Soc. Bengal 44 (2): 180. 1875, Forest Fl. Burma 1: 281. 1877; C.B.Clarke in Trimen's J. Bot. 19: 163. 1881; King, J. Asiat. Soc. Bengal 65(2): 418. 1896; Prain, Bengal Pl. 1: 340. 1903; Brandis, Ind. Trees 179. 1906; Gagnep., Fl. Indo-Chine t.1: 940. 1909, Bull. Soc. Bot. France 57: 336. 1910; Merr., Bibliogr. Enum. Born. Pl. 368. 1921; Merr., Enum. Philipp. Fl. Pl. 3: 10. 1922; Ridl., Fl. Malay Penins. 1: 486. 1922; C.E.Parkinson, Forest Fl. Andaman Isl. 133. 1923; Craib, Fl. Siam. 1(2): 316. 1926; Cowan & Cowan, Trees N. Beng. 40. 1929; Kanjilal & Das, Fl. Assam 1(2): 307. 1936; Backer & Bakh.f., Fl. Java 2: 94. 1965; Ridsdale, Blumea 22: 90. 1974, Fl. Males., Ser. 1, Spermat. 7: 775. 1976; Harid. & R.R.Rao, Forest Fl. Meghalaya 1: 248. 1985; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 318. 1996; R.N.Banerjee, Fl. West Bengal 1: 451. 1997; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 306. 1999; B.D.Naithani in Singh *et al.* (eds.), Fl. India 5: 326. 2000; R.Shanpru in N.P.Singh *et al.* (eds.), Fl. Manipur 1: 239. 2000; N.P.Singh *et al.*, Fl.

Bihar, Analysis 113. 2001; K.P.Singh in N.P.Singh *et al.* (eds.), Fl. Mizoram 1: 387. 2002; Lok *et al.*, Nat. Singap. 4: 58. 2011; G.D. Pal, Fl. Lower Subansiri Dist. 1: 213. 2013; Karthig., Angiosp. diversity of Mahatma Gandhi Marine Natl. Park 104. 2017; P.Singh & S.S.Dash, Fl. Little Andaman Isl. 84. 2021.

Type: INDIA, Eastern India, *Linnaeus*, C 1118. 1 (LINN, barcode LINN-HL 1118-1 digital image!). **Fig. 21, 23 & 24**

(*Frutex aquosus femina* Rumph. Herb. Amb. 4. 103. 1743, t. 45.)

Leea hirta Roxb. ex Hornem., Hort. Bot. Hafn. 1: 231. 1813; Roxb., Hort. Beng. 18. 1814, Fl. Ind. (Carey & Wall. ed.) 2: 469. 1824; DC., Prod. 1: 635. 1824; Blume, Bijdr. Fl. Ned. Ind. 1. 196. 1825; G.Don, Gen. His. 1: 713. 1831; Fl. Ind. (Carey ed.) 1: 656. 1832; Miq., Fl. Ned. Ind. 1(2): 612. 1859; Drury, Handb. Fl. Ind. 1: 182. 1864. *Leea scabra* Roxb. ex Roem. & Schult., Syst. Veg., ed. 15 bis [Roem. & Schult.] 4: 814, in obs. 1819. *Lectotype*: INDIA, 1815, *Wallich s.n.* (C barcode C10020286 digital image!).

Leea hirsuta Blume, Bijdr. Fl. Ned. Ind. 4: 197. 1825; Miq., Fl. Ned. Ind. 1(2): 612. 1859; Gagnep., Fl. Indo-Chine t.1: 939. 1909. *Type*: INDONESIA, **Java**, Buitenzorg, *s.d.*, *Blume s.n.* (L).

Leea kurzii C.B.Clarke, J. Bot. 19: 165. 1881. *Type*: INDIA, **Andaman Islands**, South Andaman, Water Cave, *s.d.*, *Kurz W.S. s.n.* (K barcode K000736384 digital image!).

Leea ancolana Miq., Fl. Ned. Ind. 1(2): 611. 1859. *Type*: INDONESIA, **Sumatra**, Tobing, *s.d.*, *Junghuhn s.n.* (U barcode U. 1764778 digital image!).

Leea aequata var. *villosissima* Hochr., Candollea 2: 424. 1925, **syn. nov.** *Type*: INDONESIA, **Java**, Nusa Kambangan Island, 29 Oct 1904, *Hochreutiner BPG 1866* (L barcode L 0744786 digital image!).

Shrubs, 0.5–3 m high; roots tuberous. Stems erect, stout, branched, young branches densely hairy; internodes furrowed, green; nodes not swollen, purple. Pearl glands globose, distributed on lower surface of leaves, brown. Leaves alternate, 1–2 pinnate, imparipinnate; petioles 7–21 cm long, swollen at base, furrowed, densely hispid mainly on nerves, green. Petiolar stipules 2.5–4.5 × 1–1.5 cm, obovate to

narrowly elliptic, hirsute, green; stipular scars 2.3–5 cm long, triangular; rachis 8–21 cm long, channelled on upper surface, hispid, green to purple. Leaflets opposite, oblong or broadly elliptic, distal leaflets: lamina 12–20.5 × 5–9.5 cm, lateral leaflets: lamina 6–17 × 3–7.5 cm; green above and pale green beneath, base cuneate or obtuse or rounded, margins sharply serrate or doubly serrate or dentate, apex long acuminate; petiolules: central 2–3.5 cm long, channelled on upper surface, hirsute, green, lateral 0.3–1.5 cm long, channelled on upper surface, hirsute, green or purple; secondary veins 7–18 pairs, usually 3-nerved at base, veins prominent on lower surface. Inflorescence a leaf-opposed terminal cyme, 3.5–16 cm long, branched, many-flowered, condensed; peduncles 1.5–5.5 cm long, lateral and ultimate branches short and condensed, furrowed, hirsute, green. Bracts 0.6–1.2 (–5.9) mm, lanceolate, early caducous, hirsute on margin, green. Flowers



Fig. 21. Type of *Leea aequata* L. [Linnaeus 1118. 1 (LINN barcode LINN-HL 1118-1)] © Permission of the Linnean Society of London.

4.8–5.2 mm long, actinomorphic, greenish-white. Pedicel slender, 1.3–1.5 mm long, hairy. Calyx campanulate, lobes 5, 3.4–3.7 × 2.6–2.9 mm, lobes 0.7–1.3 × 1.1–1.5 mm, apex acute, hairy, green. Corolla lobes 5, ovate, 3.1–3.6 × 1.6–1.8 mm, apex acute and hooded, margins entire, glabrous, green; corolla tube with floral disc 3.3–3.4 × 2.3–2.5 mm, white. Floral disc tubular, 2–2.1 mm long, white when young yellowish at maturity; upper free parts 1.6–1.8 mm long, deeply notched; sinuses shallow, 0.5–0.6 mm long; lower free parts 0.3–0.5 mm long. Stamens 5, syngeneis; filaments 1.2–1.4 mm long, glabrous, white; anthers 1.2–1.3 mm long, dorsifixed, dehisce longitudinally, yellow to white on lateral side, purplish on back. Ovary globose, 0.7–0.8 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1.3–1.6 mm long, slender, glabrous, yellow; stigma convex.

Systematic treatment

Fruits 0.5–1 cm diam., depressed globose, green turning to red, finally black. Seeds 6, wedge-shaped, 4.98–5.13 (5.04±0.04) × 3.74–3.91 (3.85±0.05) mm, dark brown when mature.

Flowering & fruiting: June–December.

Habitat: This plant grows in moist shady places, found mostly in secondary vegetation along with *Chromolaena odorata* (L.) R.M.King & H.Rob., (Asteraceae), *Commelina* sp. (Commelinaceae) etc.

Distribution: India (Andaman Islands, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram and West Bengal; Fig. 22), Cambodia, China, Java, Laos, Malaysia, Myanmar, Nepal, Philippines, Sumatra, Thailand and Vietnam.

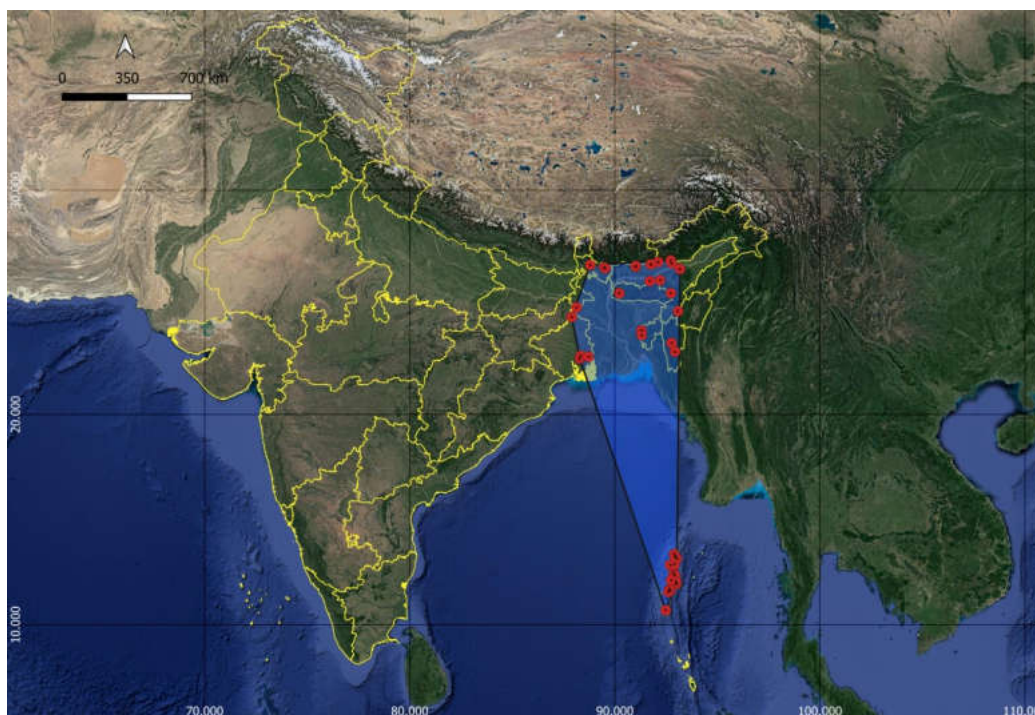


Fig. 22. Distribution of *Leea aequata* L. in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Andaman Islands**, Andaman, Oct 1900, Dr. Prain's Collector 95; *Ibid.*, Apr 1899, Dr. Prain's Collector s.n. (CAL); North and Middle Andaman district, After 15 no gate, Jarawa protected area, 10 July 2019, Amrutha 164056 (CALI barcode CALI172948); Bakultala, 06 Nov 1977, N. Bhargava 6395 (CAL, PBL barcode PBL0000005650); Basdik, towards Ushanagar, Diglipur, 08 July 2019, Amrutha 164032 (CALI barcode CALI172935, CALI172936); Diglipur, 09 July 2019, Amrutha 164052 (CALI barcode CALI172938, CALI172939); *Ibid.*, Mud

volcano, Shyamnagar, Radhanagar, 08 July 2019, *Amrutha* 164036 (CALI barcode CALI172937); Interview Island, Area near water tank No.1 Forest, 22 Sept 2010, G.S. Lakra & V.M. Radhakrishnan 28715 (PBL); Long Island, 17 Oct 1990, G.S. Lakra 15516 (PBL); *Ibid.*, 17 Oct 1990, G.S. Lakra 15534 (PBL); *Ibid.*, near Forest Rest House, 26 July 1965, N. Bhargava 2804 (PBL barcode PBL0000005652, PBL0000005653); Elphinstone Harbour, 08 June 1994, G.S. Lakra 16650 (PBL barcode PBL0000005656, PBL0000005657); Sikmandera Plot, 21 Oct 1990, G.S. Lakra 15534 (PBL); Mayabunder, 29 July 1974, N. Bhargava 1921 (CAL); Saddle Peak, Foot hill, along the Lamiya Bay, 07 July 2019, *Amrutha* 164025 (CALI); Sita Nagar Forest, 15 May 1982, V.K. Vasudeva Rao 9029 (CAL, PBL barcode PBL0000005646, PBL0000005647); Smith Island, 25 Nov 1976, N.C. Nair 4910 (CAL, PBL barcode PBL0000005648, PBL0000005649); South Andaman district, 10 km towards North from Poona Nallah, 26 July 1976, N. Bhargava 4257 (CAL); 5 Km from Ferragunj towards Barathang, 06 July 2019, *Amrutha* 164001 (CALI barcode CALI172931, CALI172932, CALI172933, CALI172934); Along Beach Dera R.F, Ferrargunj R.F., 16 Nov 2007, R.P. Pandey 26218 (PBL barcode PBL0000005672, PBL0000005673); Dundus point, Forest edge, 15 June 1993, N.P. Balakrishnan 249 (PBL barcode PBL0000005664, PBL0000005665); Havelock Island, 15 May 1974, R. Ansari 1355 (CAL, PBL barcode PBL0000005668, PBL0000005669); *Ibid.*, Camp No. 1, 10 Sept 1977, P.K. Premanath 6180 (CAL, PBL barcode PBL0000005666, PBL0000005667); *Ibid.*, Kalapathar, 02 Sept 1977, P.K. Premnath 6142 (CAL, PBL barcode PBL0000005674); Namunaghar-Hill Jungle, 01 Apr 1893, *King's Collector s.n.* (CAL); Pongi Balu, 10 July 2004, K. Karthigeyan 21455 (PBL barcode PBL0000005658, PBL0000005659!); Port Mouat-Hill Jungle, 17 Nov 1894, *King's Collector s.n.* (CAL barcode CAL0000209974); Ritchies Archipelago, Peel Island, 09 Oct 1985, Barim Ghosh 11507 (PBL barcode PBL0000005654, PBL0000005655); Viper Island, 29 July 1978, P. Basu 6679 (CAL barcode CAL0000209973, PBL barcode PBL0000005629).

Arunachal Pradesh, West Kameng district, Bhairabkunda, Amartala, 08 May 1958, G. Panigrahi 15209 (ASSAM, CAL). **Assam**, Baksa district, Indo-Bhutan border, Manas Wildlife Sanctuary, 07 June 1974, P.K. Hajra 57599 (ASSAM); *Ibid.*, 11 Feb 1974, P.K. Hajra 57324 (ASSAM); Darrang district, Bogamati, Barnadi Wildlife Sanctuary, 29 Sept 2010, C. Deori & D.K. Roy 119088 (ASSAM); Nalapara, Barnadi

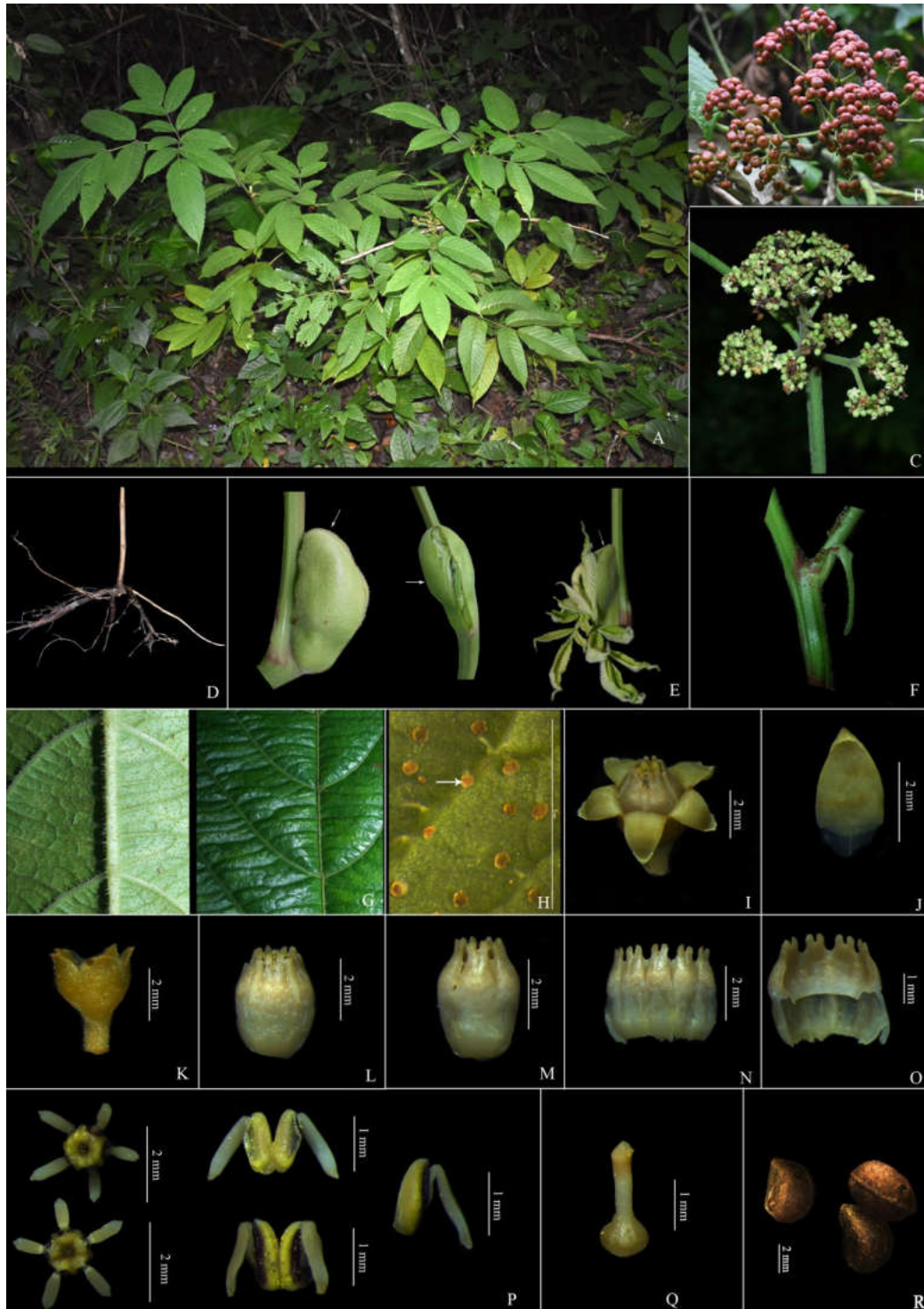


Fig. 23. *Leea aequata* L.: A. Habit; B. Infructescence; C. Inflorescence; D. Root; E. Petiolar stipule-different views; F. Bract; G. Leaf surfaces showing indumentum; H. Pearl glands; I. Flower; J. Corolla lobe; K. Calyx; L & M. Corolla tube with floral disc; N & O. Corolla tube with floral disc split open; P. Stamens; Q. Pistil; R. Seeds.

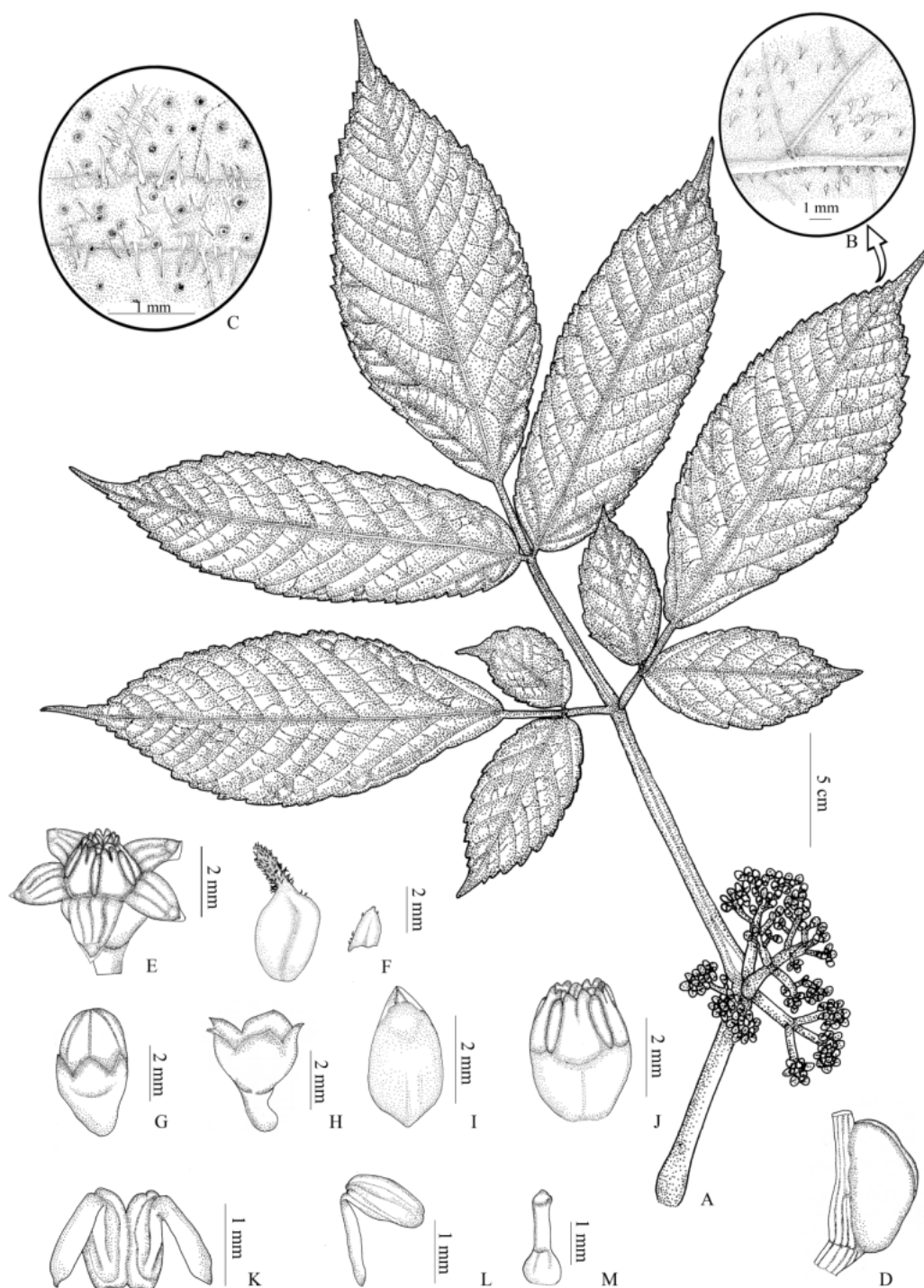


Fig. 24. *Leea aequata* L.: **A.** A twig with inflorescence; **B.** Adaxial surface of leaf; **C.** Abaxial surface of leaf; **D.** Petiolar stipule; **E.** Flower; **F.** Bracts; **G.** Flower bud; **H.** Calyx; **I.** Corolla lobe; **J.** Corolla tube with floral disc; **K & L.** Stamens; **M.** Pistil (Drawn by Amrutha A. from Amrutha 164036).

Wildlife Sanctuary, C. Deory & D.K. Roy 119009 (ASSAM); Orang-Barseola Road, 22 July 1958, G. Panigrahi 14224 (ASSAM, CAL). Dima Hasao district, Tumung Basti, Umrangso, 24 June 2007, R.S. Baruah 115633 (ASSAM). Golaghat district, Kaziranga Rain Forest, 21 Sept 1957, R.S. Rao 9705 (CAL); Panbari Reserve Kaziranga, 15 June 1963, D.B. Deb 34830 (ASSAM); Kamrup district, Garbhanga Reserve Forest, 25 May 1957, G. Panigrahi 9559 (ASSAM); Guwahati Zoological Garden from the vicinity of staff quarters, 02 July 1969, A.S. Rao 46074 (ASSAM, CAL); Jara-Reserve, Jirang Bazar, 24 May 1957, G. Panigrahi 9503 (CAL); Sattargaon, northeast of $\pm$ 8 miles of Rani, 14 June 1964, A.S. Rao 38825 (ASSAM); Morigaon district, Sonai Kushi Reserve Forest, South of Nakhola town, 18 Aug 1964, N.P. Balakrishnan 39202 (CAL); Sonitpur district, Balukpong to Tezpur, 1 km before Balipara, 01 June 2022, Amrutha 164718 (CALI). **Meghalaya**, Khasia, s.d., J.D. Hooker & J.J. Thomson s.n. (CAL); West Garo Hills district, Tura Peak, 03 June 2022, Amrutha 164734 (CALI). **Mizoram**, Aizawl district, Way to Tamdil from Aizawl, 28 Aug 2018, Amrutha 159891 (CALI); Serchhip district, Zero point, Tenzwal & Serchhip, 09 June 2022, Amrutha 164771 (CALI). **West Bengal**, Alipurduar district, Jayanthi Hill Forest, BTR east, 14 Nov 1999, A.K. Ghosh 20409 (CAL); Birbhum district, Paikar, 30 Oct 1963, Basak 1165 (CAL); Rajabhatkhawa Forest, s.d., A.K. Ghosh 20448 (CAL); Jalpaiguri district, Buxa road, 04 Sept 1981, B. Safui & Party 10309 (CAL); Chuk-Chuki, Gorumara National Park, 19 Sept 2008, V. Ranjan & Anant Kumar 44438 (CAL); Hooghly district, Konnagar, 13 Jan 1971, K.L. Mitra 6 (CAL); Howrah district, Baksara, Howrah, 08 June 1961, D.C. Bhowmik 13 (CAL); Malda district, Gour, 18 Nov 1965, R.M. Dutta 13 (CAL); North 24 Parganas district, Manikpur, 04 Aug 1961, G. Sengupta 21 (CAL); Tentulia, 31 July 1981, G.N. Tribadi 599 (CAL); South 24 Parganas district, Narendrapur Wildlife Sanctuary, 15 Dec 2008, C. Ghora 44710; *Ibid.*, 08 May 2008, C. Ghora & Party 40288; *Ibid.*, 23 Dec 2008, C. Ghora & Party 44794 (CAL).

Notes: *Leea aequata* can easily be identified from the herbarium by its persistent calyx. This species can easily be distinguished by its peculiar brown pearl glands mainly on the abaxial surface of the leaves, a feature shared by no other species in the genus. Even though the pearl glands are found in Vitaceae, they are early

caducous and very less in number unlike in *L. aequata*, which has an abundance of brown pearl glands almost all over.

3. *Leea alata* Edgew., Trans. Linn. Soc. London 20(1): 36. 1846; J.L.Stewart & Brandis, Forest Fl. N.W. India 102. 1874; M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 665. 1875; C.B.Clarke in Trimen's J. Bot. 19: 101. 1881; Duthie, Fl. Up. Gangetic Plain 1(1): 175. 1903; Brandis, Ind. Trees 179. 1906; Kanjilal & Das, Fl. Assam 1(2): 303. 1936; Ridsdale, Blumea 22: 91. 1974; Harid. & R.R.Rao, Fl. Meghalaya 248. 1985; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 317. 1996; R.Shanpru in N.P.Singh *et al.* (eds.), Fl. Manipur 1: 240. 2000; B.K.Shukla in K.P. Singh *et al.* (eds.), Fl. Uttar Pradesh 1: 350. 2016; Pusalkar & S.K.Srivast., Fl. Uttarakhand 1: 987. 2018. *Lectotype* (designated by Ridsdale, 1974): INDIA, **Uttarakhand** ('Uttaranchal', N.W. India), Dehradun ('Deyra Dhoun'), 1844, *Edgeworth* 319 (K barcode K000736383 digital image!).

Fig. 25

Shrubs, internodes furrowed. Leaves alternate, 1-pinnate, imparipinnate; petioles 3–4.5 cm long, swollen at base, furrowed. Petiolar stipules 2.5–4 cm long, narrow winged; rachis 3–13 cm long, furrowed. Leaflets opposite, oblong or broadly elliptic, distal leaflets: lamina 11–22 × 4.5–8.5 cm, lateral leaflets: lamina 11.5–25 × 2–8.5 cm; base cuneate or obtuse or obtuse, margins serrate, apex acute; petiolules: central 2–4 cm long, channelled on upper surface, hispid, green, lateral 0–0.7 cm long, hispid, channelled on upper surface, green or purple; secondary veins 6–12 pairs, usually 3-nerved at base, veins prominent on both surfaces. Inflorescence a leaf-opposed terminal cyme, 13–36 cm long, branched,



Fig. 25. Lectotype of *Leea alata* Edgew. [Edgeworth 319 (K barcode K000736383)] © Board of Trustees of the Royal Botanic Gardens, Kew.

many flowered; peduncles 10.5–29 cm long, furrowed, glabrous. Flowers red.

Flowering: June–September, fruiting not observed.

Distribution: India (Arunachal Pradesh, Assam, Uttarakhand, Uttar Pradesh, Manipur, Meghalaya, Sikkim, West Bengal; Fig. 26).



Fig. 26. Distribution of *Leea alata* Edgew. in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, N.W. India, *s.d.*, *Herb. Royle 903* (CAL). **Assam**, Barpeta district, Manas Wildlife Sanctuary, Bansbari- Mathanguri Road, 06 June 1974, *P.K. Hajra 57542* (ASSAM); Dima Hasao district, Umrangso, Tumbung Basti, 24 June 2007, *R.S. Barush 115646* (ASSAM); Goalpara district, Western Range, 09 Sept 1937, *G.K. Dekha 17554* (ASSAM); Kamrup district, Lukikhas Forest, about 2 miles south of Singra, 26 June 1964, *A.S. Rao 39118* (ASSAM); Lakhimpur district, Lakhimpur, Mar 1980, *s.coll. s.n.* (ASSAM). **Uttarakhand**, Dehradun district, Jhajra Forest, 04 Aug 1968, *K.M. Vaid 5304* (DD); Lachhiwala, Aug 1894, *J.S. Gamble 24682* (DD); Manak sidh, 19 Sept 1954, *T.S. Negi s.n.* (DD). **Uttar Pradesh**, Bahraich district,

Bahraich, 29 June 1998, *Harsukh* 21359 (CAL, D); Pilibhit district, Bargad, Pilibhit division, 23 June 1902, *Juaijat* 26059 (DD). **Sikkim**, *s.loc.*, 1878, *G. King s.n.* (CAL).

Notes: Despite our best efforts, we were not able to collect *L. alata* from the wild.

4. *Leea angulata* Korth. ex Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 97. 1863; C.B.Clarke in Trimen's J. Bot. 19: 166. 1881; King, J. Asiat. Soc. Bengal 65(2): 414. 1896; Gagnep., Bull. Soc. Bot. France 57: 334. 1910; Ridl., Fl. Malay Penins. 1: 485. 1922; M.R.Hend., Gard. Bull. Straits Settlement. 4, series 3: 242. 1928; Merr., Enum. Philipp. Fl. Pl. 3: 11. 1922; Backer & Bakh.f., Fl. Java 2: 94. 1965; Ridsdale, Blumea 22: 84. 1974, Fl. Males., Ser. 1, Spermat. 1. 7: 772. 1976; H.Keng, Gard. Bull. Singapore 45: 87. 1982; Lok *et al.*, Nat. Singap. 4: 59. 2011; B.K.Sinha, Fl. Great Nicobar Isl. 194. 1999; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 306. 1999; Jayanthi, Fl. Campbell Bay Natl. Park 92. 2017. *Lectotype* (designated by Ridsdale, 1974): INDONESIA, **Java**, Krawang, *s.d.*, *Korthals s.n.* (L barcode L 2329638!). **Figs. 27, 29–31**

Leea sambucina var. *intermedia* Ridl. J. Straits Branch Roy. Asiat. Soc. 45: 18. 1906. *Type:* Christmas Island, *Ridley s.n. (n.v.)*.

Trees, 4–7 m high; roots non-tuberous. Stems erect, stout, prickled, branched; internodes furrowed, green; nodes not swollen. Pearl glands pink, globose, mainly distributed in leaves. Leaves alternate, 1–2 pinnate, imparipinnate; petioles 2–5.3 cm long, swollen at base, furrowed, glabrous, green. Petiolar stipule 2–4.5, narrow winged, mostly half of the length of petiole, glabrous, green; stipular scar 2–4 cm long, triangular; rachis 5.5–15 cm long, channelled on upper side, glabrous, green. Leaflets opposite, narrowly to widely ovate or widely elliptic, distal leaflets: lamina 4.5–10.5 × 1.5–4 cm, lateral leaflets: lamina 1.5–11.5 × 0.8–4 cm; glabrous, green above and pale green beneath, base



Fig. 27. Lectotype of *Leea angulata* Korth. ex Miq. [*Korthals s.n.* (L barcode L 0744733)] © National Herbarium, Leiden University, Leiden, Netherlands.

obtuse to cuneate, margins crenate or serrate, apex long acuminate; petiolules: central 1–2.6 cm long, glabrous, green; lateral 0.3–0.8 cm long, glabrous, green; secondary veins 3–8 pairs, usually 3-nerved at base, veins prominent on both surfaces, glabrous. Inflorescence a leaf-opposed terminal cyme, 4.5–13 cm long, branched, many flowered, condensed; peduncles 2–9 cm long, furrowed, glabrous, green. Bracts small, 1.3–1.6 × 0.7–0.9 mm, early caducous, hispid, green. Flowers 5.8–6.3 mm long, numerous, actinomorphic, greenish-white. Pedicels slender, 2–2.5 mm long, hairy. Calyx campanulate, 3.3–4.5 × 2.4–2.6 mm, lobes 5, 0.4–0.6 × 0.7–1 mm, apex acute or short acuminate, hispid, green. Corolla lobes 5, narrowly to broadly ovate, 2.4–2.6 × 1.4–1.5 mm, apex acute, hooded, margins entire, glabrous, green; corolla tube with floral disc 3–3.2 × 2.1–2.2 mm, white. Floral disc tubular, 2.4–2.6 mm long, white when young yellowish at maturity; upper free parts 1.7–1.9 mm long, slightly notched; sinuses shallow, 0.2–0.3 mm long; lower free parts 0.5–0.7 mm long. Stamens 5, syngeneious; filaments 1.2–1.3 mm long, glabrous, white; anthers 1.3–1.4 mm long, dorsifixed, dehisce longitudinally, brownish on back. Ovary globose, 0.8–1.1 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1.2–2.2 mm long, slender, glabrous; stigma convex. Fruit up to 1 cm diam., grey at young turning black at maturity. Seeds 6, more or less obconic, 3.7–3.9 × 3–3.3 mm, light brown when mature.

Flowering & fruiting: June–December.

Habitat: This species usually prefers to grow in open areas and coastal forests. The associates are *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), Pteridophytes etc.

Distribution: India (Nicobar Islands; Fig. 28), Malaysia, Peninsular Thailand and Singapore.

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Nicobar districts, 34.1 Km away from Campbell Bay towards Galathea, 17 July 2019, *Amrutha* 164079 (CALI barcode CALI172950, CALI172951, CALI172952); Campbell bay, 24 Aug 1975, N.P. Balakrishnan 3069 (PBL PBL0000005709, PBL0000005710); *Ibid*; Be-Caury beachside, 16 July 2019, *Amrutha* 164067 (CALI barcode CALI172953, CALI172954); *Ibid.*, Near Panchayath guest house, 18 July 2019, *Amrutha* 164096 (CALI barcode CALI172955!); *Ibid.*, Near Sri Muthumani Amman Temple, 16 July 2019, *Amrutha* 164068 (CALI barcode CALI172941, CALI172942, CALI172943, CALI172944,

CALI172945, CALI172946, CALI172947, CALI172948, CALI172949); Car Nicobar, Mar 1891, *David Prain s.n.* (CAL); *Ibid.*, North Nicobar, Malacca, 06 June 1976, *N.C. Nair 1504* (PBL barcode PBL0000005712); East West Road, 06 June 2012, *S. Prabhu & R. Sathiyaseelan 918* (PBL barcode PBL0000031634); Great Nicobar, Dongi Nallah, South Nicobar, 11 Jan 2004, *J. Jayanth 19464* (PBL barcode PBL0000005705, PBL0000005706); *Ibid.*, 38 Km on North-South Road, 28 Oct 1979, *D.K. Hore 7726* (CAL barcode CAL0000209967, PBL, PBL0000005708); Katchal, *s.d.*, *S. Kurz s.n.* (CAL); *Ibid.*, Ram Nagar, 10 Mar 2012, *S. Prabhu & R. Sathiyaseelan 467* (PBL barcode PBL0000031176); Pulo Panja, Little Nicobar, 03 May 2008, *C. Murugan 26433* (PBL PBL0000025833, PBL0000025834); South Nicobar, Galathea to Pygmalion Point, 18 July 1976, *N.P. Balakrishnan 3857* (PBL barcode PBL0000005713, CAL barcode CAL0000209966).

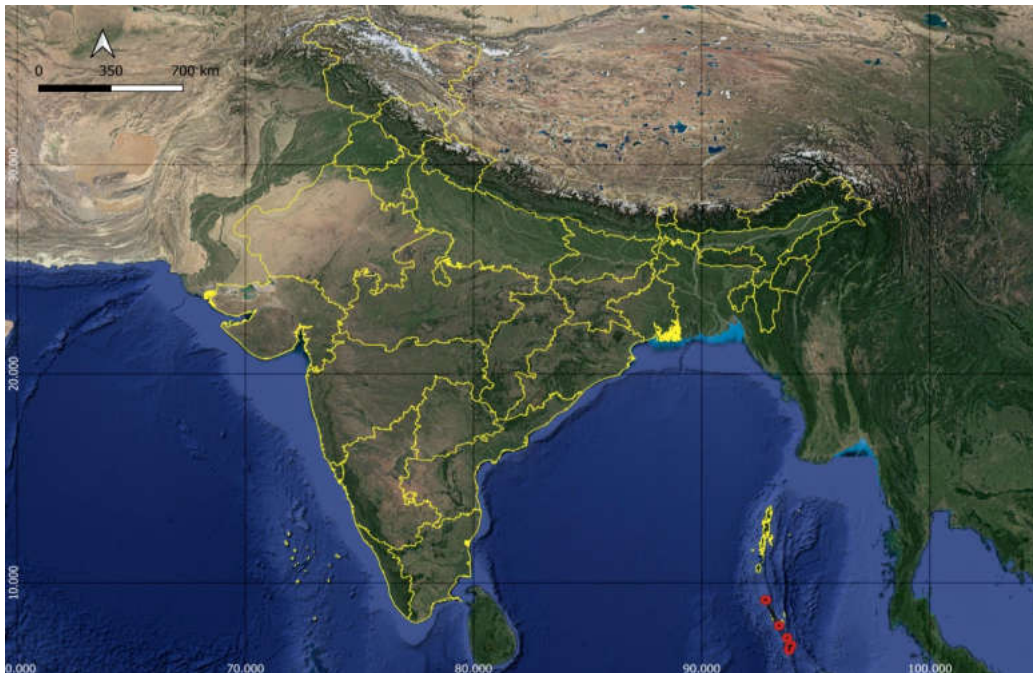


Fig. 28. Distribution of *Leea angulata* Korth. ex Miq. in India (drawn using QGIS version 3.24.3).

Notes: *Leea angulata* is one among the four spiny species of *Leea*. In India, this species is only seen in the Nicobar Islands of the Andaman and Nicobar. It is closely allied to *L. adwivedica*, a spine-bearing species described by Kumar (2000) from the Andaman Islands. Even though both species are spiny and have winged petiolar stipules, this species can be easily identified by the crenate margins of leaves, shorter lower part of floral disc and the young fruits being greyish.



Fig. 29. *Leea angulata* Korth. ex Miq.: **A.** Habit; **B & C.** Stems showing spines.

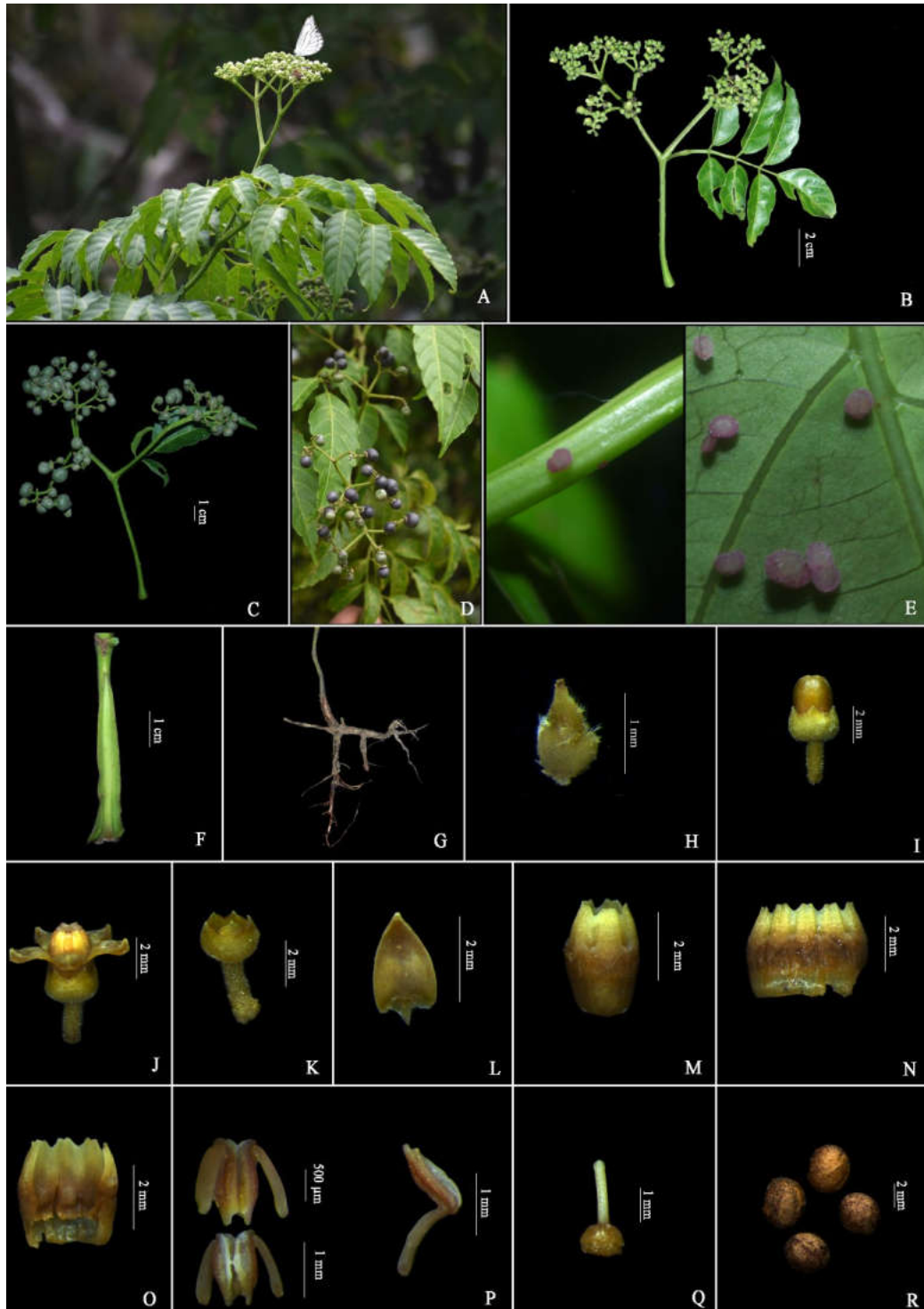


Fig. 30. *Leea angulata* Korth. ex Miq.: A & B. Inflorescence; C & D. Infructescence; E. Pearl glands on the lower leaf surface; F. Petiolar stipule; G. Root; H. Bract; I. Flower bud; J. Flower; K. Calyx; L. Corolla lobe; M. Corolla tube with floral disc; N & O. Corolla tube with floral disc split open; P. Stamens; Q. Pistil; R. Seeds.



Fig. 31. *Leea angulata* Korth. ex Miq.: **A.** A twig with inflorescence; **B.** Stem; **C.** Petiolar stipule; **D.** Bract; **E.** Flower bud; **F.** Flower; **G.** Calyx; **H.** Corolla lobe; **I.** Corolla tube with floral disc; **J & K.** Stamens; **M.** Pistil (Drawn by Amrutha A. from Amrutha 164096).

5. *Leea asiatica* (L.) Ridsdale, Bot. Hist. Hort. Malabaricus 189. 1980; N.C.Nair & A.N.Henry, Fl. Tamil Nadu 82. 1983; G.Panigrahi & S.K.Murti, Fl. Bilaspur Dist. 169. 1984; B.D.Naithani, Fl. Chamoli 128. 1984; Manilal, Fl. Silent Valley 61. 1988; V.S.Ramach. & V.J.Nair, Fl. Cannanore 107. 1988; B.G.Kulkarni, Fl. Sindhudurg 88. 1988; J.L.Ellis, Fl. Nallamalais 107. 1990; S.M.Almeida, Fl. Savantwadi 1: 105. 1990; Lakshmin. & B.D.Sharma, Fl. Nasik Dist. 131. 1991; S.K.Malhotra & S.Moorthy, Fl. Taroba Natl. Park 37. 1992; Karthik. & An.Kumar, Fl. Yavatmal Dist. 43. 1993; K.K.Khanna in D.M.Verma (ed.), Fl. Madhya Pradesh 1: 293. 1993; Sivar. & P.Mathew, Fl. Nilambur 156. 1996; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 318. 1996; N.D.Paria & S.P.Chattopadhyay, Fl. Hazaribagh Dist. 491. 2000; R.Shanpru in N.P.Singh *et al.* (eds.), Fl. Manipur 240. 2000; T.K.Sarma & A.K.Sarkar, Fl. Palamau Dist. 155. 2002; S.R.Yadav & Sardesai, Fl. Kolhapur Dist. 122. 2002; R.Mathur in N.P.Singh *et al.* (eds.), Fl. Jammu & Kashmir 1: 840. 2002; Anand Kuar, Fl. Indravati Tiger Reserve 78. 2003; K.G.Bhat, Fl. Uduppi 116. 2003; Arisdason *et al.* in P.Daniel (ed.), Fl. Kerala 1: 765. 2005; S.G.Pradan & B.D.Sharma, Fl. Sanjay Gandhi Natl. Park 170. 2005; Puneekar & Lakshmin., Fl. Anshi Natl. Park 162. 2011; R.Manikandan & Lakshmin., Fl. Rajiv Gandhi Natl. Park 113. 2013; Datar & Lakshmin., Fl. Bhagavan Mahavir Natl. Park 81. 2013; K.G.Bhat, Fl. South Kanara 309. 2014; G.D.Pal, Fl. Lower Subansiri Dist. 1: 214. 2013; B.K.Shukla in K.P.Singh *et al.* (eds.), Fl. Uttar Pradesh 1: 351. 2016; K.N.Reddy & C.S.Reddy, Fl. Telangana 148. 2016; S.S.Dash & P.Singh, Fl. Kurung Kumey Dist. 383. 2017; Pusalkar & S.K.Srivast., Fl. Uttarakhand 1: 988. 2018. *Phytolacca asiatica* L., Sp. Pl. 474. 1753. *Type*: Rheede, Hort. Mal. 2: t.26. 1679.

Figs. 32, 34–38

Leea crispa L., Mant. Pl. 124. 1767; Linnaeus, Syst. Nat. ed. 2. 2: 627. 1767; DC., Prodr. I. 635. 1824; Roxb., Fl. Ind. (Carey & Wallich ed.) 2: 468. 1824; G.Don, Gen. Hist. 1: 712. 1831; Roxb., Fl. Ind. (Carey ed.) 1: 655. 1832; Miq., Ann. Mus. Bot. Lugduno-Batavum 1: 95. 1863; M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 665. 1875; Kurz, Forest Fl. Burma 1: 280. 1877; C.B.Clarke in Trimen's J. Bot. 19: 135. 1881; T.Cooke, Fl. Bombay 1: 259. 1903; Prain, Bengal Pl. 1: 340. 1903; Talbot, Forest Fl. Bombay 1: 327. 1909; Gamble, Fl. Madras 1: 240. 1918; Ridsdale, Blumea 88. 1974; Deb, Fl. Tripura 1: 419. 1981; A.K.Mukh., Fl. Pachmarhi & Bori Reserves 68. 1984; Guha Bakshi, Fl. Murshidabad Dist. 91. 1984; Chowdhery & Wadhwa, Fl. Himachal Pradesh 1: 157. 1984; Harid. & R.R.Rao, Forest Fl. Meghalaya 249. 1985; D.M.Verma

et al. (eds.), Fl. Raipur, Durg & Rajnandgaon 78. 1985; R.S.Rao, Fl. Goa, Diu, Daman, Dadra & Nagarhaveli 1: 86. 1985; Kothari & Moorthy, Fl. Raigad Dist. 71. 1993; S.D.Deshp. *et al.*, Fl. Mahabaleshwar & adjoining 142. 1995; A.S. Chauhan, Fl. Namdapha 141. 1996; R.N.Banerjee, Fl. West Bengal 1: 452. 1997; V.Abraham, Fl. Trombay 20. 1997; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 318. 1996; P.K.Bhattach. & K.Sarkar, Fl. West Champaran Dist. 227. 1998. *Type*: SOUTH AFRICA, Cape of Good Hope Province, *Royen, A. Van & Linnaeus, C.* 59 (LINN Barcode LINN-HL 1118-2 digital image!).

Leea pinnata Andrews, Bot. Repos. 5: t. 355. 1804. *Type*: Bot. Repos. 5: Andrews plate 355.

Leea herbacea Buch.-Ham., Trans. Linn. Soc. London 14(1): 228–229. 1823; C.B. Clarke in Trimen's J. Bot. 19: 137. 1881; R.S.Rao, Fl. Goa, Diu, Daman, Dadra & Nagarhaveli 1: 86. 1985; Prain, Bengal Pl. 1: 340. 1903; Brandis, Ind. Trees 180. 1906; Haines, Fl. Chota Nagpur 280. 1910; Gamble, Fl. Madras 1: 240. 1918. *Type*: INDIA, **Bihar**, Munger ['Mungger'], *Hamilton* 606 (E, Barcode E00393045 digital image!).

Leea aspera Wall. ex G.Don, Gen. Hist. 1: 713. 1831, *syn. nov.* *Type*: NEPAL, Wallich 6824 G (K Barcode K001124910 digital image!).

Leea aspera Edgew., Trans. Linn. Soc. London 20(1): 36. 1846. *nom. illeg.*; M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 665. 1875; Clarke in Trimen's J. Bot. 19: 136. 1881; T.Cooke, Fl. Bombay 1: 259. 1903; Duthie, Fl. Up. Gangetic Plain 1(1): 176. 1903; Brandis, Ind. Trees 180. 1906; Haines, Fl. Chota Nagpur 280. 1910; Gamble, Fl. Madras 1: 240. 1918. *Leea edgeworthii* Santapau in Rec. Bot. Surv. India 16: 54. 1953; V.Singh, Fl. Banswara Rajasthan 64. 1983; S.Y.Kamble & S.G.Pradhan, Fl. Akola Dist. 46. 1988; Oommachan & Shrivastava, Fl. Jabalpur 66. 1996. *Lectotype* (designated by Ridsdale, 1974): Himalaya, 1814, *M.P. Edgeworth* 318 (K barcode K000736569 digital image!).

Leea pumila Kurz, J. Asiat. Soc. Bengal Pt. 2. 41(4): 302. 1872; M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 666. 1875. *Type*: MYANMAR, Bago ('Pegu'), Karen Country and Hills, Toukyeghat, *s.d.*, *Kurz* 107 (K barcode K000736372 digital image!).

Subshrubs to shrubs, 1–5 m high; roots tuberous. Stems erect, stout, jointed, crisped or furrowed glabrous, with branching; nodes swollen. Pearl glands globose, white. Leaves alternate, quinate-pinnate, pinnate or bipinnate, imparipinnate; petioles 1.5–

4 cm long, swollen at base, furrowed or crispate, glabrous, green. Petiolar stipules 1.5–13 × 1–2 cm, falcate, glabrous, creamy, green or pink; stipular scars triangular, as long as the length of petiole; rachis 3–17 cm long, furrowed or crispate, glabrous, green. Leaflets opposite, ovate-oblong or elliptic, distal leaflets: lamina 7–18.5 × 2.5–9.5 cm; lateral leaflets: lamina 3–23 × 2–10 cm, dark green above and pale green beneath, adaxial surface glabrous or 1–3 rows of stiff hairs in between nerve pairs, abaxial surface glabrous to hispid, base cordate or obtuse, or round, margins crenate or serrate to sharply serrate, apex acute, caudate or acuminate; petiolules: central 2–8 cm long, channelled on upper surface, glabrous, green; lateral 0.5–2.5

cm long, glabrous, channelled on upper surface, green; secondary veins 5–16 pairs, 5-nerved at base, veins more prominent on lower surface, hispid. Inflorescence a leaf-opposed terminal cyme, 1.5–16 cm long, branched, lateral branches angled; peduncles 0.5–6.5 cm long, furrowed or moderately crispate, glabrous, green. Bracts 1–3 mm long, narrowly to widely triangular, green, persistent, hispid.

Flowers 4.5–6.7 mm long,

actinomorphic, greenish-white or greenish pink. Pedicel slender, 1.3–2.5 mm long, hispid, green. Calyx campanulate, 3–5 × 2–2.6 mm, lobes 5, the lobes 0.7–1.3 × 1.1–1.3 mm, apex obtuse to rounded, green. Corolla lobes 5, ovate, 2.8–4 × 1.2–1.6 mm, apex acute, hooded, margins entire, glabrous or with small glands, green; corolla tube with floral disc 3.5–3.8 × 2.2–2.6 mm. Floral disc tubular, 3–3.3 mm long, white or white tinged with pink at apex; upper free parts 1.8–2.2 mm long, slightly notched; sinuses shallow, 0.6–0.9 mm long; lower free parts 0.85–1.1 mm long, almost the length of the corolla tube. Stamens 5, free; filaments 1.25–1.5 mm long, glabrous, white; anthers 1–1.4 mm long, dorsifixed, dehisce longitudinally, two longitudinal slits, white on lateral side, purplish on back. Ovary globose, 1–1.1 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1–1.8 mm long, slender, glabrous, green; stigma convex. Fruit 1–1.2 cm diam., depressed



Fig. 32. Type of *Leea asiatica* (L.) Ridsdale [Rheede, Hort. Mal. 2: t.26. 1679].

Systematic treatment

globose, green turning to black at maturity. Seeds 6, more or less obconic, smooth, $4.03\text{--}4.31 \times 3.35\text{--}3.72$ mm.

Flowering & fruiting: June–December.

Habitat: *Leea asiatica* prefers a variety of habitats such as rock crevices, Ghats margins and roadsides. It is found growing along with *Adiantum* sp. (Pteridaceae), *Impatiens minor* (DC.) Bennet, *I. balsamina* L. (both Balsaminaceae) and some grasses.

Distribution: India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Himachal Pradesh, Jammu, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Orissa, Rajasthan, Sikkim, Tamil Nadu, Telangana, Tripura, Uttar Pradesh, Uttarakhand, and West Bengal; Fig. 33), Bangladesh, Bhutan, Cambodia, China, Laos, Myanmar, Nepal, Thailand and Vietnam.

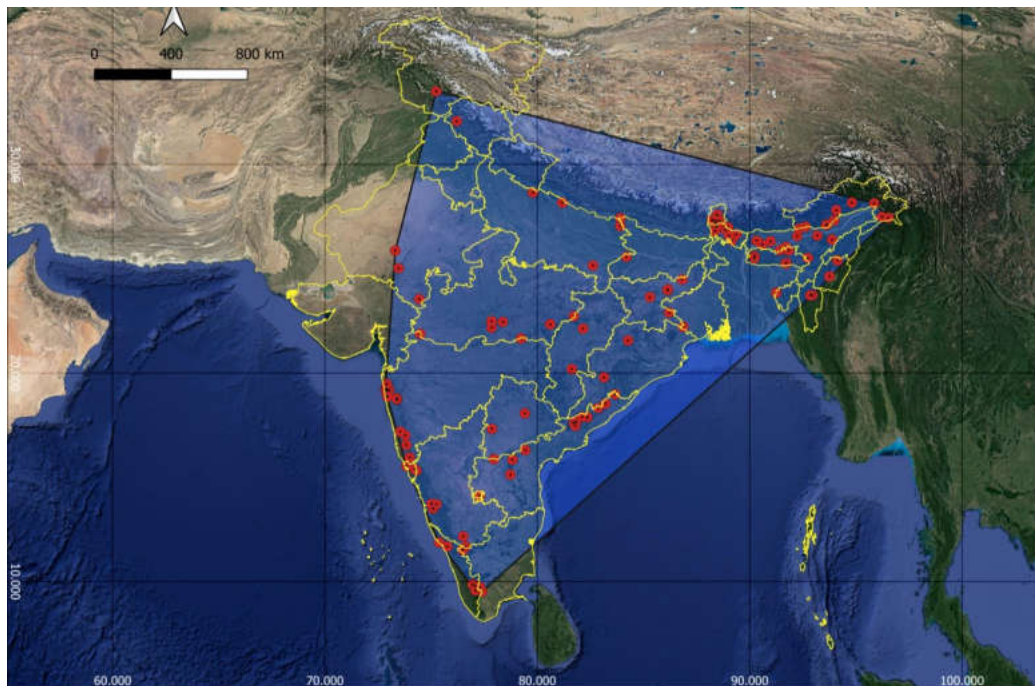


Fig. 33. Distribution of *Leea asiatica* (L.) Ridsdale in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Andhra Pradesh**, Alluri Sitharama Raju district, Araku Valley, 15 Sept 1961, *N.P. Balakrishnan* 577 (CAL); Chintapalli, 28 Aug 1966, *G.V. Subbarao* 28132 (MH); Maredumilli, 22 June 1965, *G. V. Subbarao* 24283 (MH); East

Godavari district, Near Kakur teak, 21 Sept 1980, G. V. Subba Rao 68506 (BSID BSID0008115); Godavari district, Rampa Hill, 08 Aug 1914, M.S. Ramaswami 1556 (CAL); Kurnool district, Pecheruvu R.F., 03 Dec 1984, R.R.V. Raju 2189 (CAL); Nandyal district, Way to upper Ahobilam, 29 Aug 1965, J.E. Ellis 25578 (MH); Prakasam district, Rolla Penta, 14 Aug 1972, J.E. Ellis 42263 (MH); Srikakulam district, Salur Forest, 10 Sept 1962, N.P. Balakrishnan 1074 (CAL); Visakhapatnam district, Galikonda area, 13 Oct 1964, G. V. Subba Rao 21663 (MH); Vizianagaram district, Elwinpeta, 15 Aug 1957, S.K. Wagh 7016 (BLAT). **Arunachal Pradesh**, Changlang district, Miao Forest, 05 Aug 2018, Amrutha 159828 (CALI); Namdapha National Park, 25 Dec 1993, A.S. Chauhan 99528 (ASSAM); *Ibid.*, 05 Aug 2018, Amrutha 159830 (CALI); Lower Dibang Valley district, Roing, 24 Aug 2018, Nikhil Krishna 159872 (CALI); Lower Subansiri district, Kimin-Khuni-Pahar, 24 Sept 1959, G. Panigrahi 19337 (CAL); Papum Pare district, Itanagar, 20 July 1994, G.D. Pal 6375 (ARUN); *Ibid.*, Senki View, 30 May 2022, Amrutha 164711 (CALI); West Kameng district, After 2 km from Bhalukpong, on the way to Sessa, 01 June 2022, Amrutha 164720 (CALI); West Siang district, Aalo, 19 Aug 2018, Amrutha 159853 (CALI). **Assam**, Barpeta district, Baguri, 18 Aug 1975, P.K. Hajra 52338 (ASSAM); Darrang district, Silbori Range office surroundings, 30 Nov 1975, P.K. Hajra 65354 (BLAT); Dima Hasao district, Umrangso, Tumbung Basti, 17 June 2022, Amrutha 164785 (CALI); Golaghat district, Kazhiranga National Park, Daflang beel, 14 Apr 1975, P.K. Hajra 63034 (ASSAM); Golpara district, Goalpara, 12 July 1919, Upendranath Kanjilal 7580 (BLAT); Kamrup Metropolitan district, Garbhanga Forest of south Kamrup, 13 June 1964, A.S. Rao 38788 (ASSAM, CAL); Chandubi Lake, North and North West of Rajapara, 17 May 1964, R.S. Rao 38880 (ASSAM); Karbi Anglong district, Garampani, 30 Oct 1956, G. Panigrahi 4288 (ASSAM); Kokrajhar district, Kokrajhar, Chakrashila Wildlife Sanctuary, 24 June 2006, Ranjit Daimary 111623 (ASSAM); Lakhimpur district, North Lakhimpur, 13 May 1966, D.M. Varma 42218 (ASSAM); *Ibid.*, Innerline beyond Kimin River, 23 Nov 1957, G. Panigrahi 11494 (ASSAM, CAL); Kakoi Reserve, 13 May 1966, D.M. Varma 46218 (ASSAM); Sonitpur district, Near Lama Camp, Sonai Rupai Sanctuary, 10 Apr 1976, P.K. Hajra 65409 (ASSAM). **Bihar**, Madhubani district, Ganauli Forest, July 2002, Rajeev Kr. Singh 30923 (CAL); West Champaran district, Naurangia 12 Sept 1965, S.P. Banerjee

445 (CAL); Kotraha Forest, Valmiki Tiger Reserve, July 2002, *Rajeev Kr. Singh* 31033 (CAL); Valmiki Nagar Forest, July 2002, *Rajeev Kr. Singh* 30967 (CAL). **Chhattisgarh**, Kondagaon district, Keshkal, 23 Aug 1959, *K. Subhramanyam* 8581 (MH). **Goa**, North Goa district, Porvorim, 04 Sept 1983, *K.C. Kanodia* 89760 (BSI); South Goa district, Dudhsagar, 17 Sept 1976, *Ansari* 124025 (BSI); Molem- Belgaum Road, 17 Sept 1970, *N.P. Singh* 124205 (BSI). **Jharkhand**, Deoghar district, Trikut Hill, *s.d.*, *J.K. Das & Party* 22343 (CAL); Giridih district, Parasnath Wildlife Sanctuary, 19 Nov 2003, *Vinay Ranjan & K.L. Maity* 33624 (CAL); *Ibid.*, 02 Oct 2004 *Vinay Ranjan & K.L. Maity* 37200 (CAL); Hazaribagh district, Madhuban, 05 Oct 1883, *C.B. Clarke* 33661 (CAL); Jamshedpur district, Pindraber, Dalma Wildlife Sanctuary, 15 Sept 2000, *P. Chakraborty & P. Satyanarayana* 28710 (CAL); Ramgarh district, Patratu, *s.d.*, *s.coll.* 24072 (CAL). **Karnataka**, Chamarajanagar district, Way to Bandipur, 26 Aug 1964, *B.D. Naithani* 21238 (MH); Mysuru district, Katedevargudi, 04 Sept 1961, *A.S. Rao* 73611 (BSI); Shimoga district, Agumbe, Cattle shed, Nalur Road, 17 June 1961, *R. Sundara Raghavan* 74139 (CAL, BSI); *Ibid.*, Someswar Ghat, 30 Aug 1963, *R. Sundara Raghavan* 90322 (CAL); Hulikal, 22 May 1962, *R. Sundara Raghavan* 80918 (CAL); *Ibid.*, 28 June 1963, *R. Sundara Raghavan* 90285 (CAL); Tirthahalli, 24 May 1962, *R. Sundara Raghavan* 80945 (CAL); Tumkur district, Pavagada, 28 Oct 1965, *J.L. Ellis* 25738 (MH); Uttara Kannada district, Benne Forest, 19 July 1960, *K. Subhramanyam* 10474 (MH). **Kerala**, Idukki district, Anchuruli- Thekkadi, 04 Oct 1972, *B.D. Sharma* 42411 (MH); Painav, 25 May 1982, *C.N. Mohanan* 74008 (CAL, MH); Vandiperiyar, 25 May 1965, *K. Vivekanandham* 24328 (MH); Kannur district, Chandanathode, 08 Nov 1978, *V.S. Ramachandran* 58613 (CAL, MH); *Ibid.*, 29 Apr 1979, *V.S. Ramachandran* 61639 (CAL, MH); *Ibid.*, Way to Mananthody, 24 June 1965, *J.L. Ellis* 25114 (MH); Kozhikode district, Kuttiyadi, Submerged area, 24 June 1965, *B.D. Naithani* 24182 (CAL). **Madhya Pradesh**, Anuppur district, Between Amarkhantak & Mai Ki Bagiya, 28 Oct 1960, *J.K. Maheshwari* 4293 (CAL); Balaghat district, Kanha National Park, 31 July 1964, *George Sehaller* 196 (CAL); Betul district, Baretha Ghat, 19 July 1964, *G. Panigrahi* 4273 (CAL); Chhindwara district, Sanwari, 23 July 1964, *G. Panigrahi* 4388 (CAL); Indore district, 1 ½ miles east of Khurdi, 19 Oct 1962, *A.S. Rao* 83901 (CAL);



Fig. 34. *Leea asiatica* (L.) Ridsdale: **A-O.** Different populations showing variations in habit.

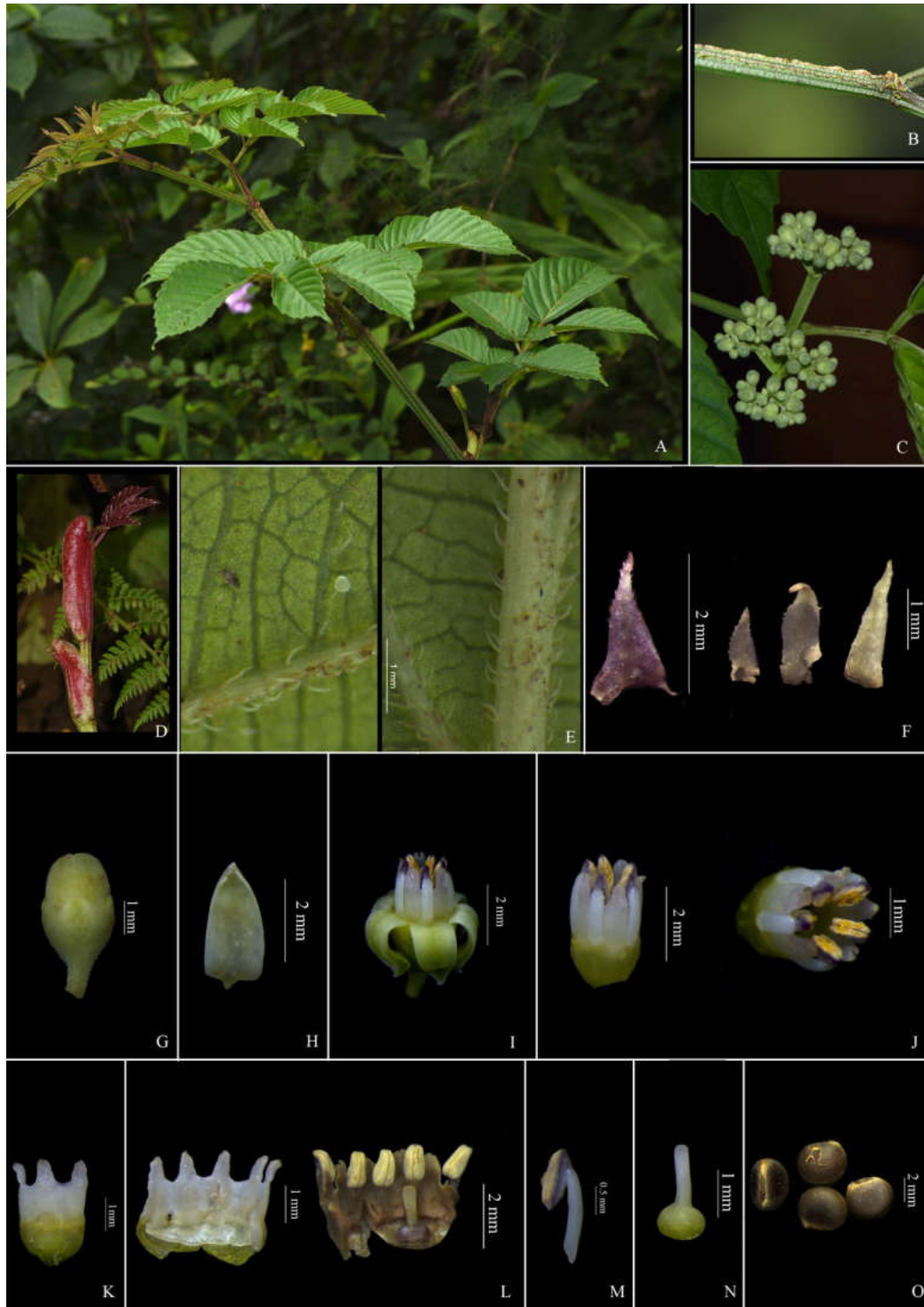


Fig. 35. *Leea asiatica* (L.) Ridsdale: **A.** Habit; **B.** Stem; **C.** Inflorescence; **D.** Petiolar stipule; **E.** Pearl glands & Trichomes; **F.** Bracts; **G.** Flower bud; **H.** Corolla lobe; **I.** Flower; **J & K.** Corolla tube with floral disc; **L.** Corolla tube with floral disc split open; **M.** Stamen; **N.** Pistil; **O.** Seeds.



Fig. 36. Variation in *Leea asiatica* (L.) Ridsdale: **A.** Inflorescence; **B.** Stems; **C.** Petiolar stipules.



Fig. 37. *Leea asiatica* (L.) Ridsdale: **A.** A twig with inflorescence; **B.** Flower; **C.** Bract; **D.** Corolla lobe; **E.** Calyx; **F.** Corolla tube with floral disc; **G.** Stamen; **H.** Pistil; **I.** Petiolar stipule (Drawn by Amrutha A. from Amrutha 159896).

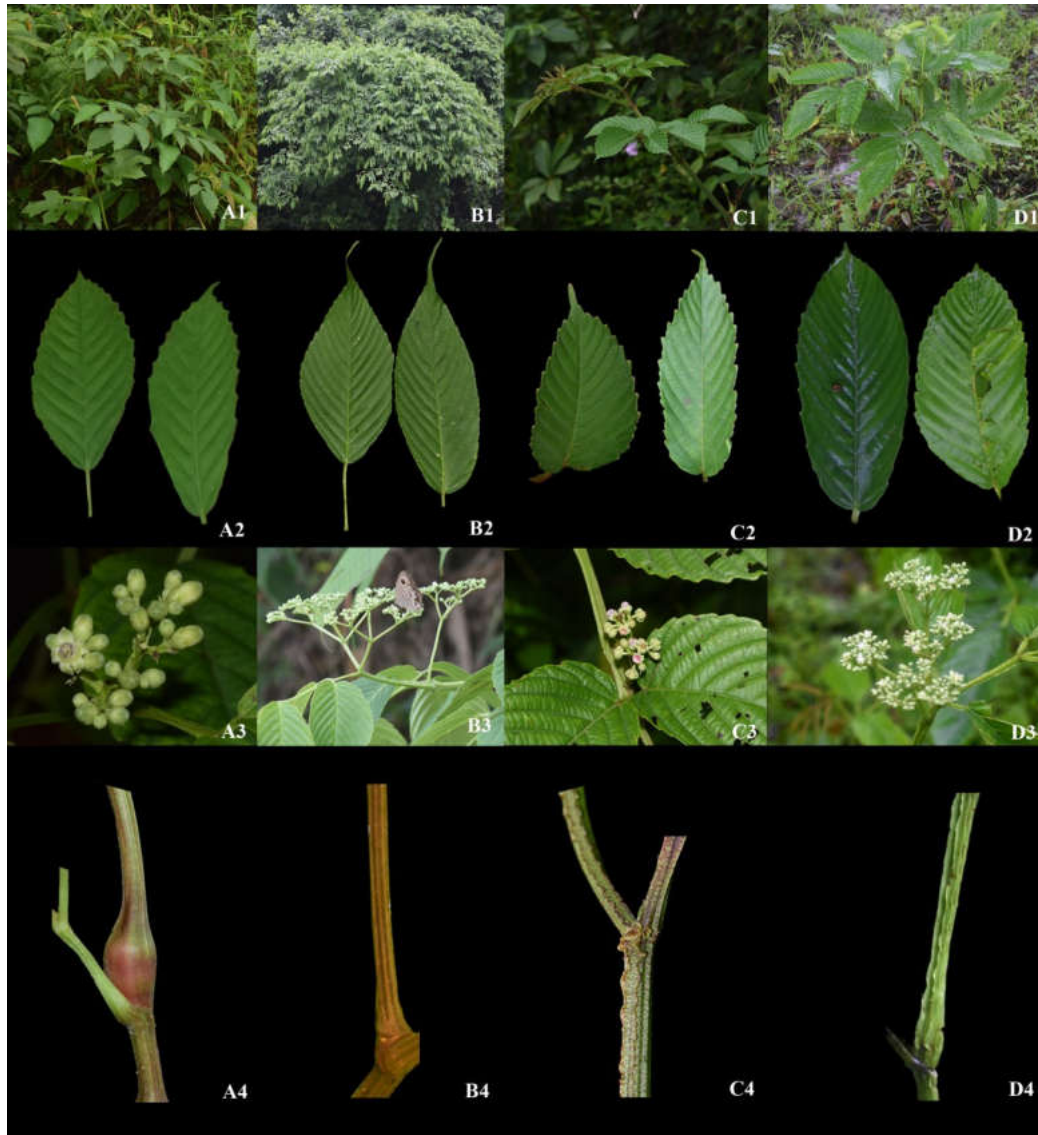


Fig. 38. *Leea asiatica* (L.) Ridsdale: Intraspecific variations: **A1–D1.** Habits; **A2–D2.** Leaflets; **A3–D3.** Inflorescence; **A4–D4.** Stems.

Hoshangabad district, Dhupgarh, 20 Aug 1949, V. Narayanaswami 3302 (CAL); Kesla, 22 July 1961, J. Joseph 12840 (CAL, MH); Katni district, Cattle breeding farm, Pakariya, 23 Oct 1960, J.K. Maheswari 4099 (CAL). **Maharashtra**, Kolhapur district, Amba Ghat, 19 Sept 2018, Amrutha 153253 (CALI); Gaganbawada Road, 20 Sept 2018, Amrutha 153257 (CALI); Mumbai city district, Aarey Colony, Goregaon, 20 Aug 1955, G.L. Shah 4828 (BLAT); Mumbai Suburban district, Andheri Mahakali Temple, 21 Sept 1957, G.L. Shah 9080, 9081, 9084, 9085 (BLAT); Jogeshwari, 08 Aug 1953, H. Santapau 15770 (BLAT); Malad, along Railway station, 10 Aug 1954, G.L.

Ibid., Quarry Hills, 15 Aug 1957, G.L. Shah 8891, 8892, 8893 (BLAT); Nagpur district, Pench National Park, 15 Sept 1987, S.Y. Kamble 169375 (BSI); Nandurbar district, Toranmal, 15 Aug 1965, R.D. Pataskar 105721 (CAL); Pune district, Forest above Bhushi Lake, 29 June 1964, B. Venkata Reddi 97985 (BSI); Korigad fort, 13 Aug 2018, Amrutha 153247 (CALI); Lonavala-on the way to Tiger point, 24 June 1956, S.K.J. 2404 (BSI); Raigad district, Uran, 05 Sept 1960, P. Divakar 1381, 1382 (BLAT); *Ibid.*, 3 July 1961, P. Divakar 2358 (BLAT); Ratnagiri district, Sangameshwar road, 14 Nov. 2017, Amrutha 153237 (CALI); Usgaon, 17 Sept 1961, N.Y. Das 3901, 3902, 3903 (BLAT); Satara district, Khandala, Battery Hill Plateau, 19 Aug 1945, H. Santapau 6998 (BLAT); *Ibid.*, Behrans Plateau, 01 Aug 1914, H. Santapau 91/14 (BLAT); *Ibid.*, Meroli Road, 15 Sept 1957, S.D. Mahajan 16761 (CAL); *Ibid.*, Monkey Hill, 4 Oct 1944, H. Santapau 5113 (BLAT); *Ibid.*, Sausage Hill, 20 Aug 1944, H. Santapau 4722 (BLAT); Khandala Ghat, Way to Lonavala, 13 Aug 2018, Amrutha 153245 (CALI); Khandala to Meroli, 15 June 1956, S.K. Jain 2283 (CAL); Sindhudurg district, Amboli Ghats, 21 Sept 2018, Amrutha 153261 (CALI); Ascending Amboli Ghat from Danoli, 17 Sept 1984, B.G. Kulkarni 102081 (BSI); Thane district, Chandip, 27 Aug 1960, N.Y. Das 1830 (BLAT); Mulgaon, 03 July 1941, H. Santapau 91.9H (BLAT); Mumbra, 31 July 1953, K.V. Shenoy 239 (BLAT); *Ibid.*, 12 Aug 1954, K.V. Shenoy 4042 (BLAT); Sanjay Gandhi National Park, 22 July, 1961, G.L. Shah 10349 (BLAT); *Ibid.*, 30 Aug 1961, R.S. Rao 32740 (CAL); Shivansai, 16 Aug 1959, N.Y. Das 327 (BLAT); Washim district, Karanja-Uran, 17 July 1960, P. Divakar 890, 891 (BLAT). **Manipur**, Bishenpur district, Bishenpur, Nov 1907, Meebold 6419 (CAL); Senapati district, Nongmaiching, 02 Aug 1953, D.B. Deb 798 (CAL). **Meghalaya**, East Khasi Hills district, From Cherrapunji-Mawmluh, 27 Sept 1956, G. Panigrahi 3553 (CAL); Mawmluh, 25 Aug 2018, Amrutha 159867 (CALI); *Ibid.*, 3 miles at Dukan, 27 Sept 1956, G. Panigrahi 3553 (ASSAM); *Ibid.*, on the way to Tyrna Village, 23 Sept 1967, H. Deka 37757 (ASSAM); Jaintia Hills district, Garampani to Raliang road, 22 Aug 1968, N.P. Balakrishnan 46947 (ASSAM); Ri-Bhoi district, Forest Plantation Nongpoh, 1 mile North of Nongpoh gate, 11 June 1964, A.S. Rao 38752 (ASSAM); West Garo Hill district, Hollaidanga Reserve Forest, 05 Sept 1975, M. K.V. Rao 61544 (ASSAM); West Jaintia Hills district, I.B. Dawki, 27 Aug 1956, G. Panigrahi 3034 (CAL); Tura, 29 Aug 1962, D.B. Deb 28863 (ASSAM). **Mizoram**, Aizawl district, Way to Tamdil,

28 Aug 2018, *Amrutha* 159896 (CALI); Seling, Aizawl-Seling-Champhai Road, 07 June 2022, *Amrutha* 164747 (CALI). **Orissa**, Kalahandi district, Ghana Forest, 20 Aug 1983, *B. Safui & Party* 13386 (BSID BSID0008116); Sambalpur district, Hathigirdha, 4 Nov 1986, *Sauris Panda & Das* 257 (CAL). **Rajasthan**, Banswara district, Puna Pathar Forest block, 20 Aug 1976, *V. Singh* 2929 (CAL); Udaipur district, Near Parshuram Mahadev temple, Aravalli Hills, 27 Aug 1975, *B.V. Shetty* 1929 (CAL). **Sikkim**, Sikkim, 05 Oct 1884, *C.B. Clarke* 36242 (CAL); *Ibid.*, 1862, *T. Anderson* 296 (CAL); *Ibid.*, Mungo, 05 Oct 1884, *C.B. Clarke* 36242 (CAL); East Sikkim district, On the way to Rumtek, 06 Aug 1981, *B. Krishna* 1651 (BSHC); Gangtok district, Singtam, 13 May 1967, *N.C. Mazumder & R.M. Dutta* 208 (CAL); Teesta Valley, 14 Oct 1908, *W.W. Smith* 494 (CAL); South Sikkim district, Yangang, 15 Aug 2013, *D.K. Agarwal & S.K. Rai* 38773 (BSHC); West Sikkim district, Rishi, way to Phamrong falls, 29 July 2018, *Amrutha* 159807 (CALI); Tashiding, 29 July 2018, *Amrutha* 159809 (CALI). **Tamil Nadu**, The Nilgiris district, Gudalur Ghat, 20 Nov 1883, *M.A. Lawson s.n.* (MH); *Ibid.*, 28 Aug 2020, *Amrutha* 164706 (CALI); Theni district, Cumbum Reserved Forest, 28 Sept 1925, *K.C. Jacob* 17789 (MH); Suranganar, Cumbam Valley, 21 June 1959, *K. Subhramanyam* 8102 (CAL); Tirunelveli district, Kottamalai R.F., 04 Aug 1975, *E. Vajravelu* 46440 (MH). **Telangana**, Karimnagar district, Nimmagudem Sivan, 04 Sept 1986, *T. Ravi Shankar* 83669 (BSID, barcode BSID0010416); Vikarabad district, Forest near Ananthagiri, 01 Sept 1960, *N.P. Balakrishnan* 10962 (MH). **Tripura**, West Tripura district, Agartala, Barjalai Hills, 01 Oct 2014, *P.M. Debbarman* 235 (CAL). **Uttar Pradesh**, Bahraich district, Nishangara, 20 Nov 1964, *G. Panigrahi* 6485 (CAL); Mirzapur district, Jharo, 15 Oct 1969, *G. Panigrahi* 12549 (CAL); Pilibhit district, Dhanara rain Forest, Pilibhit, 27 Aug 1972, *C.L. Malhotra* 50481 (CAL); Prayagraj district, Chatham lines, 10 Oct 1963, *V.N. Singh* 973 (CAL); Tehri Garhwal district, Dewat, 13 June 1972, *B.D. Naithani* 48258 (CAL). **West Bengal**, Cooch Behar district, *s.loc., s.d.*, *S. Bandyopadhyay* 3194 (CAL); Darjeeling district, Darjeeling, 07 Sept 1869, *C.B. Clarke* 9114 (CAL); *Ibid.*, Aug 1881, *J.S. Gamble* 9736 (CAL); Kurseong-siliguri, 29 June 1960, *H. Kanai & G. Murata* 2980 (CAL); Sukna, 12 Oct 1950, *K. Biswas* 9803 (CAL); *Ibid.*, Mahananda Wildlife Sanctuary, 23 Nov 2006, *T.K. Paul & Anant Kumar* 41244 (CAL); Jalpaiguri district, Chapramari, 23 May 1975, *J.K. Sikdar* 303 (CAL); Chilapata, 18 Sept 1975, *J.K. Sikdan* 598 (CAL);

Nagrakata, 06 Nov 1958, S.K. Mukherjee 4584 (CAL); Kalimpong district, Way to Keni breed nursery, Kalimpong, 30 July 2018, Amrutha 159818 (CALI); Teesta, 02 Aug 2018, Amrutha 159825 (CALI); Paschim Medinipur district, Nekra Khunda, Gopiballabhpur Range, 30 Nov 1975, S.K. Maji 2400 (CAL); Purulia district, Ajodhya Hill, 15 July 1963, M. Chatterjee 209 (CAL); Matha, 11 Sept 1964, K.G. Malick 84 (CAL); *Ibid.*, Hill slope, 12 Sept 1965, K.G. Malick 199 (CAL).

Notes: *Leea asiatica* is the only species having free stamens and the anthers dehiscing through two slits. It is a highly polymorphic species, with a considerable number of synonyms and morphotypes. They show variation in habit, leaf characters and petiolar stipule. The leaves are acute to long acuminate and serrate to sharply serrate. Based on stem and leaf characters, two taxa are widely accepted, *L. crispa* and *L. aspera* Wall. ex G.Don. *Leea crispa* is usually distinguished from *L. aspera* by its crispate stems and the lack of white adpressed hairs on the intercostal spaces of leaves (Lawson, 1875). However, an examination of specimens at different herbaria and live materials from different geographical areas in India, revealed the existence of many intermediates. We could collect crispately stemmed plants with acute apex (from Jowai, Meghalaya and Tumbung Basti, Umrangso, Assam) which exactly matches with the Linnaean type (Fig. 38D1–D4). However, a population collected from Maharashtra, showed moderately crispate stem, but some population showed crispation only on the channels of the petiole (Fig. 38C4); some others are with ridged or furrowed stems (Fig. 38A4 & B4). However, all the populations share almost the same floral characters. Hence, the nature of stem cannot be taken as a good character to segregates different entities in this complex. Hence, we consider this species in a broad sense and accommodate all the entities under the name *L. asiatica*.

Nomenclatural notes: Wallich mentioned a name *Leea aspera* Wall. in Roxb. Fl. Ind. (Carey ed.) 2: 468. 1824, *ad nota* was a *nomen nudum*. Later in 1831, G. Don validated this name. In 1846, Edgeworth proposed a name *L. aspera* for another taxon and cited the collection locality as Himalaya, it became a later homonym. Subsequently, Santapau (1953) proposed a new name (*nom. nov.*) *Leea edgeworthii* Santapau to replace the name *L. aspera* Edgew. However, Ridsdale (1974) considered both the names as conspecific with *Leea crispa* L. (1767).

Ridsdale (1980) realised that the plate of Rheede's Nalugu (1679) was the basis for the Linnaean name *Phytolacca asiatica* L. As a result, Ridsdale (1980) came up with a new combination, *L. asiatica* (L.) Ridsdale. As well, he found that the Linnaean name *L. crispa* described in 1767 was conspecific with *L. asiatica*, which was therefore reduced to a synonym, since *L. asiatica* has priority over *L. crispa*.

Leea aspera, Wall. Cat. 6825, was a misidentification and belongs to *L. robusta* Roxb. Ridsdale treated *L. aspera* Wall. ex G.Don as the synonym of *L. macrophylla*. In the note (Fl. Ind. Ed. Carey. 2: 468. 1824) Wallich clearly mentions that in *L. aspera*, stamens are distinct and this character is also mentioned by G. Don (1831) while validating the name. After a critical examination of the type and live material, we found *L. aspera* Wall. ex G.Don was conspecific with *L. asiatica* (L.) Ridsdale, hence treating it into the synonymy.

6. *Leea compactiflora* Kurz, J. Asiat. Soc. Bengal, Nat. Hist. 42(2): 65. 1873, Forest Fl. Burma 1: 279. 1877; C.B.Clarke in Trimen's J. Bot. 19: 163. 1881; Ridsdale, Blumea 22: 88. 1974; J.Joseph, Fl. Nongpoh and vicinity 72. 1982; Harid. & R.R.Rao, Forest Fl. Meghalaya 248. 1985; A.S.Chauhan, Contr. Fl. Namdapha 140. 1996; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 318. 1996; B.D.Naithani in N.P.Singh *et al.* (ed.), Fl. India 2000; R.Shanpru in N.P.Singh *et al.* (eds.), Fl. Manipur 1: 240. 2000; N.P.Singh *et al.*, Fl. Bihar, Analysis 114. 2001; T.K.Sarma & A.K.Sarkar, Fl. Palamau Dist. 156. 2002; K.P.Singh in N.P.Singh *et al.* (eds.), Fl. Mizoram 1: 388. 2002; G.D.Pal, Fl. Lower Subansiri Dist. 1: 215. 2103, excl. *syn. L. trifoliata*; B.K.Shukla in K.P.Singh *et al.* (eds.), Fl. Uttar Pradesh 1. 351. 2016, excl. *syn. L. trifoliata*; S.S.Dash & P.Singh, Fl. Kurung Kumey Dist. 384. 2017, excl. *syn. L. trifoliata*; Pusalkar & S.K.Srivast., Fl. Uttarakhand 1: 989. 2018. *Type: Kurz s.n., Martaban (n.v.).* **Figs. 40 & 41**

Leea bracteata C.B.Clarke in Trimen's J. Bot. 19: 164. 1881; Kanjilal & Das, Fl. Assam 1(2): 308. 1936; Deb, Fl. Tripura 1: 419. 1981; A.K.Mukh., Pachmarhi & Bori Reserves 68. 1984. *Lectotype* (designated by Ridsdale, 1974): INDIA, **Sikkim**, Hook.f. & Thomson 169 (K barcode K001615004 digital image!).

Perennial, subshrub, 1–2 m high; roots non-tuberous. Stems erect or straggling, stout, jointed, with branches, young stem hispid or pubescent; internodes furrowed or round, green; nodes not swollen; pearl glands globose, more on inflorescences, white. Leaves alternate, pinnate to bipinnate, imparipinnate; petioles 7–21 mm

Systematic treatment

long, base bulged, sheathing the stem, glabrous, green. Petiolar stipule narrow winged, 4–8 cm long, extending to half of petioles; stipular scars triangular; rachis 5–31 cm long, channelled on upper surface, hispid, green. Leaflets opposite, ovate-widely ovate or obovate, distal leaflets: lamina 14–32 × 6.5–13.5 cm, lateral leaflets: lamina 7.5–30 × 4–13 cm, glabrous, young leaves green or brown, mature leaves green on upper surface and pale green on lower, base cuneate to rounded, margins serrate, apex long acuminate or caudate; petiolules: central 3–8 cm long, green, lateral 0.4–2.5 cm long; secondary veins 7–16 pairs, 3-nerved at base, vein raised on abaxial side. Inflorescence terminal, a leaf-opposed cyme, 8–22 cm long, many-flowered, condensed, hispid; peduncles 1–4 cm long, furrowed, pubescent, green, hispid. Flowers 4–6.2 mm, actinomorphic, greenish with brown tinges. Pedicels slender, 1.5–2 mm long, hispid. Bracts 3.6–8.3 × 1.9–5 mm, broadly ovate, conspicuous, persistent, green, hispid. Calyx campanulate, 3.5–5.6 × 3–3.3 mm, 5-lobed, lobes 0.9–1.1 × 0.75–1.9 mm, ovate or widely ovate, apex acute, green, hispid; corolla lobes 5, ovate-oblong, 2.7–3.5 × 1.9–2.4 mm, apex acute, hooded, margin entire, glabrous, green; corolla tube with floral disc 3.1–3.3 × 3–3.2 mm. floral disc 1.6–2.4 mm long, orange-red; upper free part 1.1–1.8 mm long, notched; sinuses shallow, 0.25–0.4 mm long; lower free part 0.8–1 mm long. Stamens 5, syngeneceous; filaments 1.25–1.3 mm long, glabrous, white; anthers 1.2–1.3 mm long, dehisce longitudinally, purple on backside, creamish on margin. Ovary globose, 0.95–1.1 mm long, superior, 4–6-loculed, one ovule in each locule, placentation axile; style slender, 1.1–2.2 mm long, glabrous, creamy; stigma round; Fruit berry, yellow when young turning black at maturity, 6-seeded; Seed wedge-shaped, 4.72–4.91 × 3.72–3.85 mm, light brown when mature.

Flowering: May–November.

Habitat: This species is usually found to growing near roadsides and forest margins. The common associates are *Elatostemma* sp., *Boehmeria glomerulifera* Miq., (both Urticaceae) *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae) and some ferns and grasses.

Distribution: India (Arunachal Pradesh, Assam, Bihar, Manipur, Meghalaya, Mizoram, Sikkim, Uttarakhand, Uttar Pradesh and West Bengal; Fig. 39), Bhutan, China, Laos, Myanmar and Vietnam.

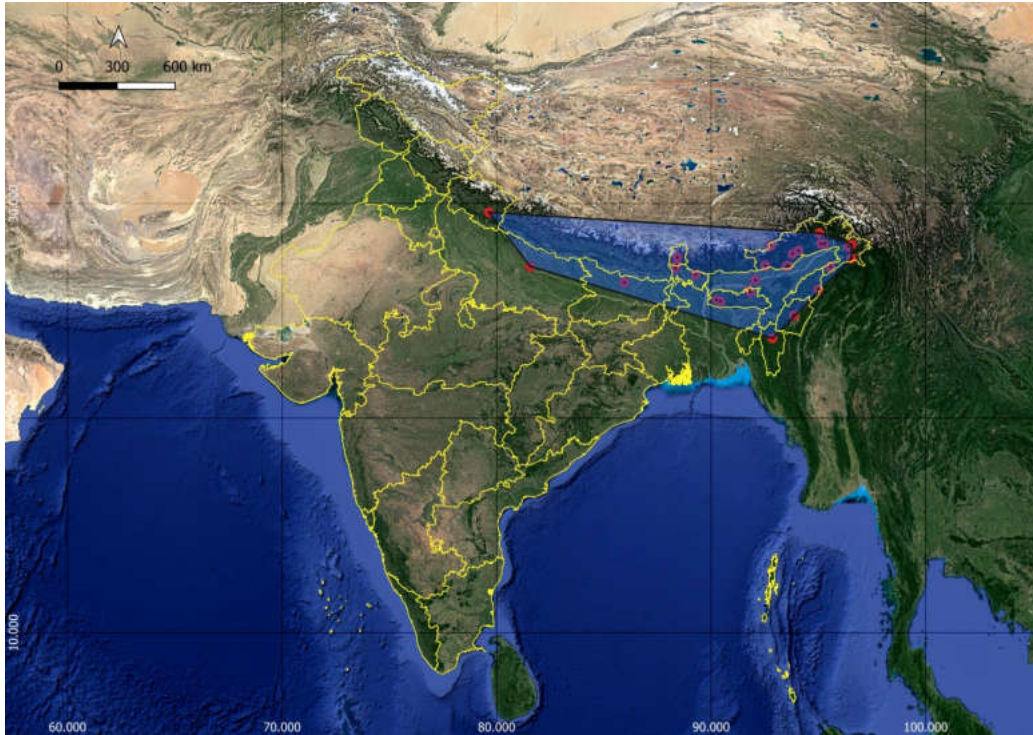


Fig. 39. Distribution of *Leea compactiflora* Kurz in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Arunachal Pradesh**, Anjaw district, Hayuliang-Borpu, 25 Nov 1957, *R.S. Rao* 10819 (CAL); Changlang district, Namdapha National Park, 05 Aug 2018, *Amrutha* 159829 (CALI); East Siang district, Rengging, 24 Feb 1912, *I.H. Burkill* 36711 (CAL); Rotung, 31 Dec 1911, *I.H. Burkill* 37599 (CAL); Lower Subansiri district, Innerline beyond Kimin River up to 1 mile along the road to Ziro, 23 Nov 1957, *G. Panigrahi* 11469 (CAL); Lohit district, Way to Tidding from Tezu, 10 Aug 2018, *Amrutha* 159836 (CALI); Lower Subansiri district, Way to Raga, 16 Aug 2018, *Amrutha* 159850 (CALI); Papum Pare district, 5 km from Chimpu, 03 Aug 1994, *G.D. Pal* 6709 (ARUN); Itanagar-Hydel, 25 Sept 1978, *G.D. Pal* 76051 (ARUN); Senki view, Itanagar, 30 May 2022, *Amrutha* 164710 (CALI); Tirap district, Lai Longsong, 19 June 1961, *D.B. Deb* 25781 (CAL); Rusa-Bimalpur, 07 Sept 1958, *G. Panigrahi* 17025 (CAL); West Kameng district, Sessa Village, 01 June 2022, *Amrutha*

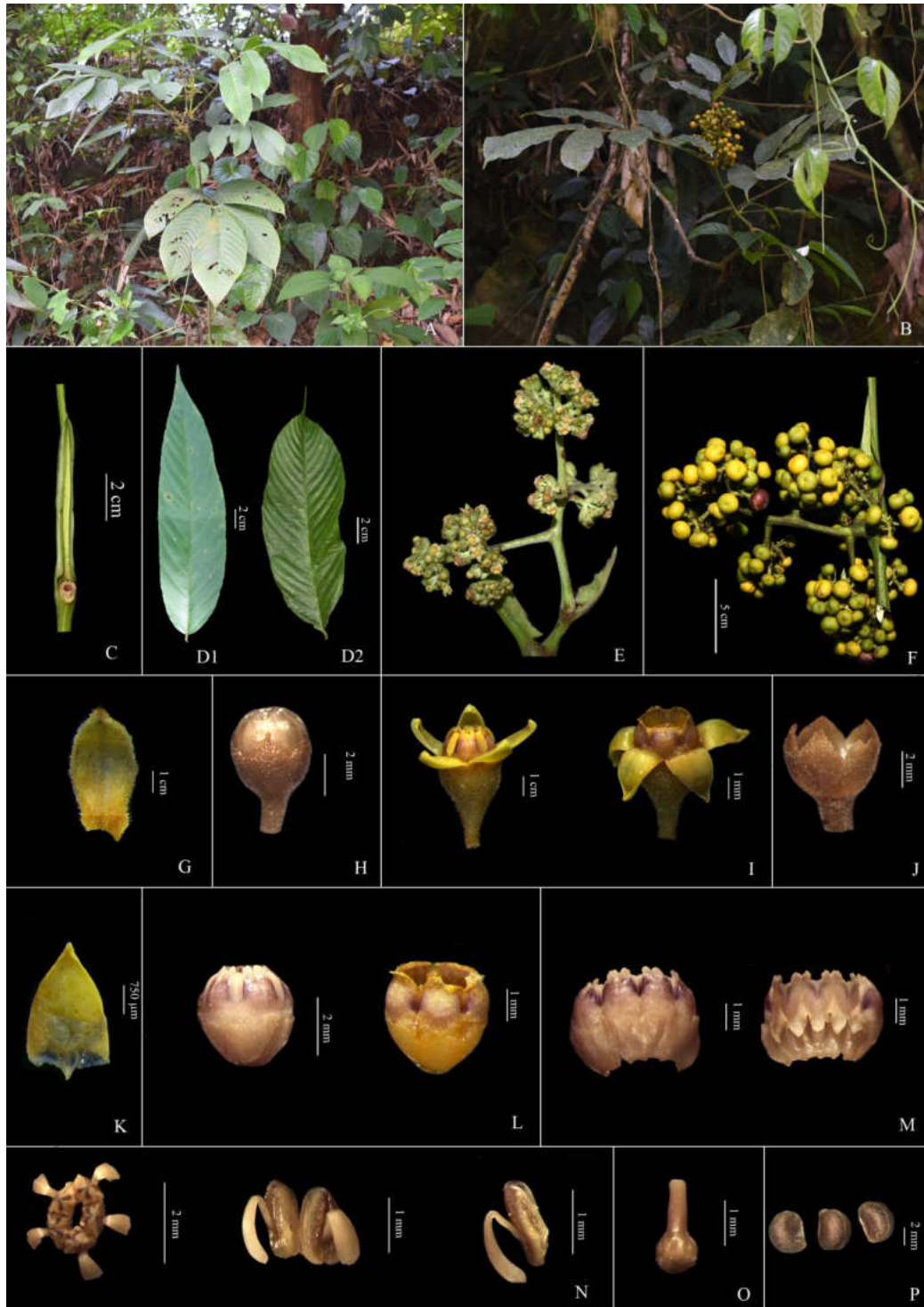


Fig 40. *Leea compactiflora* Kurz: **A.** Habit; **B.** Fruiting twig; **C.** Petiolar stipule; **D1 & D2.** Leaflets; **E.** Inflorescence; **F.** Infructescence; **G.** Bract; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe; **L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil; **P.** Seeds.

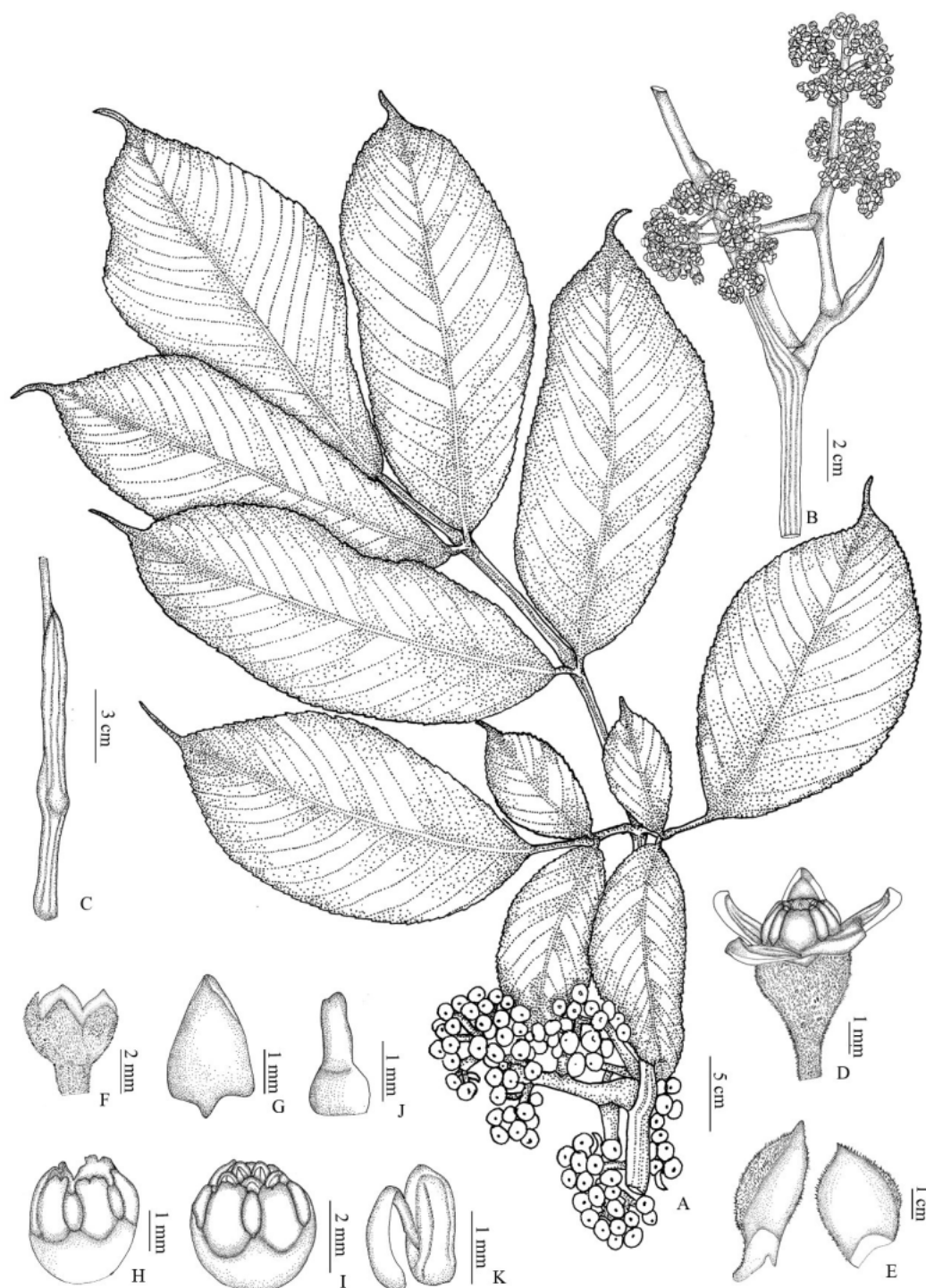


Fig. 41. *Leea compactiflora* Kurz: A. Fruiting twig; B. Inflorescence; C. Petiolar stipule; D. Flower; E. Bract; F. Calyx; G. Corolla lobe; H & I. Corolla tube with floral disc; J. Pistil; K. Stamens (Drawn by Amrutha A. from Amrutha 159829).

164722 (CALI); Upper Siang district, Way to Hawa Camp, Yingkiong, 02 Aug 2018, *Amrutha* 159865 (CALI); West Siang district, Kane WLS, 13 Sept 2008, *S.S. Dash* 32228 (ARUN). **Assam**, Darrang district, Darrang, 22 Apr 1914, *Upendranath Kanjilal s.n.* (ASSAM). **Meghalaya**, Ri-Bhoi district, Balaiba Tilla, Nongpoh, 12 May 1965, *J. Joseph* 42328 (ASSAM); Nongpoh, 13 May 1914, *Upendranath Kanjilal* 3977 (ASSAM); West Garo Hills district, 1 Km after entry gate, foothills of Tura Peak, 03 June 2022, *Amrutha* 164735 (CALI); Rongsingiri, Nokrek Biosphere Reserve, 17 Oct 2007, *V.N. Singh & Bikarma Singh* 115870 (ASSAM). **Mizoram**, Aizawl district, Seling, Aizawl-Seling-Champhai Road, 07 June 2022, *Amrutha* 164748 (CALI). **Nagaland**, Jabocka, Naga Hills, Apr 1899, *Dr. Prains Collector* 907 (CAL). **Sikkim**, *s.d.*, *Kurz s.n.* (CAL); *Ibid.*, 11 Jan 1874, *G. King* 839 (CAL); Darjeeling district, Rungbee, 8 Oct 1908, *W.W. Smith* 282 (CAL); Gangtok district, Singtam, 18 May 1967, *N.C. Mazumder & R.M. Dutta* 269 (CAL). **West Bengal**, Alipurduar district, Dayamara, Jaldapara National Park, 09 May 2014, *K. Karthigeyan* 61470 (CAL barcode CAL0000209976).

Notes: In contrast to other species that flower in June, this species blooms in May and species can easily be identified due to its conspicuous persistent bracts. The shape of leaves varies in *L. compactiflora*. Some populations show narrowly oblong leaves with long acuminate apex (Fig. 40D1), while others have obovate leaves with a cuspidate apex (Fig. 40 D2). However, the floral characters remain the same in both the populations.

Nomenclatural notes: For the type sheet of *L. compactiflora*, we searched all the possible herbaria especially the sheet deposited by Kurz. However, we were unable to locate a specimen by Kurz collected from the type locality, Martaben or even from Burma.

7. *Leea grandifolia* Kurz, J. Bot. 13: 325. 1875; C.B. Clarke in Trimen's J. Bot. 19: 138. 1881; King, J. Asiat. Soc. Bengal 65(2): 411. 1896; Ridsdale, Blumea 22: 87. 1974; B.K. Sinha, Fl. Great Nicobar Isl. 194. 1999; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 307. 1999; Jayanthi, Fl. Campbell Bay Natl. Park 93. 2017. *Type:* INDIA, **Nicobar Islands**, Katchal, Feb 1875, *Kurz s.n.* (K barcode K000736386 digital image!).

Figs. 42, 44 & 45

Systematic treatment

Shrubs, 2–3 m high; roots non-tuberous. Stems erect, stout, jointed, branched, glabrous; internodes furrowed, green; nodes not swollen, adventitious root arising from nodes, green. Pearl glands globose, white-yellow. Leaves alternate, trifoliate to 1-pinnate, imparipinnate; petioles 10.5–22 cm long, terete, swollen at base, base furrowed, sheathing the stem, glabrous, green. Petiolar stipules obovate-oblong, 3–5 × 1–1.5 cm, glabrous, green; stipular scars 3–4.5 cm long, triangular; rachis 14.5–19 cm long, terete, glabrous, green. Leaflets opposite, elliptic to widely elliptic or orbicular, distal leaflets: lamina 20–39 × 15–25 cm; lateral leaflets: lamina 17–34 × 11–17.5 cm; glabrous on upper and lower surface, green above and pale green beneath, base truncate or round or obtuse, margins serrate, apex acuminate or acute; petiolules: central 6.5–10.5 cm long, terete, glabrous, green; lateral 2–5.5 cm long, terete, glabrous, green, secondary veins 10–14 pairs, usually 3



Fig. 42. Type of *Leea grandifolia* Kurz [Kurz s.n. (K barcode K000736386)] © Board of Trustees of the Royal Botanic Gardens, Kew.

(–4) nerved at base, veins prominent on both surface, glabrous on upper surface, hispid on primary and secondary veins on lower surface.

Inflorescence a leaf-opposed terminal dichasial cyme, 7–11 cm long, branched, many flowered, condensed; peduncles 2.5–5.5 cm long, furrowed, glabrous, green. Bracts small, 1.2–1.6 × 1.3–1.4 mm, widely ovate, early caducous, glabrous, greenish-white. Flowers 5.5–6.7 mm long, numerous, actinomorphic, greenish-white. Pedicel slender, short, 0.9–1.2 mm long, glabrous. Calyx campanulate, 3.6–4.5 × 3.2–3.3 mm, lobes 5, 1.4–1.5 × 1.4–1.8 mm, apex acute to obtuse, glabrous, green. Corolla lobes 5, broadly ovate, 4.1–4.5 × 2.3–2.5 mm, thick, apex acute and hooded, margins entire, glabrous, green; corolla tube with floral disc 3.5–3.9 × 3.2–3.8 mm, white. Floral disc tubular, 2.2–2.4 mm long, white when young yellowish at maturity; upper free parts 1.8–2 mm long, notched; sinuses shallow, 0.6–0.7 mm

Systematic treatment

long; lower free parts 0.4–0.6 mm long. Stamens 5, syngeneceous; filaments 1.2–1.5 mm long, glabrous, white; anthers 1.6–1.7 mm long, dorsifixed, dehisce longitudinally, yellow on lateral side, purplish on back. Ovary globose, 0.9–1 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1.1–1.2 mm long, slender, glabrous; stigma convex. Fruit 1–1.5 cm diam., green turning to black at maturity. Seeds 6, more or less obconic, $3.91\text{--}4.22 \times 3.31\text{--}3.42$ mm, dark brown when mature.

Flowering & fruiting: June–February.

Habitat: This species grows in the coastal forests of Nicobar Islands and also in open sunny places in sandy soil along with *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *L. angulata* (Vitaceae), *Pandanus* sp., *Phyllanthus amarus* Schumach. & Thonn. (Euphorbiaceae), *Desmodium* sp. (Fabaceae) and Pteridophytes.

Distribution: India. Endemic to Nicobar Islands; Fig. 43.

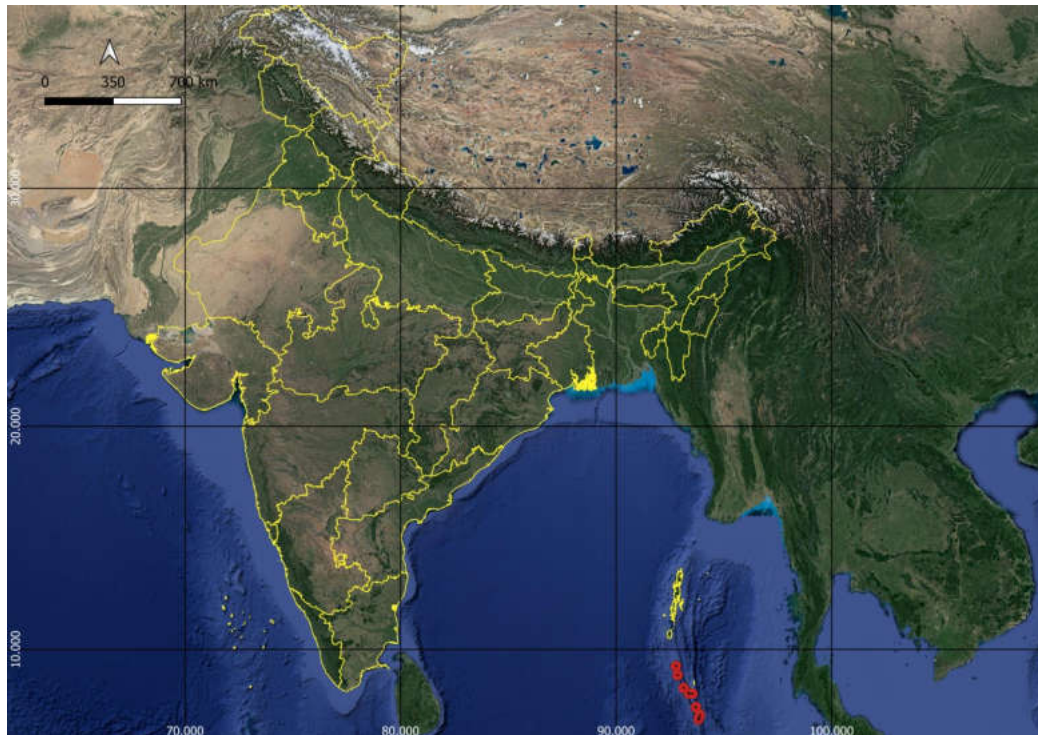


Fig. 43. Distribution of *Leea grandifolia* Kurz in India (drawn using QGIS version 3.24.3).

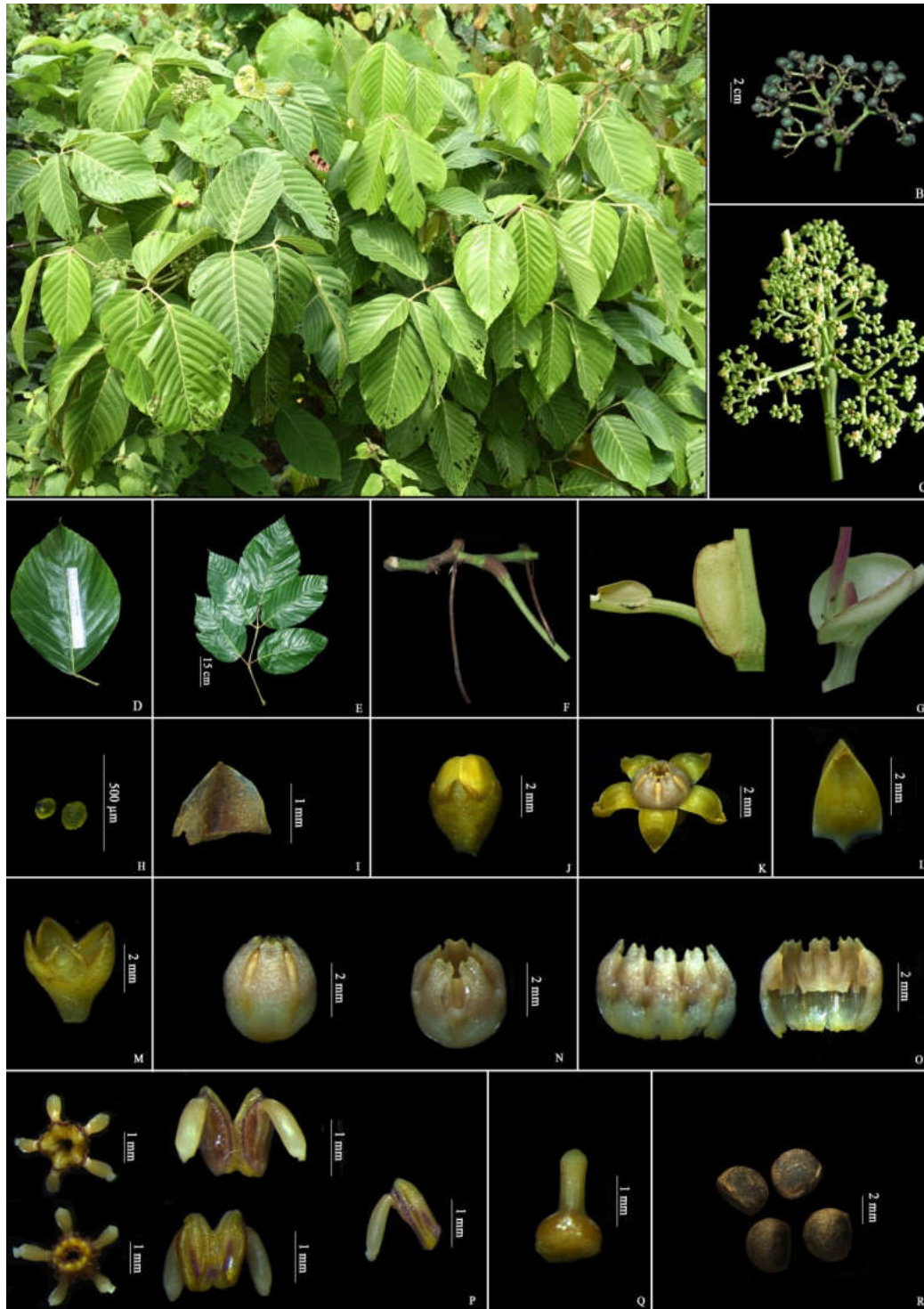


Fig. 44. *Leea grandifolia* Kurz: **A.** Habit; **B.** Infructescence; **C.** Inflorescence; **D** & **E.** Leaves; **F.** Adventitious roots; **G.** Petiolar stipules; **H.** Pearl glands; **I.** Bract; **J.** Flower bud; **K.** Flower; **L.** Corolla lobe; **M.** Calyx; **N.** Corolla tube with floral disc; **O.** Corolla tube with floral disc split open; **P.** Stamens; **Q.** Pistil; **R.** Seeds.

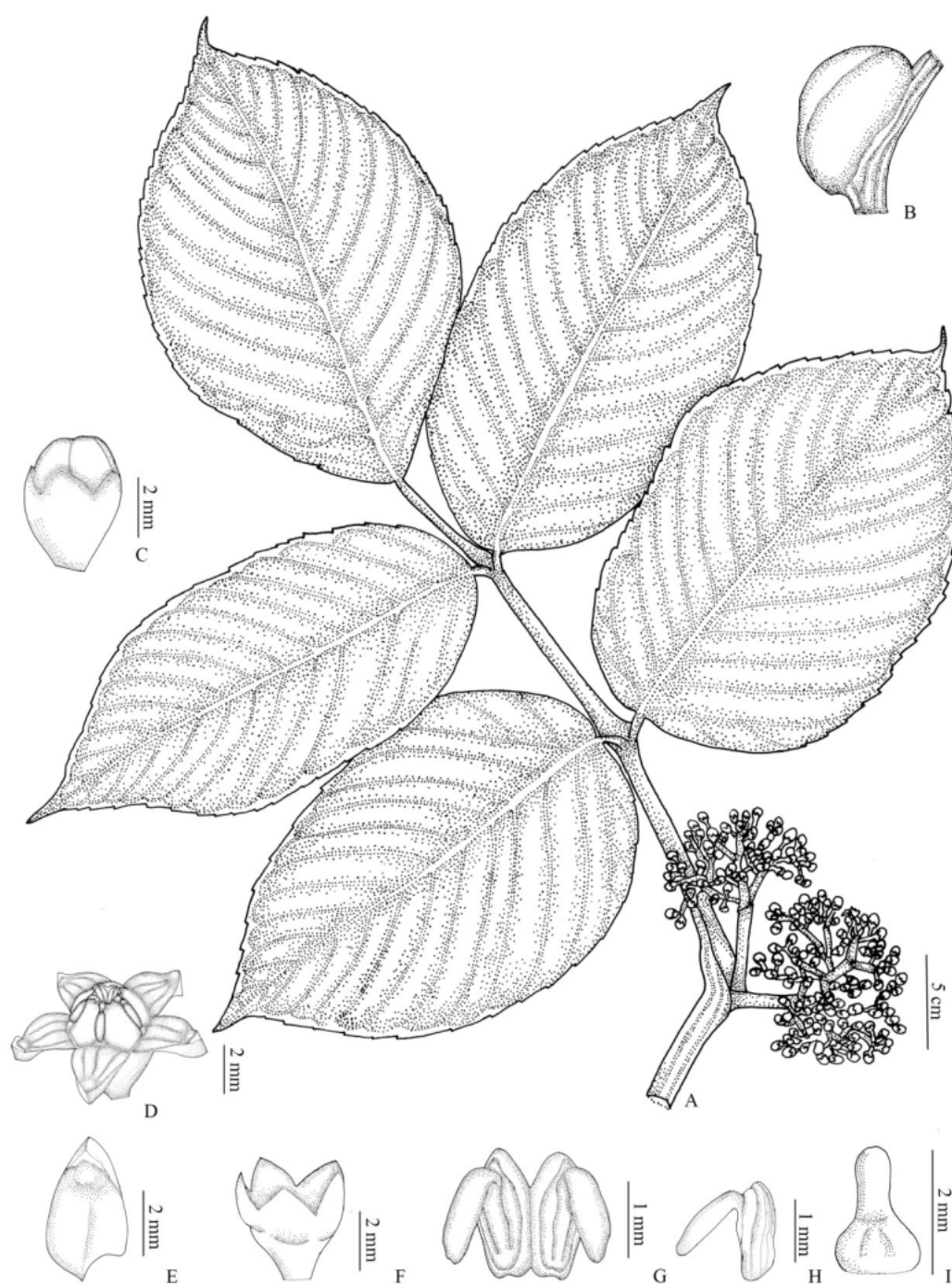


Fig. 45. *Leea grandifolia* Kurz: **A.** Twig with inflorescence; **B.** Petiolar stipule; **C.** Flower bud; **D.** Flower; **E.** Corolla lobe; **F.** Calyx; **G & H.** Stamens; **I.** Pistil (Drawn by Amrutha A. from Amrutha 164066).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Nicobar district, 2 km away from Galathea towards Shastri Nagar, 17 July 2019, *Amrutha* 164077 (CALI barcode CALI172969); 4 km after Gandhinagar towards Galathea, 01 July 2019, *Amrutha* 164092 (CALI barcode CALI172964, CALI1729665, CALI172966, CALI172967, CALI172968, CALI172970); 7 km on North-South Road, 20 Aug 1975, *N.P. Balakrishnan* 2985 (PBL barcode PBL0000005804!); 18 km on road to Pygmalion Point, 17 July 1976, *N.P. Balakrishnan* 3821 (PBL barcode PBL0000005802, PBL0000005803, PBL0000005805, PBL0000005806, PBL0000005807, CAL); Battimalv, Mar 1891, *D. Prain s.n.* (CAL); Campbell Bay, Be-Caury beach side, 16 July 2019, *Amrutha* 164066 (CALI barcode CALI172971, CALI172972, CALI172973, CALI172974, CALI172975, CALI172976, CALI172977); Galathea Bay, 23 Mar 1966, *K. Thothatri & S.P. Banerjee* 11485 (CAL); Great Nicobar, Navy Dera, 22 Feb 2003, *J. Jayanthi* 19415 (PBL barcode PBL0000005800, PBL0000005801); Katchal, Feb 1875, *Kurz s.n.* (CAL); Little Nicobar (South Nicobar), Kopra, 11 Apr 2011, *C. Murugan* 28392 (PBL barcode PBL0000025835); *Ibid.*, Menchal (W), 07 May 2008, *C. Murugan* 26555 (PBL barcode PBL0000025841, PBL0000025842); Mus, Car Nicobar, 09 June 1974, *N.C. Nair* 1575 (PBL barcode PBL0000005798, PBL0000005799); *Ibid.*, 14 Nov 1975, *N.C. Nair* 2890 (CAL, PBL barcode PBL0000005793, PBL0000005794); Safeth Balu, Teressa Island, 05 Aug 2012, *S. Prabhu & R. Sathiyaseelan* 1040 (PBL barcode PBL0000031755); West Bay, Katchal Island, 15 Feb 1977, *P. Chakraborty* 5231 (CAL barcode CAL0000209946, PBL); *Ibid.*, Pondha, 02 Apr 1979, *M.K. Vasudeva Rao* 7493 (CAL barcode CAL0000209945, PBL barcode PBL0000005795, PBL0000005796,).

Notes: In contrast to all other species that occur in the forest margins or along the roadsides, this species confined to beach sides.

8. *Leea guineensis* G.Don, Gen. Hist. 1: 712. 1831; Hiern, Cat. Welw. PI. 1: 164. 1896; Descoings in Humbert (ed.), Fl. Madag. fam. 124 bis 6. 1967, Fl. Gabon 14: 116. 1968; Ridsdale, Blumea 22: 92. 1974, Fl. Males., Ser. 1, Spermat. 7: 777. 1976; Deb, Fl. Tripura 1: 418. 1981; B.D.Sharma *et al.*, Fl. Karnataka, Analysis 56. 1984; H.O.Saxena & Brahmam, Fl. Orissa 1: 338. 1994; Sivar. & P.Mathew, Fl. Nilambur 156. 1996; R.N.Banerjee, Fl. West Bengal 1: 452. 1997; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 307. 1999; K.P.Singh in N.P.Singh *et al.* (eds.), Fl. Mizoram 1: 389. 2002; Arisdason *et al.*, in P.Daniel (ed.), Fl. Kerala 1: 764. 2005; S.S.Dash & P.Singh, Fl. Kurung

Kumey Dist. 384. 2017; P.Singh & S.S.Dash, Fl. Little Andaman Isl. 85. 2021. *Type*: SIERRA LEONE, G. *Don s.n.* (BM barcode BM000843770 digital image!).

Figs. 46, 48 & 49

Leea acuminata Wall. ex C.B.Clarke in Trimen's J. Bot. 19: 141. 1881; King, J. Asiat. Soc. Bengal 65(2): 415. 1896; Brandis, Ind. Trees 179. 1906; Gagnep., Fl. Indo-Chine t.1: 941. 1909, Bull. Soc. Bot. France 57: 336. 1910; C.E.Parkinson, Forest Fl. Andaman Isl. 133. 1923; Haines, Bot. Bihar Orissa Pt. 1. 207. 1925; Craib, Fl. Siam. 1(2): 316. 1926; Cowan & Cowan, Tr. N. Beng. 40. 1929; Kanjilal & Das, Fl. Assam 1(2): 304. 1936; H.Hara, Fl. E. Himalaya 199. 1966; Deb & R.M.Dutta in J. Bombay Nat. Hist. Soc. 69(3): 570. 1972. *Type*: BANGLADESH, Sylhet ('Sillet'), *s.d.*, *De Silva & Gomez* 6830 (K K001124927 digital image!).

Leea manillensis Walp., Nov. Actorum Acad. Caes. Leop. Carol. Nat. Cur. 19 (Suppl. 1): 314. 1843. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): PHILIPPINES, Manila, *s.d.*, *Meyen s.n.* (K barcode K000736475!; *isolectotype*: BR barcode BR0000005117314 digital image!).

Leea aurantiaca Zoll. & Moritzi, Natuur- Geneesk. Arch. Ned.-Indië ii. 577. 1845; Miq., Fl. Ned. Ind. 1(2): 610. 1859; Backer & Bakh.f., Fl. Java 2: 94. 1965; R.N.Banerjee & Babu, Indian Forester 97 (1): 19. 1971. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): INDONESIA, East Java, foot of Mount Semeru, 1844, *Zollinger* 2297 (P barcode P00697975 digital image!; *isolectotypes*: G barcode G00368561 digital image!, G00368562 digital image!, L barcode L 0013652 digital image!, MEL barcode MEL2451239 digital image!, P barcode P00697973 digital image!, P00697974 digital image!).

Leea laeta Wall. ex Kurz, J. Asiat. Soc. Bengal Pt. 2. Nat. Hist. 42(2): 65. 1873. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): MYANMAR, Prome, Irrawaddy River, *s.d.*, *Wallich* 6831 A (K barcode K001124928 digital image!).

Leea wightii C.B. Clarke in Trimen's J. Bot. 19: 105. 1881; Gamble, Fl. Madras 1: 240. 1918. *Lectotype* (designated by Ridsdale, 1974): INDIA, **Tamil Nadu**, Courtallum, s.d., Wight 523 (K barcode K000736380 digital image!).

Leea parva Elmer, Leaf. Philipp. Bot. 1: 317. 1908. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): PHILIPPINES, Lucban, Province of Tayabas, Luzon, May 1907, A. D. E. Elmer 9175 (K barcode K000736474 digital image!, *isolectotype*: A barcode A00051625 digital image!).

Leea negrosense Elmer, Leaf. Philipp. Bot. 2: 494. 1908. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): PHILIPPINES, Dumaguete, Cuernos Mountains, Province of Negros Oriental, Negros, May 1908, A. D. E. Elmer 10174 (NY barcode NY00415204 digital image!; *isolectotypes*: G barcode G00368565 digital image! & G00368566 digital image!, HBG barcode HBG- 518936 digital image!, A barcode 00051623 digital image!, K barcode K000736479 digital image!, U barcode U 0111110 digital image!, L barcode L 0013657 digital image!, MO barcode MO-260968 digital image!, US barcode US00094619 digital image!).

Leea euphlebia Merr., Philipp. J. Sci., C. 9: 452. 1915. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): PHILIPPINES, Luzon, Bontoc subprovince, Bauco, April–October 1910, Father M. Vanoverbergh 444 (L barcode L 0716929 digital image!; *isolectotypes*: A barcode A00051620 digital image!, L barcode L 0013656 digital image!, U barcode U 0247550 digital image!).

Leea luzonensis Elmer, Leaf. Philipp. Bot. 8: 3104. 1919. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): PHILIPPINES, Los Banos (Mt. Maquilang), Province of Laguna, Luzon, June–July 1917, A. D. E. Elmer 17776 (K barcode K000736472 digital image!, *isolectotypes*: BM barcode BM000838191 digital image!, HBG barcode HBG- 518937 digital image!, GH barcode GH00051622 digital image!, NY barcode NY00415202 digital image!, P

Systematic treatment

barcode P00697977 digital image!, U barcode U 0111111 digital image!, L barcode L 0013658 digital image!, MO barcode MO- 171247 digital image!, CAL barcode CAL0000024241 digital image!).

Leea schomburgkii Craib, Bull. Misc. Inform. Kew 1926(8): 358. 1926. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): THAILAND, Ang Hin, 1850, Sir R. Schomburgk 256 (K barcode K000323721 digital image!; *isolectotype*: P barcode P00490973 digital image!).

Shrubs, 1–2 m high; roots non tuberous. Stems erect, stout, branched; internodes terete, green to purple; nodes jointed. Pearl glands globose, white. Leaves alternate, 1–2 pinnate, imparipinnate; petioles 4.5–16 cm long, swollen at base, terete, glabrous, green to purple. Petiolar stipules 2.8–4.5 × 0.8–1.2 mm, oblong, enclosing the base of young stem or inflorescence, glabrous, pale green; stipular scar 2.6–3.5 mm long, triangular; rachis 4.5–24 cm long, channelled on upper side, glabrous, green to purple. Leaflets opposite, ovate to oblong or elliptic to widely elliptic, young leaflet purple, distal leaflets: lamina 9–22.6 × 3–9 cm, lateral leaflets: lamina 4.5–25 × 2–9.5

cm; one rows of stiff hairs in between two lateral vein on upper surface; green above and pale green beneath, base cuneate or obtuse or round, margins coarsely serrate to sharply serrate, apex long acuminate; petiolules: central 2–5.3 cm long, channelled on upper side, glabrous, green to purple; lateral 0.2–2 cm long,

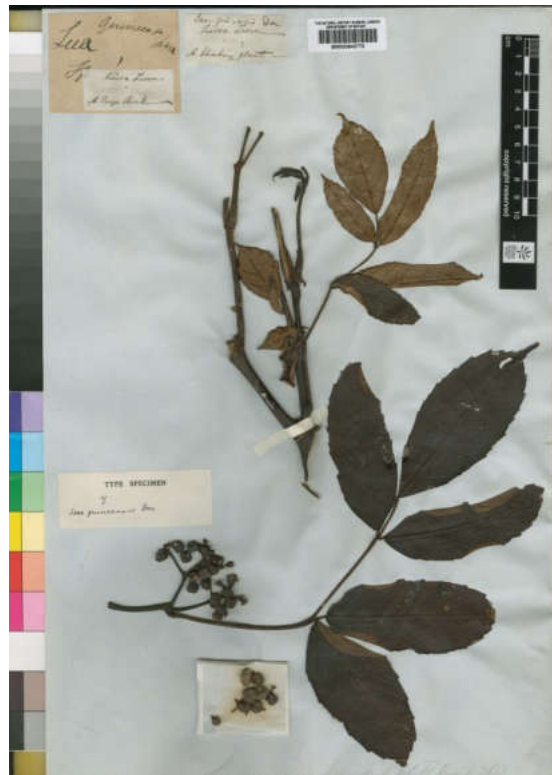


Fig. 46. Type of *Leea guineensis* G.Don [G.Don s.n. (BM barcode BM000843770)] © Board of Trustees of History Museum, London, England.

channelled on upper side, glabrous, green to purple; secondary veins 5–15 pairs, 3-nerved at base, veins prominent on both surfaces, glabrous. Inflorescence a leaf-opposed terminal cyme, 3–13 cm long, branched, many flowered, lax; peduncles 1–6 cm long, terete, glabrous, green or red. Bracts $1.6\text{--}2 \times 1\text{--}1.1$ mm, early caducous. Flowers 4–5 mm long, numerous, actinomorphic, orange to reddish white. Pedicel short or nearly absent, glabrous. Calyx campanulate, $2\text{--}2.9 \times 2\text{--}2.4$ mm, lobes 5, $0.8\text{--}1.3 \times 0.8\text{--}1.2$ mm, apex acute to obtuse to round, glabrous, red to orange. Corolla lobes 5, ovate, $2.3\text{--}2.8 \times 1.3\text{--}1.8$ mm, apex acute and hooded, margins entire, glabrous, red to orange; corolla tube with floral disc $2.5\text{--}3.2 \times 2\text{--}2.5$ mm. Floral disc tubular, 1.4–1.8 mm long, white when young yellowish at maturity; upper free parts 1–1.3 mm long, emarginate; sinuses shallow, 0.3–0.5 mm long; lower free parts 0.5–0.8 mm long. Stamens 5, syngeneic; filaments 0.6–0.9 mm long, glabrous, white; anthers 0.8–1.2 mm long, dorsifixed, dehisces longitudinally, brownish on back. Ovary globose, 0.6–0.9 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 0.8–2 mm long, slender, glabrous; stigma convex. Fruit 1–1.3 cm diam., red turning black at maturity. Seeds 6, more or less obconic or round, $4.43\text{--}4.78 \times 4.02\text{--}4.12$ mm, light brown when mature, muricate.

Flowering & fruiting: June–January.

Habitat: The species mostly grows among the secondary vegetation in forest margins. It can also be seen in marshy areas. In the Andaman Islands, this species was found as a continuous patch in the Jarawa Forests of Middle Andaman. The most common associates are *Acmella paniculata* (Wall. ex DC.) R.K.Jansen (Asteraceae) and *Selaginella* sp. (Selaginellaceae).

Distribution: India (Andaman Island, Arunachal Pradesh, Assam, Karnataka, Kerala, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal; Fig. 47) Africa, Java, Malaysia, Myanmar, Philippines and Thailand.

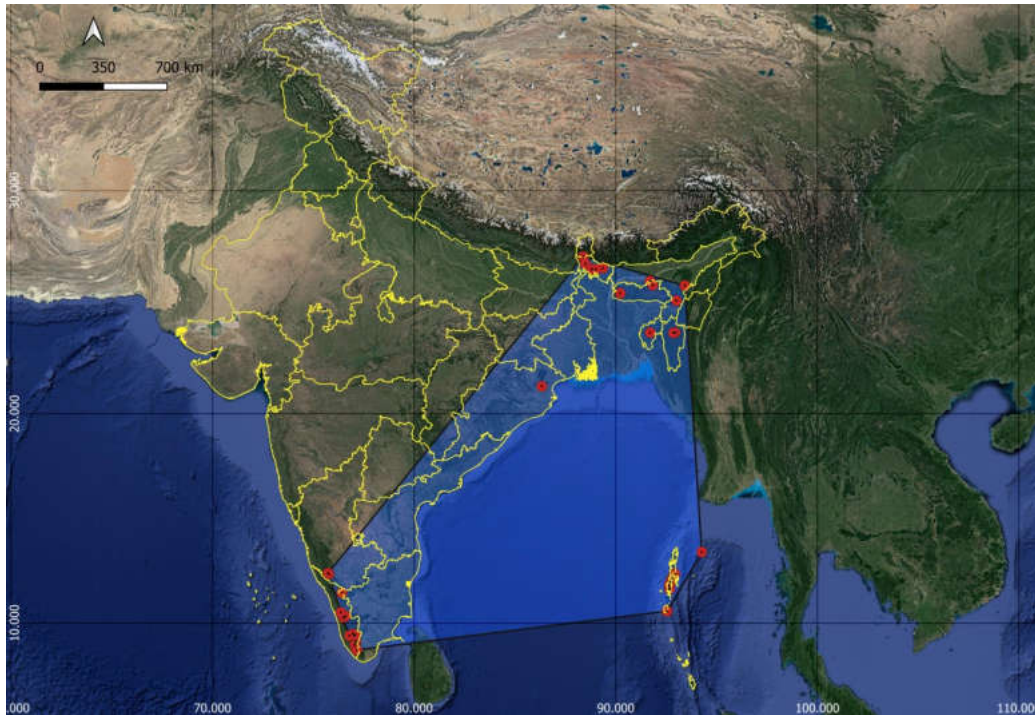


Fig. 47. Distribution of *Leea guineensis* G. Don in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Andaman, Oct 1900, Dr. Prain's Collector 95 (CAL); North and Middle Andaman district, Barathang Island, Kenchi Road, 14 July 1977, N. Bhargava 5891 (CAL, PBL barcode PBL0000005697, PBL0000005698); *Ibid.*, Sundergrh, Barathang, 23 July 1975, N. Bhargava 2496 (PBL barcode PBL0000005699, PBL0000005700); Jarawa Protected Area, Middle Andaman, Amrutha 164060 (CAL); Middle and Long Island, 30 July 1975, N. Bhargava 2865 (PBL barcode PBL0000005688); Near Polar Camp, Narcondrum Island, N.C. Nair 6204 (PBL); South Andaman district, Caddlegunj, 21 May 1892, Dr. King's Collector s.n. (CAL); Corby's Cove, 13 Feb 1892, Dr. King's Collector s.n. (CAL); Jirkathang, 2 July 1978, N.P. Balakrishnan & P. Basu 6666 (PBL barcode PBL0000005695, PBL0000005696); Near Jirkathang, 20 July 1976, N. Bhargava 3795 (PBL barcode PBL0000005691, PBL0000005692); Namunaghar, 19 Sept 1991, Dr. King s.n. (CAL); Near Hut Bay, Little Andaman, 13 Jan 1976, N. Bhargava 3422 (PBL). **Assam**, s.loc., 1880, C.E.C. fisher s.n. (CAL); s.loc., s.d., Jenkins s.n. (CAL); Dima Hasao district, Diphu Forest, 30 Sept 1935, G.K. Dekha s.n. (ASSAM); Haflong, Sept 1993, Shaik Mokim 306 (CAL); Kamrup district, Garbhanga

Reserve Forest, 25 May 1957, *G. Panigrahi* 9556 (CAL); Gizang Forest, 26 June 1964, *A.S. Rao* 39150 (CAL); Sattargaon, northeast of $\pm$ 8 miles of Rani, 14 June 1964, *A.S. Rao* 38823 (CAL). **Karnataka**, Kodagu district, Kodagu, 23 July 1976, *S.R. Ramesh* 1927 (CAL); *Ibid.*, May 1918, *Bell* 3961 (CAL). **Kerala**, Idukki district, Koruthode, 12 Aug 1993, *Jomy Augustine* 12236 (CALI barcode CALI105486); Kollam district, Alappad-Achancoil, 28 May 1979, *C.N. Mohanan* 63045 (CAL, MH); Chinnapalaruvi, 03 Oct 2017, *Amrutha* 153235 (CALI barcode CALI172978, CALI172979, CALI172980, CALI172981); Kollam, *s.d.*, *Deepthy et al.* 63823 (TBGT); Kulathupuzha, 19 Aug 1993, *E.S. Santhosh Kumar* 17755 (TBGT); Palaruvi, 01 Oct 2017, *Amrutha* 153230 (CALI barcode CALI172983, CALI172984, CALI172985, CALI172986); Malappuram district, Gudalloor Road, 02 June 1982, *Philip Mathew* 33247 (CALI); Nadugani Power House, 18 Oct 1972, *J.L. Ellis* 43243 (MH); Way to Nadugani Power house, 24 May 1971, *J.L. Ellis* 38513 (MH); Palakkad district, Elival, South Malabar, 08 Aug 1910, *C.E.C. Fischer* 1992 (CAL); Pathanamthitta district, Attathode R.F., Sabarimala way, *E. Vajravelu* 80615 (CAL, MH); *Ibid.*, 02 Sept 1977, *N.C. Nair* 50812 (MH, CAL); Sabarimala, 13 Oct 1988, *Anilkumar N.* 980 (CAL); Sabarimala-Pamba, 14 Apr 1978, *C.N. Mohanan* 55503 (CAL, MH); Triveni-Sabarimala, 10 Oct 1972, *B.D. Sharma* 42453 (MH); Thiruvananthapuram district, Bonoccord, 18 Oct 2016, *Deepthy & Usha* 67996 (TBGT); Sasthanada, 13 May 1992, *A. Nazarudheen* 14257 (TBGT); *Ibid.*, 23 Apr 2008, *C.G. Vishnu* 63006 (TBGT); Thrissur district, Kannamkuzhy, 26 June 1996, *A.G. Pandurangan & G. Rajkumar* 30428 (TBGT); Orukomban, 11 Nov 2007, *Amitha Bachan* 123371 (CALI barcode CALI107987, CALI107988, CALI107989); Peechi, Valiyamedu, 18 Sept 1990, *N. Sasidharan* 5724 (CALI barcode CALI107990). **Meghalaya**, West Garo Hills district, Tura Peak, 13 Oct 2017, *Santhosh Nampy & Vishnu Mohan* 156894 (CALI barcode CALI172987); *Ibid.*, Foot hills, after the entry gate, 03 June 2022, *Amrutha* 164731 (CALI); Tura upper Chandmari hill, 06 July 1976, *M.K.V. Rao* 64216 (ASSAM). **Mizoram**, Aizawl district, Seling, Aizawl-Seling-Champhai Road, 07 June 2022, *Amrutha* 164747 (CALI); Tamdil, 07 June 2022, *Amrutha* 164744 (CALI); Way to Tamdil, 28 Aug 2018, *Amrutha* 159893 (CALI); Ri-Bhoi district, Nongpoh, Khasia, 10 May 1885, *C.B. Clarke* 38108 (CAL); East Khasi Hills district, Therriaghat, 05 Oct 1910, *D. Hooper* 34734 (CAL). **Orissa**, Kendujhar district, Bangura from Bankura, 04 July 1957, *G. Panigrahi* 8631 (ASSAM). **Sikkim**, *s.loc.*, May 1862, *T. Anderson* 654 (CAL); *s.loc.*, 26 Aug 1875, *G. King* 2333 (CAL); *s.loc.*, 11 June 1877, *G. King* 4905 (CAL); Gangtok district,

Singtam, 15 May 1967, N.C. Mazumder & R.M. Dutta (CAL). **West Bengal**, Alipurduar district, Chilapata, 05 June 2013, K. Karthigeyan 59348 (CAL barcode CAL0000209969); Darjeeling district, Darjeeling, Teesta, 19 June 1960, H. Kanai, G. Murata & M. Togashi 2978 (CAL); Jalpaiguri district, Kathambari, 25 Apr 1962, S.K. Mukerjee 5581 (CAL); Kalimpong district, Teesta, 02 Aug 2018, Amrutha 159823 (CAL).

Notes: Two distinct populations of *L. guineensis* were observed during our field exploration. One in Andaman Island with a bushy habit, while in the mainland population was 1–2 m tall, often with a straggling nature. However, the floral characters, nature of petiolar stipule, and seed characters of both the forms are same.

Nomenclatural notes: Ridsdale (1974) considered *L. guineensis* as highly variable and synonymized 30 names of previous authors under it. We were unable to accept all synonyms since some taxa can be considered distinct species. For example, he had synonymized *L. cumingii*, a species having woolly hairy stems and setaceous to hispid hairs on the upper leaf surface. It should be considered a distinct species, and it needs to be reinstated. The Indian species shows less variation in terms of inflorescence and leaves.

Typifications: Zollinger and Moritzi (1845) published a name *Leea aurantiaca* with a short diagnosis “*Suffruticosa, caule tereti inferne glabro superne punctato-asperulo, foliis pinnatis, foliolis ovato - oblongis acuminatis basi obtusis supra basin subduplicato - serratis glabris. Calyx corollaque aurantiascentes*”. In the protologue they mentioned “Herb. No. 2297” and the provenance of the species is indicated as “*Ad pedium montis Semiroe in sylvis primaevis co. 2-4000' s. m. X 1844*”. After an extensive search, we could trace 7 specimens of Zollinger with the same collection number at L, P, MAL and G. Ridsdale (1974) inadvertently lectotypified the name by selecting Zollinger 2297 but cited 2 herbaria simultaneously. So, these constitute syntypes. Among these, we chose a specimen housed at P (P00697975!) as the lectotype of the name *L. aurantiaca* because it is the more complete and informative material showing some diagnostic features (leaflet ovate-oblong, acuminate at apex, obtuse at base and margins serrate). Furthermore, this sheet contains drawings of floral parts presumably drawn by Zollinger.

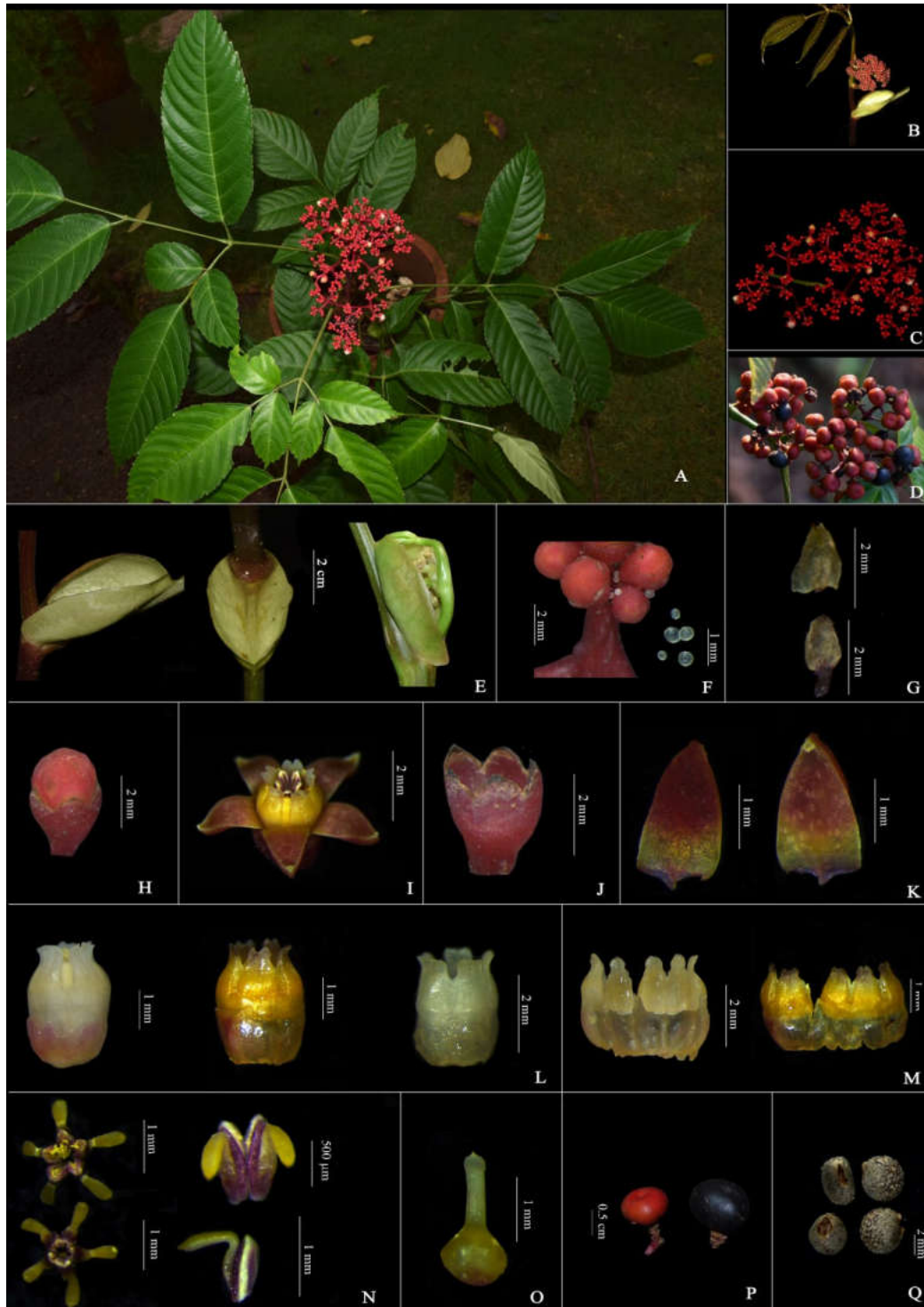


Fig. 48. *Leea guineensis* G.Don: **A.** Habit; **B & C.** Inflorescence; **D.** Infructescence; **E.** Petiolar stipules; **F.** Pearl glands; **G.** Bracts; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe; **L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil; **P.** Fruit; **Q.** Seeds.



Fig. 49. *Leea guineensis* G.Don: **A.** A flowering twig; **B.** Petiolar stipule; **C.** Flower bud; **D.** Flower; **E.** Calyx; **F.** Corolla lobe; **G.** Corolla tube with floral disc; **H & I.** Stamens; **J.** Pistil; **K.** Seeds (Drawn by Amrutha A. from Amrutha 153235).

Leea laeta was first proposed by Wallich (1828) in his catalogue with catalogue number 6831, it is a *nomen nudum*, hence illegitimate. He also mentioned two specimens 6831 A and 6831 B collected from two different localities. Subsequently, in 1873 Kurz validated this name and he did not mention any specimen as the type. Ridsdale (1974) in his revision, designated type as 'Type: Wallich 6831 (K)'. However, we traced two relevant specimens with collection numbers 6831 A and 6831 B at K herbarium. Hence, type citation by Ridsdale can be accepted as the first-step lectotypification. The specimen 6831 A was collected by Wallich from Irrawaddy River, Myanmar whereas 6831 B was from an unknown locality. Hence, 6831 A (K001124928!) is the best choice as the lectotype since it was collected by the original author. Additionally, this sheet (with leaves bipinnate, leaflets oblong or ovate-lanceolate, apex acuminate, margins crenate-serrate) perfectly agree with the description in the protologue.

Leea parva was originally described by Elmer (1908a) based on his own collection from the Philippines. He included only one collection (9175, A. D. E. Elmer, Lucban, Province of Tyabas, Luzon, May 1907) in the protologue. After an extensive search in various herbaria, the authors traced two duplicates (syntypes, Art. 9.6 of ICN) with the same collection number one each at K and A herbarium. Both are exactly matching with the description and specimen label information included in the protologue. The specimen at Kew (K000736474!) is selected here as the lectotype because it is the more complete and informative material showing diagnostic features such as leaflets being subentire towards the base, abruptly terminating into an acuminate point at apex. Ridsdale (1974) also cited two herbaria (A & K) having duplicates (syntypes).

Leea negrosense was originally described by Elmer (1908b) from Negros, Philippines. While describing this species, he cited "Type specimen A. D. E. Elmer 10174". Ridsdale (1974) cited four duplicates of Elmer's specimens available at BO, K, L and US. During the present study, ten herbarium specimens were traced under the same gathering at various herbaria, including two sheets at G, and one each at HBG, A, K, NY, U, L, US and MO. All these are syntypes (Art. 9.6 of ICN), among these, the specimen housed at NY (NY00415204!) is selected here as the lectotype

since this sheet contains an additional paper label with field notes by the original author, Elmer.

Merrill (1915) described *Leea euphlebia* Merr. species based on the collection by Father M. Vanoverbergh from Luzon, Philippines. In the protologue he cited "Luzon, Bontoc subprovince, Bauco, Father M. Vanoverbergh 444, April to October 1910, on hillocks, altitude about 1,400 meters". Four duplicates of specimens were found in two herbaria, 3 in L (L 0013656!, L 0716929! and U 0247550! [U collections are now incorporated in L]) and one at A (A00051620). Ridsdale (1974) cited "Type: *Vanoverberg 444* (A, K, L)". This citation can be considered as first-step lectotypification as he cited one specimen in more than one herbaria. We could not trace any specimen at K as mentioned by Ridsdale. Among the available materials, the well-preserved specimen housed at L (L 0716929) herbarium is selected here as the lectotype. Certainly, this specimen is a part of the original material as it shows some diagnostic features (leaflets brownish when young, ovate to oblong-lanceolate, base acute or obtuse, apex caudate-acuminate, margins prominently serrate and inflorescence dense) of *L. euphlebia*. All other duplicates are isoelectotypes.

Elmer (1919) described *L. luzonensis* based on his collection (*Elmer 17776*) from the Philippines. Ridsdale (1974) cited "Type: *Elmer 17776* (A, BO, G, K, L, P, U) in this revision. The authors traced nine duplicate specimens from various herbaria including K, BM, HBG, GH, NY, P, U and L. The authors were not able to locate any duplicates at A, although Ridsdale (1974) cited this herbarium as having the 'type'. All the materials can be considered as syntypes (Art. 9.6 of ICN), and hence there is a need for second step lectotypification (Art. 9.17 of ICN). The specimen at K (K000736472!) is selected here as the lectotype, as it is a well-preserved one and most complete material which agrees with the description in the protologue especially in having leaflets with broadly obtuse to rounded base, and irregularly serrate margins. All others are isoelectotypes.

Walper (1843) described *Leea manillensis* based on a specimen collected by Meyan from Manila, Philippines. The authors traced two specimens (syntypes, Art.

9.6 of ICN) collected by Meyen one each at K and BR which perfectly agreed with the protologue. Additionally, both the sheets bear the same specimen label information included in the protologue. Ridsdale (1974) in his revision cited "*Type: Meyen s.n., Manila, Philippines (K, P)*". However, the authors were not able to locate a specimen at P. Ridsdale choice could be considered as first step lectotypification. The sheet housed at K (K000736475!) is selected here as the lectotype, a well-preserved specimen with a lax inflorescence as mentioned in the protologue.

Craib (1926) described *Leea schomburgkii*, with a diagnostic phrase "*L. sambucina* Willd. *foliolis grosse serratis vel dentatis, nervis lateralibus in dentes excurrentibus, floribus rubris recedit*" and cited two specimens, Schomburgk 256 and Collins 427 but wrote as type in Schomburgk collection. Following a thorough search, we could locate two specimens of Schomburgk with the same collection number, one each at K and P. Since these two specimens are syntypes, there is a need for lectotypification. Ridsdale (1974) also cited "*Type: Schomburgk 256 (K, P)*". Among these, the specimen at K (K000323721!) is selected here as the lectotype since this sheet contains a large inflorescence with numerous buds. Additionally, there is a slip affixed on the sheet that contains a description of *L. schomburgkii* by Ridsdale, which indicates that this was intended to be the lectotype.

9. *Leea indica* (Burm.f.) Merr., Philipp. J. Sci. 14(2): 245. 1919, Bibliogr. Enum. Born. Pl. 368. 1921, Enum. Philipp. Fl. Pl. 3: 11. 1922; Craib, Fl. Siam. 1(2): 318. 1926; Santapau in Rec. Bot. Surv. India 16: 55. 1953; Deb & R.M.Dutta in J. Bombay Nat. Hist. Soc. 69(3): 570. 1972; Ridsdale, Blumea 22: 95. 1974, Fl. Males., Ser. 1, Spermat. 7: 779. 1976; Deb, Fl. Tripura 1: 419. 1981; V.Singh, Fl. Banswara Rajasthan 65. 1983; N.C.Nair & A.N.Henry, Fl. Tamil Nadu 82. 1983; Panigrahi & Murti, Fl. Bilaspur Dist. 170. 1984; B.D.Sharma *et al.*, Fl. Karnataka, Analysis 56. 1984; A.C.Sm., Fl. Vit. Nova 3: 714. 1985; Harid. & R.R.Rao, Forest Fl. Meghalaya 250. 1985; R.S.Rao, Fl. Goa, Diu, Daman, Dadra & Nagarhaveli 1: 87. 1985; K.K.N.Nair & M.P.Nair, Fl. Courtallum 184. 1987; B.V.Shetty & V.Singh, Fl. Rajasthan 1: 190. 1987; V.S.Ramach. & V.J.Nair, Fl. Cannanore 107. 1988; Manilal, Fl. Silent Valley 61. 1988; B.G.Kulk, Fl. Sindhudurg 89. 1988; S.M.Almeida, Fl. Savantwadi, 1: 105. 1990; Vajr., Fl. Palghat Dist. 127. 1990; J.L.Ellis, Fl. Nallamalais 108. 1990; N.A.Harriman in Dassan. &

Fosberg (eds.), Revis. Handb. Fl. Ceylon 7: 392. 1991; K.M.Matthew, Excurs. Fl. Central Tamil Nadu 95. 1991; S.D.Deshp. *et al.*, Fl. Mahabaleshwar & adjoining 142. 1993; Kothari & Moorthy, Fl. Raigad Dist. 71. 1993; K.K.Khanna in D.M.Verma (ed.), Fl. Madhya Pradesh 1: 293. 1993; H.O.Saxena & Brahman, Fl. Orissa 1: 339. 1994; M.Mohanan & A.N.Henry, Fl. Thiruvananthapuram 122. 1994; A.S.Chauhan, Contr. Fl. Namdapha 141. 1996; Hajra *et al.*, Mat. for the Fl. Arunachal Pradesh 1: 319. 1996; Sivar. & P.Mathew, Fl. Nilambur 157. 1996; R.N.Banerjee, Fl. West Bengal 1: 452. 1997; B.K.Sinha, Fl. Great Nicobar Isl. 194. 1999; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 308. 1999; Moorthy in N.P.Singh & Karthik. (eds.), Fl. Maharashtra, Dicot. 1: 567. 2000; R.Shanpru in N.P.Singh *et al.* (eds.), Fl. Manipur 1: 240. 2000; B.D.Naithani in N.P.Singh *et al.* (eds.), Fl. India 5: 337. 2000; P.P.Sharma & N.P.Singh, Ethnobot. Dadra, Nagar Haveli & Daman 91. 2001; N.P.Singh *et al.*, Fl. Bihar, Analysis 114. 2001; N.Mohanan & Sivad., Fl. Agasthyamala 170. 2002; S.R.Yadav & Sardesai, Fl. Kolhapur Dist. 122. 2002; K.P.Singh in N.P.Singh *et al.* (eds.), Fl. Mizoram 1: 389. 2002; K.G.Bhat, Fl. Uduppi 116. 2003; Anil Kumar *et al.*, Fl. Pathanamthitta 137. 2005; Arisdason *et al.* in P.Daniel (ed.), Fl. Kerala 1: 767. 2005; S.G.Pradan & B.D.Sharma, Fl. Sanjay Gandhi Natl. Park 171. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 182. 2009; Puneekar & Lakshmin., Fl. Anshi Natl. Park 162. 2011; Lok *et al.*, Nat. Singap. 4: 62. 2011; J.H.F.Benj. & G.V.S.Murthy, Fl. Sri Venkateswara Natl. Park 92. 2013; G.D.Pal, Fl. Lower Subansiri Dist. 1: 215. 2013; Datar & Lakshmin., Fl. Bhagavan Mahavir Natl. Park 81. 2013; K.G.Bhat, Fl. South Kanara 309. 2014; B.K.Shukla in K.P.Singh *et al.* (eds.), Fl. Uttar Pradesh 1: 352. 2016; K.N.Reddy & C.S.Reddy, Fl. Telangana, 148. 2016; S.S.Dash & P.Singh, Fl. Kurung Kumey Dist. 384. 2017; Jayanthi, Fl. Campbell Bay Natl. Park 93. 2017; Karthig., Angiosp. diversity Mahatma Gandhi Marine Natl. Park 104. 2017; Pusalkar & S.K.Srivast., Fl. Uttarakhand 1: 990. 2018; Britto, Fl. Central & North Tamil Nadu 616. 2019; M.Y.Kamble, Fl. North Andaman Isl. 43. 2020; Mourya *et al.*, Fl. Udaipur Wildlife Sanctuar. 23. 2021; P.Singh & S.S.Dash, Fl. Little Andaman Isl. 85. 2021. *Staphylea indica* Burm.f., Fl. Ind. 75. 1768., t. 24, f. 2. 1768. *Aquilegia sambucina* L., Mant. Pl. Altera 211. 1771, *nom. illeg. superfl.* *Leea sambucina* (L.) Willd., Sp. Pl., ed. 4. [Willdenow] 1(2): 1177. 1798, *nom. illeg. superfl.*; DC., Prodr. I. 635. 1824; Roxb., Fl. Ind. (Carey & Wall. ed.) 2: 470. 1824; Spreng. Syst. Veg. 1: 670. 1825; Blume, Bijdr.

Fl. Ned. Ind. 4: 196. 1825; G.Don, Gen. His. 1: 712. 1831; Roxb. Fl. Ind. (Carey ed.) 1: 657. 1832; Miquel, Fl. Ned. Ind. 1 (2): 611. 1859, Fl. Ned. Ind., Eerste Bijv. 3: 519. 1861, Ann. Mus. Bot. Lugduno-Batavi 1: 98. 1863; Benth. Fl. Austral., 1: 451. 1863; Kurz, J. Asiat. Soc. Bengal 44(2): 179. 1875; J.L.Stewart & Brandis, Forest Fl. N.W. India 102. 1874; M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 666. 1875; Kurz, Forest Fl. Burma 1: 279. 1877; C.B.Clarke in Trimen's J. Bot. 19: 139. 1881; King, J. Asiat. Soc. Bengal 65(2): 414. 1896; Talbot, Syst. List Trees Bombay 57. 1894, Tr. Shr. Woody Clim. Bomb. Presid. 105. 1902; Koord. & Valeon., Bijdr. 9: 8. 1903; Duthie, Fl. Up. Gangetic Plain 1(1): 176. 1903; T.Cooke, Fl. Bombay 1: 260. 1903; Prain, Bengal Pl. 1: 340. 1903; Brandis, Ind. Trees 179. 1906; Talbot, Forest Fl. Bombay 1: 327. 1909; Haines, Forest Fl. Chota Nagpur 280. 1910; Gagnep., Bull. Soc. Bot. Fr. 336. 1910; Gamble, Fl. Madras 1: 240. 1918; Kirt. & B.D.Basu, Indian Med. Pl. 351. 1918; Gagnep., Fl. Indo-Chine t.1: 941. 1909; Ridl., Fl. Malay Penins. 1: 484. 1922; C.E.Parkinson, Forest Fl. Andaman Isl. 132. 1923; Haines, Bot. Bihar Orissa Pt 1. 208. 1925; Cowan & Cowan, Trees N. Beng. 40. 1929; Kanjilal & Das, Fl. Assam 1(2): 307. 1936; Backer & Bakh.f., Fl. Java 2: 94. 1965. *Type*: Burm.f., Fl. Ind.75, t.24, fig.2.

Figs. 50, 52–54

Aquilicia ottilis Gaertn., Fruct. Sem. Pl. 1: 275. 1788. [*Ottilis zeylanica* Gaertn. Fruct. Sem. Pl. 1. t. 57. 1788.]. *Leea ottilis* DC., Prodr. [A. P. de Candolle] 1: 636. 1824.

Leea gigantea Griff., Not. Pl. Asiat. 4: 697. 1854; Kurz, J. Asiat. Soc. Bengal 42(2): 65. 1873, J. Asiat. Soc. Bengal 44(2): 179. 1875, Forest Fl. Burma 1: 280. 1877; C.B.Clarke in Trimen's J. Bot. 19: 140. 1881; Ridley in Trans. Linn. Soc. London 3(9): 288. 1893; King, J. Asiat. Soc. Bengal 65(2): 412. 1896; Brandis, Ind. Trees 179. 1906; Gagnep., Bull. Soc. Bot. France 57: 336. 1910; Ridl., Fl. Malay Penins. 1: 484. 1922; Craib, Fl. Siam. 1(2): 317. 1926; Merr., Enum. Pl. Sumatra 8: 99. 1934. *Type*: MYANMAR, Madamaca, Mawlamyine [Moulmein], Oct 1834, *Griffith s.n.* (K barcode K000736371 digital image!).

Leea viridiflora Planch., Hort. Donat. 6. 1858. *Type*: INDIA, **Kerala**, Malabar, *s.d.*, *Hugel s.n.* (*n.v.*).

Leea sumatrana Miq., Fl. Ned. Ind. 1(2): 610. 1859. *Leea sambucina* Willd. var. *sumatrana* Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 99. 1863; *Type*: INDONESIA, **Sumatra**, Padang, *s.d.*, *Junghuhn s.n.* (L barcode L 2337266 digital image!).

Leea biserrata Miq., Fl. Ned. Ind., Eerste Bijv. 3: 518. 1861; King, J. Asiat. Soc. Bengal. 65(2): 415. 1896. *Leea sambucina* Willd. var. *biserrata* Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 99. 1863. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): INDONESIA, Banka, *Teijsmann, JE s.n.* (L barcode L 2337702 digital image!; *isolectotype*: L 2337259 digital image!).

Leea sambucina var. *heterophylla* Zipp. ex Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 99. 1863. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated here): NEW GUINEA, *s.d.*, *Zippelius s.n.* (L barcode L 0013677 digital image!; *isolectotype*: L barcode L 0013676 digital image!).

Leea sambucina var. *simplex* Zipp. ex Miq., Ann. Mus. Bot. Lugduno-Batavi 1: 99. 1863. *Type*: NEW GUINEA, *s.d.*, *Zippelius s.n.* (L barcode L 0013678 digital image!).

Leea sambucina var. *occidentalis* C.B.Clarke in Trimen's J. Bot. 19: 166. 1881. *Lectotype* (designated here): *s.loc.*, *s.d.*, *s.coll.* Cat. no. 6824 B (K barcode K001124904 digital image!).

Leea umbraculifera C.B.Clarke in Trimen's J. Bot. 19: 141. 1881; Gamble, Man. Ind. Timb. ed.2. 191. 1902; Brandis, Ind. Trees 179. 1906; Cowan & Cowan, Trees N. Beng. 40. 1929; Kanjilal & Das, Fl. Assam 1(2): 306. 1936; H.Hara, Fl. E. Himalaya 200. 1966; Deb & R.M.Dutta in J. Bombay Nat. Hist. Soc. 69 (3): 570. 1972; J. Joseph, Fl. Nongpoh and vicinity 73. 1982. *Lectotype* (designated here): INDIA, **Sikkim**, *s.d.*, *J. D. Hooker s.n.* (K barcode K001327102 digital image!).

Leea ramosii Merr., Philipp. J. Sci. 17: 282. 1921, Enum. Philipp. Fl. Pl. 3: 14. 1922. *Type*: PHILIPPINES, Siargao Island, June 1919, *Ramos & Edaño Bur. Sci.* 34945 (P barcode P00697984 digital image!).

Leea expansa Craib, Bull. Misc. Inform. Kew 1926(8): 358. 1926; Craib, Fl. Siam. 1(2). 317. 1926. *Type*: THAILAND, Ko Chang (Kaw Chang), 29 Sept 1924, Kerr A.G.F. 9236 (K barcode K000323720 digital image!).

Shrubs or trees, 1.5 to 10 m high; roots non-tuberous. Stems erect, stout, single-stemmed or multi-stemmed with numerous stilt roots, with small warted projection, branched; internodes terete or furrowed, purple to green, coarsely muricate; nodes not swollen, green.

Pearl glands globose, white, distributed in leaves and inflorescences. Leaves alternate, 2–3 pinnate, imparipinnate; petioles 7–22 cm long, swollen at base, furrowed, glabrous, green to purple. Petiolar stipule 2–3 × 1–1.5 cm, oblong to lance-ovate or obovate, glabrous, green; stipular scar 2.5–4 cm long, triangular; rachis 6–23 cm long, channelled on adaxial surface, glabrous, green to purple. Leaflets opposite, narrowly to broadly oblong or narrowly to broadly ovate to lance-ovate or widely elliptic, young leaflets purple

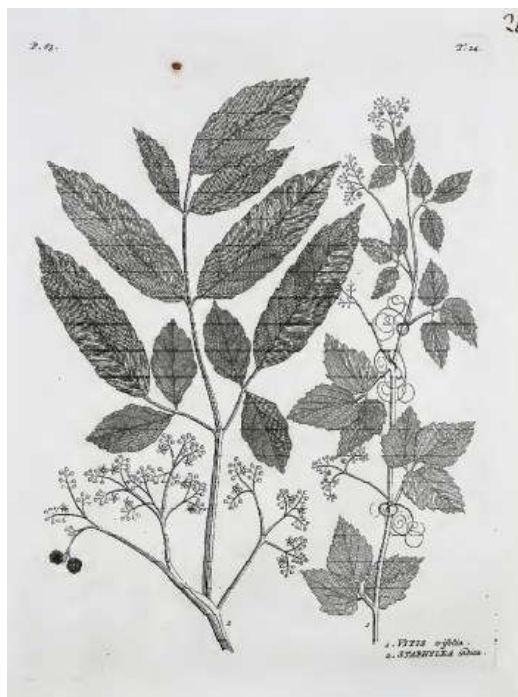


Fig. 50. Type of *Leea indica* (Burm.f.) Merr. [Burm.f. Fl. Ind. 75, t. 24, fig. 2. (lefthand side specimen)].

or green or brown, distal leaflets: lamina 7.5–21 × 19–10 cm, lateral leaflets lamina: 3.5–27 × 2–10.6 cm, glabrous on both surfaces, dark green above and pale green beneath, base cordate or obtuse, margins crenate-serrate or dentate, apex short or long or abruptly acuminate; petiolules: central 1.5–6.5 cm long; lateral 0.2–2.5 cm long; secondary veins 6–17 pairs, usually 3-nerved at base, veins prominently raised on abaxial surface, glabrous. Inflorescence a leaf-opposed terminal dichasial cyme, 6–28 cm long, branched, condensed or lax, many-flowered; peduncles 25–15 cm long, furrowed, glabrous or pubescent, green. Flowers 5–6.2 mm long,

Systematic treatment

numerous, greenish-white. Pedicels slender, 0.7–1.5 mm long, hairy. Bracts 1.7–3.2 mm long, narrowly to broadly ovate, early caducous, hispid, green. Calyx campanulate, 3–4.4 × 2–3.3 mm, lobes 5, 0.8–1.3 × 0.6–1.3 mm, apex acute or obtuse, glabrous or hairy, green. Corolla lobes 5, narrowly to broadly ovate, 2.5–4 × 1.5–2.8 mm, apex acute and hooded, margins entire, glabrous, pale green; corolla tube with floral disc 2.9–4 × 2.4–3 mm, white turning yellow at maturity. Floral disc tubular, 1.8–2.4 mm long, white when young yellowish at maturity; upper free parts 1.5–1.8 mm long, lobes notched, sinuses shallow, 0.5–0.9 mm long; lower free parts 0.3–0.8 mm long. Stamens 5, syngeneceous; filaments 1–1.4 mm long, glabrous, white turning yellow at maturity; anthers dorsifixed, 1.3–1.6 mm long, dehisces longitudinally, yellow or white on lateral side, purplish on ventral. Ovary globose, 0.6–1.2 mm long, 6-loculed, ovule one in each locule, placentation axile, green; style 0.5–1.8 mm long, glabrous, green; stigma convex. Fruits berry, 0.8–1.3 cm diam., globose, green turning black. Seeds 6, more or less obconic, 4.21–4.52 (4.40 ± 0.09) × 3.13–3.42 (3.25 ± 0.08) mm, dark brown when mature, surface smooth.

Flowering & fruiting: Almost throughout the year with a peak from June to October.

Habitat: This species grows in almost all types of habitats including moist shady places, forest margins and riversides. The major associates are *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *Rauwolfia tetraphylla* L. (Apocynaceae) and *Cardiosperm helicacabum* L. (Sapindaceae).

Distribution: India (Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Karnataka, Kerala, Lakshadweep, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Sikkim, Tamil Nadu, Telangana, Tripura, Uttar Pradesh, Uttarakhand and West Bengal; Fig. 51), Bangladesh, Burma, Cambodia, Ceylon, China, Fiji, Hainan, Java, Laos, N. & S. Vietnam, N. Australia, Nepal, New Hebrides, Philippines, Santa Cruz Islands, Solomon Islands, Thailand and throughout Malesia. In India, it shows the widest distribution in south India. It is distributed in almost all districts of Kerala.

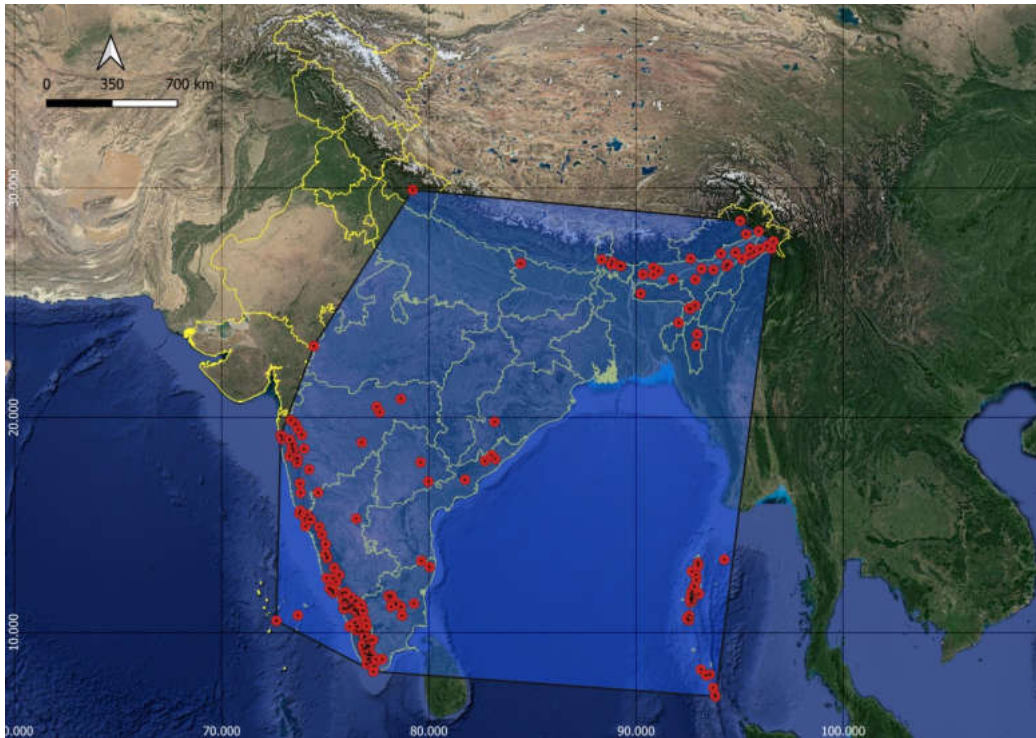


Fig. 51. Distribution of *Leea indica* (Burm.f.) Merr. in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Nicobar district, Great Nicobar Island, 1 km after Vijaynagar, way to Galathea, 17 July 2019, *Amrutha* 164095 (CALI barcode CALI172996, CALI72997, CALI172998); *Ibid.*, 9 km East-West Road, 23 Sept 1989, *S.K. Srivastava* 14834 (PBL); *Ibid.*, East-West Road, 17 July 2019, *Amrutha* 164089 (CALI); Katchal, Feb 1875, *Kurz s.n.* (CAL); *Ibid.*, West Bay, 15 Feb 1977, *P. Chakraborty* 5232 (CAL); Malacca, Car Nicobar, 10 Aug 1973, *N.P. Balakrishnan* 418 (MH); *Ibid.*, 01 Mar 1974, *N.C. Nair* 918 (CAL); North and Middle Andaman district, Aerial Bay, 05 Dec 1976, *N.P. Balakrishnan & N.C. Nair* 4993 (CAL); After 15 No. Gate, Jarawa Protected Area, 10 July 2019, *Amrutha* 164055 (CALI barcode CALI172992); Baratang Island, Kenchi Road, 14 July 1977, *N. Bhargava* 5892 (CAL); *Ibid.*, Opposite to Jetty, 22 Jan 1979, *P. Basu* 7337 (CAL); Barren Islands, Apr 1931, *David Prain s.n.* (MH); *Ibid.*, Apr 1891, *David Prain s.n.* (BSI, CAL); Betapur, 22 July 1974, *N. Bhargava* 1834 (CAL, PBL); Camp No. 15, 24 Km from Rangat, *N. Bhargava* 6339 (CAL); Interview Island, 25 Apr 1964, *J.L. Ellis & R. Ramamurthy* 18944 (PBL barcode PBL0000005737); Narcondam, Mar 1891, *David*

Prain s.n. (CAL); Way to Shyam Nagar, Radhanagar, Diglipur, 08 July 2019, *Amrutha* 164033 (CALI barcode CALI173000, CALI172991); Saddle Peak, 07 July 2019, *Amrutha* 164024 (CALI); Saddle Peak Range, 28 Mar 1977, *N.P. Balakrishnan* 5408 (CAL, PBL); Taralait Bay, 08 Feb 1959, *K. Thoathatri* 9194 (MH); South Andaman district, 5 km from Ferrargunj towards Baratang, 06 July 2019, *Amrutha* 164002 (CALI barcode CALI172988, CALI172989, CALI172990); Chitia Tapu, 29 May 1974, *K. Thoathatri & N.C. Nair* 1064 (CAL); Dhanikari, Island Forest, 14 July 1973, *N.P. Balakrishnan* 309 (PBL); East base of Mount Harriet, *Kurz s.n.* (CAL); Homfreygunj, 14 Apr 1964, *J.L. Ellis & K. Ramamurthy* 18802 (MH, PBL); Hut Bay, 05 Jan 1976, *N. Bhargava* 3326 (PBL); *Ibid.*, 10 Feb 1981, *P.K. Premanath* 8444 (CAL); Near Hut Bay, 13 Jan 1976, *N. Bhargava* 3422 (CAL); Jirkathang, 16 July 1976, *N. Bhargava & P. Chakraborty* 3777 (PBL); Little Andaman, 18 Apr 1964, *K. Thoathatri* 10300 (CAL); *Ibid.*, Dugong Creek, 01 Sept 1976, *N. Bhargava* 4328 (CAL); *Ibid.*, 27 Nov 1977, *N. Bhargava* 6583 (CAL); *Ibid.*, Way to forest nursery, 01 Jan 1976, *N. Bhargava* 3280 (CAL); Namunaghar, 19 Sept 1891, *Dr. King s.n.* (MH); Neil Island, 16 Nov 1978, *P. Basu* 7040 (CAL, PBL); Port Blair, Lamba Line, 24 May 2008, *S. Kumar* 27605 (PBL barcode PBL0000005740, PBL0000005741); Rangachang Forest Range, 10 July 1973, *N.P. Balakrishnan* 274 (PBL); Ritchie's Archipelago, 10 Oct 1975, *Borim Ghosh* 11543 (PBL); Rutland Island, Baegon Bageecha, 10 Apr 1978, *N.C. Nair* 6959 (CAL); *Ibid.*, Badakhali, 07 May 2003, *K. Karthigeyan* 19507 (PBL barcode PBL0000005738, PBL0000005739); Sippighat, 12 Sept 1973, *N.P. Balakrishnan* 334a (PBL); *Ibid.*, 25 Nov 1978, *P. Basu* 7068 (CAL, PBL); Way to Shoal Bay, 22 Mar 1991, *A.A. Ansari* 95494 (MH). **Andhra Pradesh**, Godavari district, Rampa Hills, 26 Sept 1920, *V. Narayanaswami* 177 (CAL); Visakhapatnam district, Modalammagudi, Minumuluru, 14 Apr 1976, *G.V. Subha Rao* 47348 (MH); Punyagiri-s kota, 23 Dec 1969, *G.V. Subha Rao* 32784 (MH); Towards Borra, 09 Aug 1973, *G.V. Subha Rao* 44267 (MH). **Arunachal Pradesh**, Changlang district, Changlang, 19 June 1961, *D.B. Deb* 25785 (CAL); Diban surroundings, 28 Sept 1994, *G.D. Pal* 7239 (ARUN); Margherita to Jairampur, 10 Oct 1959, *R. S. Rao* 19917 (CAL); Namchik, 13 Oct 1959, *R.S. Rao* 20184 (CAL); East Siang district, Pasighat-Ahowali, 10 Nov 2013, *M. Bhaumik* 29636 (ARUN); Lower Dibang Valley district, Deopani River, on way north of Roing, 03 Oct 1969, *A.S. Rao* 48220 (CAL); Tirap district, Changlang-Khela, 20 Aug 1958, *G.*

Panigrahi 14430 (CAL); Deomali, 19 Oct 1959, *R.S. Rao* 20313 (CALI); West Kameng district, Bhalukpong, 11 Sept 1964, *J. Joseph* 39784 (CAL). **Assam**, Barpeta district, Baguri, 13 Aug 1975, *P.K. Hajra* 52879 (ASSAM); Bongaigaon district, Panbari, 14 Aug 1975, *P.K. Hajra* 52912 (ASSAM); Dima Hasao district, Borail Res., 15 May 1915, *Upendranath Kanjilal* 5711 (ASSAM); Goalpara district, Chinimari, 12 July 2016, *M. Bhaumik* 110265 (ASSAM); Hatigaon, 13 Sept 1937, *G.K. Deka* 12139 (ASSAM); Hailakandi district, Katakhal, 14 Dec 1914, *Upendranath Kanjilal* 4871 (CAL); Kokrajhar district, Chakrashila Wildlife Sanctuary, 01 Nov 2006, *Ranjit Daimary* 111862 (ASSAM); *Ibid.*, 28 July 2007, *Ranjit Daimary* 110531 (ASSAM); *Ibid.*, 06 July 2008, *Ranjit Daimary* 118173 (ASSAM); Lakhimpur district, North Lakhimpur to Kadam Reserve, 14 May 1966, *D.M. Varma* 46300 (ASSAM); Nagaon district, Doboka R.F., 4 miles south of Kaphitoli, 28 Aug 1964, *N.P. Balakrishnan* 39527 (CAL); Sivasagar district, Tingalibam Garden Hills, Oct 1898, *Dr. Prain's Collector* 88 (CAL); Tinsukia district, Makum, Dihing River, 16 Mar 1894, *G.A. Gammie* 48 (CAL); Upper Dihing Reserve, East Block, Khejan River (Digboisikkim), 09 July 1959, *G. Panigrahi* 18889 (CAL); Jorhat district, Camp-Gibbon WLS, 11 June 2010, *Ranjit Daimary* 117955 (ASSAM); Gibbon WLS, Camp 1, 22 Feb 2011, *Ranjit Daimary* 121593 (ASSAM); *Ibid.*, Camp 2, 10 June 2010, *Ranjit Daimary* 116061 (ASSAM); Karbi Anglong district, Kaliani, 18 June 1963, *D.B. Deb* 35118 (ASSAM); Karimganj district, Badarpur, May 1912, *s.coll.* 29327 (BLAT); Lakhimpur district, Marghirita, 04 Feb 1939, *G.K. Doka* 12138 (ASSAM); Nagaon district, Bimali-Kanchanjuri, 28 Nov 1975, *P.K. Hajra* 65245 (ASSAM). **Goa**, North Goa district, Aldana, in thickets near stream, 03 Jan 1966, *J. Pallithanam* 462 (BSI); Chapora, 05 Sept 1965, *John Cherian* 88556 (BSI); Pernem, 18 Nov 1962, *R.S. Rao* 84926 (BSI); Valpoi, 05 Oct 1964, *R.S. Raghavan* 103239 (BSI); South Goa district, Canacona, 10 Apr 1963, *K.C. Kanodia* 88116 (BSI); Colem, 09 May 1963, *K.C. Kanodia* 88500 (BSI); Dudhsagar in Mollem, 23 Sept 1974, *M.K. Ghosh* 10838 (CAL); Vern Village, 15 Aug 1963, *K.C. Kanodia* 89354 (BSI). **Karnataka**, Dakshina Kannada district, Charmadi, 24 Feb 1962, *R.K. Arora* 694 (CAL); Jalsur, 20 Nov 1920, *C.E.C. Fischer* 4522 (CAL); Sullia, 16 Feb 1962, *R.K. Arora* 623 (CAL); Hassan district, Bisle, 23 Apr 1958, *S.D. Mahajan* 34847 (BSI); *Ibid.*, 05 June 1957, *S.D. Mahajan* 19845A (BSI); Kodagu district, Bhagamandala, 13 Mar 1960, *R.K. Arora* 61525 (BSI); Koppal district, Anegundi, 18 Apr 1958, *RKA*

33894 (BSI); Uttara Kannada district, Mattigar Village, Sirsi, 24 Apr 1956, S.D. Mahajan 1268 (BSI); Siddapur, 04 May 1956, G.S. Puri 1851 (BSI); Teligiri Forest, Yellapur, 16 Nov 1957, S.K. Jain 3465A (BSI); Yellapur, May 1917, L.J. Sedgwick 2444 (CAL); *Ibid.*, 12 Mar 1957, S.K. Jain 16543 (CAL); Shimoga district, Agumbe, 13 May 1960, R. Sundara Raghavan 62438 (BSI, CAL); *Ibid.*, Balehalli, 27 May 1957, S.D. Mohanan 19531 (CAL); *Ibid.*, Galingudda, 13 May 1962, R. Sundara Raghavan 80507 (CAL); Hulikal, 21 Feb 1962, R. Sundara Raghavan 79575 (BSI, CAL); Hulikal-Agumbe Road, 01 May 1980, C.J. Saldanha & B. Gurudev Singh 11351 (CAL); Sagar-Jog Road, 15 June 1961, R.S. Raghava 74092 (BSI); Varahi-Yadur Forest Road, 25 May 1962, R. Sundara Raghavan 80898 (BSI, CAL). **Kerala**, Eranakulam district, Iringol Kavu, *s.d.*, V. Sarojini Menon 12214 (TBGT); Thundathal Range, 23 Aug 1965, K.M. Sebastine 25336 (MH); Idukki district, Area near Kappakanam, 28 May 1982, C.N. Mohanan 74057 (MH); Arjunankotta, 31 Mar 1995, Jomy Augustine 15109 (CALI barcode CALI105487); Kulamavu, 24 Sept 1981, C.N. Mohanan & B. Ramanujam 71942 (CAL); Kurisumala, 12 Sept 1984, V.T. Antony 721 (MH, CAL); Kuttikanam-Peerumedu, 25 Sept 1964, K. Vivekananthan 21377 (MH); Meenmutty, 14 Feb 1982, C.N. Mohanan 73244 (MH); Near Pallivasal, 23 Apr 1964, K.M. Sebastine 18390 (MH); On the way to Valara Water falls, 20 Mar 1982, R. Rajan 73090 (CAL, MH); Painavu, 20 Aug 1981, K. Vivekananthan & V.S. Raju 71125 (CAL, MH); Near Painav, Nagampara Range, 23 Jan 2019, Vishnu mohan 168925 (CALI barcode CALI172999); Periyar, Kuruthode, 12 Aug 1993, Jomy Augustine 12236 (CALI); Puttuparai to Peruvanthanam, 22 May 1965, K. Vivekananthan 23969 (MH); Kannur district, Chandanathode-way to Kannothe, 25 June 1965, J.L. Ellis 18652 (MH); Chandanathode, 15 Dec 1978, V.S. Ramachandran 53975 (CAL, MH); Kalliasseri, 22 June 1980, R. Ansari 64984 (CAL, MH); Kannothe R.F., 10 July 1978, V.S. Ramachandran 57536 (CAL, MH); Kottiyoor R.F., 15 Nov 1978, V.S. Ramachandran 58241 (CAL, MH); Madayippara, 19 July 2019, Jeomol 153205 (CALI barcode CALI173006); *Ibid.*, Climber zone, 14 July 2011, C. Pramod 126674 (CALI barcode CALI129404, CALI129405); Pappinisserri, 16 May 1982, V.J. Nair 73920 (CAL, MH); Payyavur, 05 Oct 1979, R. Ansari 64753 (CAL, MH); Thalipparamba Farm, 19 May 1906, C.A. Barber 7771 (MH); *Ibid.*, 12 Oct 1905, C.A. Barber 7135 (MH); Kasargod district, Perdala, 07 May 1982, V.J. Nair 71056 (CAL, MH); Kollam district,

Achankovil, 29 May 1979, C.N. Mohanan 61274 (CAL, MH); Aryankavu boarder, 21 Dec 1978, C.N. Mohanan 59589 (MH, CAL); Chavarakavu, 09 July 2003, Geeta Kumari & Deepthi Kumari 50882 (TBGT); *Ibid.*, Kulathupuzha, 06 June 1979, C.N. Mohanan 63130 (CAL, MH); *Ibid.*, 24 Feb 1996, T. Dhruvan 27979 (TBGT); Muthalathodu Achankovil section, Aryankavu Range, 05 Dec 1961, K.N. Subhramanian 77444 (BSI); Palaruvi, 01 Oct 2017, Amrutha 153229 (CALI); Punalur-Ottakkal, 11 Aug 1978, C.N. Mohanan 58450 (CAL, MH); Rosemala, 29 May 2012, Deepthi, Usha & A.G. Pandurangan 76242 (TBGT); Thenmala, 15 June 1984, N. Mohanan 163 (TBGT); *Ibid.*, Ayyappan Kavu, 02 Oct 2017, Amrutha 153231 (CALI barcode CALI173034); *Ibid.*, Dharpakulam, 03 Oct 2017, Amrutha 153234 (CALI barcode CALI173035); Kallada River Valley, 07 Feb 1961, K.N. Subhramanian 70360 (BSI); Kottayam district, Kulamavu, 24 Sept 1981, B. Ramanujam 71942 (MH); S.B.C. Botanical Garden-Changanassery, 12 Apr 1984, V.T. Antony 377 (MH); Kozhikode district, Kakkayam, 25 Aug 2017, Amrutha 153221 (CALI barcode CALI173022, CALI173021, CALI173020); *Ibid.*, Near Dam, 25 Aug 2017, Amrutha 153219 (CALI barcode CALI173018, CALI173017); Thalayadu, on the way to Vayalada, 17 Sep 2017, Nikhil Krishna & K.K. Jeomol 153228 (CALI barcode CALI173033); Malappuram district, Calicut University Campus, 19 Nov 1971, K.P. Navaneetha Kumar 31 (CALI); *Ibid.*, 30 Dec 1974, T.C. Ayishabi 5677 (CALI); *Ibid.*, 10 Feb 1976, K. Sulekha 23351 (CALI); *Ibid.*, 5 Aug 1982, K. Marry Mathew 1646 (CALI); *Ibid.*, 30 Dec 1984, A.M. Rema 4631 (CALI); *Ibid.*, 13 Feb 1985, K. Leela 46263 (CALI); *Ibid.*, 15 Oct 1988, P. Elsie Ouseph 43191 (CALI); *Ibid.*, 04 Feb 2003, Thomson Mani 90707 (CALI); *Ibid.*, 18 Nov 2003, A. Swapna Thomas 94663 (CALI); Calicut University Ladies Hostel premises, 19 July 2017, Amrutha 153204 (CALI barcode CALI173010, CALI173011, CALI173012); Canoli Plot, 07 Nov 1980, *s.coll.* 29126 (CALI); Gudallor Road, 14 Aug 1981, *s.coll.* 28576 (CALI); Koonolmadu, Kakkancherry, 02 Aug 2017, Amrutha 153207 (CALI); Nadugani, 28 Aug 2017, Amrutha 153225 (CALI barcode CALI173026, CALI173027, CALI173028, CALI173029, CALI173030, CALI173031, CALI173032); Nilambur, 28 Aug 2017, Amrutha 153222 (CALI barcode CALI173025, CALI173024, CALI173023); Poolakkapara-Nedumkayam, 25 Feb 1970, J.L. Ellis 33566 (MH); Thenhippalam, 25 Aug 1970, Dhanalakshmi C 614 (CALI barcode CALI141439); Vadapuram, 19 Aug 1983, *s.coll.* 34203 (CALI); Vaniampuzha, *s.d.*, *s.coll.* 34320 (CALI); Villunniyal, near

Calicut University Campus, 09 Aug 2017, *Amrutha* 153212 (CALI barcode CALI173013); *Ibid.*, 17 Aug 2017, *Amrutha* 153215 (CALI barcode CALI173016); *Ibid.*, 18 Aug 2017, *Amrutha* 153216 (CALI barcode CALI173015, CALI173014); Palakkad district, Dhoni R.F., 18 July 1963, *J. Joseph* 17176 (MH); Mandampally Forest: Mukkali, 06 Apr 1978, *N.C Nair* 56621 (CAL, MH); Mukkali Forest, 14 July 1969, *E. Vjaravelu* 32105 (MH); Muthikulam, 27 Apr 1979, *E. Vajravelu* 62929 (MH, CAL); Palakkayam-Kanjirapuzha Submergible Forest, 21 July 1964, *K.M. Sebastine* 20902 (MH); Silent Valley, 22 Sep 1969, *E. Vajravelu* 33274 (MH); *Ibid.*, 23 Sept 1977, *R. Ansari* 51457 (CAL, MH); Silent Valley-Damsite, 04 Dec 1981, *K.S. Prasannakumar* 10242 (CALI barcode CALI102890, CALI192891); *Ibid.*, 31 July 1995, *Ajayakumar & Saji* 25812 (TBGT); *Ibid.*, 4 Oct 1979, *N.C. Nair* 64205 (CAL); Silent Valley R.F., 22 June 1984, *B.V. Shetty* 81289 (MH); *Ibid.*, Pathenthode, 07 Apr 1983, *T. Sabu* 11353 (CALI barcode CALI102892, CALI102893); *Ibid.*, Poochappara, 07 July 1996, *T.S. Nayar* 25847 (TBGT); Pathanamthitta district, Angamoozhy Forest, 05 May 1988, *R. Chandrasekaran* 88413 (MH); Attathodu, 14 Mar 2991, *S. Binu* 3059 (TBGT); Goodrical, 13 July 1994, *A.G. Pandurangan & M. Raveendran* 01916 (TBGT); Gurunathan Mannu, 07 May 1989, *R. Chandrasekaran* 89241 (MH); Kakkad Forest near Moozhiar River, 7 May 1991, *R. Chandrasekaran* 88448 (MH); Moozhiyar, 21 Mar 1978, *C.N. Mohanan* 54333 (CAL, MH); *Ibid.*, 10 Sep 1987, *N. Anilkumar* 28 (MH); Nilakkal, 26 Feb 1988, *N. Anilkumar* 517 (MH); Kallar, 18 Sept 1913, *C.C. Calder & M.S. Ramaswami* 479 (CAL); Kallar River bed-Konni, 17 Nov 1976, *M. Chandrabose* 49087 (CAL, MH); Pamba, 24 June 1968, *D.B. Deb* 30198 (MH); Pamba to Anathode, 16 Dec 1974, *K. Vivekanathan* 45295 (MH); Between Pamba to Ayyapan Temple, 02 Sept 1977, *N.C. Nair* 50817 (CAL, MH); Pulikkayam, 29 Apr 1992, *A. Nazarudeen* 14212 (TBGT); Ranni R.F., 5 Apr 1980, *C.N. Mohanan* 68339 (CAL, MH); *Ibid.*, 17 May 1980, *C.N. Mohanan* 65067 (CAL, MH); Thiruvananthapuram district, Athirumala, 23 Jan 1987, *N. Mohanan* 9286 (CALI barcode CALI100593); *Ibid.*, 13 May 1988, *N. Mohanan* 9830 (TBGT); Bonaccord, 25 Apr 1990, *N. Mohanan* 8263 (TBGT); *Ibid.*, 12 Oct 2014, *Usha & Deepthi* 84454 (TBGT); *Ibid.*, 12 Mar 2016, *Usha & Deepthi* 86494 (TBGT); Garden Site, 13 June 1984, *V.S. Raju* 156 (TBGT); *Ibid.*, 07 May 1984, *T.S. Nayar* 213 (TBGT); Karamanayar-Bonaccord, 17 Nov 1995, *M. Navas* 23470 (TBGT); Njaraneeli, 03 Mar 2016, *H. Ancy* 86807 (TBGT); Palode Botanical Garden Campus,

12 Apr 2016, *Usha & Deepthi* 82293 (TBGT); Pongalapara, 15 May 1988, *N. Mohanan* 9286 (TBGT); Ponmudi, 19 Feb 1959, *M.Y. Ansari* 50234 (BSI); *Ibid.*, 17 Sept 1968, *K.M. Matthew* 9096 (RHT barcode RHT012728); *Ibid.*, 31 July 1978, *N. Mohanan* 56999 (CAL); Sastahanada, 26 Mar 1992, *A. Nasarudheen* 14118 (TBGT); Thrissur district, Athirappali R.F., 10 Dec 1965, *K.M. Sebastine* 26729 (MH); Athirappally Water fall, 04 Feb 1984, *K. Ramamurthy* 72763 (MH, CAL); *Ibid.*, 17 Mar 1982, *R. Rajan* 73047 (CAL); Chimmini Dam Area, 21 Mar 1980, *K. Ramamurthy* 66242 (MH); Mathilakam, Kodungallur, 06 Aug 2017, *Amrutha* 153211 (CALI barcode CALI173009, CALI173008, CALI173007); Poringal, 23 Feb 1957, *G.S. Puri* 15926 (BSI); Vazhachal, 12 Mar 2005, *K.H. Amitha Bachan* 123629 (CALI barcode CALI107985, CALI107986); Vettilappara, 23 Jan 1982, *K. Ramamurthy* 72920 (CAL); Wayanad district, Pookode Lake, 10 Apr 2001, *A.K. Pradeep* 70527 (CALI); Sultan Battery, 10 Feb 1964, *J.L. Ellis* 18652 (MH); Thirunelli, near Papanashini, 27 July 1984, *R.T. Balakrishnan* 40318 (CALI). **Lakshadweep**, Androth Island, 30 Nov 1960, *B.M. Wadhwa* 68432 (BSI); Karathottam area, 16 Feb 1975, *P. Bhargavan* 101931 (MH); Kavaratti, 19 Feb 1959, *B.M. Wadhwa* 45479 (BSI); *Ibid.*, 04 Dec 1960, *B.M. Wadhwa* 68710 (CAL); *Ibid.*, 20 Oct 1959, *K.S. Srinivasan s.n.* (CAL); Way to Mullakunnu, 12 Apr 1994, *P. Bhargavan* 101804 (MH); Way to Navodaya school, 26 Jan 1996, *P. Bhargavan* 1062900 (MH). **Maharashtra**, Kolhapur district, Amba Ghat, 19 Sep 2018, *Amrutha* 153251 (CALI); Gaganbowda Road, 20 Aug 2018, *Amrutha* 153256 (CALI barcode CALI173036, CALI173037, CALI173038, CALI173039, CALI173040); Mumbai Suburban district, Malad, along railway track, 10 Aug 1954, *G.L. Shah* 158A (BLAT); Trombay Hills, 27 July 1958, *Balan Nair B* 3393 (BLAT); Vihar Lake, 18 Sept 1954, *H.S. SJ* 19582 (BLAT); Nashik district, Igatpuri, Sept 1917, *H. Santapau* 18641 (BLAT); Pune district, Base of forest, Warak Village Hill, Mulshi area, 22 Mar 1963, *R.S. Rao* 87461 (BSI); Dhup-Rahat, Varandha, 15 June 1957, *V.D. Vartak* 9202 (AHMA); Foot of Chauva Hills (Khed taluka), 22 Apr 1961, *K.P. Janardhanan* 72118 (BSI); Kadathali-Wagjoi Forest on the way to Mangaon (Ambavane), 24 Mar 1964, *B. Venkata Reddi* 96182 (CAL); Khandala, Apr 1941, *H. Santapau* 91.2 H (BLAT); Kopre, Junnar Taluka, 28 Feb 2001, *Nagarkar S.B.* 945 (AHMA); Korifort, 13 Sept 2018, *Amrutha* 153246 (CALI); Lonavala, *s.d.*, *B.A. Razi* 5127 (BLAT); Mangaon Forest-Ambavane-14 m south of Lonavala, 04 Feb 1964, *B. Venkata Reddi* 95987 (CAL); Near Hirdoshi, 07 June 1958,

V.D. Vartak 13390 (AHMA); Sakarpathar, 25 Dec 1962, Seshagiri Rao Rolla 85251 (BSI, CAL); St Xavier's Railway Bridge, Khandala, 13 Mar 1944, H. Santapau 3703 (BLAT); *Ibid.*, 22 Apr 1942, H. Santapau 91. 23 (BLAT); Susale, Mulshi, 02 Oct 1991, D.K. Kulkarni s.n. (AHMA); Raigad district, Matheran, 6 Dec 1958, N.A. Irani 2599 (BLAT); *Ibid.*, 30 Mar 1918, H. Santapau 18635 (BLAT); *Ibid.* 20 Jan 1962, G.L. Shah 10521 (BLAT); *Ibid.*, Garbut point, 22 Feb 2006, S.C. Majumdar & S.K. Das 192410 (BSI); Matheran Waterfall, 26 May 1959, N.A. Irani 4076 (BLAT); Satara district, Fitzgerald Ghat, 29 Dec 1950, P.V. Bole 208 (BLAT); Mahabaleshwar-Mahad Road, 6 Apr 1956, G.S. Puri 296 (BSI); *Ibid.*, 06 Apr 1956, G.S. Puri 304 (CALI); Mahabaleshwar to Prathap Ghat, 26 May 1954, P.V. Bole 1093 (BLAT); M'war, 22 July 1955, V.D. Vartak 833 (AHMA); Thane district, Ajoba Parvat Slope, Near Valmiki, 16 Oct 1967, K.V. Billore 111935 (CAL); Wardha district, Shivagaon, 21 Sept 1957, J.A. Vasavada 17303 (CAL); Washim district, Karanja, 21 Sept 1960, P. Divakar 1559 (BLAT); Karli, 25 Apr 1903, G.A. Gammie 16221 (BSI). **Meghalaya**, Khasi Hills, 10 Oct 1886, C.B. Clarke 44954 (CAL). **Mizoram**, Serchhip district, Keitum, 23 Jan 1963, D.B. Deb 31223 (CAL). **Orissa**, Kalahandi district, Nivangiri, Kalahandi, 30 Apr 1956, S.K. Mukherjee 4146 (CAL). **Sikkim**, s.loc., 26 Aug 1875, G. King 1332 (CAL); Teesta River, 14 Apr 1875, G. King 2500 (CAL). **Tamil Nadu**, Chennai district, Layola, Madras, 28 Dec 1953, J. Pallithanam 1295 (RHT barcode RHT012698); *Ibid.*, May 1957, J. Pallithanam 2584 (RHT barcode RHT012699); Coimbatore district, Anamalais, 16 Mar 1931, V. Narayanaswami 5368 (MH); Koomati-Anamalai, 26 Dec 1990, V.B. Hosagondan 94546 (MH); Maruthamalai, 21 Sept 1956, K.M. Sebastine 803 (CAL, MH); *Ibid.*, 28 Sept. 1956, K.M. Sebastine 888 (CAL); Mylon's Bungalow to Muthukulam, 21 Aug 1960, A.N. Henry 381 (MH); Sadivayal to Siruvani foot, 13 Aug 1960, A.N. Henry 189 (MH); Sholaimangadayar submergible area, 27 July 1963, K.M. Sebastine 16700 (MH, CAL); Udumparai-Anamalai, 15 May 1903, C.A. Barker 5895 (MH); Kanyakumari district, Around Kalikesam River-Baltimore, 30 Aug 1976, A.N. Henry 48142 (CAL, MH); Lawnz-in Botanical Garden Singapore, 3 Sept 1929, Naiz s.n. (MH); S.T. Mangad, 28 Mar 1979, A.N. Henry & Swaminathan 61587 (CAL, MH); Madurai district, Sabarigiri-Vellimalai, 23 Aug 1990, V. Lakshmanan 94301 (MH); Salem district, Namakkal, Kolli Hills, Ghat Road, Sothuparai, 09 Aug 2000, K.M. Matthew 62254 (RHT barcode

RHT012724); *Ibid.*, Gundar Shola, 18 Apr 1978, A. Mohan 13049 (RHT barcode RHT012715); *Ibid.*, 06 Aug 1979, K.M. Matthew 24194 (RHT barcode RHT012720); *Ibid.*, 23 Apr 1980, K.M. Matthew 27671 (RHT barcode RHT012721); *Ibid.*, 27 Apr 1981, K.M. Matthew, S.J. Britto & N. Rani 28239 (RHT barcode RHT012722); *Ibid.*, Peria Shola, above Sottuparai, 21 Oct 1978, K.M. Matthew 18682 (RHT barcode RHT012718); *Ibid.*, Shoolavanthi Shola, 03 Oct 2001, K.M. Matthew 63115 (RHT barcode RHT012725); *Ibid.*, 15 Aug 1976, K.M. Matthew 3268 (RHT barcode RHT012712); *Ibid.*, Koottaru, 12 Apr 1976, K.M. Matthew & C. Rajamani 2135 (RHT barcode RHT012710); *Ibid.*, Omalur, 30 July 1976, A.I. Arokiasamy 2884 (RHT barcode RHT012711); *Ibid.*, Yercaud, Shevaroy, Kodikadu, 12 May 1978, V. Alphonse amalraj 13716 (CAL, RHT barcode RHT012716); Tenkasi district, Courtallam, 5 June 1976, C.E. Ridsdale 23 (MH); *Ibid.*, Five fall, 22 Mar 1958, K. Subramanyam 5628 (CAL, MH); The Nilgiris district, Gudalur 11 Mar 1969, D.B. Deb 31665 (MH); *Ibid.*, near Woodbriar estate, 18 Nov 1958, K.M. Sebastine 7389 (CAL, MH); Kulivayal R.F., 25 July 1972, E. Vajravelu 41792 (MH); Theni district; Suruli Falls, 24 Apr 1960, B.V. Shetty 10290 (CAL, MH); Vannathipparai, 15 Sep 1925, K.C. Jacob 17711 (MH); Tiruchirapalli district, Dept. Garden, 07 Apr 1970, K.M. Matthew 11240 (RHT barcode RHT012695); Pachaimalai, 27 July 1970, K.M. Matthew 11727 (RHT barcode RHT012696); *Ibid.*, Thuraiyur, Kaikatty, near Kannimar Shola, 19 Mar 1978, K.M. Matthew 24088 (RHT barcode RHT012709); *Ibid.*, Kannimar Shola, 19 Mar 1978, K.M. Matthew 12452 (CAL, RHT barcode RHT012708); *Ibid.*, Karuppankad Thittu, 11 July 1976, K.M. Matthew 2448 (RHT barcode RHT012704); *Ibid.*, 11 July 1976, K.M. Matthew 2449 (RHT barcode RHT012705); *Ibid.*, 05 Oct 1977, A.I. Arockiasamy & A. Mohan 9092 (RHT barcode RHT012706); SIC: Conservatory, 21 Aug 2001, K.M. Matthew 73189 (RHT barcode RHT012726); *Ibid.*, Tiruchirapalli, Sept 1964, s.coll. 47 (RHT barcode RHT012694); Tirunelveli district, Ambasamudram-Kannikkatti, Injikuzhi, s.d., K.M. Matthew 15626 (RHT barcode RHT012729); *Ibid.*, 31 Dec 1977, K.M. Matthew 15659 (RHT barcode RHT012730); Kannikatti, 22 Sep 1921, K.C. Jacob s.n. (MH); *Ibid.*, 06 July 1964, A.N. Henry & Chandrabose 19293 (MH); Mundanthurai to Kannikkatti, 20 Feb 1913, D. Hooper & M.S. Ramaswami s.n. (CAL); Nanguneri Taluk, Sengaltheri-Kakachi, 25 Jan 1979, K.M. Matthew 16309 (RHT barcode RHT012731); Sengaltheri, 21 Sep 1967, E. Vajravelu 29215 (MH); Upper Dam to

Kannikatti, 13 July 1959, K. M. Sebastine 8537 (CAL, MH). **Telangana**, Chittoor district, Kailasa Kona, 30 July 1986, Ranga Charyulu 676 (MH); Vikarabad district, Ananthagiri, 24 Sept 1961, N.P. Balakrishnan 781 (BSID barcode BSID0008111, CAL); Warangal district, 8 km towards North from Pasra, 18 Sept 1996, R.K. Premnath 108228 (MH). **Tripura**, Unakoti district, Unakoti, 15 Aug 1960, D.B. Deb 2577 (CAL). **Uttar Pradesh**, Allahabad district, Chatham line, 09 July 1964, R. Prasad 3299 (CAL). **West Bengal**, Alipurduar district, Jaldapara National Park, s.d., K. Karthigeyan 59029 (CAL); Darjeeling district, Mongpoo, 23 Sept 1875, C.B. Clarke 24804 (CAL); Pauhabari, Aug 1890, J.S. Gamble 8318 (CAL); *Ibid.*, Aug 1881, J.S. Gamble 9733 (CAL); Jalpaiguri district, Buxa Road, 04 Sept 1981, B. Safui & Party 10310 (CAL); Chapramari Wildlife Sanctuary, 24 July 2002, J. Bhattacharjee & Party 31132 (CAL); Gorumara National Park, Chuck Chuki, 19 Sept 2010, V. Ranjan & Anant Kumar 44590 (CAL); *Ibid.*, Garati, 30 Nov 2009, V. Ranjan & Anant Kumar 44527 (CAL); Khunia Tower Range, 23 Sept 2008, V. Ranjan & Anant Kumar 44654 (CAL).

Notes: *Leea indica* is widely dispersed species in this genus, which always exhibits notable variations in terms of habit, leaflet characteristics and the nature of bracts and inflorescence. They are typically shrubs, though modest trees up to 10 meters tall are occasionally seen. Leaflets show variation with regard to dimension and serration (Fig. 52). With regard to bracts, two types of inflorescences were observed. One with early caducous bracts and the other with bracts detached just prior to flowering. In such cases, the cyme contains a mature central bud and two lateral buds. Each lateral bud is covered by a pair of small bracts and the whole unit is covered by two large bracts (Fig. 53G). The length of the inflorescence varies from 6–28 cm and it can also be condensed or lax (Fig. 53F).

Ridsdale (1974) considered *L. indica* as a polymorphic species and accepted that his taxonomic circumscriptions produced species complexes that cover a broad range of variability, both geographically and ecologically. Ridsdale synonymized many names of previous authors with greenish-white flowers under *L. indica* and according to him, a field-based study is needed to redefine the circumscription of this taxon.



Fig. 52. *Leea indica* (Burm.f.) Merr.: **A-I.** Different populations showing variation in habit.

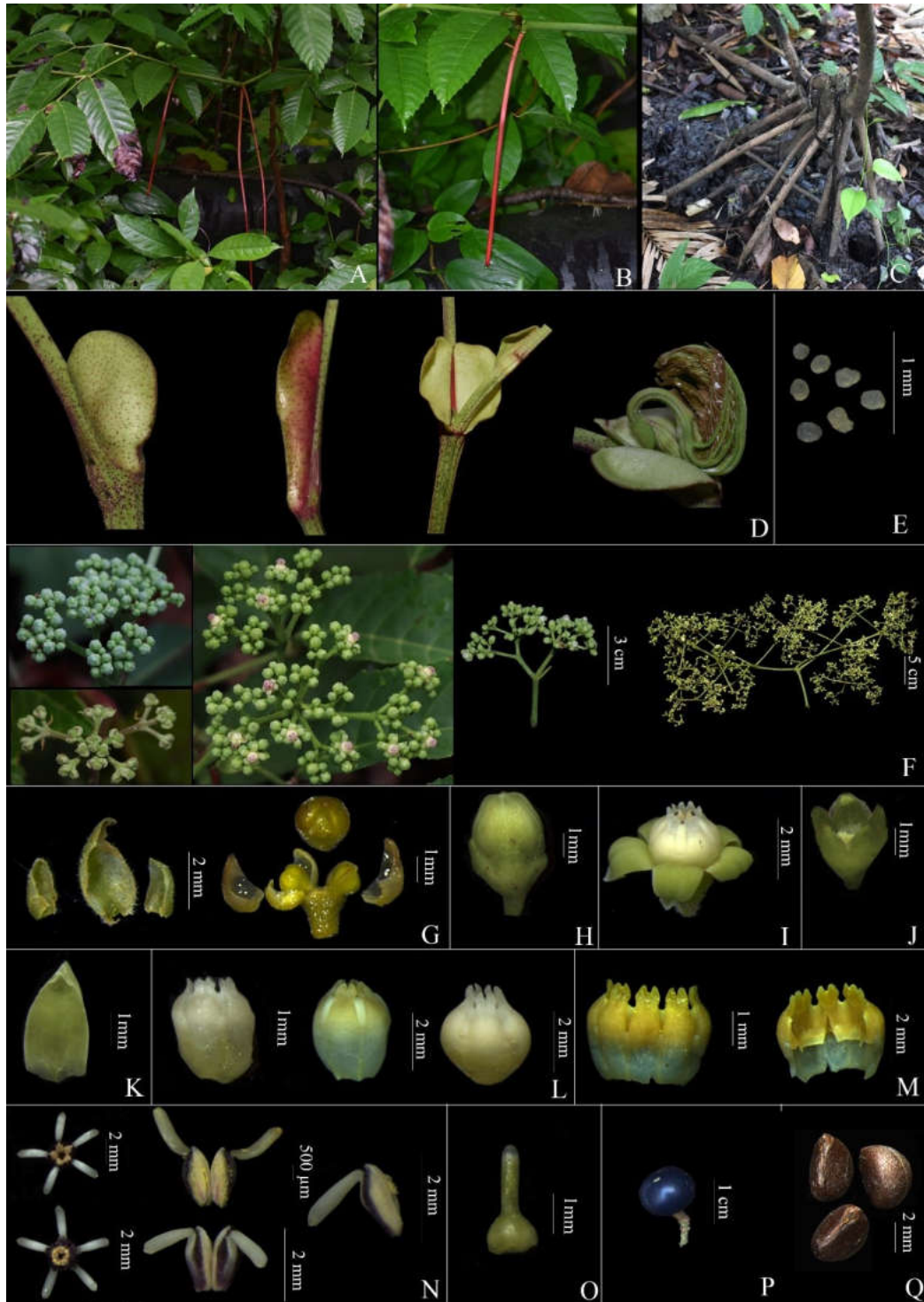


Fig. 53. *Leea indica* (Burm.f.) Merr.: **A-C.** Adventitious roots; **D.** Petiolar stipules—different views; **E.** Pearl glands; **F.** Inflorescence; **G.** Bracts; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe; **L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil; **P.** Fruit; **Q.** Seeds.



Fig. 54. *Leea indica* (Burm.f.) Merr.: **A.** Habit; **B.** Petiolar stipule; **C.** Flower; **D.** Calyx; **E.** Corolla lobe; **F.** Corolla tube with floral disc; **G.** Bracts; **H-J.** Stamens; **K.** Pistil; **L.** Seeds (Drawn by Amrutha A. from Amrutha 153204).

This species is closely similar to *L. guineensis* and mainly distinguishable by the colour of the flower. *Leea guineensis* possess red or reddish flowers and in *L. indica* flowers are greenish-white. Molina *et al.* (2013) pointed out that, even Ridsdale struggled to correctly identify non-flowering duplicates of a Philippine specimen by Fenix 24980 (UC & US), which he marked separately as being *L. indica* and *L. guineensis*.

Typifications: Miquel (1860) described *Leea biserrata* in *Flora van Nederlandsch Indie*, designating the collection by Teijsmann from Banka, Indonesia as the type. In 1863, he provided a detailed account on the genus *Leea* in his *Annales Musei Botanici*. In this treatment, he altered the rank of his *L. biserrata* into a variety of *Leea sambucina* Willd. Ridsdale cited: *Teysmann s.n.*, Banka (L, U) as the type. We located two duplicates from L herbarium having the label of Teijsmann but not from U. As these are syntypes, there is a need for second step lectotypification (Art. 9.17 of ICN). Among these, we selected a sheet with barcode L 2337702! as the lectotype because the sheet bears a small twig of both inflorescence and fruit, and relevant diagnostic features (leaflets ovate-elliptic-oblong, acuminate at apex, margins serrate, and flowers short pedicellate) mentioned in the protologue.

Leea sambucina var. *heterophylla* was originally described by Miquel based on the manuscript of Zippelius. In the protologue the author cited only one specimen as “*Nova Guinea: Zippelius*” but without the name of the herbaria, where the material preserved. We found two specimens at L herbarium, both having an annotation by Zippelius in his own handwriting. Ridsdale (1974) wrote as “Type: *Zippelius s.n.*, New Guinea (L)”, inadvertently lectotypified the name with no clear designation of a single specimen. As there is a need for second step lectotypification (Art. 9.17 of ICN), since both the sheets are in good condition, the sheet with barcode L 0013677! bearing the manuscript of Zippelius attached to it, is selected as lectotype in the second step lectotypification.

When C.B. Clarke (1881) first described *Leea sambucina* var. *occidentalis* in the revision of Indian species of *Leea*, he cited four specimens as “*Wallich List 6824 A, 6824B, 6824D and 6824H*”, but did not designate any of them as holotype in the protologue. Hence, all should be considered as syntypes. After a thorough search in

various herbaria, the authors were able to locate four sheets, all at K herbarium. The specimens 6824 A and 6824 D are mounted on a single sheet, one sheet of 6824 B and two sheets of 6824 H. Ridsdale was aware of these syntypes but did not lectotypified the name. Hence, among the syntypes cited in the protologue, the authors selected *Wallich 6824 B* (K001124904!), as lectotype, a well-preserved sheet having both fruits and inflorescence.

Leea umbeaculifera was described by C.B. Clarke (1881) based on a specimen from India. While describing this species he referred to five gatherings (J.D. Hooker, Wallich, Booth, Masters, Jenkins and C.B. Clarke) and according to Art. 9.6 of ICN (Turland *et al.*, 2018), they constitute syntypes. While searching for original materials in various herbaria the authors could trace six original collections by J.D. Hooker, C.B. Clarke and Jenkins at Kew Herbarium. However, we were not able to trace the sheets of Booth and Masters in any herbaria. Among these, three specimens were C.B. Clark's own collections (K001327099!, K001327100! & K001327104!), two are collected by Hooker (K001327101!, K001327102!) and one (K001327106!) by Jenkins from Assam. The sheet (K001327099!) contains a label in Clarke's own handwriting showed that it was collected later (4 Oct 1885) and cannot considered as a syntype. Among the other materials, the authors selected J.D. Hooker's specimen (K001327102!) from Sikkim as lectotype, as it is a well-preserved specimen, perfectly matching with the characters (leaflets narrow lanceolate, acuminate at apex; corymb very large and lax) mentioned in the protologue.

10. *Leea latifolia* Wall. ex Kurz, J. Asiat. Soc. Bengal 44(2): 178. 1875; C.B. Clarke in Trimen's J. Bot. 19: 138. 1881; King, J. Asiat. Soc. Bengal 65(2): 410. 1896; Talbot, Tr. Shr. Woody Climb. Bomb. Presid. ed. 2. 105. 1902; T. Cooke, Fl. Bombay 1: 260. 1903; Talbot, Forest Fl. Bombay 1: 330. 1909; Gamble, Fl. Madras 1: 240. 1918. *Type*: MYANMAR, Prome, 1826, *Wallich 6821* (K barcode K001124896 digital image!).

Figs. 55, 57–59

Leea cinerea M.A. Lawson in Hook.f. (ed.), Fl. Brit. India 1: 665. 1875. *Type*: INDIA, **Kerala**, Palakkad, (Paulghautcherry), July 1852, *Wight s.n.* (K barcode K000736388 digital image!).

Leea coriacea M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 665. 1875; Talbot, Syst. List Trees Bombay 57. 1894. *Type*: INDIA, **Maharashtra**, Konkan, s.d., Stocks, J.E. s.n. (K barcode K000736389 digital image!).

Shrubs, 1–2 m high; roots tuberous. Stems erect, stout, not branched; internodes furrowed, sheathing, green; nodes not swollen. Pearl glands globose, distributed all over the plant, white. Leaves alternate, trifoliate or 1-pinnate, imparipinnate; petioles 7.5–17 cm long, swollen at base, sheathing the stem, swollen at base, glabrous, green, furrowed. Petiolar stipule 2.5–5 × 1–2 cm, elliptic-oblong, caducous, green; stipular scar 2–4 cm long, triangular; rachis 5–22.5 cm long, channelled on upper surface, glabrous, green. Leaflets opposite, ovate-widely ovate, distal leaflets: lamina 23–49 × 16–32.5 cm; lateral leaflets: lamina 21–31 × 10–18 cm, glabrous on upper surface and puberulous on lower surface, dark green above and pale green beneath, base sub-cordate, margins



Fig. 55. Type of *Leea latifolia* Wall. ex Kurz [Wallich 6821 (K barcode K001124896)] © Board of Trustees of the Royal Botanic Gardens, Kew.

serrate, apex acute or acuminate, obtuse; petiolules: central 5–8 cm long, channelled on upper surface, glabrous, green; lateral 0.3–4 cm long, glabrous, channelled on upper surface, green; secondary veins 7–13 pairs, 3 or 5 nerved at base, veins more prominent on lower surface, glabrous. Inflorescence a leaf-opposed terminal cyme, 14–35 cm long, branched, many flowered, lax; peduncles 7–14 cm long, furrowed, glabrous, green. Bracts small, inconspicuous, early caducous, green. Flowers 5–5.3 mm long, numerous, actinomorphic, greenish-white. Pedicels slender, 0.6–1 mm long, hairy. Calyx campanulate, 3.2–3.4 × 2.4–2.5 mm, lobes 1–1.2 × 1–1.5 mm, apex acute or obtuse, hairy, green. Corolla lobes 5,

Systematic treatment

ovate, 3.5–4.2 × 1.8–2 mm, apex acute, hooded, margins entire, glabrous, green; corolla tube with floral disc 3.1–3.7 × 2.5–2.8 mm, white. Floral disc tubular, 2–2.4 mm long, white when young yellowish at maturity; upper free parts 1.5–1.6 mm long, notched; sinuses deep, 1.5–1.9 mm long; lower free parts 0.4–0.5 mm long. Stamens 5, syngeneceous; filaments 1.6–1.8 mm long, glabrous, white; anthers 2–2.1 mm long, dorsifixed, dehisce longitudinally, purplish on back and yellowish on side. Ovary globose, 0.8–0.9 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1.2–1.3 mm long, slender, glabrous; stigma convex. Fruits green at very mature stage. Not seen.

Flowering & fruiting: July–December.

Habitat: This species can be found in the open areas associated with *Costus speciosus* (J.Koenig) Sm., (Costaceae), *Barleria* sp. (Acanthaceae) and some grasses.

Distribution: India (Maharashtra; Fig. 56), Myanmar.



Fig. 56. Distribution of *Leea latifolia* Wall. ex Kurz in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Maharashtra**, Mumbai Suburban district, Goregaon, Aarey Colony, 20 Aug 1955, G.L. Shah Shah 4829 (BLAT); *Ibid.*, Aarey Colony Road, 19 Oct 2023, Amrutha 164790 (CALI); *Ibid.*, near Gavudevi Mandir, 19 Oct 2023, Amrutha 164791 (CALI); Malad, Quarry Hills, 06 Sept 1956, G.L. Shah Shah 7429 (BLAT); Sanjay Gandhi National Park, 29 Aug 1956, P.S. Herbert S.H. 2018 (BLAT); *Ibid.*, 04 Sept 1956, P.S. Herbert S.H. 2056 (BLAT); *Ibid.*, 11 Sept 1956, P.S. Herbert S.H. 2175 (BLAT); *Ibid.*, 08 Nov 1956, P.S. Herbert S.H. 2680 (BLAT); Vicinity of central dairy & U.5, 07 Nov 1957, S.C. Tavakari T 106, T 107 (BLAT); *Ibid.*, 21 Aug 1958, S.C. Tavakari T1540, T1541 (BLAT); Vihar Lake Salsette, 28 July 1951, H. Santapau 12987, 12988, 12989 (BLAT); *Ibid.*, 22 Aug 1959, H. Santapau 23182 (BLAT); *Ibid.*, 25 Aug 1956, H. Santapau 21026 (BLAT); Raigad district, Mora-Uran, 11 Sept 1960, P. Divakar P.D. 1483, 1484, 1485 (BLAT).

Notes: Wallich proposed the name *Leea latifolia* in his catalogue and later Kurz (1875) gave a detailed circumscription and hence validated the name. C.B. Clarke included this name in his revision of Indian *Leea*. However, Ridsdale (1974) synonymized *L. latifolia* under *L. macrophylla*. As highlighted by Ridsdale, *L. macrophylla* s.l. is a highly polymorphic species that exhibits a significant number of synonyms, which have emerged as complex. Ridsdale identified four basic entities which include: large unifoliate leaves, sometimes trifoliate (*L. macrophylla* s.s.); leaves large, trifoliate or 1-pinnate (including *L. cinerea*, *L. coriacea* & *L. latifolia*); leaves one or two pinnate, leaflets ovate-lanceolate (*L. parallela* Wall.); leaves 2–3 pinnate, leaflets with scattered hairs above, upper epidermis with wax deposits. (*L. robusta*). After analysing the type materials and classical Indian collections at Kew, he concluded that the flower structure of all the entities is similar. Despite this, he suggested that there was probably more than one species and further collections and field observations are required for solving this species complex. As part of this Indian revision of *Leea*, we were able to collect and study the live materials and authenticated herbarium specimens of *L. macrophylla*, *L. robusta* and *L. latifolia* come under the three entities of Ridsdale. Up on a clear examination of the type materials and live collections, it is clear that all three entities show differences and can be separated as a distinct species.

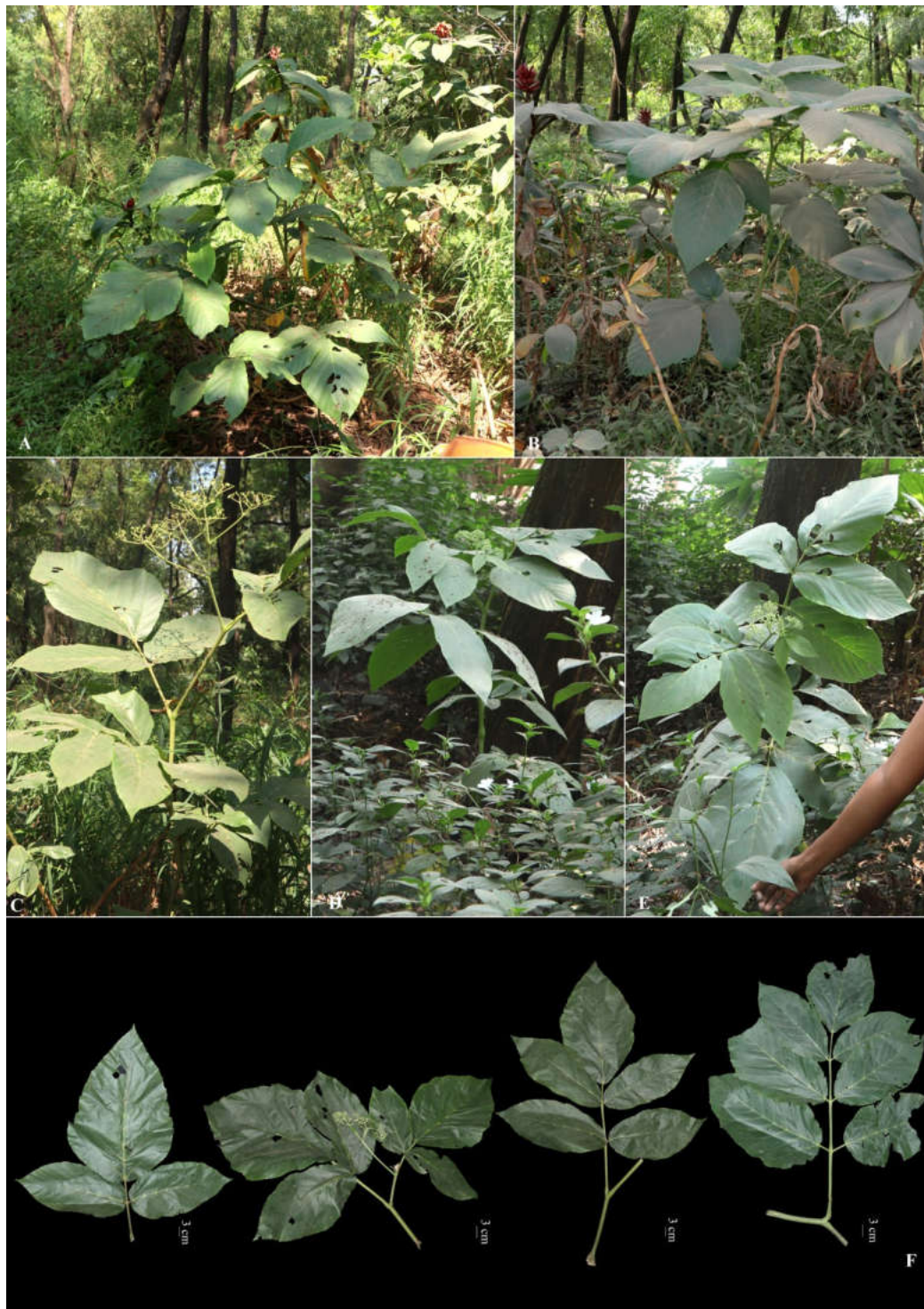


Fig. 57. *Leea latifolia* Wall. ex Kurz: **A-E.** Habit; **F.** Variation in leaves.

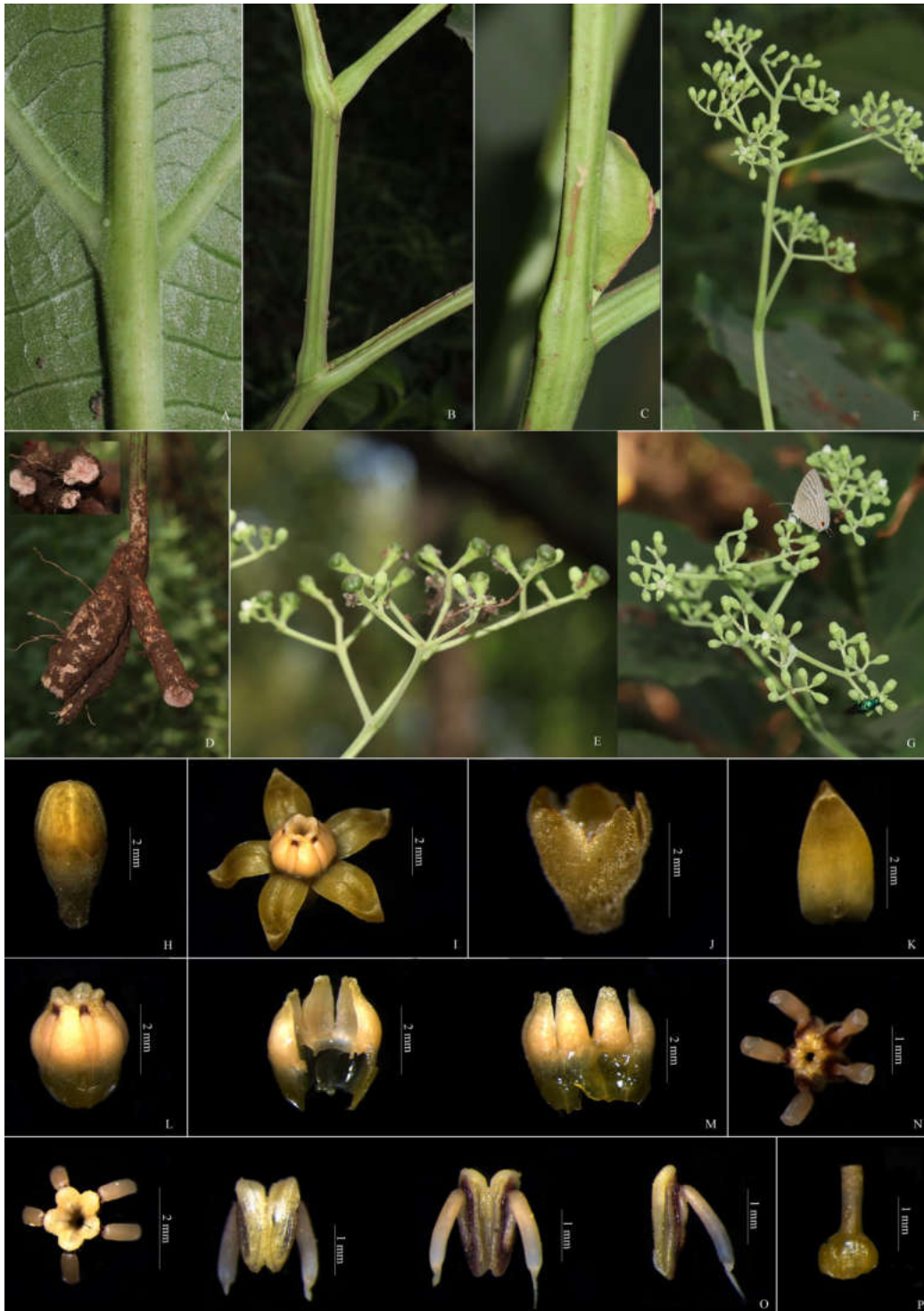


Fig. 58. *Leea latifolia* Wall. ex Kurz: **A.** Abaxial surface of leaf; **B.** Stem; **C.** Petiolar stipule; **D.** Tuberous root; **E.** Young fruit; **F & G.** Inflorescence; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe; **L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N & O.** Stamens; **P.** Pistil.

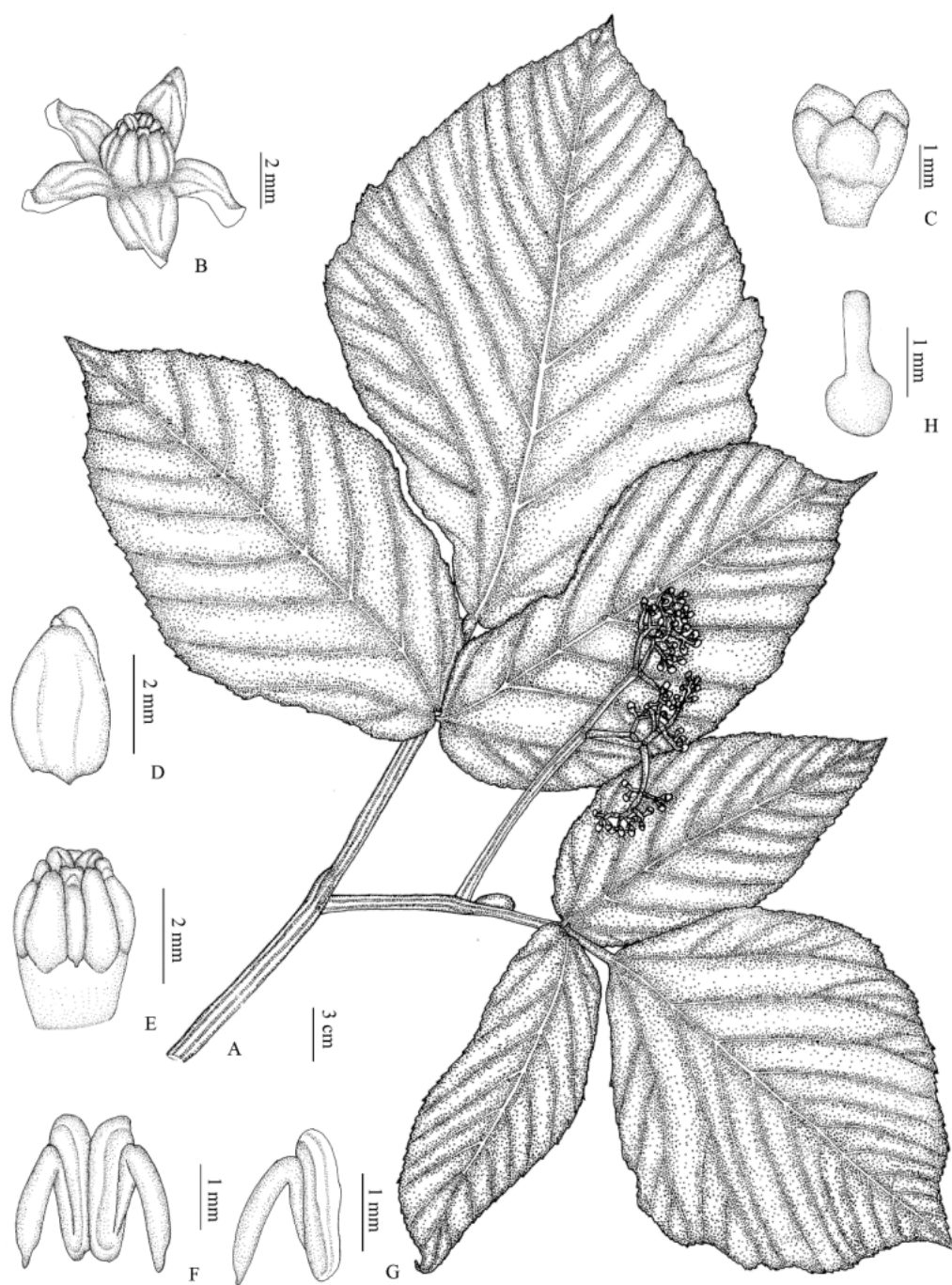


Fig. 59. *Leea latifolia* Wall. ex Kurz: **A.** A twig with inflorescence; **B.** Flower; **C.** Calyx; **D.** Corolla lobe; **E.** Corolla tube with floral disc; **F & G.** Stamens; **H.** Pistil (Drawn by Amrutha A. from Amrutha 164790).

Leea latifolia differs from *L. macrophylla* mainly by its pinnately compound leaves. *Leea macrophylla* never develop pinnately compound leaves at any stage of its growth. Other differences include corolla tube with floral disc being shorter (<3.7 mm long) as opposed to longer (>3.7 mm long) corolla tube with floral disc; short pedicel having 0.6–1 mm long (*vs.* long pedicel having 3.8–4.2 mm long).

Lawson (1875) published two species, *Leea cinerea* and *L. coriacea* based on the specimens of Wight and Dr. Stocks respectively. However, both are same and have found to be conspecific with *L. latifolia*, and hence treated as a synonym of *L. latifolia*.

11. *Leea macrophylla* Roxb. ex Hornem., Hort. Bot. Hafn. 1: 251. 1813, *nom. cons.*, Fl. Ind. (Carey & Wall. ed.), 2: 465. 1824; G. Don, Gen. Hist. 1: 713. 1831; Fl. Ind., (Carey ed.), 1: 653. 1832; Dalzell & Gibson Bombay Fl. 41. 1861; Drury, Handb. Ind. Fl. 1: 181. 1864; J.L. Stewart & Brandis, Forest Fl. N.W. India 102. 1874; Kurz, J. Asiat. Soc. Bengal 44(2): 178. 1875; C.B. Clarke in Trimen's J. Bot. 19: 137. 1881; Talbot, Syst. List Trees Bombay 54. 1897; Nairne, Fl. Pl. W. India 64. 1894; Talbot, Tr. Shr. Woody Clim. Bomb. Presid. ed. 2. 106. 1902; Prain, Bengal Pl. 1: 341. 1903; T. Cooke, Fl. Bombay 1: 259. 1903; Duthie, Fl. Up. Gangetic Plain 1(1): 176. 1903; Brandis, Ind. Trees 180. 1906; Talbot, Forest Fl. Bombay 1: 326. 1909; Gagnep., Fl. Indo-Chine t.1: 943. 1909, Bull. Soc. Bot. France 57: 336. 1910; Haines, Forest Fl. Chota Nagpur 279. 1910; Gamble, Fl. Madras 1: 239. 1918; Kirt. & B.D. Basu, Indian Med. Pl. 350. 1918; Haines, Bot. Bihar Orissa Pt 1. 207. 1925; Craib, Fl. Siam. 1(2): 318. 1926; Cowan & Cowan, Tr. N. Beng. 39. 1929; R.S. Rao, Fl. Goa, Diu, Daman, Dadra & Nagarhaveli 1: 87. 1985; D.M. Verma in D.M. Verma *et al.* (eds.), Fl. Raipur, Durg & Rajnandgaon 78. 1985, *p.p.*; P.V. Bole & J.M. Pathak, Fl. Saurashtra 496. 1988; S.M. Almeida, Fl. Savantwadi 1: 105. 1990; M.J. Kothari & S. Moorthy, Fl. Raigad Dist. 70. 1993; H.O. Saxena & Brahmam, Fl. Orissa 1: 337. 1994, *p.p.*; V.V. Sivar. & P. Mathew, Fl. Nilambur 158. 1996; R.N. Banerjee, Fl. West Bengal 1: 453. 1997, *p.p.*; Moorthy in N.P. Singh & Karthik. (eds.), Fl. Maharashtra, Dicot. 1: 568. 2000; P.P. Sharma & N.P. Singh, Ethnobot. Dadra, Nagar Haveli & Daman 91. 2001, *p.p.*; S.R. Yadav & M.M. Sardesai, Fl. Kolhapur Dist. 123. 2002; S.G. Pradan & B.D. Sharma, Fl. Sanjay Gandhi Natl. Park 172. 2005. *Neotype* (designated by Ridsdale, 1974): INDIA, **West Bengal**, Serampore, *s.d.*, *s.coll.* *s.n.* (C barcode C10020284). **Figs. 60, 62 & 63**

Leea simplicifolia Griff., Not. Pl. Asiat. 4: 697. 1854, non Zoll. & Mor. 1845. *nom. illeg.*
Type: MYANMAR, Mergui, Sept 1834, *Griffith s.n.* (K barcode K000736374!).

Leea macrophylla var. *oxyphylla* Kurz, J. Asiat. Soc. Bengal 44(2): 178. 1875. *Lectotype*
(designated here): MYANMAR, Bogo ('Pegu'), Irrawaddy and Sittang Valley, 02 Jan
1871, *Kurz 1851* (M barcode M-0217853 digital image!)

Shrubs, 1–1.5 m high; roots tuberous. Stems erect, stout, not branched; internodes furrowed, green; nodes not swollen. Pearl glands globose, distributed all over the plant, white. Petiolar stipules 5.3–8 × 2–5 cm long, obovate or sub-orbicular, glabrous, pale green; stipular scars 5.3–7.3 cm long, triangular. Leaves alternate, simple, widely ovate, lamina 41–61 × 22–56 cm, glabrous on upper surface, tomentose on lower surface, green above and pale green beneath, base cordate, margins irregularly serrate, apex acute; petioles 6.5–20 cm long, sheathing the stem, swollen at base, glabrous, green, furrowed; secondary veins 13–16 pairs, usually 3-nerved at base, veins more prominent on lower surfaces, glabrous. Inflorescence a leaf-opposed terminal cyme, 10–52 cm long, branched, many flowered, lax; peduncles 6–17 cm long, furrowed, glabrous, green. Bracts small, inconspicuous, early caducous, green. Flowers 7.4–9 mm long, numerous, actinomorphic, greenish-white. Pedicels slender, 3.8–4.2 mm long, hairy. Calyx campanulate, 4–7.7 × 2.4–2.8 mm, lobes 5, 0.9–1.3 × 0.9–1.5 mm, apex acute or obtuse, hairy, green. Corolla lobes 5, ovate, 4.2–4.5 × 1.9–2 mm, apex acute, hooded, margins entire, glabrous, green; corolla tube with floral disc 3.8–4.3 × 2.6–2.8 mm, white. Floral disc tubular, 2–2.3 mm long, white when young yellowish at maturity; upper free parts 1.7–2 mm long, apiculate; sinuses deep, 1.4–1.8 mm long; lower free parts 0.4–0.7 mm long. Stamens 5, syngeneceous; filaments 1.4–1.9 mm long, glabrous, white; anthers 2–2.1 mm long, dorsifixed, dehisce longitudinally, purplish on back yellowish on side. Ovary globose, 0.8–1 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 1.5–2 mm long, slender, glabrous; stigma convex. Fruit 1.1–1.2 cm diam., green when young, turning black at maturity. Seeds 6, more or less obconic, 4.12–4.36 × 3.67–3.72 mm light brown when mature.

Flowering & fruiting: July–December.

Habitat: Commonly seen in deciduous forests and open areas along with *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *Barleria* sp. (Acanthaceae).

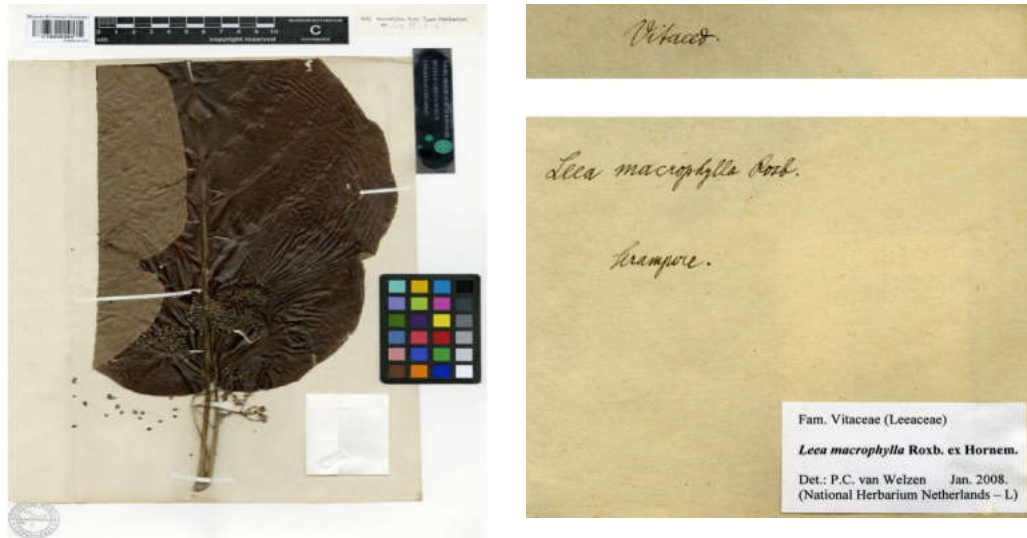


Fig. 60. Neotype of *Leea macrophylla* Roxb. ex Hornem., [s.coll. s.n. (C barcode C10020284)] Right hand side image is the rear side of the sheet bearing determinavit slip. © Board of Trustees of National History Museum of Denmark, Copenhagen, Denmark

Distribution: India (Bihar, Dadra and Nagar Haveli and Daman and Diu, Goa, Gujarat, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Telangana, and West Bengal; Fig. 61), Thailand, Myanmar.

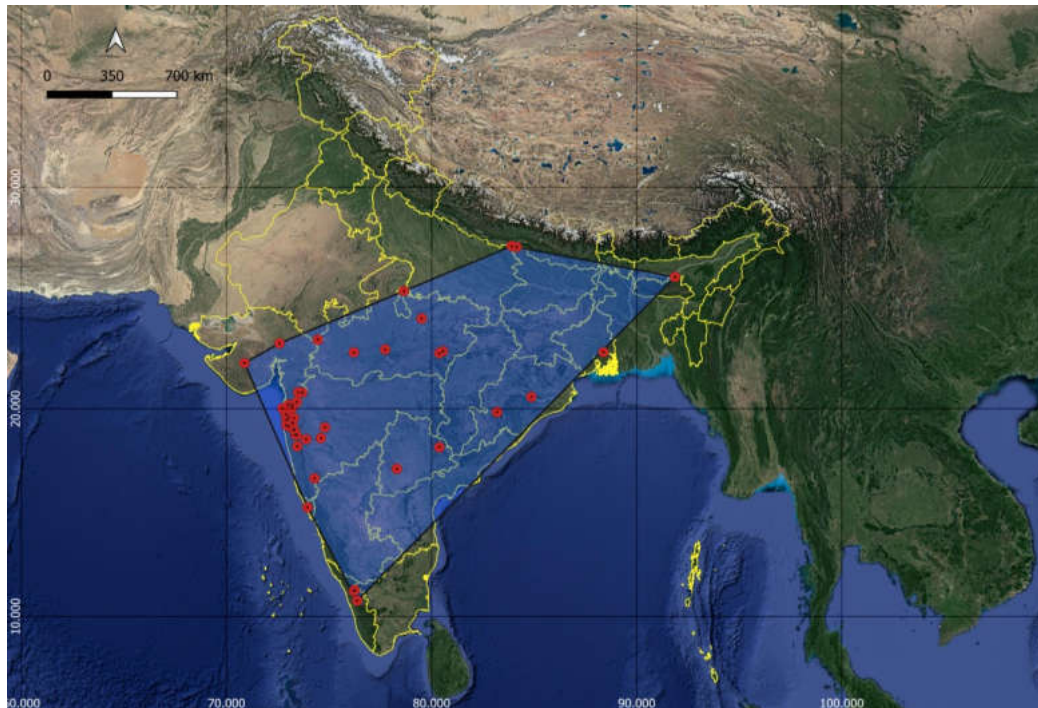


Fig. 61. Distribution of *Leea macrophylla* Roxb. ex Hornem. in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Bihar**, West Champaran district, Bhaisalotan, 18 Sept 1965, S.P. Banerjee 652 (CAL). **Dadra and Nagar Haveli and Daman and Diu**, Dadra and Nagar Haveli district, Dapada, 04 Oct 1963, M.Y. Ansari 94278 (BSI); Dudhani to Bildhari Forest, 12 Nov 1970, M.Y. Ansari 126945 (BSI). **Goa**, South Goa district, Nuvem, near Margao, 21 Aug 1963, K.C. Kanodia 89422 (BSI). **Gujarat**, Ahmedabad district, Shahpur, 16 Sept 1961, R.S Rao 81503 (BSI); *Ibid.*, 16 Sept 1961, U.R. Deshpande 81503 (BSI); Dang district, 26 Aug 1958, S.K. Jain 43023 (BSI); Waghai, 01 Sept 1954, H. Santapau 19061 (BLAT). **Kerala**, Malappuram district, Kanjirakadavu, 07 Nov 1981, Philip Mathew 25799 (CALI); Teak Museum, 28 Aug 2020, Amrutha 164701 (CALI barcode CALI173042, CALI173043, CALI173044, CALI173045, CALI173046); Vadapuram, 19 Aug 1983, Philip Mathew 34201 (CALI); *Ibid.*, 31 Aug 1982, Philip Mathew 33400 (CALI); Palakkad district, Ottappalam, 10 July 1989, S. Moorthy s.n. (MH). **Madhya Pradesh**, Indore district, 1 mile south of Nahar Jhabua, 23 Oct 1962, A.S. Rao 84133 (BSI, CAL); Mandla district, Mangalkany, 21 Aug 1962, J. Joseph 14500 (MH); Narmadapuram district, Hoshangabad, 24 July 1961, J. Joseph 12869 (MH); Tikamgarh district, Pratap Pura, 09 Sept 1957, G.S. Puri 23776 (BSI). **Maharashtra**, Ahmednagar district, KapurwadI Coast, 6 Aug 2004, A.N. Lordhi 190729 (BSI); Gadchiroli district, Allapalli, Talwada Village, 11 Sept 1963, Athuja K.K. 91541 (BSI); Mumbai Suburban district, Andheri, Mahakali Cave, 07 July 1945, H. Santapau 6757 (BLAT); *Ibid.*, 22 Sept 1957, G.L. Shah 9079 (BLAT); Kanheri Caves, 6 Sept 1941, H. Santapau 91.12 (BLAT); *Ibid.*, 06 Oct 1984, B.D. Sharma 167274 (BSI); Malad, 26 Sept 1958, G.L. Shah 9988 (BLAT); Powai Lake, 16 Nov 1957, G.L. Shah 9522 (BLAT); Nandurbar district, Karjai, 02 Oct 1941, H. Santapau 11.20 (BLAT); Nasik district, Bank of Daman Ganga River, 11 Nov 1970, M.Y. Ansari 126838 (BSI); Sawarna, on way to Gujarat border, John Cherian 111465 (BSI); Palghar district, Along Vaitarna River, Manor range, 28 Oct 1967, K.V. Billore 113274 (BSI); Vaitarna River, Vaitarna Range, 24 Aug 1967, K.V. Billore 110474 (BSI); Parbhani district, Mandewadgaon, 25 Sept 1981, K.M Rao 160474 (BSI); Pune district, Khanapur (Haveli Taluka), 11 Aug 1964, M.Y. Ansari 99803 (BSI); Tata Power Residency Colony, Khandala Ghat, Way to Lonavala, 13 Sep 2018, Amrutha 153244 (CALI); Raigad district, Matheran to water point station, 28 July 1966, B.G. Kulkarni 109828 (BSI); Neral, Jummapatti, 26 Aug 1959, N.A. Irani 4430 (BLAT); Neral, Thakurwadi, 29 Oct 1959, N.A. Irani 4731 (BLAT); Ratnagiri district, Usgaon, 11 Aug 1961, N.Y. Das 3623 (BLAT); Thane district, Khadavali (Kalyan), 17 Nov

1956, S.K. Jain 9341 (BSI); Mumbra, 09 Oct 1953, K.V. Shenoy 4712 (BLAT); *Ibid.*, 09 Oct 1953, K.V. Shenoy 4712 (BLAT); Sakharshet, R.F. Jawhar Range, 02 Sept 1967, K.V. Billore 111722 (BSI); Sanjay Gandhi National Park, 11 Sept 1956, P.S. Herbert 2168 (BLAT); *Ibid.*, 18 Sept 1956, P.S. Herbert 2272 (BLAT); *Ibid.*, 29 Sept 1956, P.S. Herbert 2391 (BLAT); Tansa lake, 19 Sept 1943, H. Santpau 2698 (BLAT). **Meghalaya**, Ri Bhoi district, Byrnihat, 20 Oct 1915, Upendranath Kanjilal 6074 (ASSAM). **Orissa**, Angul district, Katrang, 18 Oct 2015, K.C. Mohan 7083 (BSID barcode BSID0011062); Kalahandi district, Jakom, 22 Aug 1983, B. Safui & Party 13440 (BSID barcode BSID0008113). **Rajasthan**, Banswara district, Kalakhet, Kushalgarh, 11 Oct 1961, K.C. Kanodia 75667 (BSI). **Sikkim**, Himalaya, June 1875, G. King s.n. (CAL). **Telangana**, Medak district, Padmanabhapally, 24 Sept 2013, L. Rasingam & M. Sankara Rao 3771 (BSID barcode BSID0017049); Warangal district, Way to Gangaram, 02 Aug 1986, P. V. Sreekumar 84011 (BSID barcode BSID0008112). **West Bengal**, Kolkata district, Kolkata, 29 July 1883, C.B. Clarke 33574 (CAL); Royal Calcutta Golf Club, Tollygunge, 17 Nov 1965, R.L. Mitra 387 (CAL); South Sinthee, Gopal Bose Lane, 20 Sept 1987, B.C. Banerjee 15414 (CAL barcode CAL0000209978).

Notes: Ridsdale (1974) treated *L. macrophylla* as a highly polymorphic species with respect to the nature of leaves; consequently, he reduced a number of species published by earlier authors into the synonymy of *L. macrophylla*. Based on the leaf characters, he identified four basic entities in this species. He augured that floral structures are similar in all entities and they show differences only in the pinnation of leaves. He himself recommended that a complete field visit and ecological and population study be required for the proper delimitation of these taxonomically difficult taxa. Later, Mathew and Umadevi (1992) reinstated one entity (*L. robusta*), having 2 or 3 pinnate leaves and leaflets with scattered hairs above as a distinct species. However, B.D. Naithani (2000), in the *Flora of India*, followed the view of Ridsdale and synonymized *L. robusta* under *L. macrophylla*. Subsequently, most of the Indian flora followed this treatment. In the present treatment *L. robusta* is treated as a distinct species.

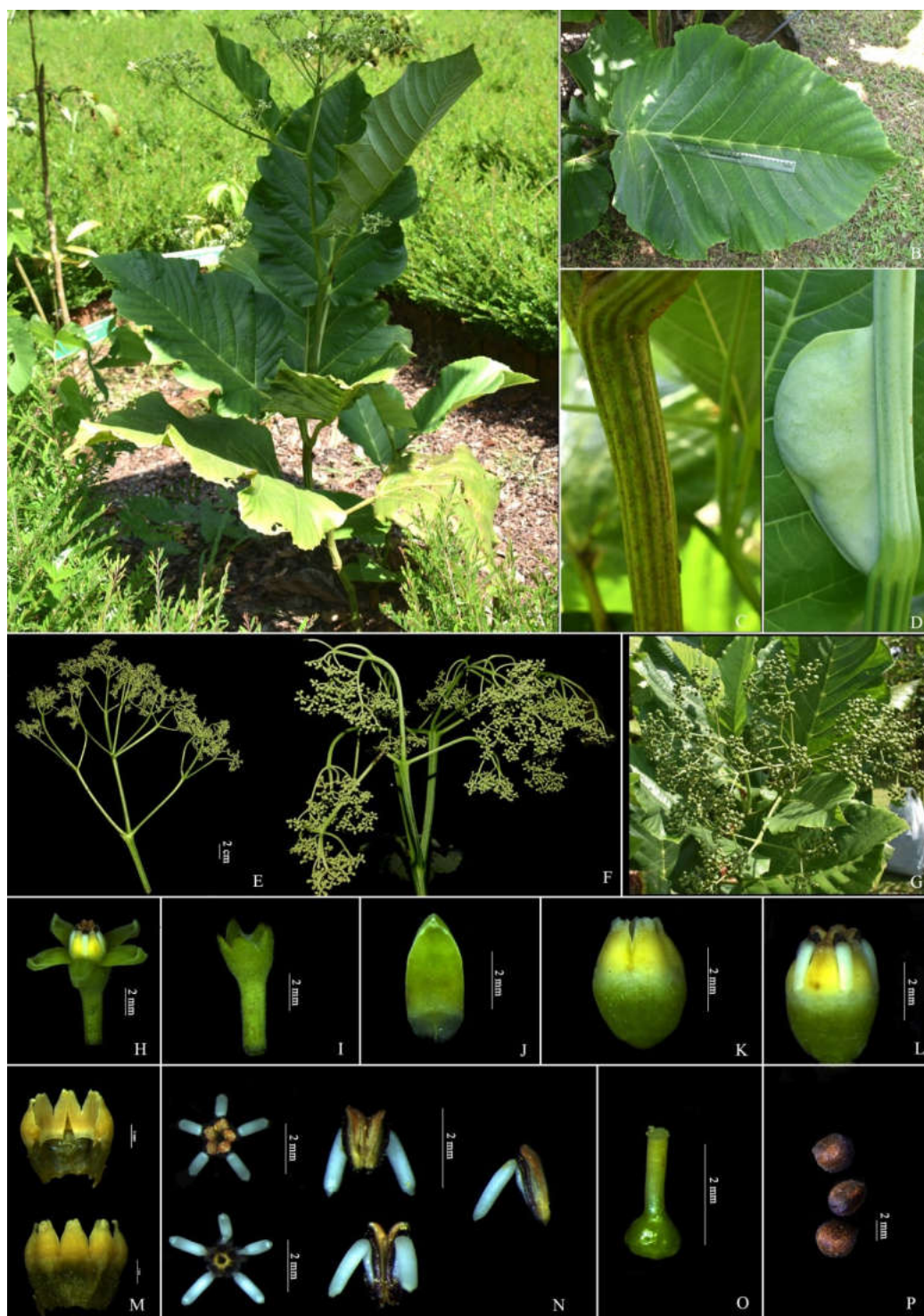


Fig. 62. *Leea macrophylla* Roxb. ex Hornem.: **A.** Habit; **B.** Leaf; **C.** Stem; **D.** Petiolar stipule; **E & F.** Inflorescence; **G.** Infructescence; **H.** Flower; **I.** Calyx; **J.** Corolla lobe; **K & L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil; **P.** Seeds.



Fig. 63. *Leea macrophylla* Roxb. ex Hornem.: **A.** A twig with inflorescence; **B.** Petiolar stipule; **C.** Flower; **D.** Corolla lobe; **E.** Corolla tube with floral disc; **F & G.** Stamens; **H.** Pistil (Drawn by Amrutha A. from Amrutha 164701).

Leea macrophylla is found most commonly as an undergrowth in deciduous forests and teak plantations. The young plants with its large leaves may often be mistaken for teak saplings (Mathew & Umadevi, 1992). *L. macrophylla* has annual shoots which generally die back in March–April to be regenerated from the rootstock during May–June. The roots of this plant yield a dye (Roxburgh, 1824) and are also used for the cure of Guinea worm (Bole & Pathak, 1988); tender stems are cooked as vegetables (Sharma & Singh, 2001).

Nomenclature notes: *Leea macrophylla* is a conserved name against *Aquilicia samudraca* Jones and *Aralia lappifolia* Retz. In the Revision of *Leea*, Ridsdale (1974) cited the type of *L. macrophylla* as “in Herb. Hornem. Roxburgh s.n., Serampore (C). However, in the proposal for the conservation of the name *L. macrophylla*, Turner and Trias-Blasi (2021) noted the sheet in Copenhagen labelled on the back “*Leea macrophylla* Roxb. Serampore” (Fig. 60) was not Roxburgh’s material since the handwriting is not Roxburgh’s. Perhaps it was a later collection, and Ridsdale’s effective lectotypification is a neotypification. The committee recommended this conservation (Applequist, 2023).

Typification: Kurz (1875) described *Leea macrophylla* var. *oxyphylla* with a diagnostic phrase “leaves ovate to ovate-oblong, acuminate, less glaucous beneath or one-coloured, glabrous” and cited two locations in Myanmar namely, Pegu and Martaban. After a thorough search in various herbaria, we were able to locate one specimen collected from Pegu from M herbarium and none from Martaban. Ridsdale was aware of these syntypes but did not lectotypified the name, hence we selected the sheet from M herbarium (M barcode M-0217853) as lectotype as it perfectly agrees with the protologue. Upon examination of the type specimen and protologue, it was determined that these taxa are conspecific with *Leea macrophylla*, as noted by Ridsdale (1974).

12. *Leea mizoramensis* Amrutha & Pradeep sp. nov. Type: INDIA, Mizoram, Aizawl, 28 Aug 2018, Amrutha 159892 (holotype CAL!; isotypes: MH!, CAL!).

Figs. 64, 66–69

Diagnosis: *Leea mizoramensis* is similar to *Leea guineensis* G.Don but can be easily be distinguished by its tuberous roots (*vs.* non-tuberous), furrowed stems (*vs.* terete

stems), furrowed petioles (*vs.* terete petioles) and furrowed rachis (*vs.* channelled rachis on its upper side), 2–5 rows of sparsely strigose hairs in between the lateral veins on upper surface (*vs.* one rows of stiff hairs in between two lateral vein on upper surface); lamina sub-coriaceous (*vs.* lamina membranous); pedicels 0.6–1.8 mm and hairy (*vs.* pedicels short or sessile and glabrous).

Shrubs, 0.5–1 m high; roots tuberous. Stems erect, stout, glabrous; internodes 1–10 cm long, furrowed, green with white spots; nodes not swollen, furrowed, purple. Pearl glands globose, distributed in inflorescence, white-yellow. Leaves alternate, 2–3 pinnate, imparipinnate; petioles 8.5–30 cm long, swollen at base, furrowed, glabrous, green to purple. Petiolar stipule 3.5–5 × 1–2.5 cm, oblong to lance-ovate, glabrous or sparsely hairy, green; stipular scar 3–4 cm long, triangular; rachis 15–45 cm long, furrowed, glabrous, green to purple. Leaflets opposite, widely ovate to elliptic, young leaflets purple; distal leaflets lamina 7–16 × 2.3–7 cm; lateral leaflets lamina 6–16 × 1–5 cm; 2–5 rows of sparsely strigose hairs in between the lateral veins on upper surface, green above



Fig. 64. Type of *Leea mizoramensis* Amrutha & Pradeep [*Amrutha* 159892 (CAL)] © Botanical Survey of India, Kolkata.

sometimes with white striation on the centre and green to purple beneath, base cordate or obtuse, margins serrate, apex acuminate, membranous; petiolules distal 1.2–6 cm long; lateral 0.5–1 cm long, secondary veins 5–15 pairs, usually 3 (–4) nerved at base, veins prominent on lower surface with erect patent hairs. Inflorescence a leaf-opposed terminal cyme, 4–26 cm long, branched, condensed, many flowered; peduncles 1–16 cm long, furrowed, pubescent, green. Bracts small, early caducous, green. Flowers 3.9–6 mm long, numerous, actinomorphic, creamy to red with intermediate shading. Pedicel slender, 0.6–1.8 mm long, hairy. Calyx campanulate, 2.8–4.4 × 2.2–2.6 mm, lobes 5, lobes 1–1.7 × 1–1.3 mm, apex acute, glabrous, yellow with pinkish-tinged apex or red. Corolla lobes 5, narrowly to

Systematic treatment

broadly ovate, $2.9-3 \times 1.5-2$ mm, apex acute and hooded, margins entire, glabrous, yellow or shades of red; corolla tube with floral disc $3-3.6 \times 2.2-2.7$ mm, white to yellow or pinkish. Floral disc tubular, 1.7–2 mm long, white or pinkish when young, yellowish at maturity; upper free parts 1.1–1.4 mm long, notched; sinuses shallow, 0.4–0.8 mm long; lower free parts 0.6–0.8 mm long. Stamens 5, syngeneic; filaments 0.8–0.9 mm long, glabrous, yellow; anthers 1.1–1.3 mm long, dorsifixed, dehisce longitudinally, yellow on lateral side, purplish on back. Ovary globose, 0.7–0.9 mm long, 6-loculed, ovule one in each locule, placentation axile, yellow; style 0.8–1.2 mm long, slender, glabrous, yellow; stigma convex. Fruit 1.1–1.2 cm diam., green turning to red, finally black. Seeds 6, more or less obconic, $3.91-4.11$ (3.98 ± 0.06) $\times$ $3.61-3.72$ (3.67 ± 0.03) mm.

Flowering & fruiting: June–December.

Habitat: *Leea mizoramensis* mostly grows in the evergreen forest floor, forest margins and wet rock crevices. Populations of this species contain 2–4 mature individuals associated with *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *Elatostema* sp., *Elatostema lineolatum* Wight (Urticaceae), *Adiantum* sp. (Pteridaceae), and grasses.

Distribution: India. To date, this species has been known only from Mizoram; Fig. 65.



Fig. 65. Distribution of *Leea mizoramensis* Amrutha & Pradeep in India (drawn using QGIS version 3.24.3).



Fig. 66. *Leea mizoramensis* Amrutha & Pradeep: **A-H.** Different populations showing variation in habit.



Fig. 67. *Leea mizoramensis* Amrutha & Pradeep: **A-H.** Inflorescence colour polymorphism.

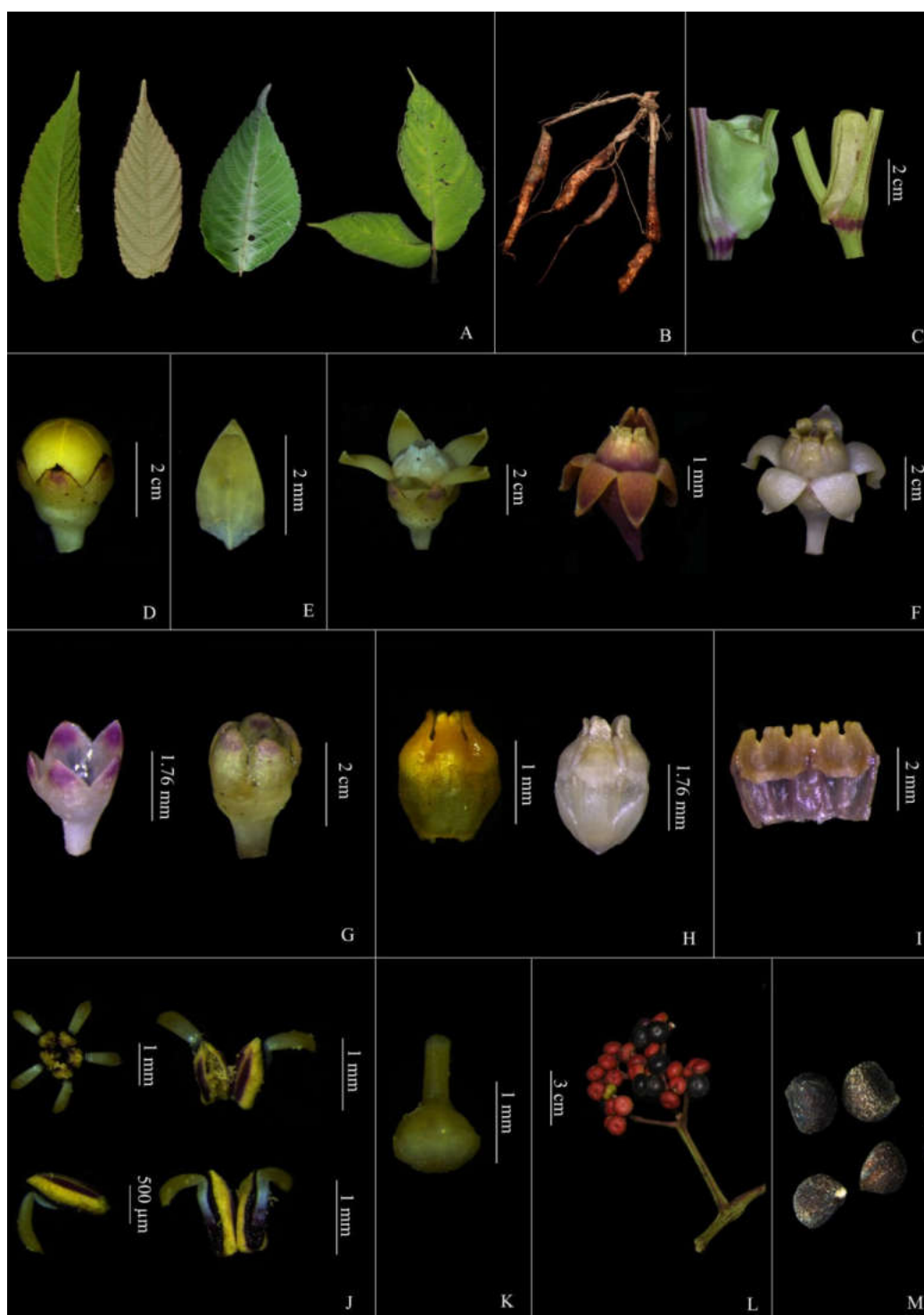


Fig. 68. *Leea mizoramensis* Amrutha & Pradeep: **A.** Variation in Leaflets; **B.** Tuberous root; **C.** Petiolar stipules; **D.** Flower bud; **E.** Corolla lobe; **F.** Flowers; **G.** calyx; **H.** Corolla tube with floral disc; **I.** Corolla tube with floral disc split open; **J.** Stamens; **K.** Pistil; **L.** Inflorescence; **M.** Seeds.

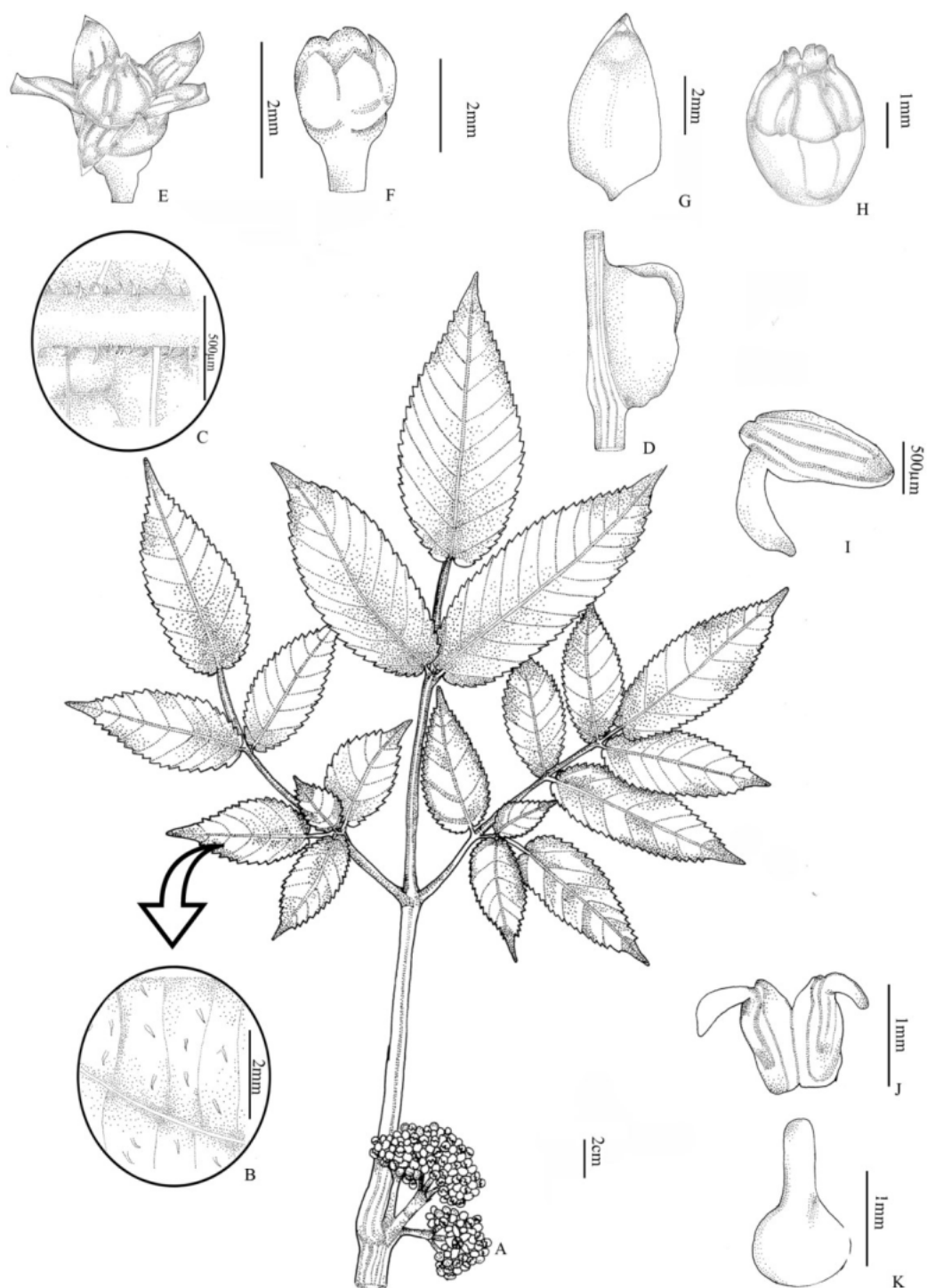


Fig. 69. *Leea mizoramensis* Amrutha & Pradeep: **A.** Habit; **B.** A portion of lamina (adaxial surface) enlarged; **C.** A portion of lamina (abaxial surface) enlarged; **D.** Petiolar stipule; **E.** Flower; **F.** Calyx; **G.** Corolla lobe; **H.** Corolla tube with floral disc; **I & J.** Stamens; **K.** Pistil (Drawn by Amrutha A. from Amrutha 159892).

Etymology: The specific epithet 'mizoramensis' refers to the type locality of *L. mizoramensis*.

Specimens examined: INDIA, **Mizoram**, Aizawl district, 1 km after Tropics of Cancer, 08 June 2022, *Amrutha* 164764 (CALI); 4 Km from Zero to Sialsuk, 10 June 2022, *Amrutha* 164773 (CALI); Aizawl, 28 Aug 2018, *Amrutha* 159887 (CALI); *Ibid.*, 07 June 2022, *Amrutha* 164739, 164740, 164741, 164742, 164758 (CALI); Aizawl-Seling-Champai Road, Seling, 07 June 2022, *Amrutha* 164750 (CALI); Sialsuk, 08 June 2022, *Amrutha* 164760, 164766 (CALI); Tamdil, near Lake, 07 June 2022, *Amrutha* 164745 (CALI); Champhai district, 5 km from Farkawn to Khankawn, 11 June 2022, *Amrutha* 164782 (CALI).

Notes. *Leea mizoramensis* exhibits considerable intraspecific variation with regard to the nature and colour of inflorescence, colour of flower and tender leaves, and shape and size of the petiolar stipule. Each collection made so far shows diverse inflorescence. It may be condensed or lax, the colour also ranges from creamy to red with intermediate shading. During our explorations to different parts of Mizoram, we were able to recognize mainly three types of populations. Individuals growing in the Farkawn exhibit red inflorescence, in contrast to one with a creamy inflorescence from Tamdil. Individuals growing at Sialsuk, a region 148 km away from Tamdil, however, exhibit an orange-hued flower. Both the creamy and red colour inflorescence is found in Aizawl. Creamy and red flower colour is discrete, but a gradient between orange and red are also encountered. Our observation highlighted the need for careful field studies particularly with regard to flower colour variation in *L. mizoramensis*.

Besides, the stipules of *L. mizoramensis* maybe oblong with wavy margins or ovate with entire margins. The colour of the tender leaves also varies from green to different shades of purple.

13. *Leea robusta* Roxb., Hort. Bengal. 18. 1814, *nom. nud.*, Fl. Ind. (Carey & Wallich ed.), 2: 468. 1824; Fl. Ind. (Carey ed.), 1: 655. 1832; G.Don, Gen. Hist. 1: 712. 1831; Drury, Handb. Fl. Ind. 1: 180. 1864; Kurz, J. Asiat. Soc. Bengal 44(2): 180. 1875, Forest Fl. Burma 1: 281. 1877; C.B.Clarke in Trimen's J. Bot. 19: 164. 1881; Talbot,

Syst. List Trees Bombay 57. 1894; King, J. Asiat. Soc. Bengal 65(2): 417. 1896; Talbot, Tr. Shr. Woody Clim. Bomb. Presid. ed. 2. 106. 1902; Gamble, Man. Ind. Timb. ed. 2. 191. 1902; Prain, Bengal Pl. 1: 340. 1903; T.Cooke, Fl. Bombay 1: 261. 1903; Talbot, Forest Fl. Bombay 1: 330. 1909; Haines, Forest Fl. Chota Nagpur 281. 1910; Gamble, Fl. Madras 1: 240. 1918; Kirt. & B.D.Basu, Indian Med. Pl. 352. 1918; Ridl., Fl. Malay Penins. 1: 486. 1922; Haines, Bot. Bihar Orissa 1: 209. 1925; Craib, Fl. Siam. 1(2): 320. 1926; Cowan & Cowan, Tr. N. Beng. 40. 1929; Kanjilal & Das, Fl. Assam 1(2): 308. 1936; Santapau in Rec. Bot. Surv. India 16: 55. 1953; H.Hara, Fl. E. Himalaya 200. 1966; Deb & R.M.Dutta in J. Bombay Nat. Hist. Soc. 69(3): 570. 1972; Deb, Fl. Tripura 1: 420. 1981; S.M.Almeida, Fl. Savantwadi 1: 106. 1990; M.J.Kothari & S.Moorthy, Fl. Raigad Dist. 71. 1993; Sanyal, Fl. Bankura Dist. 89. 1994; Sivar. & P.Mathew, Fl. Nilambur 155. 1996; Moorthy in N.P.Singh & Karthik. (eds.), Fl. Maharashtra, Dicot. 1: 568. 2000; S.R.Yadav & Sardesai, Fl. Kolhapur Dist. 123. 2002; Sunil & Sivad., Fl. Alappuzha Dist. 183. 2009. *Type: s.loc., s.d., Wallich 6826* (K barcode K001124920!).

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Leea macrophylla auct. non Roxb. ex Hornem.: DC., Prod. 1: 635. 1824; D.M.Verma in D.M.Verma *et al.* (eds.), Fl. Raipur, Durg & Rajnandgaon 78. 1985, *p.p.*; Vajr., Fl. Palghat Dist. 127. 1990; J.L. Ellis, Fl. Nallamalais 106. 1990; K.K.Khanna in D.M.Verma (ed.), Fl. Madhya Pradesh 1: 295. 1993; N.Rama Rao, Ethnobot. E. Ghats Andhra Pradesh 102. 1996; A.S.Chauhan, Contr. Fl. Namdhapa 141. 1996, *p.p.*; Hajra *et al.*, Mat. Fl. Arunachal Pradesh 1: 320, 1996, *p.p.*; P.K.Bhattach. & K.Sarkar, Fl. West Champaran Dist. 227. 1998, *p.p.*; Hajra *et al.*, Fl. Andaman & Nicobar Isl. 1: 308. 1999, *p.p.*; B.D.Naithani in N.P.Singh *et al.* (eds.), Fl. India 339. 2000, *p.p.*; P.P.Sharma & N.P.Singh, Ethnobot. Dadra, Nagar Haveli & Daman 91. 2001, *p.p.*; K.P.Singh in N.P.Singh *et al.* (eds.), Fl. Mizoram 1: 390. 2002, *p.p.*; Arisdason *et al.*, in P.Daniel (ed.), Fl. Kerala 1: 768. 2005, *p.p.*; Karthig., Angiosp. Diversity of Mahatma Gandhi Marine Natl. Park 105. 2017.

Leea aspera Wall. Cat. (not of Edgew.) 6825.

Leea diffusa M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1: 667. 1875. *Lectotype* (first step, designated by Ridsdale in Blumea 22 (1): 93. 1974; second step, designated

here): NEPAL, 1820, *Wallich Cat. No.* 6825 (K barcode K001124919 digital image!; *isoelectotype*: K barcode K001124918 digital image!).

Leea venkobarrowii Gamble, *Bull. Misc. Inform. Kew* 1: 26. 1917. *Type*: INDIA, **Tamil Nadu**, Coimbatore district, Anamalai Hills, 940 m, *J.S. Gamble 14646* (K barcode K000736387 digital image!).

Leea aequata auct. non L.: Gollamandala *et al.* in *J. Indian Bot. Soc.* 262. 2022, *p.p.*

Shrubs, 1–3 m high; roots tuberous, purple when cut. Stems erect, stout, jointed, hirsute when young and glabrous at maturity, without branching; internodes terete, green, brown at maturity; nodes not swollen. Pearl glands globose, numerous, distributed throughout the plant, white. Leaves alternate, pinnate or bipinnate, imparipinnate; petioles 6–37 cm long, swollen at base, not channelled on upper surface, hirsute, hairs are more when young, green or purple. Petiolar stipules 5–10 × 1.5–4 cm, oblong-obovate, caducous, hispid, green; stipular scars 4.5–7 cm long, triangular; rachis 8–73 cm long, channelled on upper surface, hispid, green to purple. Leaflets



Fig. 70. Type of *Leea robusta* Roxb. [*Wallich 6826* (K barcode K001124920!)] © Board of Trustees of the Royal Botanic Gardens, Kew.

opposite, ovate-widely ovate or oblong to elliptic-widely elliptic, distal leaflets: lamina 16–34.5 × 7–14 cm; lateral leaflets: lamina 5–49 × 5–15 cm, dark green above and pale green beneath, hispid or glabrous, base cordate or obtuse, margins serrate, apex acuminate or cuspidate; petiolules: central 2.5–11 cm long, channelled on

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upper surface, hispid, green or purple; lateral 0.4–4 cm long, hispid, channelled on upper surface, green or purple; secondary veins 5–15 pairs, 3 or 5-nerved at base, veins more prominent on lower surface, hispid. Inflorescence a leaf-opposed terminal cyme, 11–47 cm long, branched, lax, lateral branches long, many-flowered; peduncles 6.5–20 cm long, terete, hispid, green. Bracts early caducous, green. Flowers 5–6.5 mm long, numerous, actinomorphic, greenish-white. Pedicels slender, 1.7–2.3 mm long, hairy, green. Calyx campanulate, $3.7\text{--}4.2 \times 2.1\text{--}2.6$ mm, lobes 5, $0.8\text{--}1.3 \times 1.9\text{--}1.2$ mm, apex acute or obtuse, hairy, green. Corolla lobes 5, ovate, $3.2\text{--}3.9 \times 1.4\text{--}2$ mm, apex acute, hooded, margins entire, glabrous, green; corolla tube with floral disc $3.2\text{--}3.8 \times 1.7\text{--}2.6$ mm. Floral disc tubular, 1.8–2 mm long, white when young yellowish at maturity; upper free parts 1.3–1.5 mm long, apiculate; sinuses deep, 1.3–1.5 mm long, as long as the length of upper free part; lower free parts 0.4–0.7 mm long. Stamens 5, syngeneceous; filaments 1.3–1.6 mm long, glabrous, white; anthers 1.5–1.9 mm long, dorsifixed, dehisce longitudinally, white on lateral side, purplish on back. Ovary globose, 0.6–0.9 mm long, superior, 6-loculed, ovule one in each locule, placentation axile; style 0.9–1.3 mm long, slender, glabrous, green; stigma convex. Fruit 1.1–1.2 cm diam., depressed globose, green turning to black at maturity. Seeds 6, more or less obconic $3.62\text{--}3.82 \times 2.95\text{--}3.12$ mm, light brown when mature.

Flowering & fruiting: June–December.

Habitat: *Leea robusta* prefers moist shady areas. They are seen in forest margins, and sometimes in wet slopes. Usually found growing along with *Adiantum* sp. (Pteridaceae), *Selaginella* sp. (Selaginellaceae), *Sida rhombifolia* L. (Malvaceae), *Rauwolfia tetraphylla* L. (Apocynaceae), *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *Biophytum* sp. (Oxalidaceae), and grasses.

Distribution: India (Andaman, Andhra Pradesh, Chhattisgarh, Dadra and Nagar Haveli and Daman and Diu, Jharkhand, Karnataka, Kerala, Maharashtra, Mizoram, Orissa, Tamil Nadu, Telangana, Tripura, and West Bengal; Fig. 71), China, Myanmar, Nepal, Singapore and Thailand.

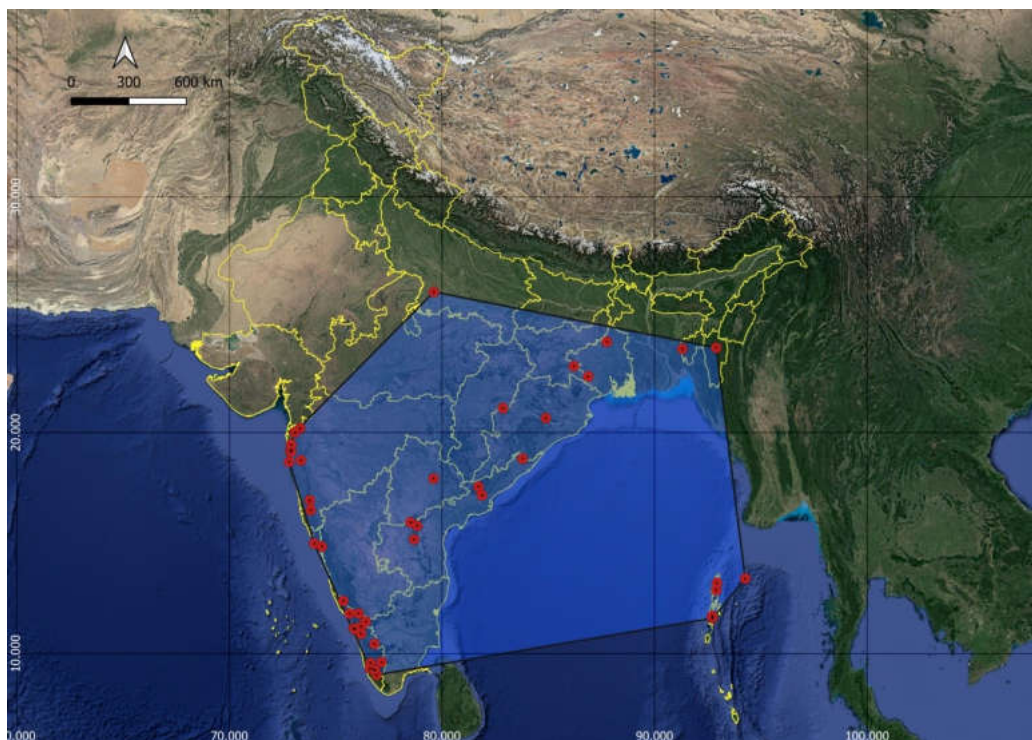


Fig. 71. Distribution of *Leea robusta* Roxb. in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Andaman, Oct 1900, *Dr. Prain's Collector* 93 (CAL); North and Middle Andaman district, 1 km away from Sitanagar, way to Mayabandar from Diglipur, 09 July 2019, *Amrutha* 164049 (CALI); After 15 No gate, Jarawa protected area, 10 July 2019, *Amrutha* 164058 (CALI barcode CALI173060); Kalimandir, Krishnapuri, Diglipur, 08 July 2019, *Amrutha* 164031 (CALI barcode CALI173058); Narcondam, 30 Oct 1904, *C.G. Rogers s.n.* (CAL); South Andaman district, Near BSI, 05 July 2019, *Amrutha* 164005 (CALI barcode CALI173048, CALI173049, CALI173050, CALI173051); Port Blair, Marine Hill Sea-shore, 27 Aug 2008, *Dr. S. Kumar* 27687 (PBL barcode PBL0000005817, PBL0000005818); *Ibid.*, Minie Bay, 05 Apr 2008, *Dr. S. Kumar* 26927 (PBL barcode PBL0000005819); South Andaman, Nov 1896, *R.L. Heinig s.n.* (CAL); Wimberligunj, 11 July 2019, *Amrutha* 164064 (CALI barcode CALI173059). **Andhra Pradesh**, East Godavari district, Rampa Hill, 08 Aug 1914, *M. S. Ramaswami* 1556 (BSID barcode BSID0008117); Ettukuru, Maredumilli, 27 Aug 1995, *M. Mohanan* 105134 (BSID barcode BSID0008119); Kurnool district, Nrusimha Narsimham, Upper Ahobilam,

09 Oct 2016, *J. Swamy & S. Nagaraju* 9064 (BSID barcode BSID0014785); Prakasam district, Rolla Penta, 14 Aug 1972, *J.L. Ellis* 42247 (MH); Srikakulam district, Seediguda, 23 Aug 1984, *P.V. Sreekumar & N. Rama Rao* 79403 (BSID barcode BSID0008118). **Chhattisgarh**, Bijapur district, Bijapur Ghats, 09 Oct 1987, *Anand Kumar* 16416 (CAL). **Dadra and Nagar Haveli and Daman and Diu**, Nagar Haveli Khanvel, Khanderi fort, 03 Oct 1963, *M.V. Ansari* 94090 (BSI). **Goa**, South Goa district, Agonda, 05 Sept 1965, *John Cherian* 85086 (BSI). **Jharkhand**, East Singhbhum district, Dalma Phar, Dalma Wildlife Sanctuary, 12 Mar 2008, *C.R. Majesh* 13866 (CAL). **Karnataka**, Uttara Kannada district, Kadra, 12 Aug 1885, *W.A. Talbot* 1281 (CAL). **Kerala**, Alappuzha district, Nootavanpara, *s.d.*, *C.N. Sunil* 2386 (CALI); Idukki district, Thekkady, 12 Sept 1995, *Jomy Augustine* 16237 (CALI barcode CALI105488); Kannur district, Chindaki Forest, 09 Oct 1965, *E. Vajravelu* 26002 (MH); Koothuparamba, Kannothe R.F., 21 Aug 1979, *V.S. Ramachandran* 64040 (MH, CAL); *Ibid.*, 13 Aug 1980, *V.S. Ramachandran* 66973 (CAL); *Ibid.*, 19 Sept 1913, *s.coll., s.n.* (MH); Kollam district, Punalur-Ottakkal, 11 Aug 1978, *C.N. Mohanan*, 58449 (MH); Kottayam district, Onamthuruthu, 25 Aug 2019, *Amrutha* 164098 (CALI barcode CALI173047); Pampady, 18 Oct 1984, *V.T. Antony* 872 (MH); Malappuram district, Calicut University Campus, *s.d.*, *Sworrupeanandhan* 778 (CALI); *Ibid.*, 18 Oct 1974, *Lila Thomas* 6220 (CALI); *Ibid.*, 20 Aug 1974, *B. Sumathy Kutty Amma* 5820 (CALI); *Ibid.*, 26 Mar 1990, *T. Rajasree* 2730 (CALI); Kakkancherry, Pallikkal, Koonolmadu, 02 Aug 2017, *Amrutha* 153206 (CALI); Near Kohinoor, 19 Nov 2018, *Amrutha* 153263 (CALI); Villunniyal, Near Calicut University Campus, 17 Aug 2017, *Amrutha* 153214 (CALI barcode CALI173053); *Ibid.*, 18 Aug 2017, *Amrutha* 153217 (CALI); *Ibid.*, 1 July 2017, *Amrutha* 153202 (CALI barcode CALI173054); Feroke, 31 July 1971, *V.V. Sivarajan* 1375 (CALI); Gudalur Road, 01 Aug 1983, *Philip Mathew* 34195 (CALI); Nadugani, 28 Aug 2017, *Amrutha* 153223 (CALI); Nadugani, Gudalur Road, 28 Aug 2020, *Amrutha* 164705 (CALI barcode CALI173057, CALI173056, CALI173055, CALI173052); Thiruvangadu, 30 Aug 1970, *V.V. Sivarajan* 477 (CALI); Vadapuram, 19 Aug 1987, *Philip Mathew* 34202 (CALI); Pathanamthitta district, Catholice College, 10 Feb 1986, *Mathew Dan* 51 (TBGT); Thannikkode-Konni R.F, 10 Aug 1980, *C.N. Mohanan* 69319 (MH); Palakkad district, Parambikulam submergible Area, 23 July 1962, *K.M. Sebastine* 14507 (CAL, MH);

Wayanad district, Begur Reserve Forest, V.S. Ramachandran 68270 (CAL). **Maharashtra**, Kolhapur district, Amba Ghat, 19 Sept 2018, Amrutha 153250 (CALI); Gaganbawada Road, 20 Sept 2018, Amrutha 153258 (CALI barcode CALI173061, CALI173062, CALI173063, CALI173064); Mumbai Suburban district, Aarey Colony, Goregaon, 20 Aug 1955, G.L. Shah 4830 (BLAT); Borivali, Kanheri Cave, 08 Aug 1943, s.coll. 2327 (BLAT); Malad, on plains, near the pond, 14 Dec 1957, G.L. Shah 9629 (BLAT); Sanjay Gandhi N.P., 28 July 1956, P.S. Herbert 1846 (BLAT); Trombay, Sept 1925, R.D. Aduad 187 (BLAT); Vihar Lake, Powai, 19 Sept 1953, H. Santapau 15996 (BLAT); Nasik district, Deodongara (Harsul), 16 Oct 1983, P.C. Narasimhan 166091 (BSI); Pune district, Khandala, 04 Oct 1944, H. Santapau 5114 (BLAT); Thane district, Chandip, 27 Aug 1960, N.Y. Das 1834 (BLAT); Chalani Forest, Sawa Range, 26 Oct 1967, K.V. Billore 113023 (BSI, CAL). **Mizoram**, Aizawl district, Way to Mizoram, 27 Aug 2018, Amrutha 159888 (CALI); Way to Tamdil, 28 Aug 2018, Amrutha 159899 (CALI); Serchhip district, Zero point, Tenzawl & Serchhip, 09 June 2022, Amrutha 164769 (CALI). **Orissa**, Angul district, Tulka, 25 Sept 2015, K.C. Mohan 6770 (BSID barcode BSID0010986); Bargarh district, Lergaon, 07 Nov 1959, G. Panigrahi 20876 B (ASSAM). **Telangana**, Warangal district, Way to Gangaram, 08 Aug 1986, P.V. Sreekumar 84036 (BSID barcode BSID0008114). **West Bengal**, Birbhum district, Beluti, Sainthia, 26 Dec 1969, R.K. Basak 1374 (CAL); Jhargram district, Chilkigarh, 14 km from Jhargram, 12 Nov 1997, J.K. Das & U.P. Samaddar 23033 (CAL); Kolkata district, Royal Botanical Garden, Kolkata, 09 Sept 1902, s.coll. s.n. (CAL).

Notes: Leea robusta is highly variable with regard to its height, size of the leaves and inflorescence, indumentum pattern on leaves and stem colour. Some plants are only 0.5 m tall, while others reach to a height of 3 m. It is also possible to find plants with purple and green stems. The plants growing in the Andaman Islands are found to be attaining a height of 3 m, and also with profuse branching. The leaves are glabrous on upper surface, mostly 2–3 pinnate and have robust, lax inflorescence. We were able to locate such plants from Mizoram as well. However, all the accessions show uniform floral morphology and seed structure.



Fig. 72. A-F. *Leea robusta* Roxb.: Different populations showing variation in habit (Photo E. by Hareesh V.S.).

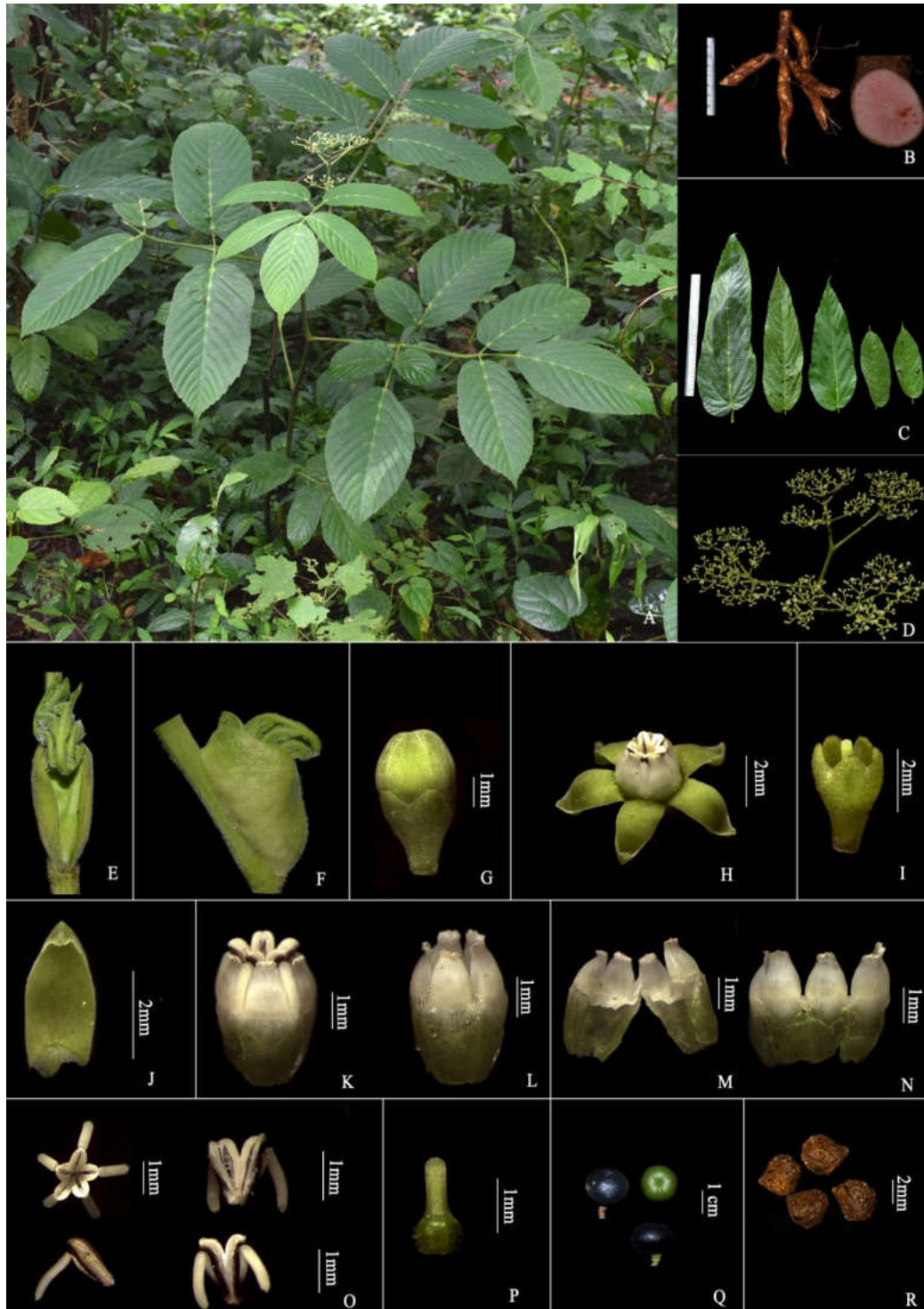


Fig. 73. *Leea robusta* Roxb.: **A.** Habit; **B.** Roots; **C.** Variation in leaflets; **D.** Inflorescence; **E & F.** Petiolar stipules; **G.** Flower bud; **H.** Flower; **I.** Calyx; **J.** Corolla lobe; **K & L.** Corolla tube with floral disc; **M & N.** Corolla tube with floral disc split open; **O.** Stamens; **P.** Pistil; **Q.** Fruits; **R.** Seeds.

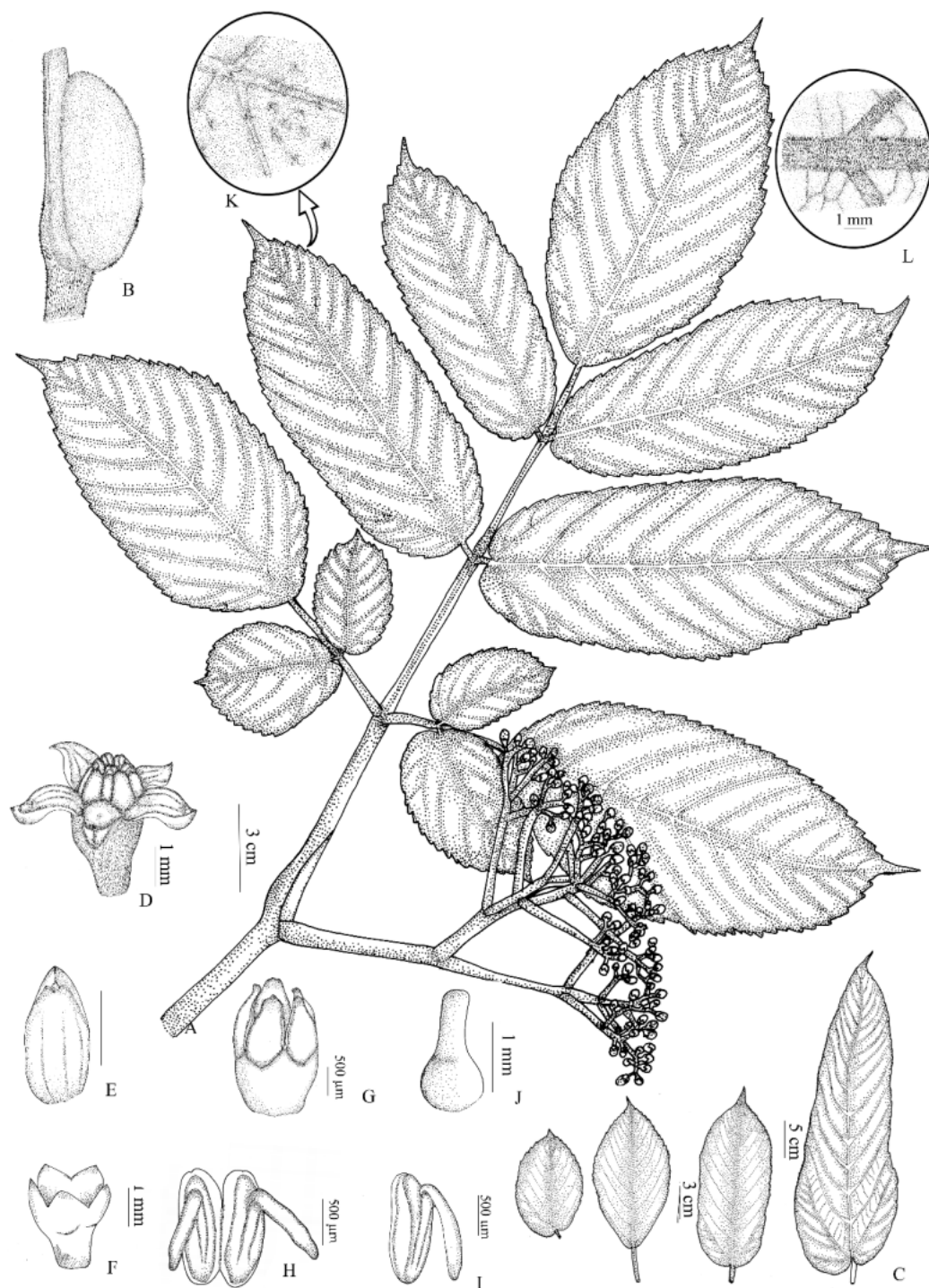


Fig. 74. *Leea robusta* Roxb.: **A.** A twig with inflorescence; **B.** Petiolar stipule; **C.** Variation in leaflets; **D.** Flower; **E.** Corolla lobe; **F.** Calyx; **G.** Corolla tube with floral disc; **H & I.** Stamens; **J.** Pistil; **K.** Adaxial surface-a portion enlarged; **I.** Abaxial surface-a portion enlarged (Drawn by Amrutha A. from Amrutha 153206).

In this species, the aerial shoots in drier regions annually die off and then regrow during the following growing season. Like many other species of *Leea*, this species exhibits leaf heteroblasty. The early leaves in the juvenile stage are frequently unifoliate, whereas later leaves are pinnate or bipinnate. Between the unifoliate and pinnate leaves, a few trifoliate leaves are also frequently observed.

Nomenclatural notes: Ridsdale (1974) synonymized *L. robusta* under *L. macrophylla*, a simple-leaved species in this genus and stated that the floral structure of both plants are similar and they differs only in the pinnation of the leaf. Later, Mathew and Umadevi (1992) carried out a revised taxonomy of the *L. macrophylla*, *L. robusta* and *L. venkobarrowii* Gamble, which had been treated as conspecific by Ridsdale (*l.c.*). Their studies showed that *L. robusta* differed from *L. macrophylla* with respect to leaves, floral disc, petiolar stipules and seed characters and hence, they reinstated *L. robusta*. They also discovered that *L. robusta* and *L. venkobarrowii* were conspecific, and treated them under the name *L. robusta*, which has priority over *L. venkobarrowii*. However, in the *Flora of India*, Naithani (2000) probably overlooking the treatment by Mathew and Umadevi (*l.c.*) and treated *L. robusta* under the synonymy of *L. macrophylla*. Following this work, most of the Indian floras still use this name as the synonym of *L. macrophylla*. However, a thorough examination of the morphology, anatomy, and SEM studies of seeds significantly confirms the reinstatement of *L. robusta* from *L. macrophylla* as observed by Mathew and Umadevi (*l.c.*). *L. macrophylla* differs from *L. robusta* in several characters including the nature of stem and leaves, petiolar stipule, size of pedicel and seed characters. The stem in *L. macrophylla* is sulcate or furrowed and glabrous against the terete and hispid hairs in *L. robusta*. Leaves are simple in the former and pinnate in the latter. It is evident that the leaves of the two taxa do not share any similar characteristics. The leaves of *L. macrophylla* do not exhibit pinnate leaves as seen in *L. robusta*. Petiolar stipule is glabrous in *L. macrophylla* and hispid in *L. robusta*. Pedicel is 3.8–4.2 mm long in *L. macrophylla* as opposed to 1.7–2.3 mm long in *L. robusta*. Seed length and testa morphology of both the species vary considerably. Seed length is 4.12–4.36 mm and smooth in *L. macrophylla* whereas, in *L. robusta*, it is 3.62–3.82 mm long and rough.

Typification: *Leea diffusa* was originally described by M.A. Lawson (1875) in Hooker's *Flora of British India*. While describing this species he did not specify a holotype, instead cited three specimens simultaneously "NIPAL, Wallich. KHASIA MTS., alt. 2–3000 ft., H. f. & T. TENASSERIM or ANDAMAN ISLANDS, Helfer". All these are syntypes according to Art. 9.6 of ICN (Turland *et al.*, 2018). In the revision of Leeaceae, Ridsdale (1974) selected Wallich material (Cat. No. 6825) as type. While searching for the type materials the authors found two relevant sheets having the same catalogue number, 6825 at Kew Herbarium (K001124918!, K001124919!). Both sheet has annotations in Wallich's own handwriting. Ridsdale (1974) effectively lectotypified by citing the material of Wallich in the first step. Among the two sheets of Wallich, the sheet (K001124919!) perfectly agrees with the protologue in leaf and inflorescence characters (leaflets acuminate at apex, margin serrate and inflorescence very large and diffuse). Hence, it is selected here as lectotype (second step, (Art. 9.17 of ICN)).

Wallich collected a species from Nepal and named it as *L. aspera* in the Wallich Catalogue (catalogue number 6825). But it was a misidentification and actually belonging to *L. robusta*. Later, Lawson (1875) published a new species, *L. diffusa* based on Wallich specimen 6825. But Clarke (1881) synonymized *L. diffusa* under *L. robusta*. Ridsdale (1974) in the revision of Leeaceae, synonymized both *L. robusta* and *L. diffusa* under *L. macrophylla*. While reinstating *L. robusta*, Mathew and Umadevi (1992) did not mention the status of *L. diffusa*. After the critical study of the type specimens and protologue, we found that the characters used to describe new species were the same as that of *L. robusta*. Hence, it is treated under the synonymy *L. robusta*.

14. *Leea setuligera* C.B.Clarke, J. Bot. 19: 105. 1881; T.Cooke, Fl. Bombay 1: 262. 1903; Santapau in Rec. Bot. Surv. India 16: 56. 1953; Ridsdale, Blumea 22: 91. 1974; S.M.Almeida, Fl. Savantwadi 1: 106. 1990; Moorthy in N.P.Singh & Karthik. (eds.), Fl. Maharashtra, Dicot. 1: 569. 2000; B.D.Naithani in N.P.Singh *et al.* (eds.), Fl. India 341. 2000; S.R.Yadav & Sardesai, Fl. Kollapur Dist. 123. 2002. *Type:* INDIA,

Maharashtra, Konkan, *s.d.*, *Dr. Stocks s.n.* (K barcode K000323732 digital image!).

Figs. 75, 77 & 78

Leea talbotii King ex Talbot, Forest Fl. Bombay 1. 329. 1909, *syn. nov.* *Lectotype* (designated by Amrutha & Pradeep, 2023): INDIA, **Karnataka**, Yellapur, North Canara, 1882, *W.A. Talbot s.n.* (BSI barcode BSI0000000045 digital image!).

Leea mastersii C.B. Clarke var. *siamensis* Craib, Fl. Siam. 1: 319. 1926. *Lectotype* (designated by Amrutha & Pradeep, 2023): THAILAND, Mî Lan, Mî Hawng Sawn, 23 May 1921, 600 m, *A.F.G. Kerr 5485* (K barcode K000323726 digital image!; *isolectotype*: K barcode K000323727 digital image!).

Perennial, subshrubs, 0.5–1 m high; roots tuberous. Stems erect, stout, jointed, without branching; internodes furrowed, purple or green; nodes not swollen. Pearl glands globose, more on inflorescences, white. Leaves alternate, pinnate to tripinnate, imparipinnate; petioles 4–13 mm long, base bulged, glabrous, brown or purple; petiolar stipules a narrow wing, 1–2.5 cm long, extending to $\frac{1}{4}$ th of petioles, hairs on the margin; stipular scars triangular; rachis 7–20 cm long, furrowed, hairy on ridges, purple. Leaflets opposite, broadly elliptic-ovate or sub-orbicular, distal leaflets lamina: 8–15 × 4.5–7.5 cm,



Fig. 75. Type of *Leea setuligera* C.B. Clarke [*Dr. Stocks s.n.* (K barcode K000323732)] © Board of Trustees of the Royal Botanic Gardens, Kew.

Systematic treatment

lateral leaflets lamina: 4.5–17.5 × 3–8.5 cm, 2–3 rows of setaceous hairs in between 2 lateral veins, dark green on upper surface and pale green on lower, base cordate-obtuse or rounded, sometimes unequal, margins usually sharply serrate, coarsely sub-entire towards base, apex acute-acuminate; petiolules: central 2–4 cm long, purple, lateral 0.1–0.5 cm long, sometimes second pair of leaflets in the bipinnate leaves sessile; secondary veins 5–10 pairs, 3-nerved at base, vein raised on abaxial side. Inflorescence terminal, a leaf-opposed umbellate cyme, 18–25 cm long, many-flowered, condensed or lax; peduncles 7.5–12 cm long, furrowed, pubescent, green, lateral branches purple. Flowers 5–6 × 4–4.5 mm, actinomorphic, creamish pink. Pedicel slender, 2.2–2.4 mm long, pubescent. Bracts c. 1.5 mm long, curved, caducous, creamish. Calyx campanulate, 4–4.6 × 2.4–2.8 mm, 5-lobed, lobes 1.1–1.6 × 1–1.5 mm, ovate or widely ovate, apex acuminate, pinkish when young, then creamish; corolla lobes 5, ovate-oblong, 2.8–3.1 × 1.5–1.6 mm, apex acute-rounded, hooded, margin entire, glabrous, creamish; corolla tube with floral disc 3.5–4 × 2–2.3 mm, floral disc 3–3.3 mm long, white with pinkish at apex; upper free part 1.5–2 mm long, slightly notched; sinuses deep, 1.5–1.8 mm long, extending almost up to the length of upper free part; lower free part 1.3–1.5 mm long. Stamens 5, syngeneceous; filaments 1.5–2 mm long, glabrous, white; anthers 1.2–1.6 mm long, dehisces longitudinally, purple on backside, creamish on margin. Ovary globose, 0.7–0.9 mm long, superior, 4–6-loculed, green, one ovule in each locule, placentation axile; style slender, 1–1.2 mm long, glabrous, creamy; stigma round, pink. Fruit a berry, green when young turning red and black at maturity, 4 (–6) seeded. Seed wedge-shaped, 4.43–4.69 × 3.72–4.21 mm, light brown when mature.

Flowering & fruiting: June–January.

Habitat: It can be seen along the roadsides and in open areas. The major associated species are *Colocasia esculenta* (L.) Schott (Araceae), *Laportea interrupta* (L.) Chew (Urticaceae), *Chromolaena odorata* (L.) R.M.King & H.Rob. (Asteraceae), *Adiantum* sp. (Pteridaceae) as well as other ferns and grasses.

Distribution: India (Karnataka & Maharashtra; Fig. 76), China, Thailand.

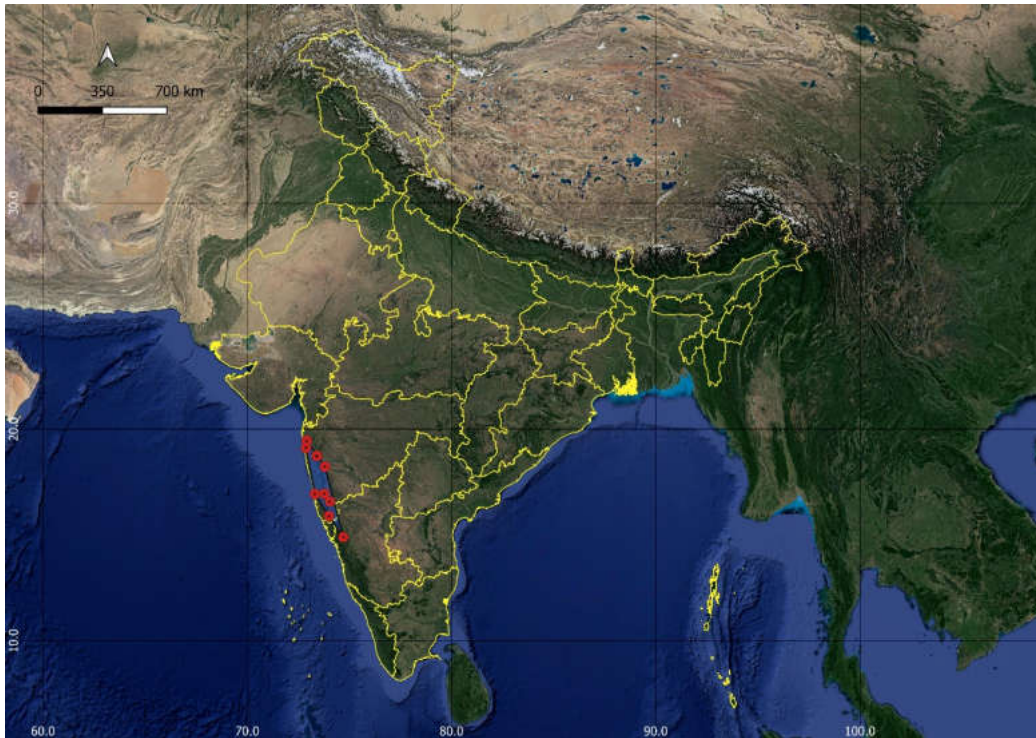


Fig. 76. Distribution of *Leea setuligera* C.B.Clarke in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Maharashtra**, Kolhapur district, Gaganbawada Road, 20 Sept 2018, *Amrutha* 153255; Way to Amba Ghat, 19 Sept 2018, *Amrutha* 153249; Way to Amboli Ghat, 21 Sept 2018, *Amrutha* 153260 (CALI); Mumbai district, Andheri Mahakali Cave, 21 Sept 1957, *G.L. Shah* 9075 (BLAT); Pune district, Khandala, 08 Jan 1946, *H. Santapau* 9132 (BLAT); Near Ambavne R.H., Mulshi Taluk, Poona, 06 Sept 1964, *B. Venkata Reddi* 90023 (BSI); Sagarpatnar Plateau, above INS Shivaji, Lonavala, 05 Sept 1996, *B. Venkata Reddi* 99001 (BSI); Thane district, Chandip, 20 June 1961, *N.Y. Das* 3400a (BLAT); *Ibid.*, 20 June 1961, *N.Y. Das* N.Y.D. 3400b (BLAT); Ratnagiri district, Near Ratnagiri, 27 June 1957, *GSP* 20062 (BSI).

Notes: Ridsdale (1974) noted some similarities between *L. setuligera* and *L. guineensis* which is not supported in our studies. *L. setuligera* is distinguished by its leaves with setaceous hairs on the upper surface, narrowly winged petiolar stipules and four seeded fruits as opposed to one row of stiff hairs in between the lateral veins on the upper surface of the leaves, oblong petiolar stipule with mostly six seeded fruits in *L. guineensis*.

Nomenclatural notes: W.A. Talbot (1909) described *Leea talbotii* based on King's unpublished manuscript housed at "Herb. Hort. Calcutta" (CAL). He compared his new species to *L. setuligera* and distinguished it as a larger plant with a pubescent corymb. While studying *Leea* specimens at BSI, Pune, we came across a note (affixed on a sheet of *L. aspera*, *sensu* Talbot, *non* Wallich) presumably written by Talbot based on a reply from King who received a specimen of *L. talbotii* sent by him on 15 July 1883. According to King, the corymb of the specimen is pubescent (as opposed to the glabrous corymb in *L. setuligera*). He also pointed out that, Clarke (Bot. Mag. 1881.p.105) considered the flowers of *L. setuligera* as red and placed it under a red-flowered section of the genus. However, King noticed that the flowers of the specimen sent by Talbot were green or greenish-yellow in colour. Hence, he concluded that this must be a new species near to *L. setuligera*. It is however clear that C.B. Clarke (1881) did not see any live specimens of the plants while describing *L. setuligera*. His description of the new taxon was solely based on Dr. Stock's preserved material and hence he was a little skeptical while describing the color of the corolla, and wrote - "Corolla red?". The author's collections of this taxon from Maharashtra had creamy corolla while the floral discs and apical portion of young sepals were prominently pinkish-tinged. It is more likely that Stock's preserved specimens might have had a pinkish tinge which Clarke possibly considered a faded red. The present study, in consultation with a number of specimens, types and living populations showed that the indumentum of leaves and inflorescence cannot be relied upon to segregate both the taxa. The flower colour of *L. setuligera* described as red (?) is also on dubious grounds. Additionally, the characters mentioned in the protologue of *L. talbotii* (young stem and branches sulcate, leaves with adpressed white hairs and, peduncle sulcate, fruits 4-seeded) are exactly matching with the characters of *L. setuligera*. Hence, *L. talbotii* King ex Talbot is considered to be a synonym of *L. setuligera*.

Typifications: While describing *L. talbotii*, Talbot did not designate any material as holotype, instead he cited only the collection details as 'common in the undergrowth of the evergreen rain forest of N. Kanara and South Konkan'. Ridsdale (1974) did not see the type material while revising Leeaceae. A thorough search for original material in various Indian herbaria resulted in locating four sheets of Talbot (BSI0000000045, BSI0000000046, BSI0000000047 & BSI0000000048)

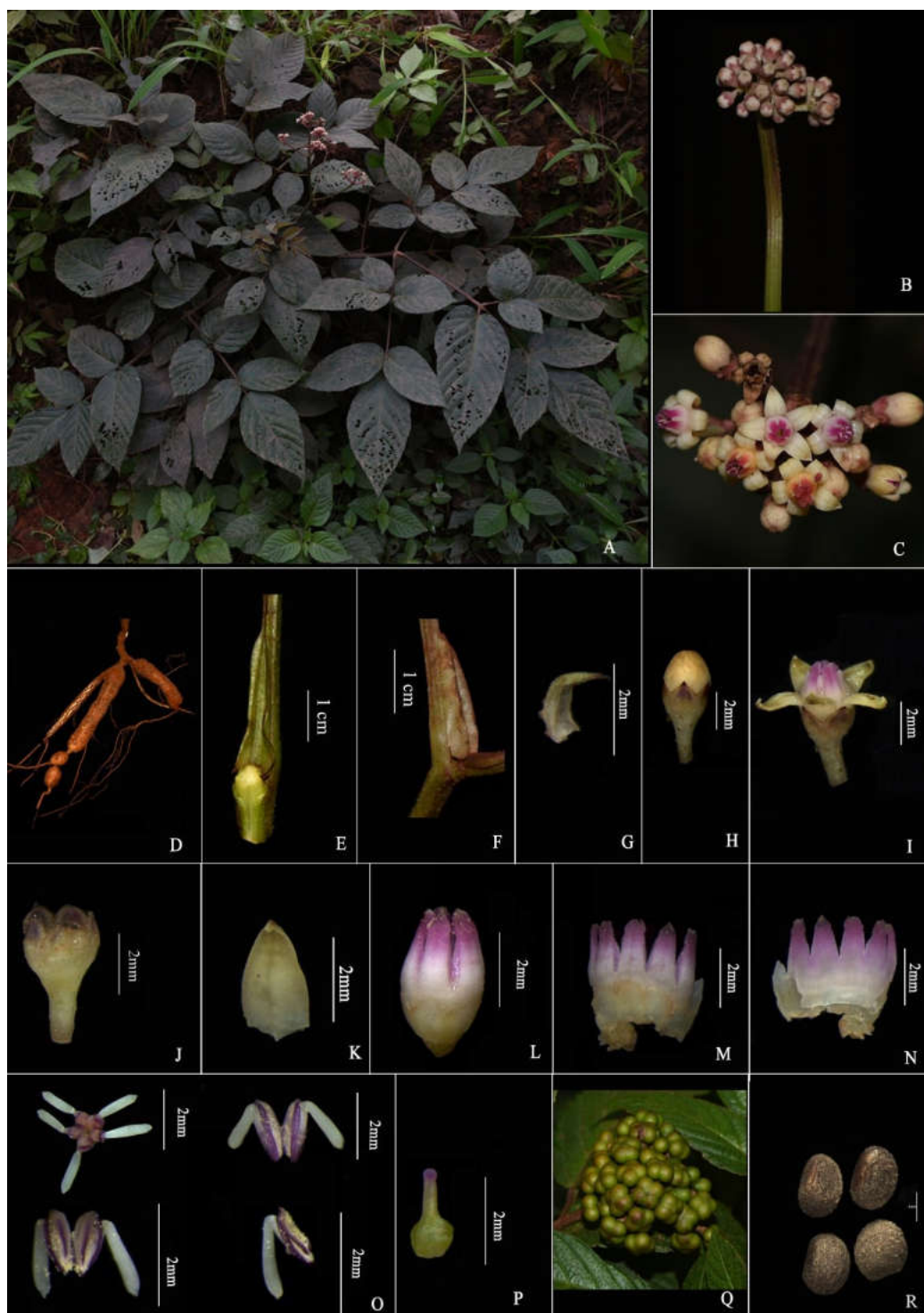


Fig. 77. *Leea setuligera* C.B. Clarke: **A.** Habit; **B & C.** Inflorescence; **D.** Tuberous root; **E & F.** Petiolar stipules; **G.** Bract; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe; **L.** Corolla tube with floral disc; **M & N.** Corolla tube with floral disc split open; **O.** Stamens; **P.** Pistil; **Q.** Infructescence; **R.** Seeds.

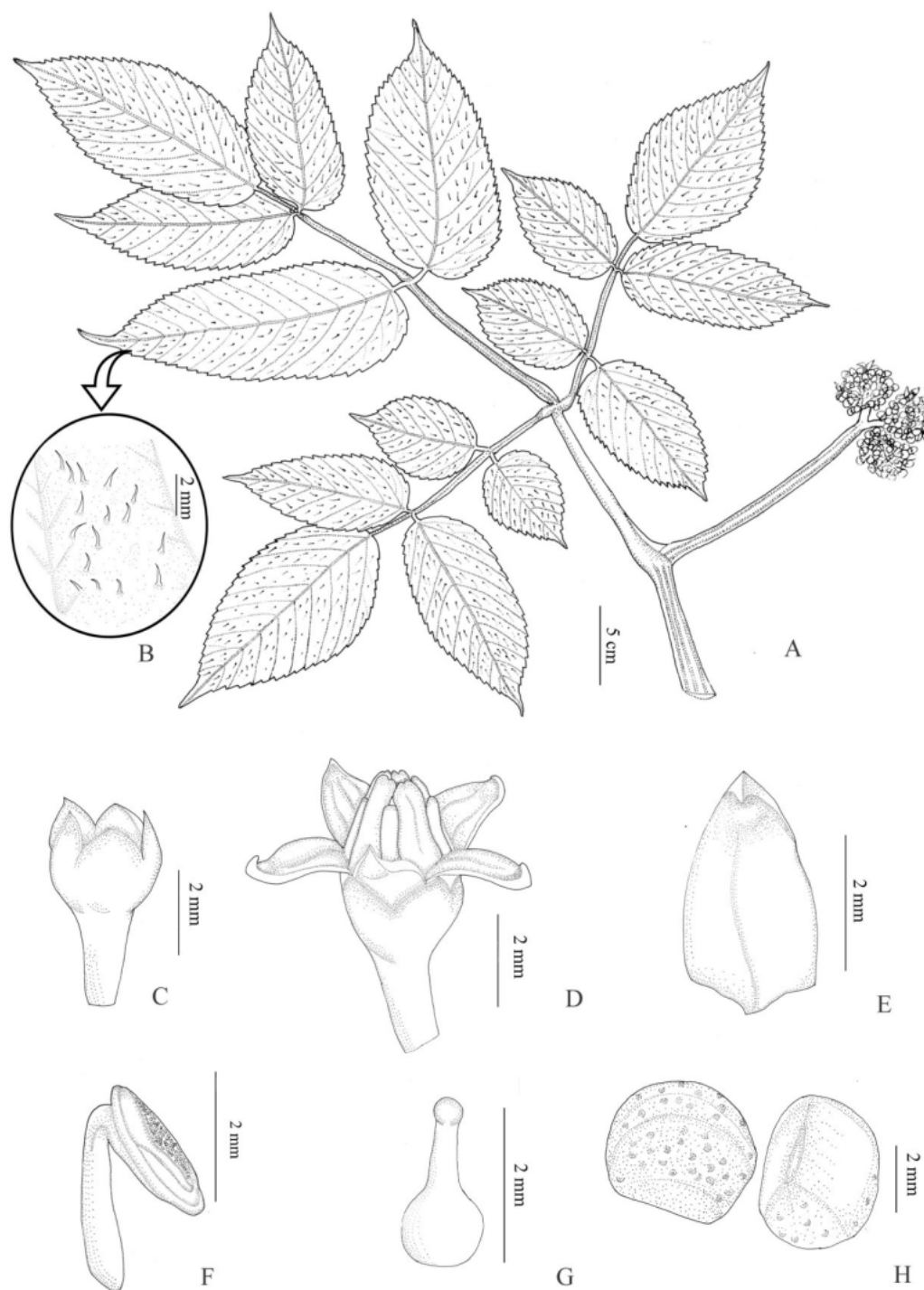


Fig. 78. *Leea setuligera* C.B. Clarke: **A.** A twig with inflorescence; **B.** Lamina portion enlarged; **C.** Calyx; **D.** Flower; **E.** Corolla lobe; **F.** Stamen; **G.** Pistil; **H.** Seeds (Drawn by Amrutha A. from Amrutha 153249).

at BSI (Pune) filed under the name *L. talbotii*. All of them labelled as “*Leea aspera* Wall.” in Roxburgh, collected from N. Canara. The sheet with barcode number BSI0000000045, collected from Yellapur, North Canara matches exactly the description in the protologue. In addition, the illustration (Fig. 195 in the protologue) agrees perfectly with the specimen in having a pinnately compound leaf and a twig holding fruits. It is most likely that the author’s description and illustration of *L. talbotii* was based on this material, hence it is selected as the lectotype

Leea mastersii C.B. Clarke var. *siamensis* Craib (1926:319) was originally described based on a specimen collected by A.F.G. Kerr from Mî Lan, Thailand. In the protologue, he mentioned only one collection as ‘PAYAP, Mî Lan, Mî Hawng Sawn, c. 600 m., Kerr, 5485’. Ridsdale (1974) while revising Leeaceae, cited the type as ‘Type: Kerr 5485 (K)’. A thorough search for Kerr’s specimens at K by the authors located two sheets (K000323726 & K000323727 digital image!) attributable to Kerr. Ridsdale’s designation of type can only be considered as the first-step lectotypification because he did not mention which one is the type material among the two duplicates. Hence, a second-step lectotypification (Turland *et al.*, 2018, Art. 9.17) is required. Barcode number K000323726 contains a label with collection details in Kerr’s own handwriting, which is designated here as lectotype.

15. *Leea sundaica* Miq., Fl. Ned. Ind. 1(2): 610. 1859; Merr., Bibliogr. Enum. Born. Pl. 369. 1921; Ridl., Fl. Malay Penins. 1: 485. 1922; Backer & Bakh.f., Fl. Java 2: 94. 1965. *Leea robusta* Blume, Bijdr. Fl. Ned. Ind. 4: 198. 1825, *non* Roxb. 1824. Type: INDONESIA, Java, Megamendung, Blume s.n. (K K000736495 digital image!).

Figs. 79, 81 & 82

Leea fuliginosa Miq., Fl. Ned. Ind., Eerste Bijv. 3: 518. 1861; *Leea sundaica* Miq. var. *fuliginosa* Miq., Ann. Mus. Bot. Lugduno-Batavi. 1: 96. 1863. Lectotype (first step, designated by Ridsdale in Blumea 22 (1): 95. 1974; second step, designated here): INDONESIA, Sumatra oriental in provinces, Palambang, Near Muara-duwa, s.d., Teysmann 3910 (L barcode L 0013666!; *isolectotype*: L barcode L 0013665 digital image!).

Leea sundaica Miq. var. *subsessilis* Miq., Ann. Mus. Bot. Lugduno-Batavi. 1: 96. 1863. Type: INDONESIA, New Guinea, Dourga stream, Zippelius A. 90b (L barcode L 0013674 digital image!).

Leea sundaica Miq. var. *pilosiuscula* Span. ex Miq., Ann. Mus. Bot. Lugduno-Batavi. 1: 96. 1863. Type: INDONESIA, Java or Timor, Spanoghe J.B. s.n. (L barcode L 0013672 digital image!).

Shrubs, up to 2–3 m tall; root non-tuberos. Stems erect, stout, rusty or white tomentose, branched; internodes terete, green; nodes swollen, purplish. Pearl glands globose, white. Leaves alternate, 1–2 pinnate, imparipinnate; petioles 13–19 cm long, swollen at base, base purplish, terete, tomentose, green. Petiolar stipule obovate to narrowly elliptic, 3–3.5 × c. 1 cm, hairy, glabrous; stipular scars triangular, 2.5–3.5 cm long; rachis 12.5–22 cm long, terete, tomentose, green. Leaflets opposite, oblong-elliptic to widely elliptic; lamina 10–31 × 5–12 cm, young leaves with 2–3 rows of stiff hairs in between two lateral veins, pale green, mature leaves glabrous on adaxial surface, abaxial surface tomentose, pale green, dark green above, base obtuse or round, margins serrate, apex acuminate; petiolules: central 4–8 cm long, lateral 1–2 cm long; secondary veins 7–16 pairs, usually 3-nerved at base, veins raised on lower surfaces, tomentose. Inflorescence a leaf-opposed, terminal cyme, 10–27 cm long, branched, lax, many-flowered, flowers crumpled; peduncles 9–14 cm long, tomentose, green. Flowers 3.5–4 mm long, numerous, greenish-white. Pedicels 0.5–1 mm long, slender, hairy. Bracts 0.14–2.1 cm long, early caducous, green. Calyx campanulate, 2.2–3 × 2–2.2 mm, lobes 5, 0.6–0.8 × 1.1–

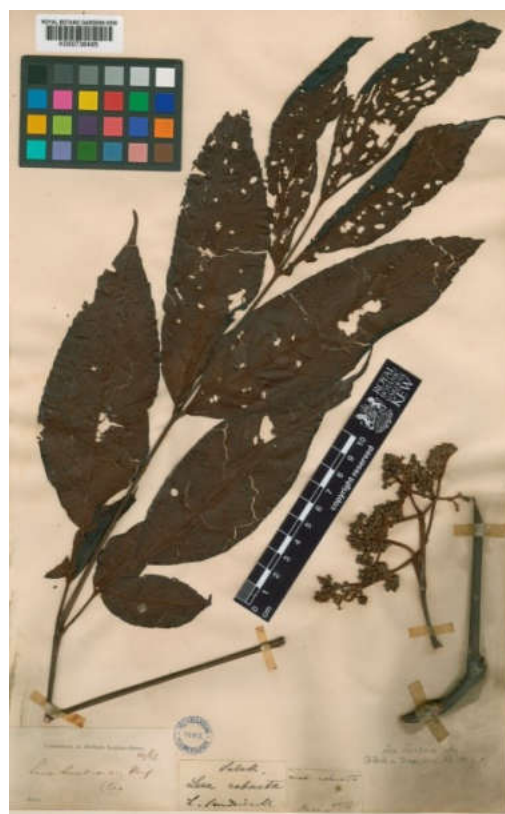


Fig. 79. Type of *Leea sundaica* Miq. [Blume s.n. (K barcode K000736495)] © Board of Trustees of the Royal Botanic Gardens, Kew.

Systematic treatment

1.2 mm, broadly ovate, apex rounded to obtuse, glabrous, green. Corolla lobes 5, ovate, $3.5\text{--}4.2 \times 1.5\text{--}1.9$ mm, apex acute and hooded, margins entire, glabrous, pale green; corolla tube with floral disc $3.4\text{--}3.9 \times 2.5\text{--}2.6$ mm, white. Floral disc tubular, 1.7–1.8 mm long; upper free parts 1.3–1.5 mm long, lobes retuse, sinuses shallow, 0.3–0.4 mm long; lower free parts 0.3–0.4 mm long. Stamens 5, syngeneis; filaments 1.2–1.4 mm long, glabrous, white; anthers dorsifixed, 1.2–1.3 mm long, elliptic, dehisce longitudinally, purple on ventral side and yellowish laterally. Ovary globose, 0.8–1 mm long, 6-loculed, ovule one in each locule, placentation axile; style 1.2–3 mm long, slender, glabrous, white; stigma convex to globose. Fruits berry, green when young turning black at maturity. Seeds 6, more or less obconic, $3.6\text{--}3.9 \times 3.4\text{--}3.5$ mm, dark brown when mature surface rough with unevenly raised portions at margin.

Flowering & fruiting: June–January.

Distribution: *Leea sundaica* is mostly distributed in Java, Borneo, Celebes and Papua (Henderson, 1928). In India, it is collected only from the Nicobar Islands; Fig. 80.

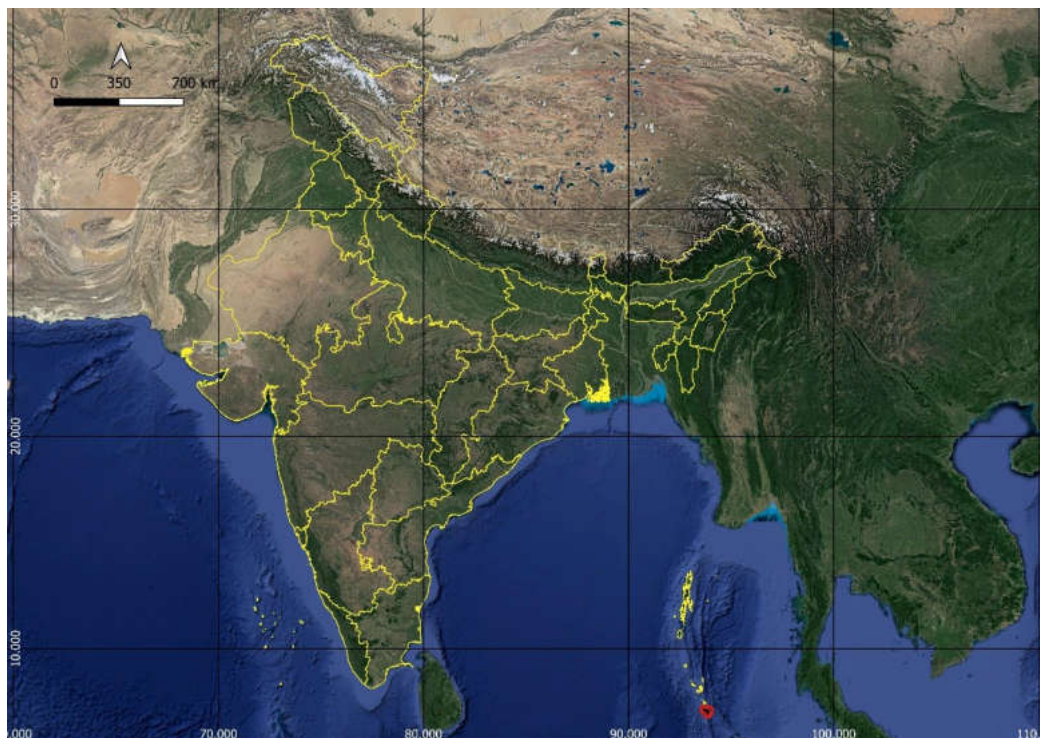


Fig. 80. Distribution of *L. sundaica* Miq. in India (drawn using QGIS version 3.24.3).

Habitat: The species grows in open areas and beach forests along with *Chromolaena odorata* (L.) R.M. King & H. Rob. (Asteraceae), and *Pandanus* sp. (Pandanaceae).

Specimens examined: INDIA, **Andaman and Nicobar Islands**, Nicobar district, Campbell Bay, Murdakkadi, 15 July 2019, *Amrutha* 164065; *Ibid.*, 16 July 2019, *Amrutha* 164069 (CALI); East-West Road, 17 July 2019, *Amrutha* 164090 (CALI).

Notes: *Leea sundaica* was first described in 1859 by Miquel based on a specimen from Java, and treated *Leea robusta* Blume [*non* Roxb. 1814] as its synonym. Later in 1860, Miquel described three more species, *L. biserrata*, *L. palembanica* and *L. fuliginosa* in his *Flora van Nederlandsch Indie, Eerste Bijvoegsel*. In 1863, he provided a detailed account on the genus *Leea* in his *Annales Musei Botanici*. In this treatment he retained *L. sundaica* as a distinct species and reduced his *L. palembanica* into synonymy. Along with this, he altered the rank of his *L. fuliginosa* to a variety and recognized two more varieties, var. *pilosiuscula* Span. ex Miq. and var. *subsessilis* Miq. under *L. sundaica*. Clarke (1881) in his revision of the Indian species of *Leea* excluded this species and cited it in an appendix based on a specimen from Java available at K (K000736495 image!). Subsequently, Ridsdale (1974, 1976) synonymized *L. sundaica* under *L. indica* (Burm.f) Merr. and stated that leaf character particularly leaf vestiture and dimension is not enough to segregate it from the more widespread *L. indicia*.

During the revision of *Leea* in India, we could locate *L. sundaica* from Nicobar Island of Andaman and Nicobar Islands. Upon careful examination of the live materials and critical survey of the literature (Lawson, 1875; Clarke, 1881; Gamble, 1918; Naithani, 2000) in consultation with the type specimens revealed *L. sundaica* as distinct. It forms a new distributional record for India and hence reinstated here. *Leea sundaica* differs from *L. indica* in plants being densely tomentose (*vs.* glabrous); nodes swollen (*vs.* non swollen nodes); lobes of upper free parts of floral disc retuse, sinuses 0.3–0.4 mm long (*vs.* lobes of upper free parts of floral disc notched, sinuses 0.5–0.9 mm long); seeds up to 3 mm wide (*vs.* more than 3 mm wide), surface of seed rough with unevenly raised portions (*vs.* surface smooth).

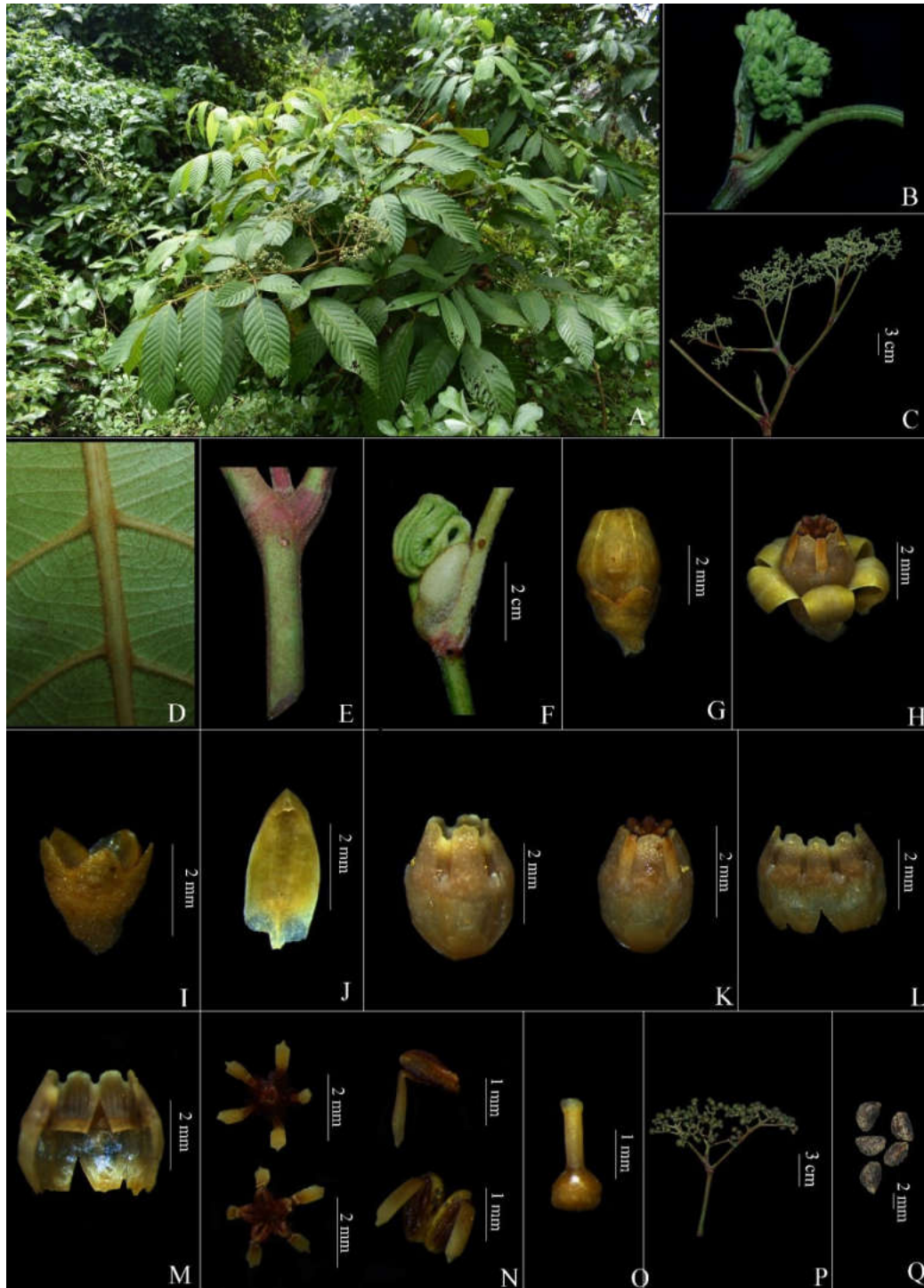


Fig. 81. *Leea sundaica* Miq.: **A.** Habit; **B.** Emerging inflorescence; **C.** Inflorescence; **D.** Abaxial surfaces of leaf; **E.** Portion of stem showing rusty tomentose hairs; **F.** Petiolar stipule; **G.** Flower bud; **H.** Flower; **I.** Calyx; **J.** Corolla lobe; **K.** Corolla tube with floral disc; **L & M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil; **P.** Infructescence; **Q.** Seeds.

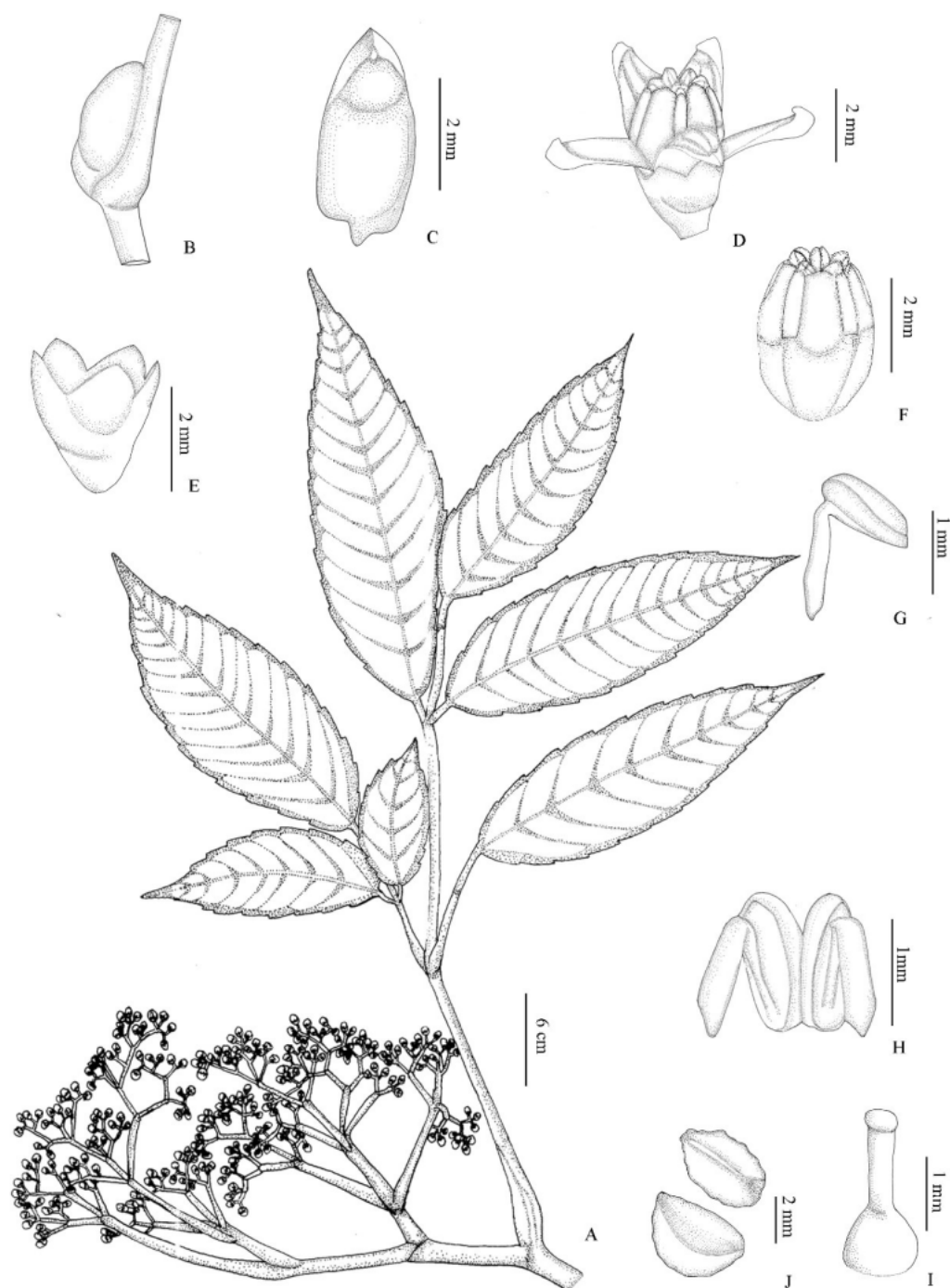


Fig. 82. *Leea sundaica* Miq.: **A.** A twig with inflorescence; **B.** Petiolar stipule; **C.** Corolla lobe; **D.** Flower; **E.** Calyx; **F.** Corolla tube with floral disc; **G & H.** Stamens; **I.** Pistil; **J.** Seeds-Lateral and frontal view (Drawn by Amrutha A. from Amrutha 164065).

Nomenclatural notes: Blume (1825) published the name *L. robusta* Blume based on a specimen collected from Meggamedong, Java, which became an illegitimate later homonym of *L. robusta* (1824). Later, Miquel (1859) published a replaced name, *L. sundaica* based on Blume's specimen and cited *L. robusta* Blume as a homotypic synonym. An exhaustive search for the original material led to locating two sheets from K and L having paper labels of Blume and written as '*L. robusta* Bl', and these sheets are to be treated as syntypes (Art. 9.6 of the ICN). One sheet from K herbarium (K000736495) has ferruginous hairs on leaves and inflorescence and the other from L herbarium (L 0744182) is glabrous. Hence, there is a need to choose a lectotype among these syntypes. In 1863, Miquel published *L. sambucina* var. *robusta* and he wrote as "*L. robusta* BL. *Partim, scil quod specimina glabra*" in the bracket, which means *L. robusta* Blume is a mixture and among which, the glabrous form was established as a new variety. Hence, the specimen from Kew (K00736495!) with the label of Blume, exactly matching with the protologue, collected from Java, is selected here as the lectotype of *L. sundaica*. However, Ridsdale's (1974) selection of type of *L. sundaica* from the L herbarium (L 0744182) is not correct as it is the type specimen of *L. sambucina* var. *robusta*.

Leea fuliginosa was originally described by Miquel in 1860 based on the specimen of Teysmann from Palembang. In the protologue, he cited: "Sumatra Orient.in prov. Palembang, prope Maura-dura (T.)". Later in 1863, he altered the rank of *L. fuliginosa* and treated it as a variety of *L. sundaica*. Ridsdale (1974) cited "Type: *Teymann* (3910) s.n., near Moeraradoewa, Palembang, Sumatra (BO, L, U)". While searching for the type material in various herbaria, we could trace 2 sheets at Leiden herbarium (L 0013665!, L 0013666!), both have the same label but could not locate material at U and BO. Among the syntypes, a well-preserved sheet (L 0013666!) with tomentose hairs on inflorescence and leaves is selected here as the lectotype.

16. *Leea trifoliata* M.A.Lawson in Hook.f. (ed.), Fl. Brit. India 1(3): 666.1875; Kanjilal & Das, Fl. Assam 1(2): 305. 1936. *Lectotype* (designated by Ridsdale, 1974): INDIA, Assam, 1845, *Jenkins* s.n. (K barcode K000736385!). **Figs. 83, 85 & 86**

Systematic treatment

Perennial, weak herbaceous plant, 0.8–1 m high; roots non-tuberous. Stems erect or wiry, jointed, warted, glabrous; internodes furrowed, green; nodes swollen; pearl glands globose, white. Leaves alternate, trifoliate or 1-pinnate with two rudimentary pair of leaf at base; petioles 7–21 mm long, slightly bulged, sheathing the stem, hairy at base, green. Petiolar stipules narrow wing, 2–2.5 cm long; stipular scars triangular; rachis 1–4 cm long, channelled and slightly winged on upper surface, hispid on margin, green. Leaflets opposite, elliptic-oblong or obovate, distal leaflets lamina: 5.5–13 × 2.7–7.5 cm, lateral leaflets lamina: 4.5–12.5 × 2–6 cm, one row of stiff hairs in between nerves on upper surface, mature leaves green on upper surface and pale green on lower, base cuneate, margins serrate, apex cuspidate caudate, abruptly acuminate; petiolules: central 1–2.5 cm long, lateral 0.2–0.7 cm long, channelled and winged on upper surface, green; secondary veins 7–16 pairs, 3-nerved at base, strigose on lower surface, vein raised on abaxial side. Bracts, 1.8–2.7 mm long, narrowly lanceolate-linear.



Fig. 83. Lectotype of *Leea trifoliata* M.A.Lawson [Jenkins s.n. (K barcode K000736385)] © Board of Trustees of the Royal Botanic Gardens, Kew.

Flowering & fruiting: June–December.

Habitat: This species mostly grows in roadsides and forest margins. They grow along with *Adiantum* sp. (Pteridaceae), *Impatiens minor* (DC.) Bennet, *Impatiens balsamina* L. (both Balsaminaceae) and some grasses.

Distribution: India (Assam & Arunachal Pradesh; Fig. 84), Myanmar.

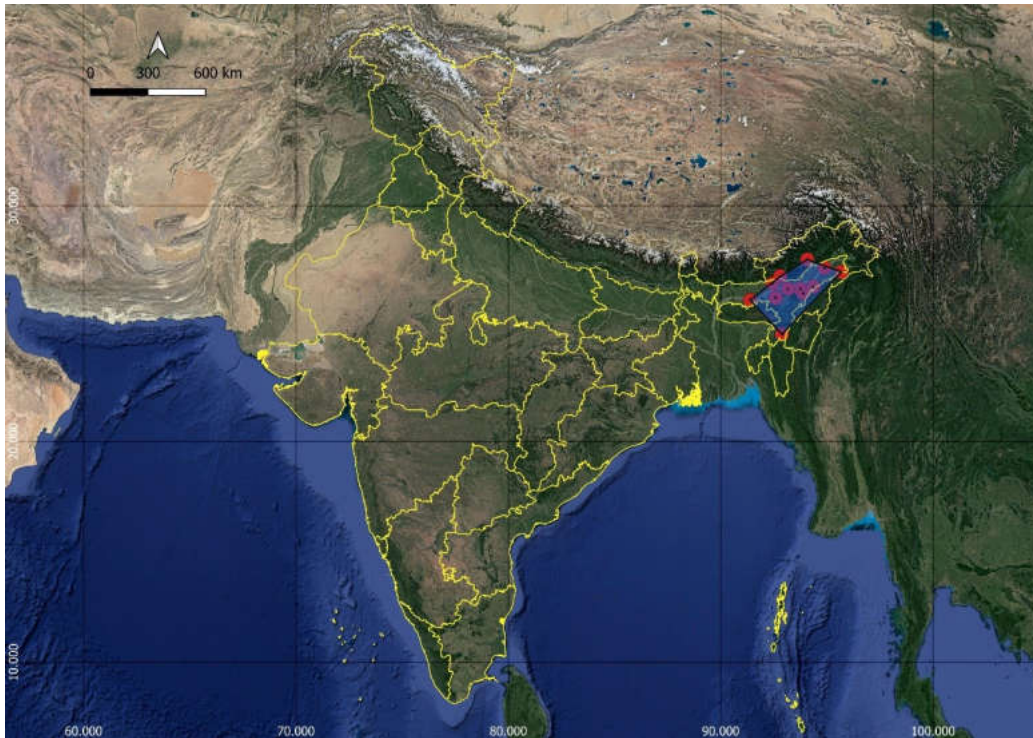


Fig. 84. Distribution of *Leea trifoliata* M.A.Lawson in India (drawn using QGIS version 3.24.3).

Specimens examined: INDIA, **Assam**, Cachar district, Bhuban Hills, Oct 1978, 74142 (ASSAM); Darrang district, Aka Hills, s.d., N.L. Bohr 17378 (ASSAM); Dibrugarh district, Dibru Reserve, eastern part, 20 Oct 1960, G. Panigrahi 21564 (ASSAM); Jorhat district, Gibbon Sanctuary, Camp-2, 12 June 2010, Ranjit Daimary 122699 (ASSAM); *Ibid.*, Camp-4, 26 Feb 2011, Ranjit Daimary 121691 (ASSAM); Kamarup district, Moyang Residence, 09 Apr 1915, U. Kanjilal 5449 (ASSAM); Karbi Anglong district, Kaliani, 18 June 1963, D.B. Deb 35116 (ASSAM); Garampani Wildlife Sanctuary, 24 Nov 1975, P.K. Hajra 65058 (ASSAM); Nagaon district, Laopani, 28 Aug 1978, P. Chakraborty 78984 (ASSAM); Sonitpur district, Batasipur, 13 May 1947, M.M. Srinivasan 22253 (ASSAM); Kanchanjuri, Kazhiranga, 12 Aug 1973, P.K. Hajra 52836 (ASSAM); Tinsukia district, Margherita forest, 22 June 1938, G.K. Duka 17010 (ASSAM). **Arunachal Pradesh**, East Kameng district, Pakke Wildlife Sanctuary, 25 Apr 2012, B.B.T. Tham 35028 (ARUN); Lower Subansiri district, Raga, 16 Aug 2018, Amrutha 159851(CALI).

Notes: *Leea trifoliata* was first described by Lawson in 1875 in Hookers's *Flora of British India* and cited three specimens collected by Jenkins, Booth and Griffith. He

described this species as a small wiry plant having 1–2 feet and noted that it was allied to *Leea aspera*. Later, Clarke (1881) treated this species under the series “*Rubriflorae*” characterized by red-coloured flowers in his revision of Indian *Leea* but admitted he was not sure about the colour of the corolla. Subsequently, Kanjilal and Das (1936) included this species in the *Flora of Assam*.

However, in 1974, Ridsdale, in his revision of Leeaceae, synonymized *Leea trifoliata* under the species *L. compactiflora*. Admittedly, his study of Indian species was based wholly on herbarium specimens available at Kew. *Leea trifoliata* is restricted to India and Burma and Ridsdale was unable to study the live plants in the field. Subsequent to this work, all other India floras followed Ridsdale’s treatments.

During our study, we were able to collect both *L. trifoliata* and *L. compactiflora*. We studied both the specimens in the field and examined authenticated specimens held at different Indian herbaria. Our observations have revealed that *L. trifoliata* differs from *L. compactiflora*.

L. trifoliata differs from *L. compactiflora* by its 0.7–1 m tall weak herbaceous plant (*vs.* over 1 m straggling or erect shrub); mostly trifoliate or 1-pinnate with basal pair of leaflets always much reduced (*vs.* pinnate to bipinnate leaves); petiolules and rachis winged (petiolules and rachis unwinged); size of the inflorescence up to 4 cm long (*vs.* size of the inflorescence 8–22 cm long); bracts narrowly lanceolate-linear (*vs.* bracts broadly ovate). *Leea trifoliata* is hence, reinstated here as a distinct species.

While describing *L. trifoliata*, Lawson cited three specimens as Assam, Jenkins; Bhotan, Booth; Mishmi Hills, Griffith and later Ridsdale (1974) designated the specimen of Jenkins as lectotype. Here we follow his typification.

Notes: *Leea trifoliata* is the only weak herbaceous plant under *Leea* in India, the rest come under the category of subshrub to shrub.



Fig. 85. *Leea trifoliata* M.A.Lawson: A & E. Habit; B. Abaxial surface of leaf with Pearl glands; C. Adaxial surface of leaf showing trichomes; D. Abaxial surface of leaf showing trichomes; F & G. Petiolar stipules; H. Rachis showing wings; I. Stems; J-L. Leaves.

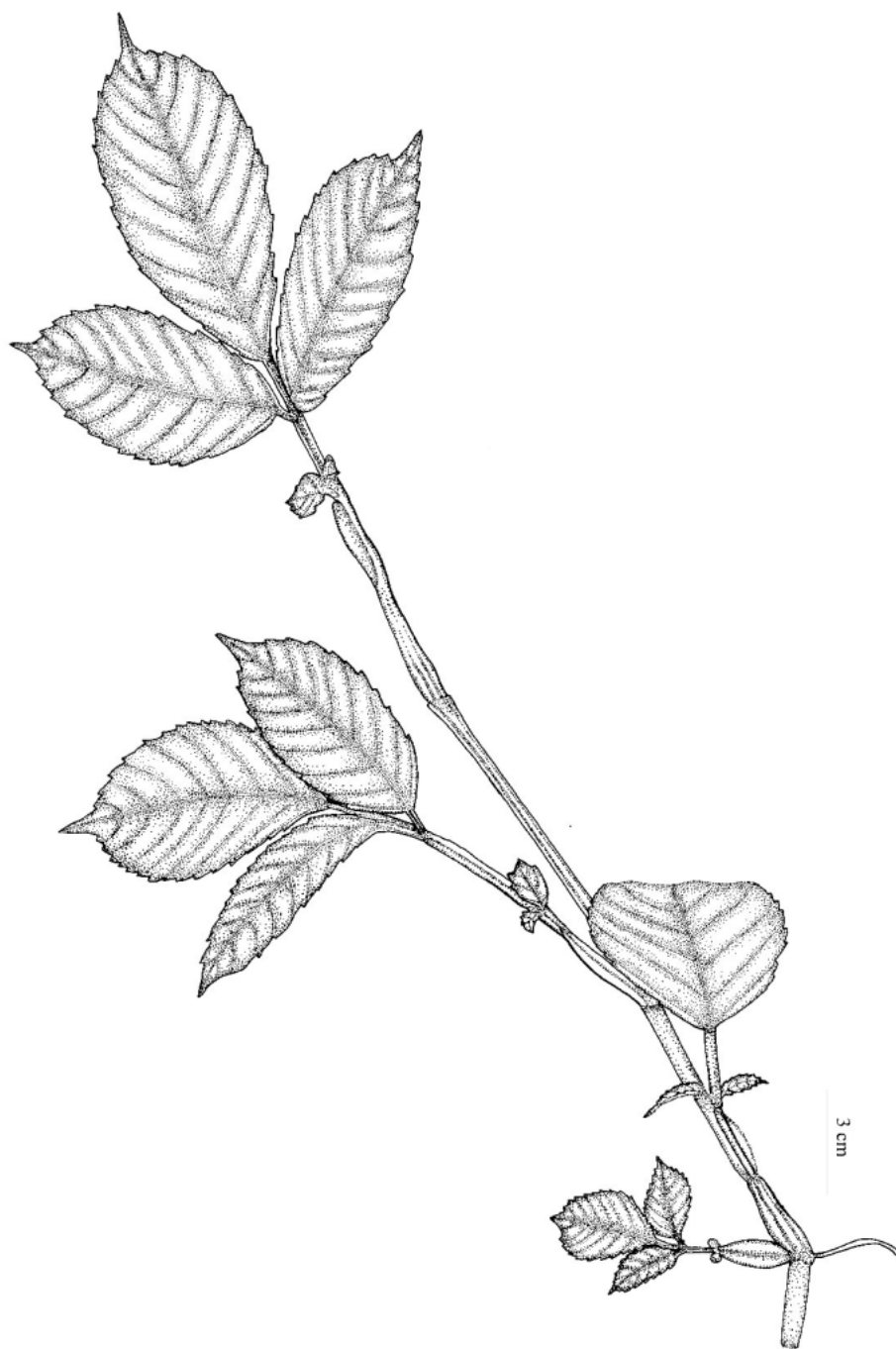


Fig. 86. *Leea trifoliata* M.A.Lawson: **A.** A twig (Drawn by Amrutha A. from Amrutha 159851).

17. *Leea tamdilensis* Amrutha & Pradeep sp. nov. Type: INDIA, Mizoram, Aizawl district., Tamdil, 28 Aug 2018, Amrutha 153265 (holotype: CAL!; isotypes: MH!, CALI!).

Figs. 87, 89 & 90

Diagnosis: *Leea tamdilensis* is similar to *L. guineensis* but can be easily distinguished by its tuberous roots (*vs.* non-tuberous), furrowed stems and petioles (*vs.* terete stems and petioles), and furrowed rachis (*vs.* channelled rachis on its upper side); seeds $3.6\text{--}3.9 \times 3.4\text{--}3.5$ mm, dark brown when mature (*vs.* seeds $4.43\text{--}4.78 \times 4.02\text{--}4.12$ mm, light brown when mature).

Shrubs, up to c. 2 m tall; roots tuberous. Stems erect, stout, glabrous unbranched; internodes furrowed, green; nodes swollen, purple. Pearl glands globose, distributed in leaves and more in inflorescence. Leaves alternate, 2–3 pinnate, imparipinnate; petioles 12–18 cm long, swollen at base, furrowed, glabrous, brown spotted. Petiolar stipules oblong, $4\text{--}5 \times 1.3\text{--}1.7$ cm, stipular scars triangular, 3.2–5 cm long; rachis 18–24 cm long, furrowed, glabrous, green. Leaflets opposite, broadly ovate to elliptic, abaxial surface of young leaflets purplish; distal leaflets lamina $14.5\text{--}16 \times 5.5\text{--}7$ cm, lateral leaflets lamina $7\text{--}14 \times 4\text{--}5$ cm; sparsely strigose with 1–2 rows of hairs in between the lateral veins on upper surface, scabridulous on lower

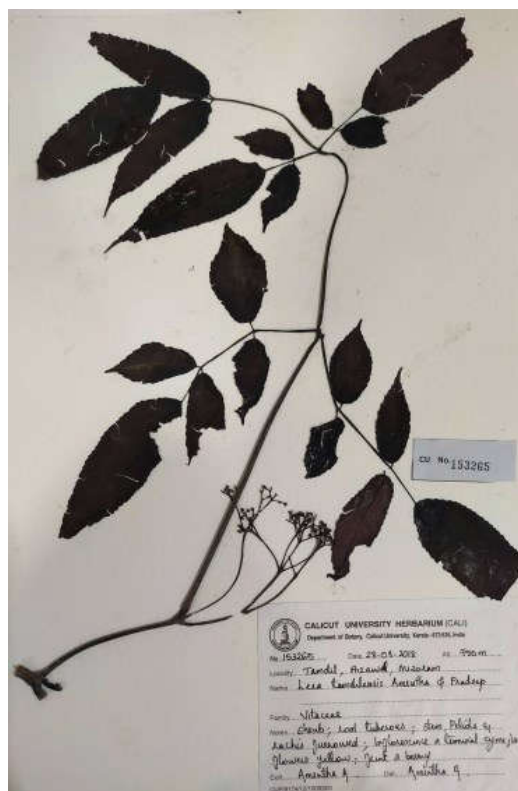


Fig. 87. Type of *Leea tamdilensis* Amrutha & Pradeep [Amrutha 153265 (CAL)] © Botanical Survey of India, Kolkata.

surface, dark green above and pale green beneath, base obtuse, margins serrate, apex acuminate; petiolules

distal: 3.5–4 cm long, lateral: 0.3–1 cm long; secondary veins 6–13 pairs, usually 3 (–4) nerved at base, veins raised on both surfaces, more prominent on upper surface, sparsely pubescent with stiff hairs on nerves. Inflorescence a leaf-opposed, terminal

Systematic treatment

cyme, c. 11 cm long, branched, many-flowered; peduncles c. 6 cm long, glabrous, green, branches purple. Flowers 3.5–4 mm long, numerous, actinomorphic, yellow. Pedicels slender, up to 0.9 mm long, glabrous. Bracts small, early caducous. Calyx campanulate, lobes 5, 3–3.2 × 2–2.4 mm, lobes 0.6–0.8 mm long, apex acute to obtuse, glabrous, red. Corolla lobes 5, ovate, c. 2.4 × 1.7 mm, apex acute and hooded, margin entire, glabrous, creamy on adaxial side, red spotted on abaxial side; corolla tube with floral disc 2.4–2.9 × 2–2.5 mm, creamy white. Floral disc tubular, 1.7–2 mm long; upper free parts 1.2–1.8 mm long, notched; sinuses shallow, 0.4–0.5 mm long; lower free parts 0.7–0.9 mm long. Stamens 5, syngenealous; filaments 0.7–0.8 mm long, glabrous, creamy yellow; anthers 0.9–1.2 mm long, narrowly elliptic, dorsifixed, dehisce longitudinally, purple. Ovary globose, 0.9–1 mm long, 6-loculed, ovule one in each locule, placentation axile; style 1–1.5 mm long, slender, glabrous, creamy; stigma convex. Fruits 1–1.1 cm diam., green turning to red, finally black. Seeds 6, more or less obconic, 3.6–3.9 × 3.4–3.5 mm, dark brown when mature.

Flowering & fruiting: June– September.

Habitat: The species grows mostly in moist shady places.

Distribution: India. Hitherto known only from the type locality Tamdil Forest range, in the Aizawl district of Mizoram; Fig. 88.



Fig. 88. Distribution of *Leea tamdilensis* Amrutha & Pradeep in India (drawn using QGIS version 3.24.3).

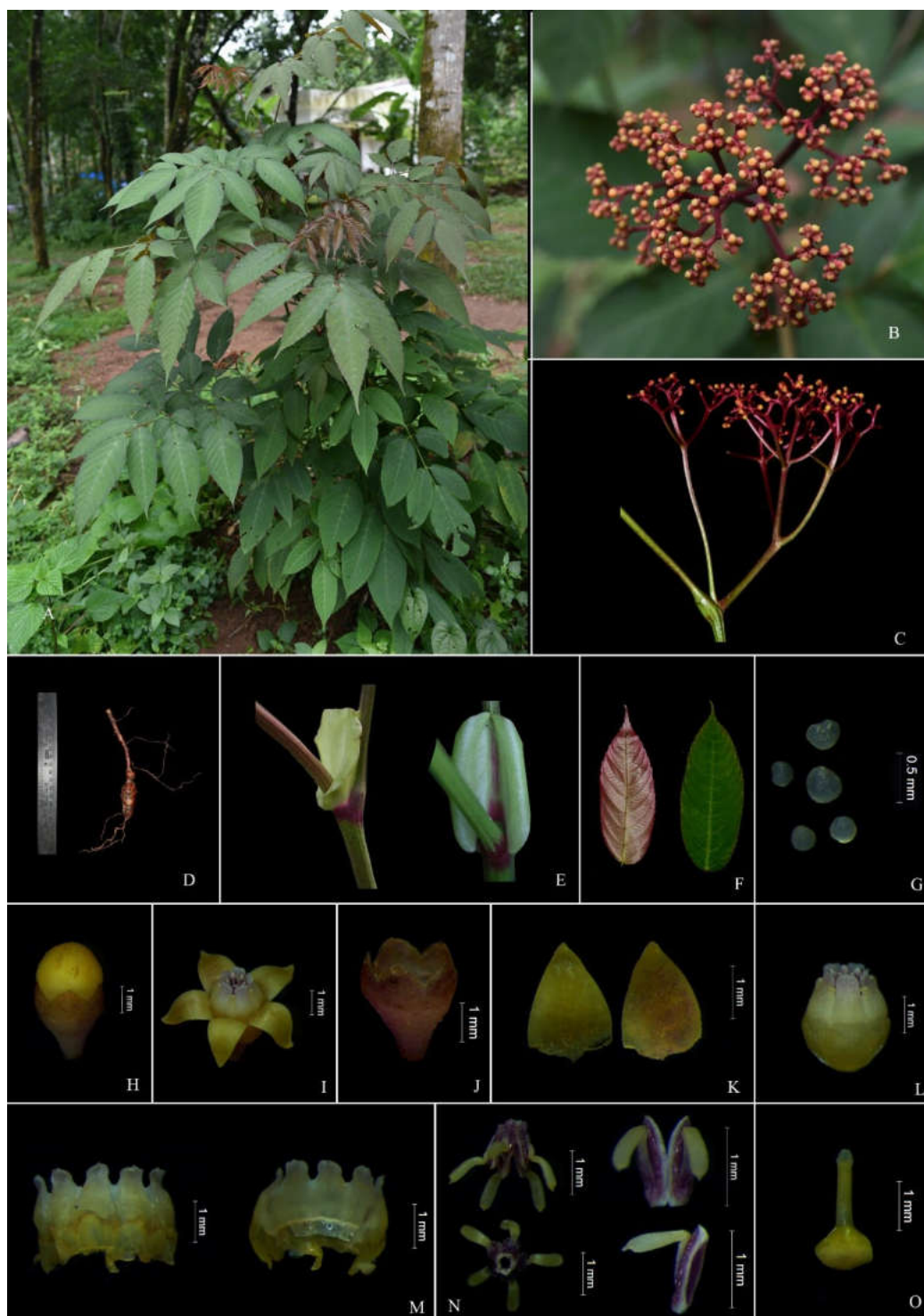


Fig. 89. *Leea tamdilensis* Amrutha & Pradeep: **A.** Habit; **B & C.** Inflorescence; **D.** Tuberous root; **E.** Petiolar stipules; **F.** Leaflets; **G.** Pearl glands; **H.** Flower bud; **I.** Flower; **J.** Calyx; **K.** Corolla lobe-dorsal and ventral view; **L.** Corolla tube with floral disc; **M.** Corolla tube with floral disc split open; **N.** Stamens; **O.** Pistil.



Fig. 90. *Leea tamdilensis* Amrutha & Pradeep: **A.** A twig with inflorescence; **B.** Lamina adaxial surface enlarged; **C.** Petiolar stipule; **D.** Flower; **E.** Calyx; **F.** Corolla lobe; **G.** Corolla tube with floral disc; **H & I.** Stamens; **J.** Pistil (Drawn by Amrutha A. from Amrutha 153265).

Discussion on Comparative morphology

Morphology serves as the basis for taxonomic descriptions and usually provides the most important data for delimiting and circumscribing taxa (Simpson, 2010). The present treatment on *Leea* is based on extensive exploration in India, and examination of large number of specimens deposited in various herbaria. The morphological variation exhibited by different taxa were also taken into account. Besides virtual databases, lives collections maintained in CUBG were also utilized for further investigations. The following discussion compares the morphology of the Indian species of *Leea*.

Vegetative characters

Habit

The genus *Leea* is the only shrubby member of the Grape family, Vitaceae, with the rest being climbers. The majority of the species in this genus are shrubs or sub-shrubs, growing to a height of 0.5 to 5 meters. In contrast, *L. adwivedica* and *L. angulata* from Andaman and Nicobar Islands are trees with a height of up to 15 m. In terms of habit, *L. indica* and *L. robusta* show the maximum variations. *L. indica* can reach a height of 1–5 m with a stem diameter of up to 30 cm, and *L. robusta*, shows a height range of 0.5–3 m.

Roots

The roots of *Leea* are tuberous or non-tuberous. Root tubers are characterized by swollen roots, which store their nutrients and are the perennating structures in *Leea*. The tuberous roots can be found in *L. robusta*, *L. macrophylla*, *L. asiatica*, *L. setuligera*, *L. mizoramensis*, and *L. tamdilensis*. As the stem dies off, the tuberous root stalk which perennate and sprouts during favourable conditions. The tubers of *L. robusta* is red when cut, and may yield a dye (Roxburgh, 1824).

Stems

The stem of *Leea* shows variation among species. The stem may be prickled or unarmed. Among the species, only *L. adwivedica* and *L. angulata* have prickled

stems, while the rest have unarmed stems. The stem may be erect, spreading or straggling. The erect stem is the common type in *Leea*. However, it is spreading in *L. asiatica* and straggling in *L. guineensis* of some populations. The stem may be branched or unbranched. It appears that the stem of *Leea* is jointed, and *L. asiatica* has bulging at the joint. The stem may be round, furrowed or crispately winged. *L. asiatica* is the only species with cripate winged stems, but occasionally has furrowed stems as well. The furrowed stem is shown by *L. macrophylla*, *L. mizoramensis* and *L. tamdilensis* and the terete stem is the characteristic feature of *L. guineensis* and *L. robusta*. But, the nature of the stem is not a constant character in *Leea* as some species (*L. indica*, *L. compactiflora*) shows both terete and round stem. The stem may covered by hairs with various lengths or it may be glabrous. In *L. macrophylla*, *L. asiatica*, *L. guineensis*, *L. mizoramensis* and *L. tamdilensis* stem is glabrous. However, *L. robusta*, *L. aequata* and *L. sundaica* have hairs on the stem. Hairs can be either hyaline or ferruginous. Ferruginous hairs are seen in *L. sundaica* and rest of them possess hyaline hairs. The hairs are more when the plants are young and falls off at maturity. In most cases, the stems are green, but sometimes they may be purple. The aerial shoots of *L. macrophylla*, *L. setuligera*, *L. robusta* and *L. asiatica* die off after every growing season and regenerate back during monsoon. In some populations of *L. asiatica* and *L. robusta*, leaves shed and new sprouts emerged during the next season.

Leaves

The leaves of *Leea* show enormous variations as noted by Ridsdale (1974). The genus consists of simple-leaved and pinnately compound leaves. *L. macrophylla* is the only species which shows simple species and all other species have various types of pinnate leaves (Fig. 6). *Leea adwivedica* mostly shows simply pinnate leaves and very occasionally bipinnate leaves. Leaves of *L. asiatica* show quinate-pinnate leaves. The lower leaves are less pinnate than the upper ones. The leaves of Indian *Leea* shows maximum diversity in shape, mature of margin, serration and vestiture. The shape of the lamina varies between species and within species. It may be ovate, oblong, elliptic, sub-orbicular and orbicular. The leaf apex can be acute, cuspidate or long or short acuminate. The leaf base may be cuneate, obtuse or rounded but oblique base is observed in some leaves of *L. adwivedica*. Nerves are usually prominent on both surfaces with the lower side being more prominent than the

upper. Most of the leaves have serrate margins except in *L. angulata*, which have crenate margins. The hair on leaves shows variation on both adaxial and abaxial surfaces. Ridsdale (1974) pointed out that *L. guineensis* is a complex species having diverse leaf characters, however, in India, *L. guineensis* shows less variation.

It is common for seedlings of the *Leea* to have different types of heteroblastic leaves (Fig. 5A-E) and the sequence of leaves covers an extremely broad spectrum of morphologies. The juvenile stage of pinnately compound-leaved species bears simple leaves in the first four nodes, which are followed by compound trifoliate, pinnate, and ultimately extremely complex multi-pinnate leaves.

Petiolar stipules

The occurrence of a petiolar stipule is a characteristic feature of *Leea*, which is used to stand out the genus from other genera of Vitaceae. This petiolar stipule encloses both the young leaves and inflorescence. There are three types of stipules seen in *Leea*, oblong-obovate, winged or falcate type. The oblong-obovate type is common in Indian *Leea* and seen in *L. indica*, *L. guineensis*, *L. grandifolia*, *L. macrophylla*, *L. robusta*, *L. aequata*, *L. mizoramensis* and *L. tamdilensis*. The winged petiolar stipule is seen in *L. adwivedica*, *L. angulata*, *L. compactiflora* and *L. setuligera*. *Leea asiatica* is the only species which shows falcate type stipule. The petiolar stipule is early caducous in oblong-obovate types and falcate type whereas, winged type stipules are persistent. There are no overlapping characters in petiolar stipule of Indian *Leea*. A winged type plant never shows an oblong-obovate or falcate type. Hence, these characters can be used to species-level delimitations. **Fig. 91**

Pearl glands

One of the distinctive features of Vitaceae is the presence of pearl glands, which are primarily found on leaves, stems, and inflorescences. They are small, lustrous pearl-like or brown-coloured structures produced from the epidermis of leaves, petioles and shoots. In most cases, they are rapidly caducous and have been lost in the drying procedure. In contrast, pearl bodies in *L. aequata* are persistent, mostly confined to the lower surfaces of leaves and are a key character used to distinguish this species.



Fig. 91. Stipules of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.

Penzig (1892) found that pearl gland formation in Vitaceae (*Ampelocissus*) includes both epidermal and sub-epidermal parenchyma. According to him pearl glands play a role in insect interaction, where they serve as ant food, thereby maintaining beneficial ant in the plant. He also found that in *Leea* species, pearl bodies are continuously harvested by ants. Pearl bodies of *L. hirsuta* (= *L. aequata*) are produced on shoots and buds and fully developed are plucked by the ants. Raciborski (1898) reported that the food bodies were rarely observed in the presence of ants, but when he excluded ants from the branches, new pearl bodies developed and remain intact. Metcalfe and Chalk (1957) found that cells in the glands are rich in protein, oils, and sugars.

Reproductive characters

Inflorescence

The inflorescence in genus *Leea* is a leaf-opposed cyme. They vary in size, with *L. macrophylla* having the largest and *L. asiatica* having the smallest inflorescences. However, individuals from the same species could differ in size. The inflorescence may be lax or condensed. In most cases, the inflorescence is with a peduncle, which is terete or furrowed. Terete peduncle is found in *L. guineensis* and *L. robusta* however, the rest of the species shows furrowed peduncle.

Fig. 92-94

Flower

The flowers in the genus *Leea* are bisexual, 4 or 5-merous, pedicellate, and actinomorphic. However, in Indian *Leea*, all the species have 5-merous flowers. The pedicel may show differences in length. *L. macrophylla* has largest pedicel and in *L. guineensis*, the pedicel is short or may be absent. The colour of the flower varies among species, and it may be greenish-white, creamy or shades of red. The greenish white flowers are found in *L. indica*, *L. macrophylla*, *L. robusta*, *L. aequata*, *L. sundaica* and *L. grandifolia*. The species such as *L. guineensis*, *L. alata* and *L. tamdilensis* show red flowers and *L. setuligera* shows creamy flowers with pink tinge. *Leea mizoramensis* exhibit colour polymorphism as the inflorescence colour range from creamy to red with intermediate shading. The green-flowered species never shows variation, as it never exhibits red or creamy flowers. However,

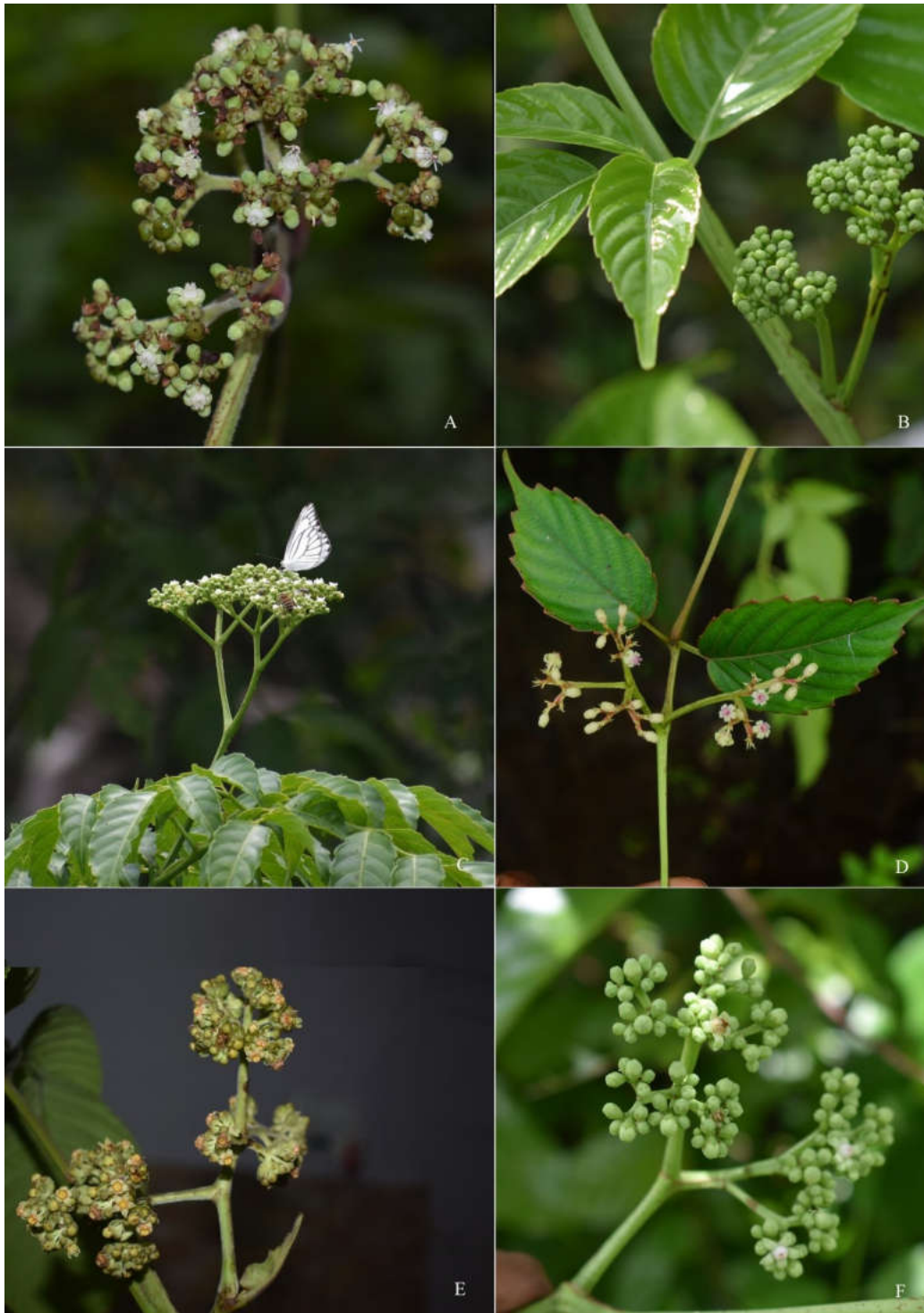


Fig. 92. Inflorescence of *Leea* L.: **A.** *L. aequata*; **B.** *L. adwivedica*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*.



Fig. 93. Inflorescence of *Leea* L.: **A.** *L. guineensis*; **B.** *L. indica*; **C.** *L. macrophylla*; **D.** *L. robusta*; **E.** *L. latifolia*; **F.** *L. mizoramensis*



Fig. 94. Inflorescence of *Leea*: **A.** *L. setuligera*; **B.** *L. sundaica*; **C.** *L. tamdilensis*.

red-coloured species shows creamy to a different shade of red as seen in *L. mizoramensis* and shows the flower colour polymorphism. In species such as, *L. compactiflora*, the calyx and corolla are green while the floral disc is brown tinged giving a different colour pattern. Hence the flower colour cannot be used as a key character to separate the species. Clarke (1881) proposed a sectional classification primarily based on the flower colour but was not accepted by subsequent authors as it shows variation.

Fig. 95

Calyx

The calyx is campanulate in all Indian species of *Leea* and has five lobes. The calyx may be glabrous or variously hairy. The glabrous calyx was present in *L. aduvivedica* and *L. grandifolia* whereas, the rest of the species show various types of hairs on the calyx.

Fig. 96

Corolla

Although the genus *Leea* have both 4-merous and 5-merous flowers, all the Indian species possess 5-merous flowers usually narrowly to widely ovate in shape. Corolla lobes do not show many differences among species, hence cannot be considered as a significant character to delimit the taxa.

Bracts

The inflorescence bears bracts at various nodes. The bracts are of two types in *Leea*, early caducous or persistent type. In early caducous types, a bract is triangular in shape and dehisces before the inflorescence becomes mature. The majority of the species show this type of bracts. In persistent types, bracts are persistent even after the inflorescence becomes mature. This type is seen in *L. compactiflora*, having widely ovate bracts and *L. asiatica*, having lanceolate or triangular bracts.

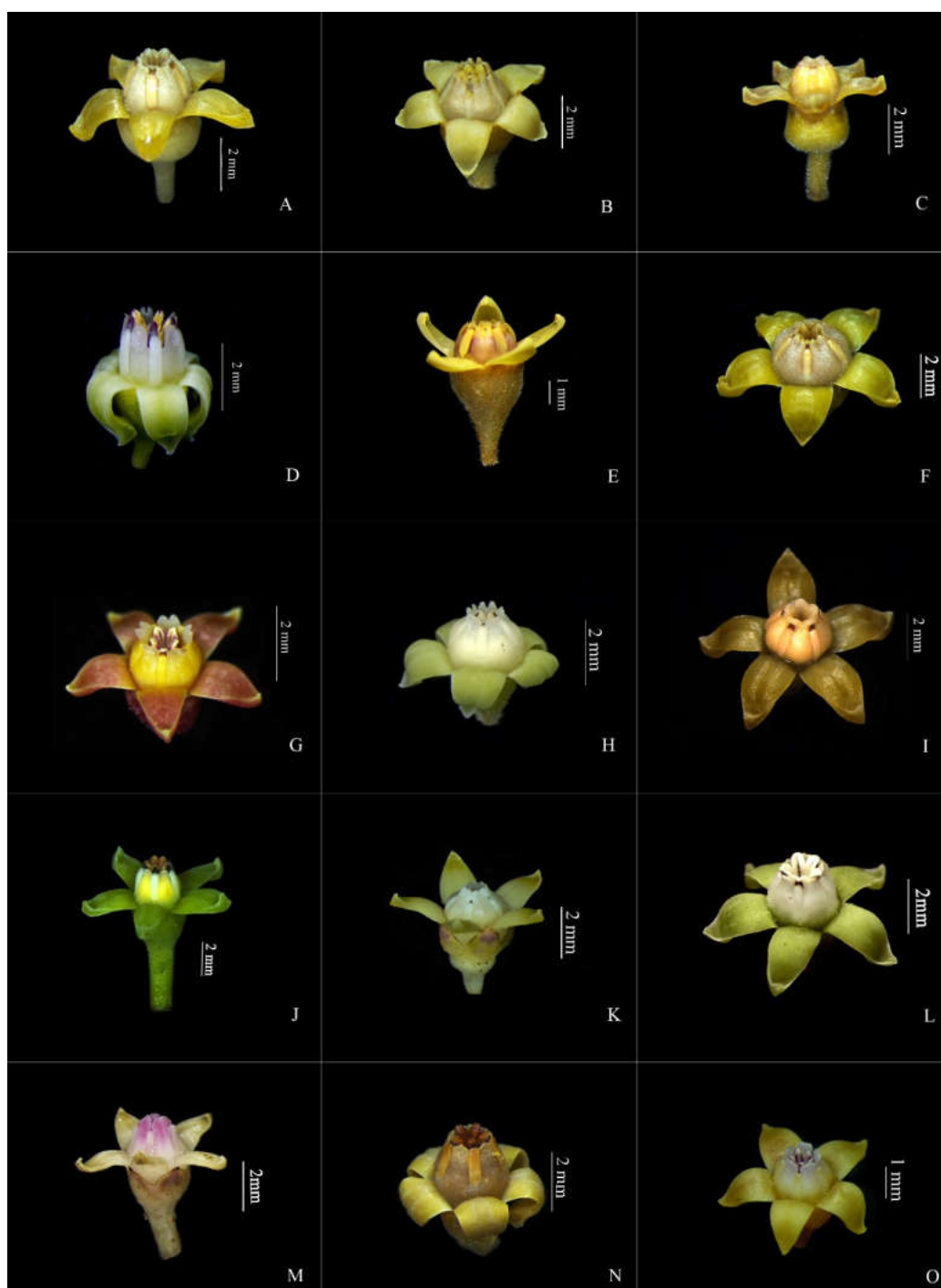


Fig. 95. Flowers of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.

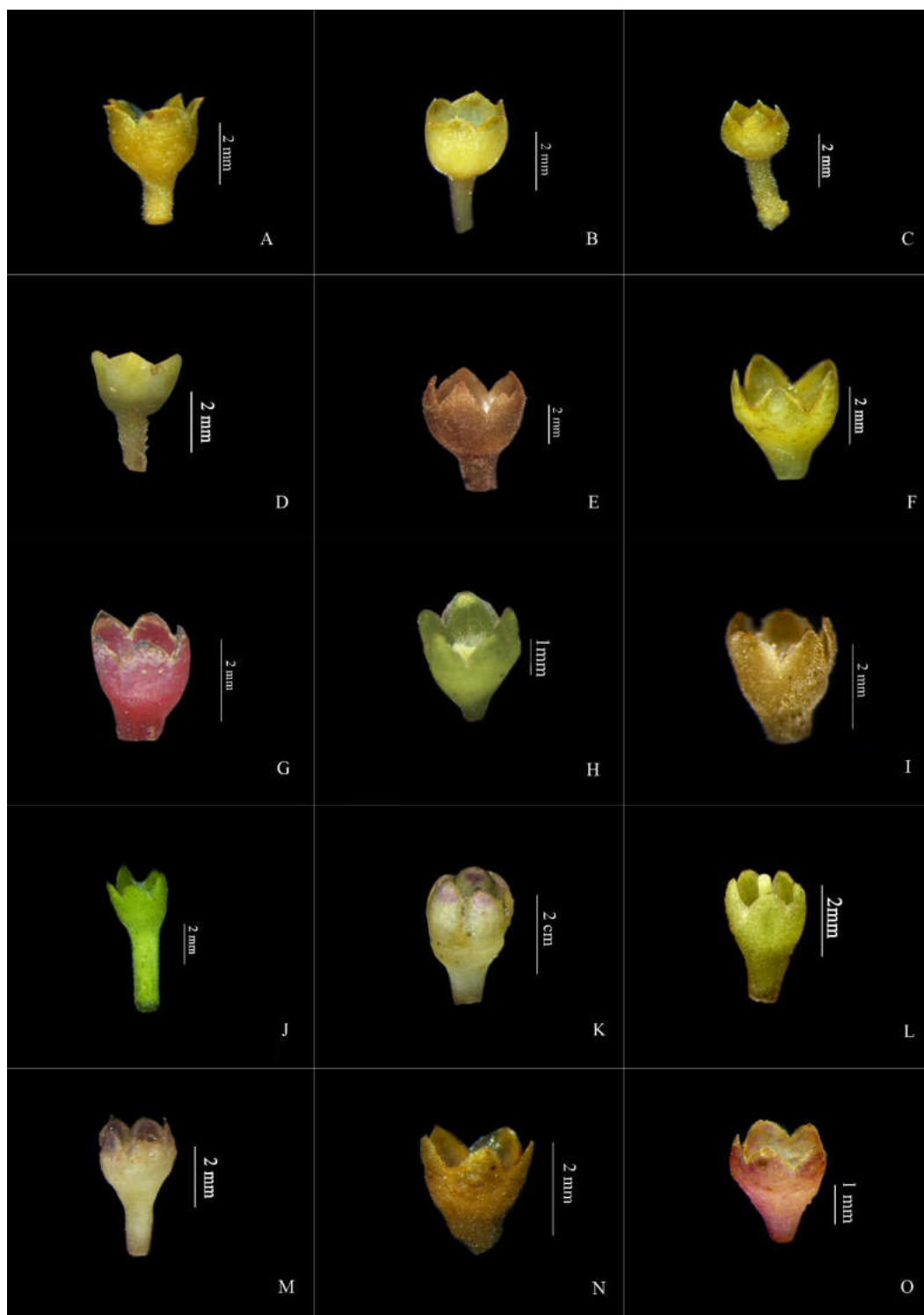


Fig. 96. Calyx of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.

Floral disc

In *Leea* the floral disc is well-developed. Earlier thought that it was a modified whorl of staminode. However, Gerrath *et al.* (1990) found that the initials of the floral disc in other genera of Vitaceae and *Leea* are the same and in *Leea* floral disc is a more elaborate structure. The floral disc is adnate to the corolla tube, giving an upper free part and a lower free part. There is a species-specific difference in the length of upper free part and lower free part, and sinus as well as the pattern of notching on the upper free part and length of the sinuses of the floral disc. The lower free part in species such as *L. indica*, *L. guineensis*, *L. macrophylla*, *L. robusta*, *L. aequata*, *L. grandifolia*, *L. compactiflora*, *L. sundaica*, *L. mizoramensis* and *L. tamdilensis* appear as a collar, whereas in *L. adwivedica*, *L. angulata*, *L. setuligera* and *L. asiatica*, the lower free part extended to almost the length of the corolla tube. There are three types of notching pattern seen on the upper free part, *viz.*, notched, retuse and apiculate.

Figs. 97 & 98

Stamen

Unlike other genera of Vitaceae, *Leea* have syngenealous stamens except in *L. asiatica*. In Indian *Leea*, stamens are five, antipetalous, alternating with the lobes of the floral disc. The filaments are exerted to the floral disc through the sinuses. When the flower become mature, the filaments detaches, and the stamens released as a unit. The filaments are connected to the anther through a connective. The filaments are slender, glabrous and white. The anthers are brown. In most cases, anthers split through single longitudinal slits, but in *L. asiatica* it splits through two longitudinal slits.

Fig. 99

Pistil

The pistils of the Indian *Leea* are almost similar in structure. It consists of ovary, style and stigma. The ovary is globose in most species except in *L. adwivedica*, where it is depressed globose with 5–6 coherent reniform segments. Style is slender and the stigma is not much differentiated and round in all species.

Fig. 100

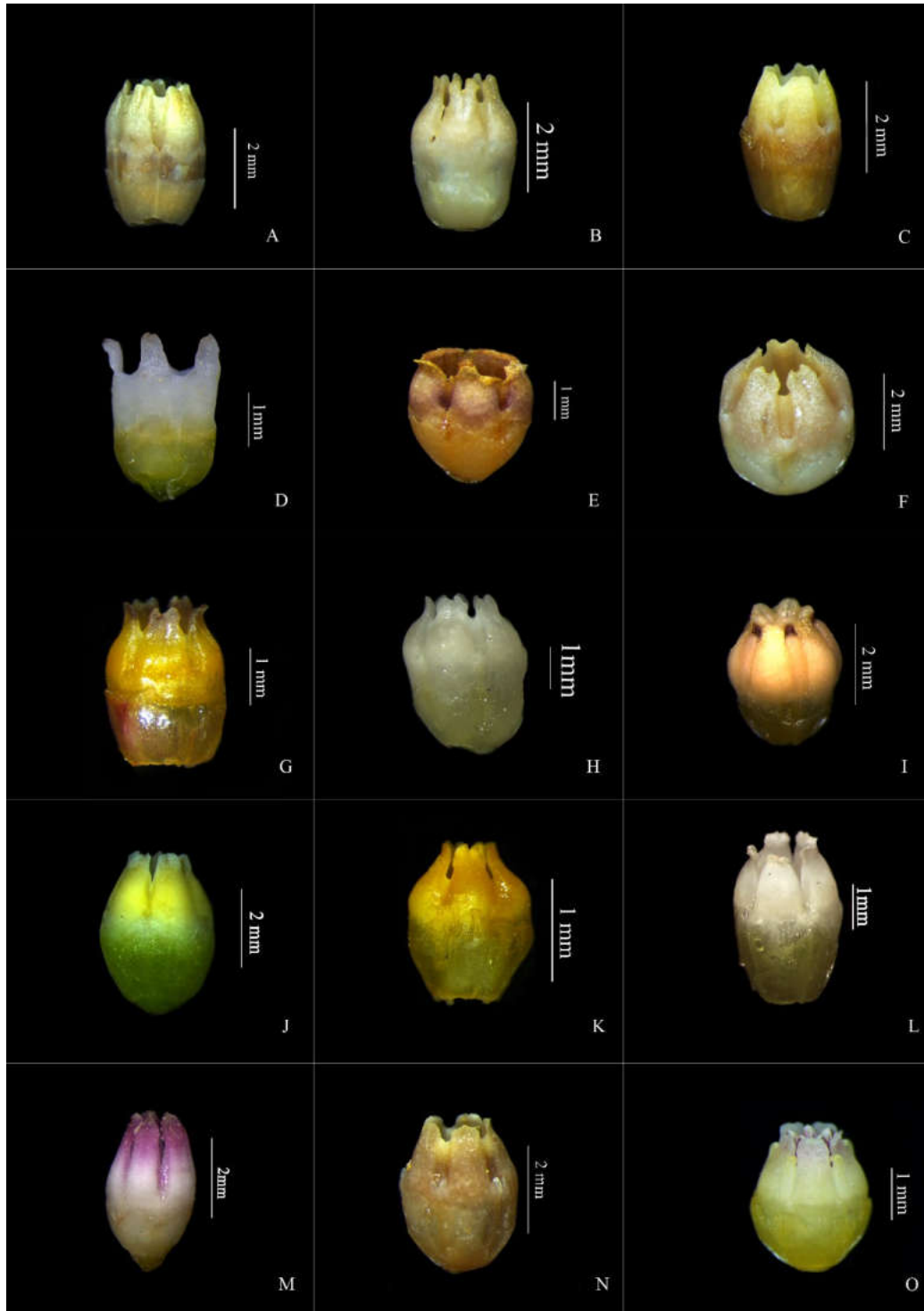


Fig. 97. Floral disc of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.

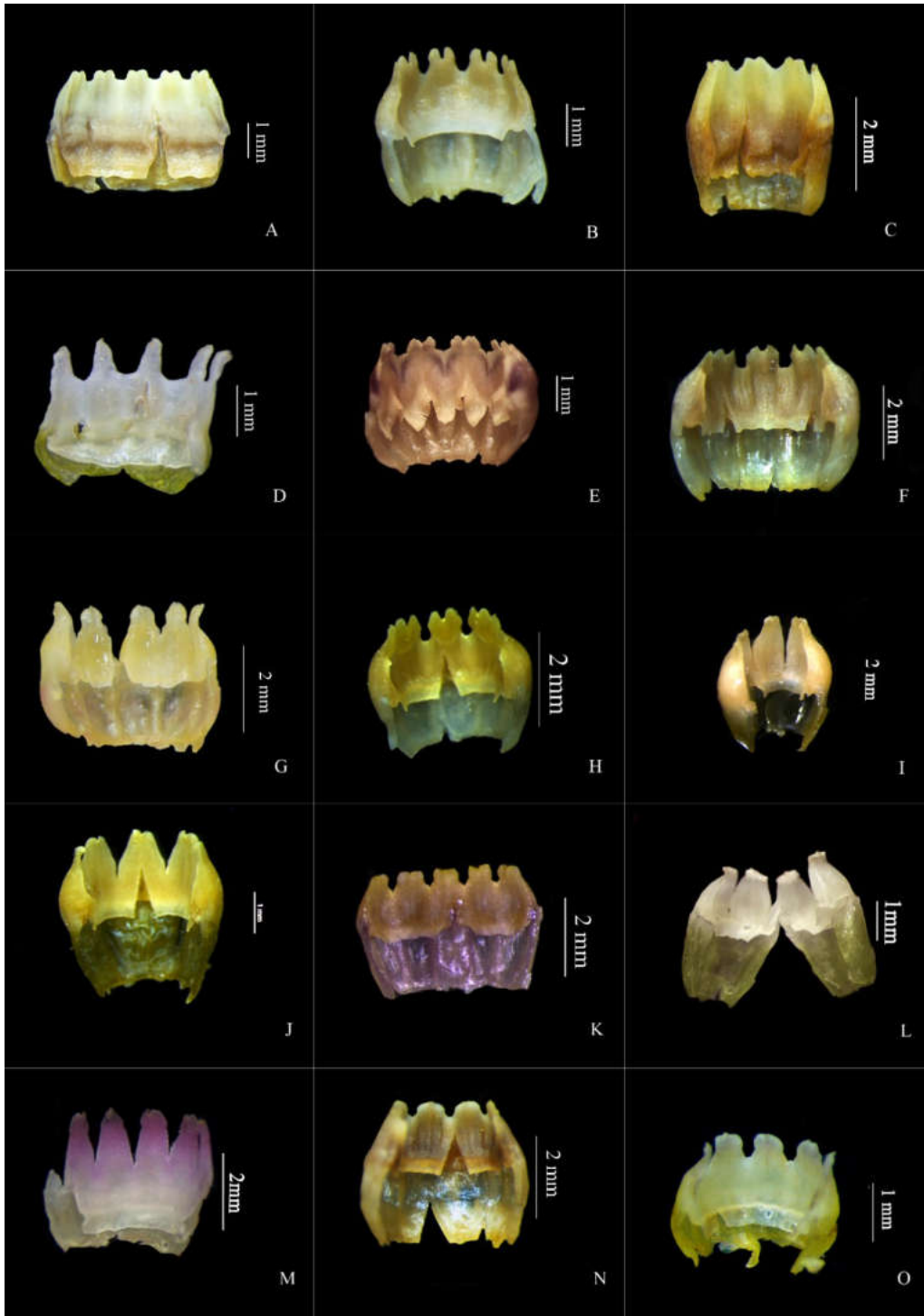


Fig. 98. Corolla tube with floral disc split open of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.



Fig. 99. Stamens of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.

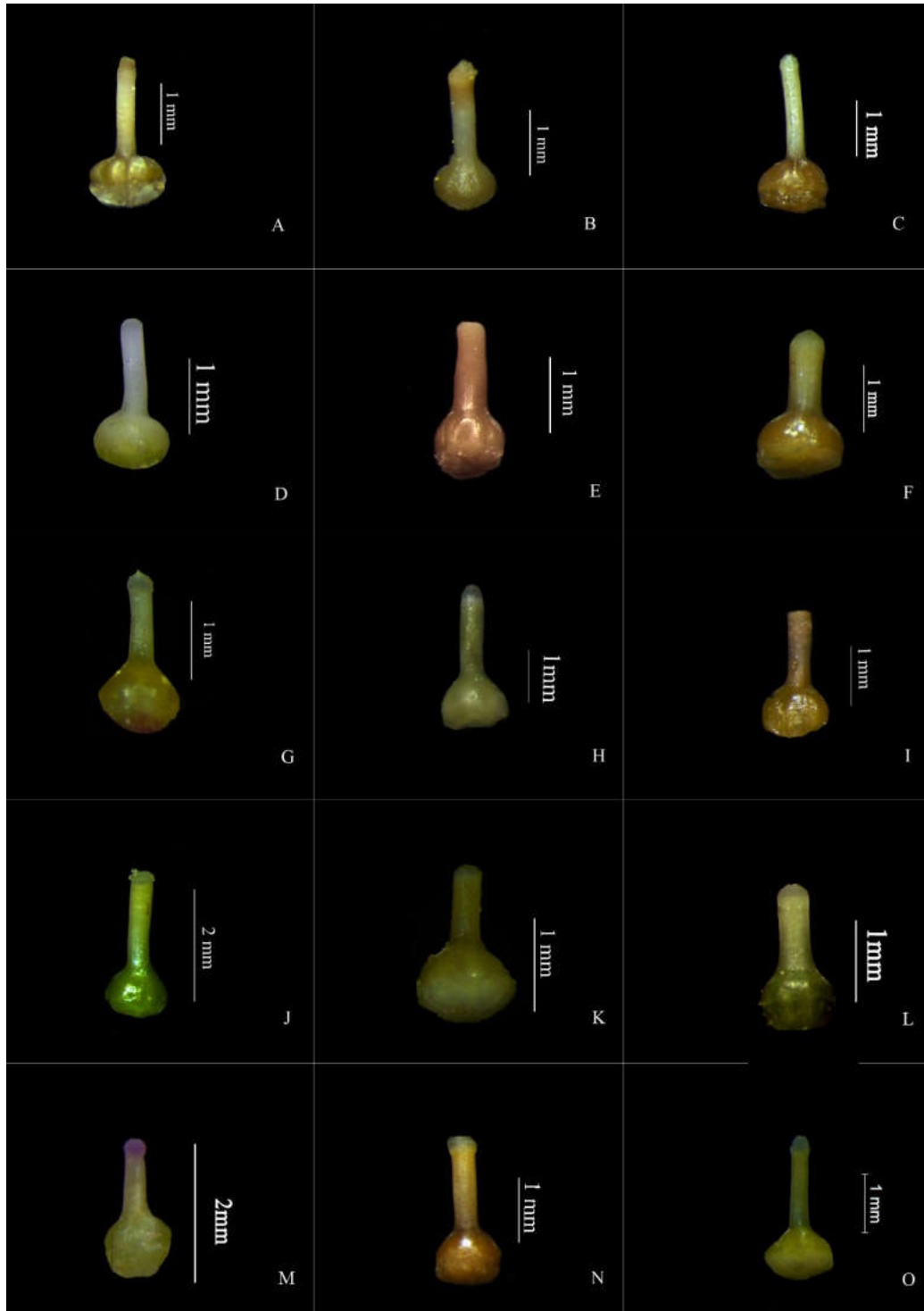


Fig. 100. Pistils of *Leea* L.: **A.** *L. advivodica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. tamdilensis*.

Fruits

Fruits are subglobose, fleshy, 4 or 6-seeded berries. It may be green, yellow red or ash-coloured when young, and at maturity, all turn into dark purple or black. Yellow fruit is seen by *L. compactiflora* whereas in *L. angulata* it is ash coloured. The fruits are red in *L. guineensis*, *L. mizoramensis*, *L. tamdilensis* and *L. setuligera*. The rest of the species shows green fruits.

"Extinction is the most irreversible and tragic of all environmental calamities. With each plant and animal species that disappears, a precious part of creation is callously erased." -

Michael Soulé, American conservation biologist

The term "biodiversity" refers to the abundance and diversity of life on Earth. It is the most important and significant aspect of our world and hence, its maintenance is very important for sustaining life. India is one of the 17 megadiversity countries harbouring a high percentage of endemism and it is the centre of diversity of various crop plants. The country also has unique biodiversity hotspots and areas with a high biological diversity. Unfortunately, as a result of increasing population growth, climate change, and lax enforcement of environmental policies, many endemic species are at risk of habitat destruction and extinction. The earth is experiencing a sixth mass extinction due to human activity in the natural environment, and many species are on the verge of extinction or are declining in number (Barnosky *et al.*, 2011; Dirzo *et al.*, 2014; Ceballos *et al.*, 2020). Species extinction and declining biodiversity are inextricably linked.

Conservation biology seeks to understand the impact of threatening processes on declining species (Pimm *et al.*, 1988; Purvis *et al.*, 2000). The accurate identification of an endangered species is a prerequisite for their conservation. It is intuitively obvious that the risk of extinction is greater for populations consisting of a few individuals than for those having many, and it is greater for populations whose densities are subject to large variations through time than for populations with low temporal variability (Pimm *et al.*, 1988). A biodiversity conservation strategy involves protecting biodiversity, uplifting it, and managing it in such a way that it generates sustainable benefits for the present and the future.

In this context, the present work provides a detailed study on the distribution, habitat and threat of each species of the genus *Leea* to assess their IUCN status and to take conservation measures for each taxon.

Habitat and ecology of *Leea*

The species of *Leea* mostly prefer a variety of habitats including forest margins, forest understory, open areas, roadsides, beach forests, rocky outcrops and ghat margins at an elevation between 17 to 2100 m. Most of the species are seen in a number of habitats. *Leea indica* is a widely distributed species, found in a variety of habitats such as, forest understory, forest margins, roadsides and the ghat margins. A highly variable species, *Leea asiatica* can be seen in ghat margins, rocky outcrops, forest margins, forest understory, and roadsides. However, some of the species exhibit characteristic preferences to a specific habitat condition. *Leea adwivedica* is only seen along the freshwater streams and *L. grandifolia* usually occurs in beach forests. The species are mostly associated with a number of herbs and shrubby angiosperms, pteridophytes and some bryophytes. All the species produce flowers and fruits during the monsoon. Some species of *Leea* have tubers and in such species the aerial shoot die back in March–April and regenerate from the rootstock in the ensuing monsoon.

Figs. 101 & 102

Conservation assessment of *Leea*

In India, the genus *Leea* is mainly restricted to South India, North India, the western peninsula and the Andaman and Nicobar Islands. During our collection trips to different geographical areas of India, a thorough study on the habitat requirement of each species was carried out and their threat was evaluated. The habitats are under severe threat due to both anthropogenic activities and natural calamities. A Conservation assessment of each species was carried out based on the IUCN Standards and Petitions Committee 2022. In light of these, conservation measures can be taken to protect these species for the future.



Fig. 101. Diversity in habitats of *Leea* L. in India



Fig. 102. Diversity in habitats of *Leea* L. in India

Different threats to *Leea*

During the field visit to different biogeographic regions of India during 2017–2023, we observed the following threats. **Fig. 103**

I. Habitat loss and fragmentation

A. Natural

1. **Tsunami:** The genus *Leea* is most diverse in Andaman and Nicobar Islands. The tsunami has severely impacted many areas of the Andaman and Nicobar Islands. Many portions of Car Nicobar and Indira Point suffered flooding during the 2004 tsunami. This poses a major threat to species that prefer coastal areas, such as *Leea grandifolia*. It is an endemic species in India, restricted to the Nicobar Islands, and the population is steadily declining as a result of natural disasters. As some areas of Indira Point in Great Nicobar were submerged, we witnessed a new road being built through the forest.
2. **Flood:** Floods have had an impact on species by altering the ecosystems. Many habitats of *Leea* in Kerala and Assam have disappeared due to floods. I have not been able to collect *L. alata* from Assam, the locality mentioned in the herbarium. Heavy rains and floods experienced every year might have caused the loss of its habitats in Assam.
3. **Land sliding:** Land sliding, particularly in Northeast India, altered the habitat of species that favour forest margins and roadsides. I have witnessed several areas of Arunachal Pradesh being severely impacted by land sliding. This will result in the degradation of habitat for species such as *L. compactiflora* with the greatest distribution in Arunachal Pradesh.

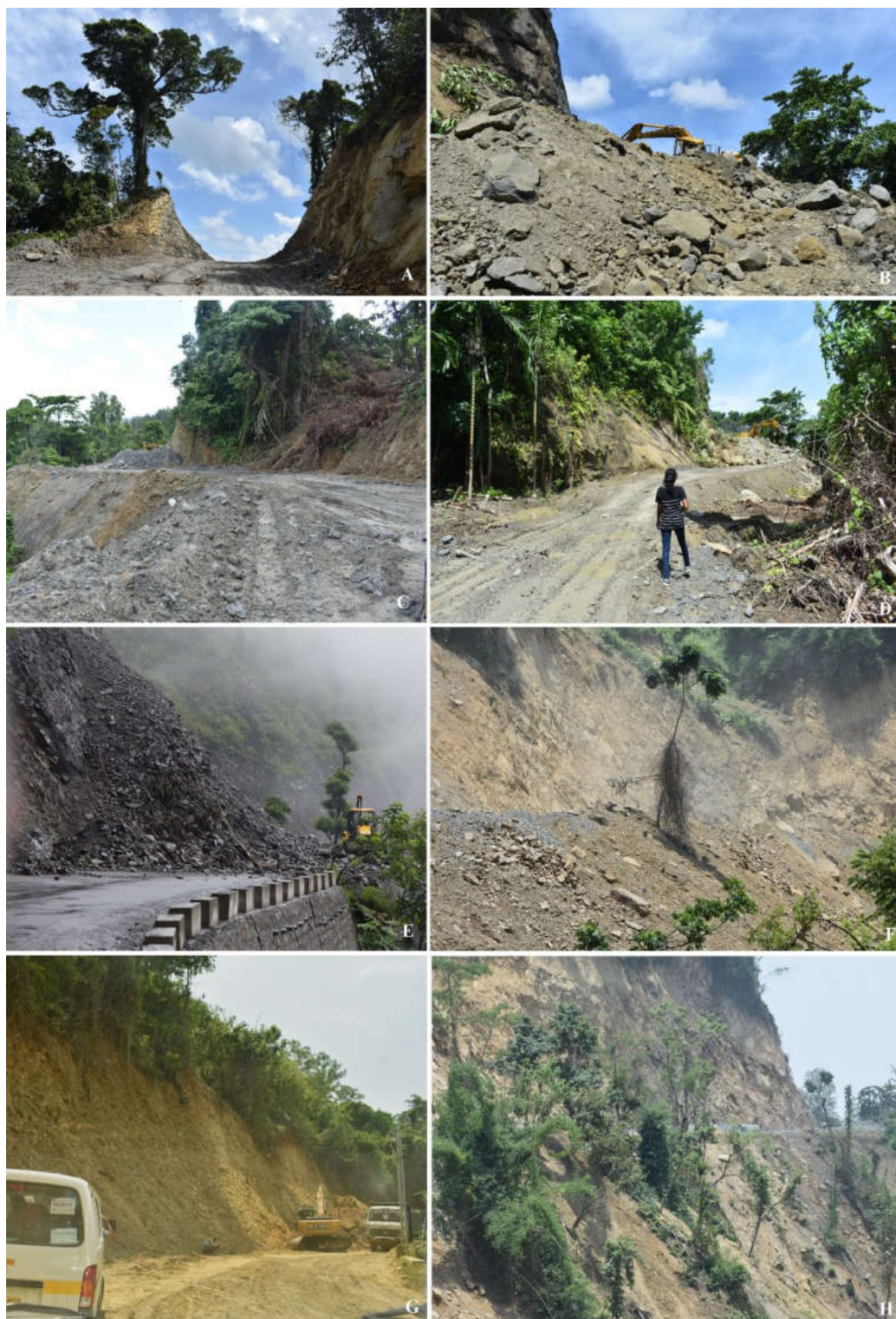


Fig. 103. A-D. Habitat destruction due to the construction of road in Nicobar Island; E-H. Habitat destruction due to land slide in Arunachal Pradesh; G. Habitat destruction due to road widening in Mizoram.

B. Anthropogenic

1. **Road widening:** As most of the species of *Leea* prefer roadsides, Ghats's margin, forest margin, and open areas, the current road widening become one cause of habitat destruction.
- II. **Over-exploitation:** Some species of *Leea* have medicinal properties and some are used as vegetables (*L. macrophylla* is used to make a dish called Dinde or Dinda by the people of Maharashtra). As these species shows the restricted distribution, over-exploitation may cause the population to decline.
- III. **Invasive species:** An introduced species that overpopulates and harms its new habitat is considered an alien or invasive species. Some associates of *Leea* (*Chromolaena odorata* (L.) R.M.King & H.Rob., etc) are invasive and affect adversely to the population.
- IV. **Agriculture and Plantation:** Agriculture deteriorate biodiversity by converting natural habitats to intensely managed systems. Jhum cultivation, a practice in Northeast India, is a type of farming in which an area of forest land is cleared and cultivated. To make the soil rich in potash and other nutrients to support the crop, the clearing is done by burning the trees. Jhum cultivation poses a serious threat to biodiversity in the northeastern states.

Conversion of forest areas into plantations destructs the habitat of many species. Both tea plantations and rubber plantations are common in Kerala, Assam and Meghalaya.
- V. **Tourism:** Due to habitat degradation and pollution, the tourism industry may be detrimental to plants, animals, and natural ecosystems., visitor traffic to sensitive ecosystems, and introduction of invasive alien species. The habitats of *Leea* in Andaman, Aizawl, Itanagar etc. are important tourist destinations and as most of the species prefer forest edges and roadsides, tourism poses a direct threat to the ecosystem.

- VI. **Mining:** Inefficiently managed mining activities have the potential to harm biodiversity and the environment.

Conservations status of the species of *Leea*

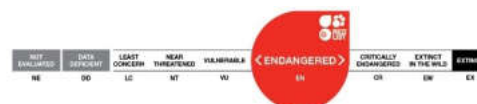
Leea aequata

We could collect this species from both the islands and the mainland. In Andaman Islands, it shows the highest diversity from south to north Andaman, but in main land, they show limited distribution, mainly restricted to the northeastern regions and we consider it as Least Concern (LC) according to IUCN criteria 2022.



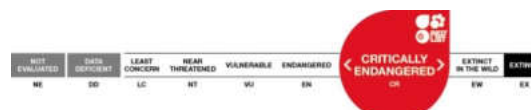
Leea adwivedica

This is an endemic species to India, with distribution confined to the Andaman Islands. The Extent of Occurrence (EOO) is calculated to be 6898 km² but the Area of Occupancy (AOO) is 20 km². As this is an Island species, there is habitat destruction due to natural calamities like tsunamis. While publishing this species, the author has pointed out that being niche-specific, clearing activities, especially of thorny and weedy plants along the freshwater streams in North Andaman pose a potential threat to the species. There were only two plants found, suggesting that the populations are not large. By considering all the threats and small population, it is better to categorise as Endangered (EN) as per IUCN criteria B2ab(iii)D.



Leea alata

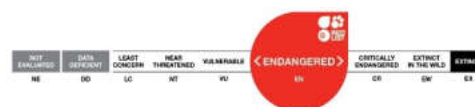
According to herbarium records, this species is found in Northeast India, primarily in Assam. I had visited every location specified in various herbaria but were unable to locate a single plant. One of the locations is in Tumung Basti in Umrangso, Assam, which annually experiences severe floods.



Consequently, flooding could result in habitat loss. A more detailed survey is needed, and at present, this species is categorized as Critically Endangered (CR).

Leea angulata

This species is only distributed in the Nicobar Islands. The Extent of Occurrence (EOO) is calculated to be 3584 km² but the Area of Occupancy (AOO) is 48 km² due to the limited populations. They tend to prefer open areas with a single mature plant at each location. Being an Island species, natural disasters such as tsunami can wipe out the population at any time. Even though the areas in Nicobar are protected, by considering the threat and number of populations and localities, it is best to categorise as Endangered (EN) as per the IUCN criteria B2b(iii)D.



Leea asiatica

There is a restricted distribution of this species in southern India, but it is highly diverse in the northeastern and western peninsular parts of the country. Mostly, they prefer rocky outcrops and margins of forests, roads, and Ghats and we consider it as Least Concern (LC) according to IUCN criteria 2022.



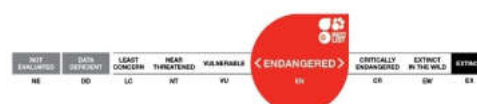
Leea compactiflora

This species is found in Northeast India, especially in Arunachal Pradesh. The Extent of Occurrence (EOO) is calculated to be 621113.36 km² and the Area of Occupancy (AOO) is 112.00 km². They are mostly seen in forest margins and on the roadside. Because of its number of populations and localities, this species can be considered as Least Concern (LC) according to IUCN Criteria and Categories (2022).



Leea grandifolia

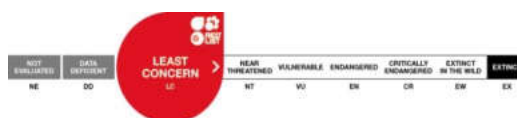
This species is endemic to India, only seen in the Great Nicobar Islands of Andaman and Nicobar Islands. The Extent of Occurrence (EOO) is calculated to be 5947 km² and the Area of Occupancy (AOO) is 60 km². As they prefer mostly beach forests there is a high



chance for habitat destruction due to tsunami. We noticed some areas near Galathea submerged as a result of the 2004 tsunami. The tsunami destroyed the road and as a result, a new road was built clearing the forest. Besides, the number of individuals in each population is less than five. Even though the areas in Nicobar are protected, by considering the threat and number of populations, it is best to categorize them as Endangered (EN) as per the IUCN (2022) criteria B2b(iii)D.

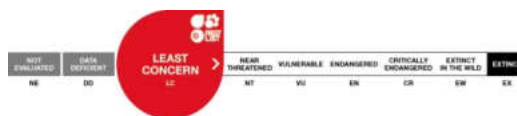
Leea guineensis

This species is found in 8 states and 2 union territories of India. They mostly grow among the secondary vegetation of forest margins. It can be also seen in marshy areas. The Extent of Occurrence (EOO) is calculated to be 2598632 km² and the Area of Occupancy (AOO) is 160 km². Because of a high population and localities, this species can be considered as Least Concern (LC) according to IUCN Criteria and Categories (2022).



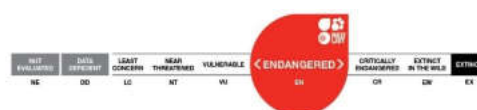
Leea indica

This is the widely distributed species in this genus, mainly in the southern part of India. Because of a high population and localities, this species can be considered as Least Concern (LC) according to IUCN Criteria and Categories (2022).



Leea latifolia

In India, this species is limited to Kerala and Maharashtra. The Area of Occupancy (AOO) is calculated to be 32 km². They are mainly preferred to grow in open areas near the roadside. Each population contains less than 5 mature individuals. The habitat of Mumbai Suburban is highly polluted as it is a metropolitan city. It was observed during our study that waste was dumped in the plant-growing area. By considering all these facts, here it is categorized as Endangered (EN), B2b(iii) according to IUCN Criteria and Categories (2022).



Leea macrophylla

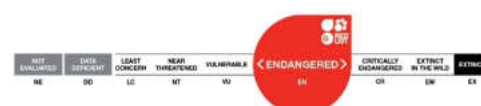
This species shows a moderate distribution in India, mainly located in the western peninsular region. The

Extent of Occurrence (EOO) is calculated to be 1827382 km² and the Area of Occupancy (AOO) is 176 km². They are usually seen as undergrowth in deciduous forests and open areas. Because of the number of populations and localities at present, it is categorized as Least Concern (LC) according to IUCN Criteria and Categories (2022).

*Leea mizoramensis*

This species is only located in Mizoram, India, with an Extent of Occurrence (EOO) of 2096.89 km².

The Area of Occupancy (AOO) for all localities is an estimated 32.00 km². It is known from 14 locations and each population consists of less than 5 mature individuals. Mizoram, especially Aizawl is a popular tourist destination, hence the population is at risk of decline as the locations are frequently visited by domestic and foreign tourists. As this species is mostly seen along roadsides and none of the locality comes under a protected area, there is a high risk of habitat destruction due to road widening which is ongoing in several districts of Mizoram. With the fragmented occurrence and threat to the habitat, at present, it is best to be categorized as Endangered (EN), [B2b(iii)D (IUCN 2022: Version 15)] according to the IUCN Red list category and criteria.

*Leea robusta*

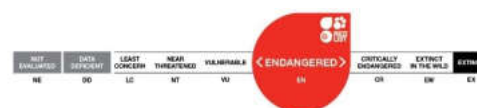
This species shows a moderate distribution in India. The Extent of Occurrence (EOO) is estimated to be

3244290 km² but the Area of Occupancy (AOO) is 212 km². A total of 11 states and two union territories are known to have this species, which grows mainly on open forest margins, roadsides, lateritic slopes and Ghats's margins. Because of a high population and localities, this species can be considered as Least Concern (LC) according to IUCN Criteria and Categories (2022).



Leea setuligera

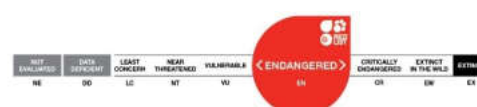
This species is only seen in Maharashtra and shows very limited distribution with each population consisting of less than five mature individuals. The Extent of Occurrence (EOO) is calculated to be 28178 km² and the Area of Occupancy (AOO) is 40 km². They prefer open areas mainly along roadsides. Therefore, grazing and expansion of roads may pose a serious threat to this species. Here it is considered as endangered (EN) according to the IUCN criteria B2b(iii)D, as it shows a narrow distribution range and a small population.

*Leea sundaica*

The species could be collected only from 2 localities in the Great Nicobar Islands, Campbell Bay and East-West Road, 34 Km away from Campbell Bay. Though it is an island, the area is prone to natural calamities like tsunami. The Extent of Occurrence (EOO) is less than 232 km² and the Area of Occupancy (AOO) is 12 km². Hence, it is placed under Endangered (EN), B1B2ab(i&ii)D, after considering the narrow range of distribution, small population and according to IUCN Criteria and Categories (2022)

*Leea trifoliata*

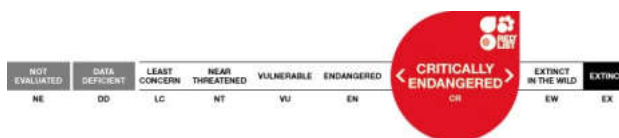
This species remains restricted in two northeastern states, Assam and Arunachal Pradesh and prefers to grow in open areas adjoining evergreen forest. The Extent of Occurrence (EOO) is calculated to be 68312.16 km² and the Area of Occupancy (AOO) is 48 km². As per the large extent of occurrence of this species is not fall into any of the threat categories. However, the area of occupancy is small. Besides, each population contains less than five mature individuals. Due to its narrow range of distributions and small AOO this species could be categorized at present as Endangered (EN), B2b(iii) according to IUCN Criteria and Categories (2022).



Leea tamdilensis

This species is known only from a single population at the type locality, Tamdil,

Mizoram. We observed less than five mature individuals. The default Area of Occupancy (AOO) is 4 km². As a fragmented population with a narrow distribution range, this population is exposed to habitat destruction due to the anthropogenic pressure in that area. Taking these aspects, it is here considered as Critically Endangered (CR), B1B2ab(iii)D.

**Ex-situ conservation of *Leea***

Attempts have been made to conserve the species of *Leea* in Calicut University Botanical Garden (CUBG), Kerala, India. Almost all of the species from different regions of India are conserved. It includes a total of 50 accessions of 15 species (Fig. 104–106). In the Botanical Garden, a special area for planting *Leea* samplings was established. The introduced *Leea* plants were flowering well in the Botanical Garden, and most of them set flowers and fruits. *Leea aequata* have shown profuse regeneration profusely in the field (Fig. 107 C–E).

Propagations in *Leea*

1. Plantlets: The seeds are mostly viable. It took almost one year of dormancy period to germinate the seed naturally. Attempts are done to carry out to germinate the seeds by soaking in wet cotton. It took more than one 30-40 days to sprout the seed (Fig. 107C–E).
2. Stem cutting: It is common for species of *Leea* to develop adventitious roots on their stems. The cuttings of 15-20 cm long with 2 or 3 nodes are either dipped in water or placed on a wet piece of paper. It took 5–6 days for the formation of the callus on the stem (Fig. 107A & B).
3. Adventitious root: Species like *L. indica*, *L. guineensis* and *L. grandiflora* develop adventitious roots.



Fig. 104. *Ex-situ* conservation of *Leea* in Calicut University Botanical Garden (CUBG).



Fig. 105. *Ex-situ* conservation of *Leea* in Calicut University Botanical Garden (CUBG).



Fig. 106. *Ex-situ* conservation of *Leea* in Calicut University Botanical Garden (CUBG).



Fig. 107. Propagations in *Leea*: **A & B.** Stem cutting; **C-E.** Seedling; **F.** Tuberous root.

4. Tubers: Some species of *Leea* produce root tubers, such as *L. macrophylla*, *L. robusta*, *L. setuligera*, and *L. asiatica*. In the case of *L. setuligera*, *L. macrophylla*, and *L. asiatica*, the aerial shoots die after each growing season and are replaced by new roots during the next monsoon season (Fig. 107F).

Future Perspectives and Recommendations for Conservation

1. Knowledge sharing with forest officials and to provide a list of endemic and threatened taxa of *Leea* and their habitat requirements.
2. Interact with local people and make them aware of the need for conservation.
3. Design a special hydroponics system for the rooting of stems for threatened taxa (Lok *et al.*, 2011 created a particular hydroponics system and proved successful in generating roots).
4. Predict the possible habitat for threatened species using niche modelling and reintroduce it in a new habitat.
5. Several butterflies and other pollinators visit this genus, making it a good candidate for a butterfly garden.
6. *Leea* flowers generally attract large numbers of butterflies, and hence it can be recommended for butterfly gardens, and the seedlings can be raised in the CUBG for distribution to the required institutes.

Anatomical characters play an increasingly important role in the formation of natural or phenetic groups (Davis & Heywood, 1963) and they have been largely applied to the elucidation of evolutionary trends and interrelationship of taxa at and above the species level (Sivarajan, 1991). Anatomical data can often reveal with greater confidence the homologies of morphological character states, and they can help in the interpretation of evolutionary polarity (Stuessy, 1990). It has been proved that foliar anatomy has taxonomic utility in several families of vascular plants (Carlquist, 1957, 1991; Ickert-Bond *et al.*, 2018). Stace (1989) has suggested that wood, leaf epidermis and cuticle, as well as trichomes and stomata, provide valuable taxonomic evidence.

There have been few studies on the leaf anatomy of *Leea*. Metcalfe and Chalk (1957) showed the differences in leaf anatomy in the family Ampelideae and suggested the applications of anatomical data to the solution of taxonomic problems. Najmaddin *et al.* (2011a, b, 2013, & 2014) also studied the anatomy of some species of *Leea* and compared them to other members of the Vitaceae in order to assess anatomical differences for the delimitation of these closely related families. The present study aims to document additional leaf anatomical characters in the genus *Leea* in India to determine its taxonomic importance and to find the interrelationship among the species. This work focuses on foliar anatomy, including lamina, midrib, rachis, and margin, along with epidermal characters and trichome nature.

Materials and methods

To evaluate the taxonomic utility of anatomical characters, foliar anatomical studies of all the collected species of *Leea* were carried out.

For anatomical characterization, fresh as well as the samples preserved in FAA were subjected to cross-sections. The second pair of leaflets of a pinnately compound leaf were chosen. Transverse hand sections of the middle portions of the

midrib, rachis and lamina (Fig. 108) were made manually using a commercial razor blade.

To study the epidermis, mainly the abundance, distributions and types of stomata and trichomes, an epidermal peel of upper and lower was prepared following the procedure used by Stace (1989). The sections and pieces of leaf epidermis were stained by 1 % safranin or toluidine blue for 2-3 minutes. Excess stain was rinsed off with distilled water, sections were mounted using glycerol on a glass slide.

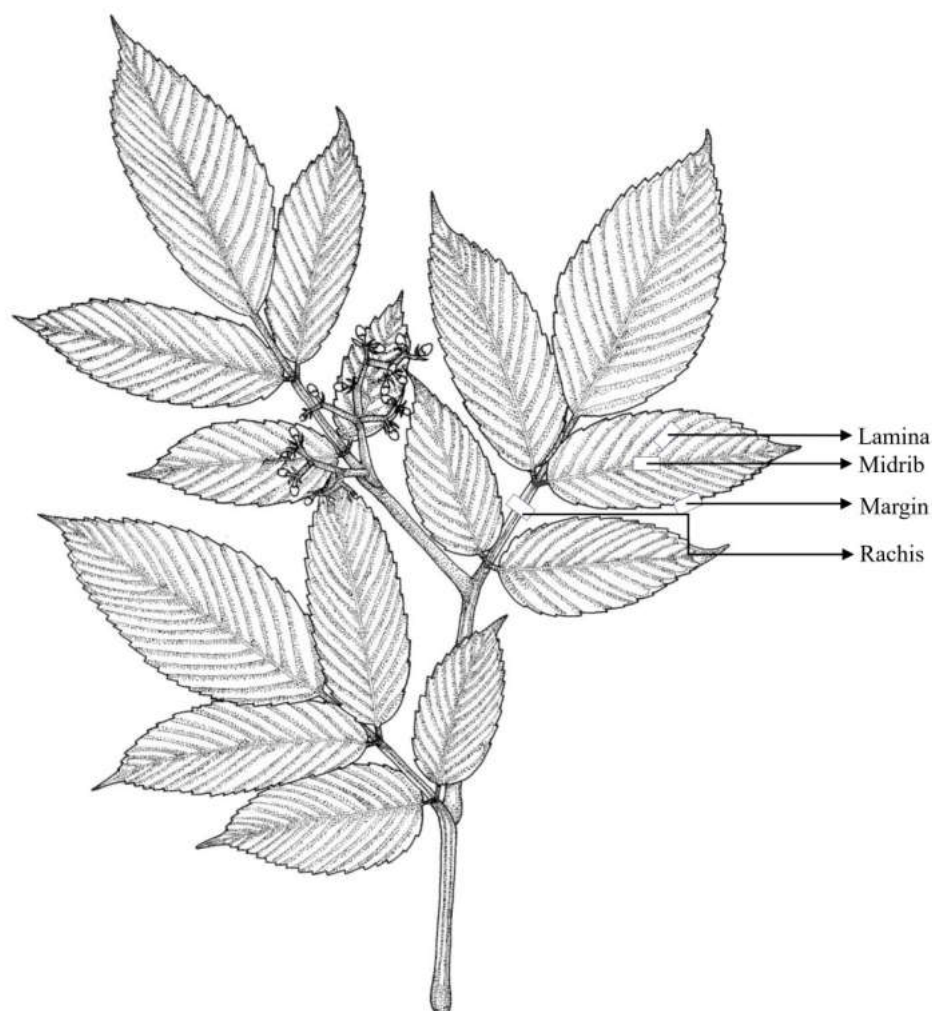


Fig. 108. Diagrammatic representation of different foliar parts of *Leea* used for anatomical sections.

Photomicrographs of all the sections were captured by using a DM2000 LED microscope attached with DMC4500 Camera (Leica, Germany) with 4X, 20X, 40X and 100X magnifications.

To determine the consistency of anatomical characteristics and to calculate the mean and standard error among various cross sections, at least five cross sections per population and for the lamina, rachis, and midrib were taken. Ten paradermal slides were created for each species, and 30 measurements of stomatal length and width were recorded on each slide.

Anatomical features of leaflets were described according to the terminology of Esau (1965), Fahn (1990) and Metcalfe and Chalk (1957). The description and terminology of trichomes and leaf epidermal cells mainly follow Payne (1978).

The number of epidermal cells and stomata were counted on the same ocular and an average of 20 was taken. For the determination of the stomatal index following the formula of Salisbury (1927) was used.

$$SI (\%) = \frac{\text{Stomatal density}}{\text{Stomatal density} + \text{Epidermal density}} \times 100$$

Statistical analysis

The data was presented as mean $\pm$ standard error. The quantitative data were processed using the software SPSS version 20.0 to determine minimum, maximum, average mean and standard error. One-way Analysis of Variance (ANOVA) and Duncan's multiple range tests were done to validate the results.

Result

General anatomical characters

Fig. 109

Midrib

In the midrib region, adaxial and abaxial surfaces show differences among species. A single layer of epidermis covers both surfaces, and some species exhibit papillae on the epidermis. The epidermis consisted of compactly arranged parenchyma cells with cuticle on the outer walls. The epidermis is followed by the

collenchymatous hypodermis which is usually 2–6-layered, further followed by the parenchymatous cortex. The parenchymatous cells are closely packed without intercellular space. A patch of angular collenchyma cells can be seen on the adaxial surfaces. The vascular system is represented by collateral vascular bundles arranged as a ring, which consists of 6 bundles in most of the species except in *L. angulata* (four bundles) and *L. macrophylla* (more than six bundles). The vascular bundles are equal sized, or it may be unequal in some species. An accessory vascular bundle can be seen on the adaxial surface except in *L. adwivedica*, *L. angulata*, *L. mizoramensis*, *L. macrophylla* and *L. setuligera*. The sclerenchymatous strata connecting the entire vascular bundles vary in number among species. The pith consists of parenchymatous cells.

Rachis

In cross-section, the adaxial and abaxial surfaces of the rachis show different shapes with species. It consists of a single-layered epidermis which follows the chlorenchymatous hypodermis. Below the hypodermis, 2–3 layers of collenchymatous strata are present. A ring of five prominent vascular bundles together with smaller bundles makes up the vascular system of the rachis. An accessory vascular bundle is present in all the species on either side of the grooves on the adaxial surface. The number of layers of sclerenchymatous strata connecting the vascular bundles varies among species. Pith is parenchymatous and shows variation in thickness among species.

Lamina

Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of lamina varies among species. Epidermis is single-layered both adaxially and abaxially with adaxial cells being larger than the abaxial cells. The cells are rectangular or barrel-shaped with cuticularized outer walls. The adaxial cells may be with or without papillae. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade parenchyma composed of rectangular, attenuated and vertical cells, lies just internal to the adaxial epidermis, arranged perpendicular to the upper epidermis. It may be single-layered or 2-layered and

occasionally 3-layered, arranged without intercellular space. The spongy parenchyma can be seen towards the abaxial epidermis. The number of layers of spongy parenchyma varies among species. The cells are irregularly shaped and vary from rounded to polygonal compactly arranged cells.

Leaf margins

Margin is tapering towards the tip in all species, and it may be bent or straight. The length and number of layers of the hyaline region vary with species. Mesophyll consists of palisade and spongy cells.

Cellular inclusions

Raphides and druses are the crystals found in leaf parts of *Leea* and are distributed in the lamina, midrib and rachis. Aside from this, starch grains are also present.

Epidermal characters

In most species, the epidermis is uniseriate and has a smooth cuticle; however, it can occasionally be papillate. The cells of the leaf epidermis were irregular or polygonal in shape. In all cases, the anticlinal walls of adaxial epidermal cells are straight or straight-sinuous. Epidermal cells with irregular shapes always have sinuate anticlinal walls.

Stomata

The leaves of *Leea* are mostly hypostomatic (stomata present on abaxial surfaces only) with the exception of *L. robusta*, *L. macrophylla*, *L. latifolia* and *L. sundaica*, which are amphistomatic (stomata can be seen on both abaxial and adaxial surfaces). In amphistomatic leaves, the abaxial surfaces have a greater number of stomata than the adaxial surfaces. In *Leea*, two types of stomatal complexes were observed *viz.*, anisocytic and anomocytic, with anisocytic type being more prevalent. There is a clear disparity in stomatal density among different species.

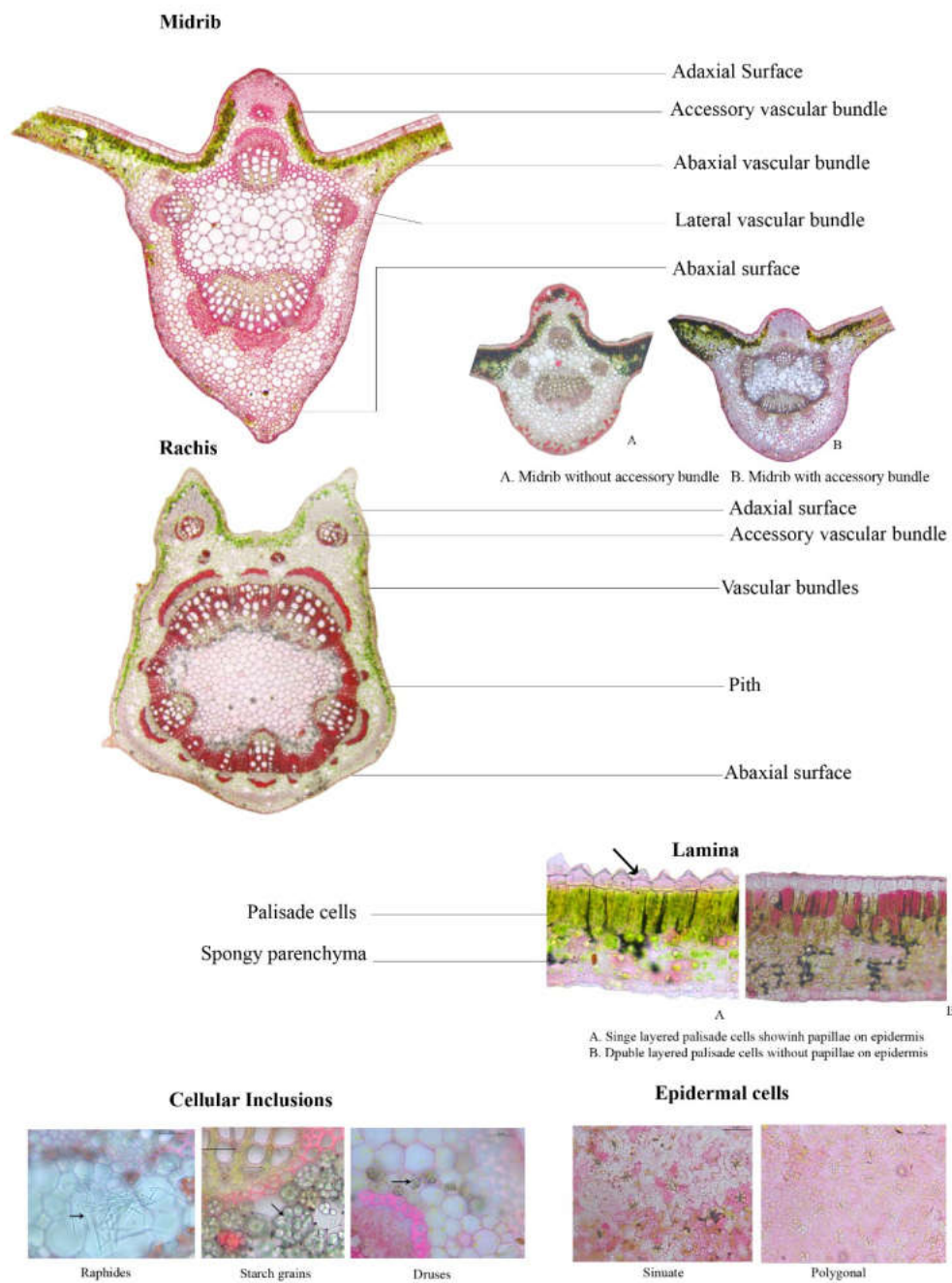


Fig. 109. General anatomical characters of *Leea*.

Key to the species using Foliar anatomical and epidermal characters

1. Leaves amphistomatic2
1. Leaves hypostomatic3
2. Midrib consists of more than 6 vascular bundles*L. macrophylla*
2. Midrib consists of 6 vascular bundles4
3. Palisade parenchyma single layered5
3. Palisade parenchyma double layered.....6
4. Accessory vascular bundle absent*L. latifolia*
4. Accessory vascular bundle present.....7
5. Anomocytic type of stomata8
5. Anisocytic type of stomata9
6. Sclerenchymatous strata connecting the entire vascular bundles present;
accessory vascular bundle is present10
6. Sclerenchymatous strata connecting the entire vascular bundles absent;
accessory vascular bundle is absent11
7. Abaxial surface of the rachis wide V-shaped; anticlinal walls of the abaxial
surfaces of the epidermal cells are strongly sinuate*L. robusta*
7. Abaxial surface of the rachis wide U-shaped; anticlinal walls of the abaxial
surfaces of the epidermal cell straight to slightly wavy *L. sundaica*
8. Cuticle ornamented*L. asiatica*
8. Cuticle smooth.....*L. trifoliata*
9. Grooves of the rachis contain a central protrusion; pearl glands contain central
cells surrounding large palisade-like epidermal cells.....*L. aequata*
9. Grooves of the rachis without central protrusion; pearl glands absent12
10. Adaxial surface obconic, slightly dilated below the middle with a keel;
parenchymatous adaxial hypodermal layer absent*L. guineensis*
10. Adaxial surface convex; parenchymatous adaxial hypodermis present.....
..... *L. indica*

11. Epidermis non-papillate; adaxial surface of rachis U-shaped and abaxial surface V-shaped; Adaxial rachis groove 265.06–417.55 (356.11±6.33) μm deep..... *L. angulata*
11. Epidermis papillate; adaxial surface and abaxial surfaces of rachis wide U-shaped; adaxial rachis groove 149.73–204.96 (182.75±2.74) μm deep *L. adwivedica*
12. Epidermal cells polygonal on the abaxial surface 13
12. Epidermal cells sinuate on the abaxial surface..... 14
13. Thickness of lamina $\leq 212 \mu\text{m}$; adaxial parenchymatous hypodermal layer absent..... *L. compactiflora*
13. Thickness of lamina $> 212 \mu\text{m}$; adaxial parenchymatous hypodermal layer present..... *L. grandifolia*
14. Epidermis non-papillate *L. setuligera*
14. Epidermis papillate 15
15. Non-glandular trichomes present on the midrib region; accessory vascular bundles absent *L. mizoramensis*
15. Non-glandular trichomes absent on the midrib region; accessory vascular bundles present *L. tamdilensis*

1. *Leea adwivedica*

Figs. 110 & 111

Midrib: In cross-section, midrib is 1002.79–1206.18 (1117.17±13.07) $\times$ 905.65–1174.17 (987.15±13.12) μm . Adaxial surface is convex and abaxial surface is wide U-shaped. Epidermis is single-layered, papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is present. Collenchymatous strata on the abaxial surface are 3–5-layered. The vascular system is represented by collateral vascular bundles consisting of six bundles arranged in a ring. Lateral bundles and adaxial bundles are almost equal-sized. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles is absent. The pith is parenchymatous. The cells are circular or polygonal arranged without

intercellular spaces and the thickness is 137.52–192.64 (170.88±11.25) μm . Druses and starch grains are distributed in pith and cortex.

Rachis: In cross-section, rachis is 2375.00–2973.78 (2607.68±33.08) $\times$ 2141.59–2519.46 (987.15±13.12) μm . Adaxial surface and abaxial surfaces are wide U-shaped. Adaxial rachis groove is 149.73–204.96 (182.75±2.74) μm deep without any protrusion. Epidermis is single-layered with a smooth cuticle. Hypodermis is 2–4-layered and chlorenchymatous. Below the hypodermis, 3–5-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 1093.49–1704.71 (1396.12±32.89) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 168.17–250.6 (204.40±3.59) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisades usually 2-layered, rarely 3, and 51.46–98.24 (73.18±2.51) μm thick. Spongy parenchyma 5–7-layered, compactly arranged without intercellular spaces, 55.18–125.46 (80.48 $\pm$ 3.67) μm thick. Starch grains are immersed in spongy parenchyma. Druses and raphides are seen in mesophyll region. Lamina margin is slightly tapering towards the tip. The hyaline portion is absent.

Stomata: Leaves are hypostomatic and show anomocytic stomata. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy on abaxial surfaces and straight on adaxial surface. Stomatal frequency is 16–26 (20.07±0.96) mm^2 . Stomatal length ranges from 20.20–24.50 (22.85±0.42) μm . Stomatal index is 14.52–30.26 (22.27±1.74).

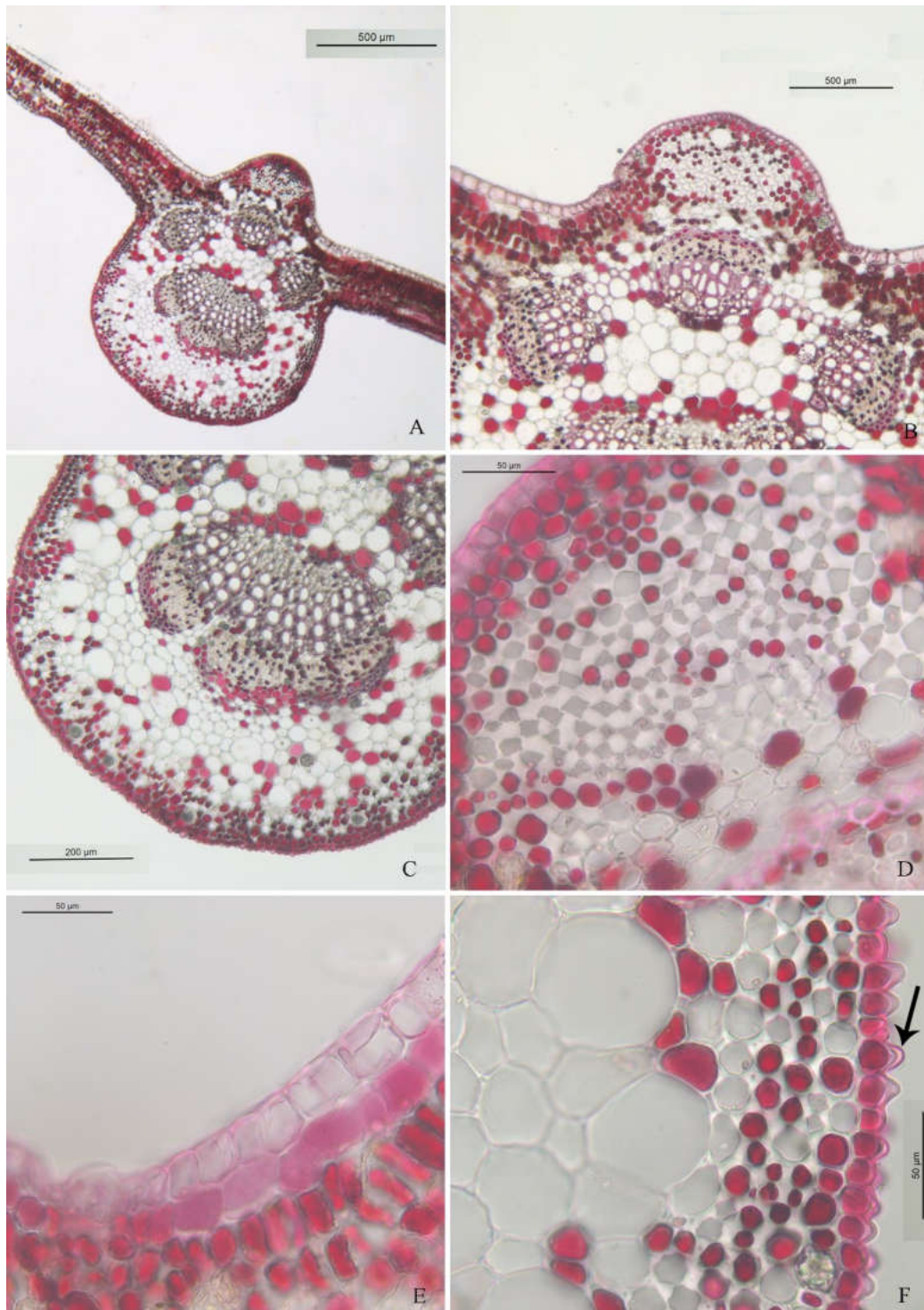


Fig. 110. *Leea adwivedica* K.Kumar: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Abaxial surface - portion enlarged; **E.** Midrib - a portion enlarged showing hypodermis; **F.** Midrib-portion enlarged showing papillate epidermis.

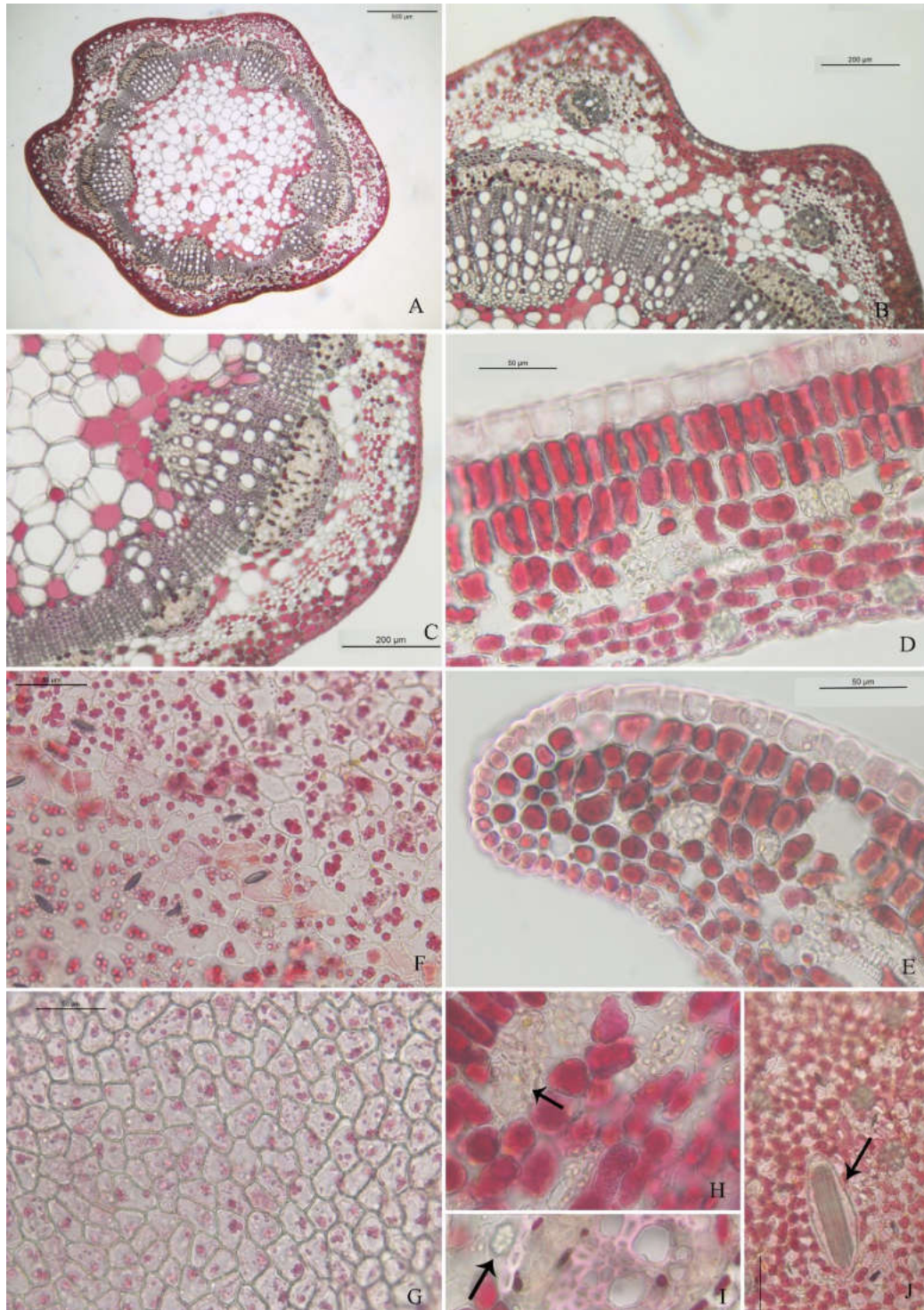


Fig. 111. *Leea adwivedica* K.Kumar: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Starch grains; **I.** Druses; **J.** Raphides.

2. *Leea aequata***Figs. 112 & 113**

Midrib: In cross-section, midrib is 1722.95–2225.08 (2011.55 ± 28.81) $\times$ 923.63–1478.98 (1206.31 ± 19.29) μm . Adaxial surfaces obconic, bulbous from base to above the middle, short and abruptly tapering towards the apex and abaxial surfaces are wide V-shaped. Epidermis is single-layered, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermis is present. Collenchymatous strata on the abaxial surface are 3–4-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–2-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 179.9–555.13 (436.91 ± 22.17) μm . Druses, raphides and starch grains are distributed in pith and cortex.

Rachis: In cross-section, rachis is 1954.12–2536.17 (2261.09 ± 38.13) $\times$ 1507.16–2408.55 (1868.69 ± 45.73) μm . Adaxial surface is U-shaped with a protrusion and abaxial surface is wide U or V-shaped. Adaxial rachis groove is 335.91–549.78 (448.92 ± 10.05) μm deep with a central protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 3–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 946.11–1823.38 (1262.83 ± 47.70) μm thick. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of lamina varies from 65.07–112.01 (92.62 ± 2.03) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are round or barrel-shaped or rectangular. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered and 17.97–29.59 (23.48 ± 0.59) μm thick. Spongy parenchyma is 4–6-layered, compactly arranged without intercellular spaces, 30.65–62.11 (46.43 ± 1.76) μm thick. Pearl glands is present on the lower epidermis. Druses are distributed in some epidermal cells and raphides are seen in mesophyll cells. Mesophyll cells often with air cavities. Lamina margin is tapering and bends towards the tip. The hyaline portion consists of 3-layered thin-walled parenchymatous cells.

Stomata: Leaves are hypostomatic and show dominantly anisocytic stomata but sometimes with anomocytic stomata. Epidermal cells are irregular on adaxial and abaxial surfaces. Anticlinal walls are strongly sinuate both adaxially and abaxially. Stomatal frequency is 16–21 (18.3 ± 0.47) mm². Stomatal length ranges from 18.01–22.29 (20.74 ± 0.49) µm. Stomatal index is 14.04–20.79 (16.99 ± 0.69).

Trichome: This species shows only one type of trichome; non-glandular unicellular trichome with pointed ends. All the trichomes have a multicellular base and a thick, acicular apical cell. **Fig. 112F, Fig. 113K.**

Anatomy of pearl gland: They are spherical structures attached by a short stalk. In cross-section, it consists of 2 parts. Small, central cells surround large palisade-like epidermal cells and open to the exterior via a single apical stoma (Fig. 112J). These glands are distributed in the lamina, rachis and midrib.

3. *Leea angulata*

Fig. 114

Midrib: In cross-section, midrib is 943.58–1133.75 (1006.42 ± 8.89) × 652.62–784.70 (727.35 ± 6.67) µm. Adaxial surface is convex and abaxial surface is wide U-shaped. Epidermis is single-layered, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is present. Collenchymatous strata on abaxial surfaces are 2–3-layered. The vascular system is represented by collateral vascular bundle consisting of 4 bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles are absent. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 69.56–122.06 (88.08 ± 2.90) µm. Druses and starch grains are distributed in pith, vascular bundles and cortex.

Rachis: In cross-section, rachis is 1703.82–2082.08 (1811.30 ± 21.37) × 1444.61–1843.61 (1557.16 ± 21.23) µm. Adaxial surface is U-shaped and abaxial surface is V-shaped. Adaxial rachis groove is 265.06–417.55 (356.11 ± 6.33) µm deep without any protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 3–4-layered and chlorenchymatous. Below the hypodermis, 3–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 802.66–1146.77 (906.55 ± 16.89) µm in thickness. Druses and starch grains are dispersed in the ground parenchyma.

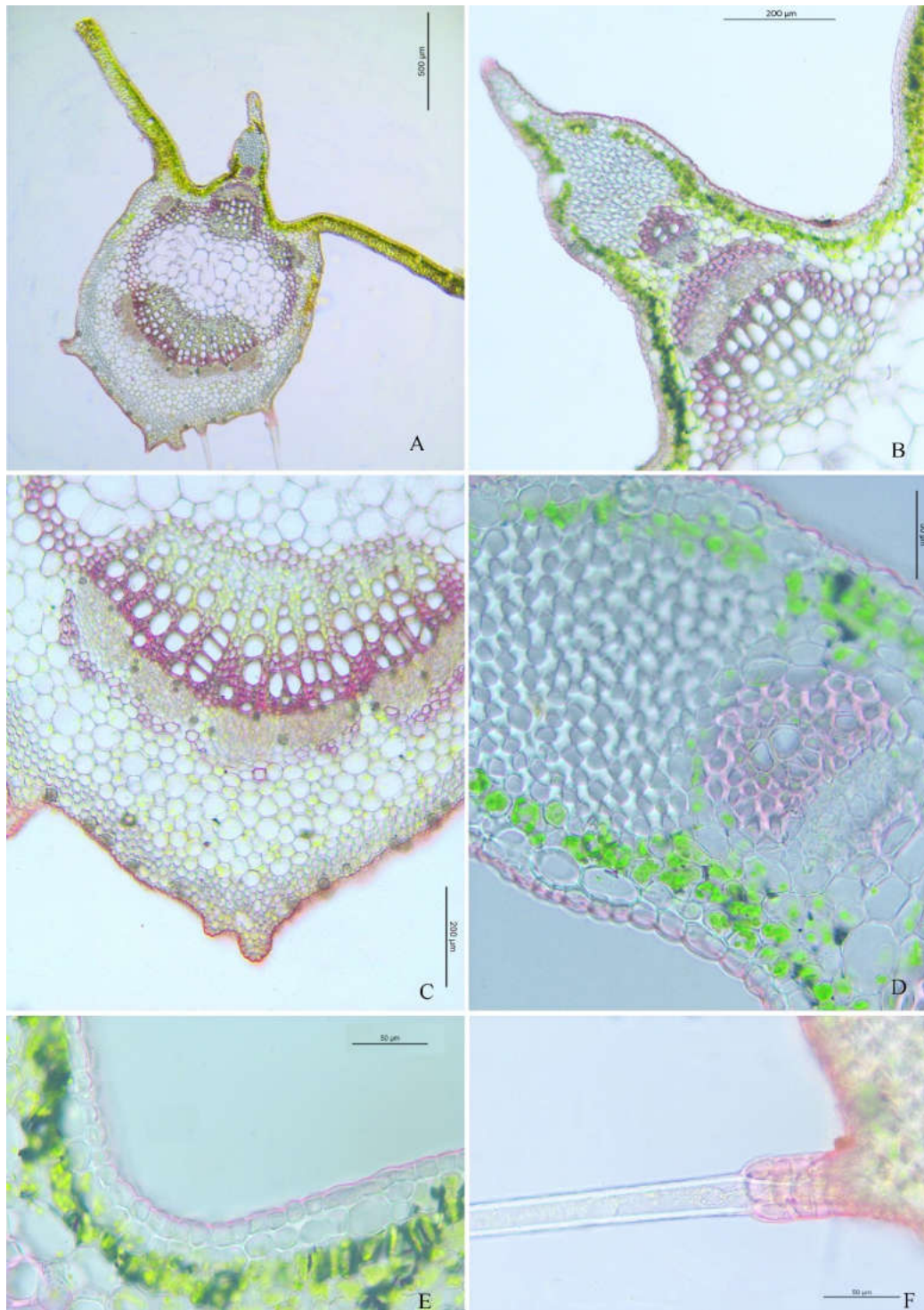


Fig. 112. *Leea aequata* L.: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Abaxial surface - a portion enlarged showing accessory vascular bundle; **E.** Midrib - a portion enlarged showing hypodermis; **F.** Trichome showing multicellular base with thick cell.

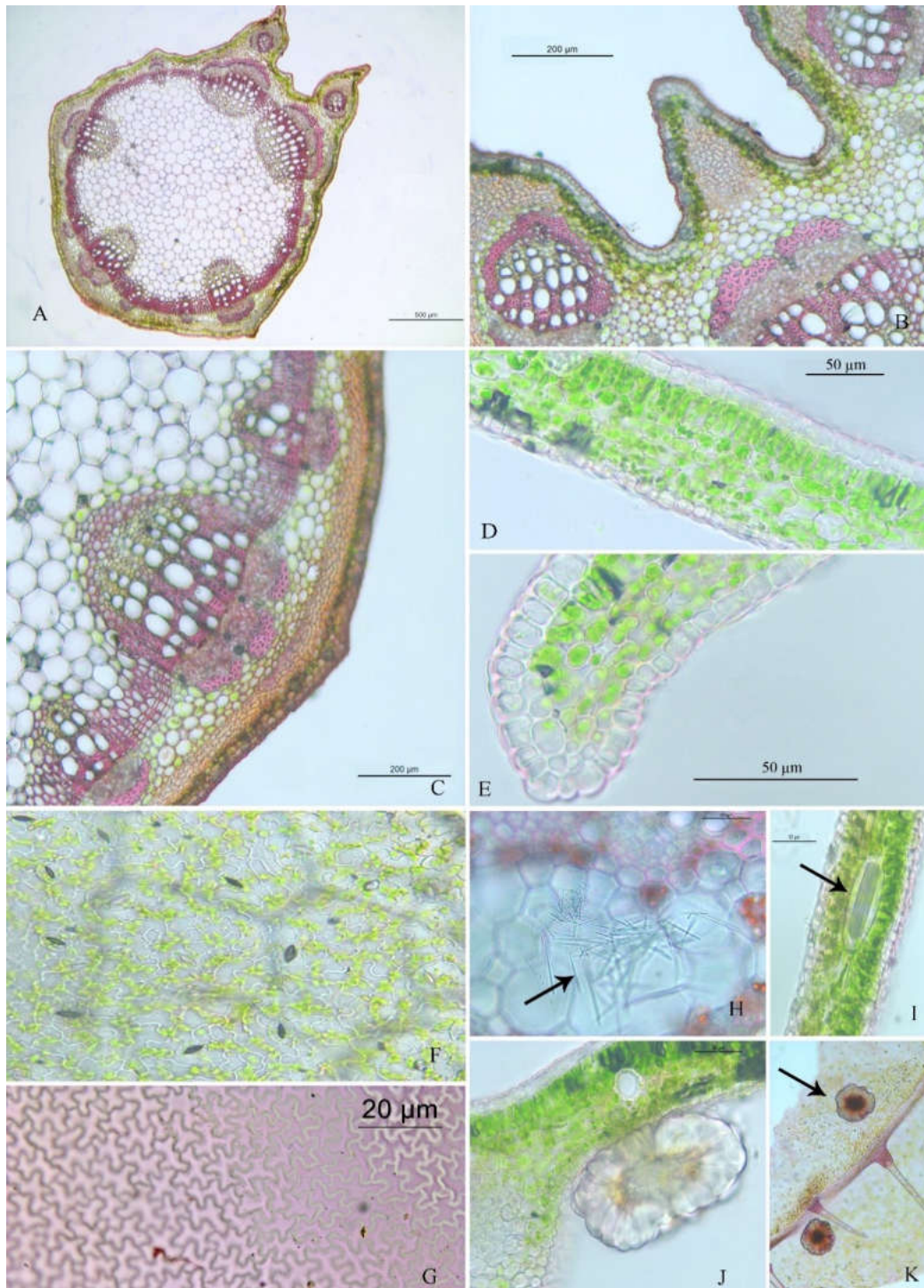


Fig. 113. *Leea aequata* L.: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis showing protrusion; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of adaxial surface of leaf; **G.** Para-dermal section of abaxial surface of leaf; **H. & I.** Raphides; **J.** Transverse section of pearl gland; **K.** Pearl gland.

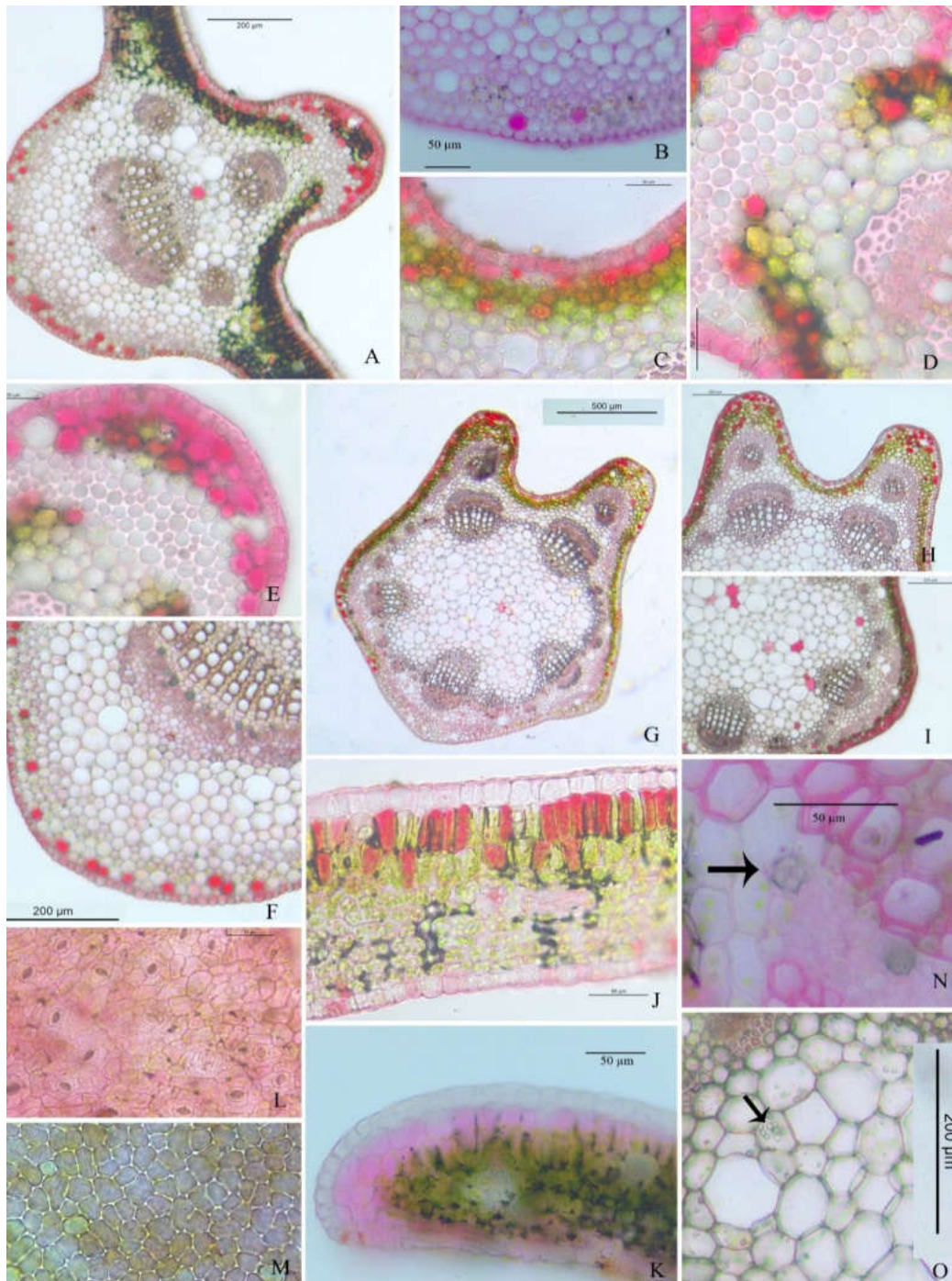


Fig. 114. *Leea angulata* Korth. ex Miq. Transverse section of leaf parts: **A.** Midrib; **B.** Midrib- portion enlarged showing epidermal cells; **C.** Midrib - a portion enlarged showing hypodermis; **D.** Adaxial surface - portion enlarged showing the absence of accessory vascular bundle; **E.** Adaxial surface of midrib; **F.** Abaxial surface of midrib; **G.** Rachis; **H.** Adaxial surface of rachis; **I.** Abaxial surface of rachis; **J.** Lamina; **K.** Leaf margin; **L.** Para-dermal section of abaxial surface of leaf; **M.** Para-dermal section of adaxial surface of leaf; **N.** Druses; **O.** Starch grains.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 151.51–202.96 (170.61 ± 2.14) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or round or barrel-shaped. Mesophyll is divided into palisade and spongy parenchyma. Palisade is 2-layered, 47.37–70.16 (59.69 ± 1.04) μm thick. Spongy parenchyma is 5–6-layered, compactly arranged without intercellular spaces, 51.53–84.46 (72.12 ± 1.53) μm thick. Druses and raphides are distributed in mesophyll cells. Lamina margin is very slightly tapering towards the tip. The hyaline portion consists of three-layered thin-walled parenchymatous cells.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy on abaxial surfaces and straight adaxially. Stomatal frequency is 20–26 (22.8 ± 0.69) mm^2 . Stomatal length ranges from 17.74–23.76 (21.49 ± 0.57) μm . Stomatal index is 11.17–17.9 (14.29 ± 0.60).

4. *Leea asiatica*

Figs. 115 & 116

Midrib: In cross-section, midrib is 1196.61–1507.72 (1324.23 ± 17.04) $\times$ 738.08–878.92 (810.90 ± 6.63) μm . Adaxial surface is obconic, slightly dilated below the middle and abaxial surface is V or wide V-shaped with a short keel. Epidermis is single-layered non-papillate with ornamented cuticle. Parenchymatous adaxial hypodermis is absent. Collenchymatous strata on the abaxial surfaces are 1–2-layered. The vascular system is represented by collateral vascular bundles consisting of six bundles arranged in a ring. Lateral bundles are larger than the adaxial bundles. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are single-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 142.64–180.02 (167.60 ± 1.7) μm . Druses and starch grains are distributed in pith and cortex.

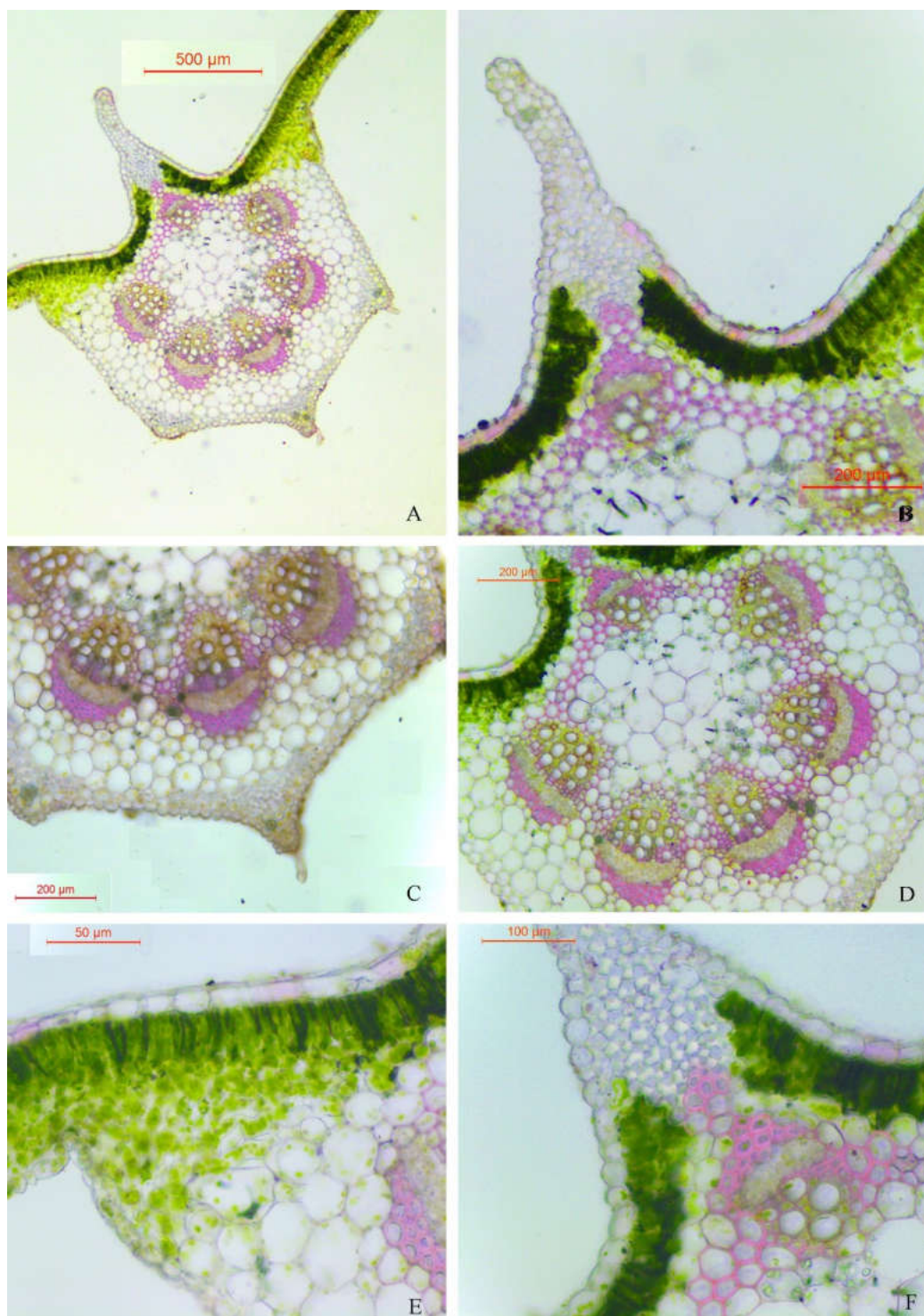


Fig. 115. *Leea asiatica* (L.) Ridsdale: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Midrib - a portion enlarged showing vascular bundles; **E.** Midrib - a portion enlarged showing absence of hypodermis; **F.** Accessory vascular bundle.

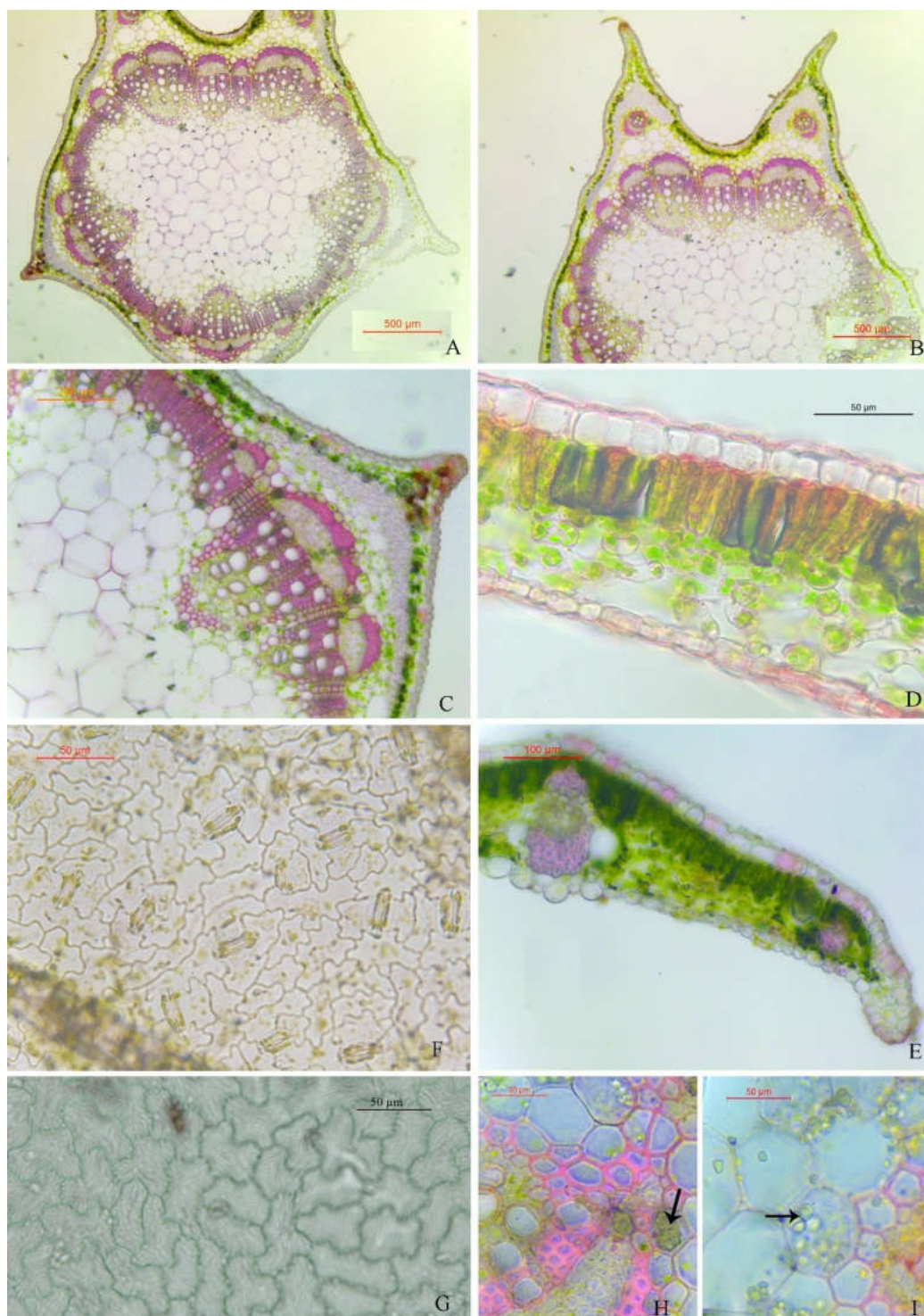


Fig. 116. *Leea asiatica* (L.) Ridsdale: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Druses; **I.** Starch grains.

Rachis: In cross-section, rachis is $2310.39\text{--}2617.55$ (2495.08 ± 15.81) $\times$ $2007.00\text{--}2469.29$ (2264.94 ± 22.36) μm . Adaxial surface is U-shaped and abaxial surface is V-shaped with a tapering end. Adaxial rachis groove is $565.19\text{--}609.98$ (593.63 ± 2.11) μm deep without a protrusion. Epidermis is single-layered, non-papillate, with ornamented cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, collenchymatous cells are present as a patch. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and $933.98\text{--}1112.39$ (981.60 ± 6.00) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the leaves varies from $102.24\text{--}185.77$ (153.26 ± 3.16) μm . Epidermis is uniseriate with ornamented cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisades is single-layered, $34.67\text{--}986.00$ (58.19 ± 1.84) μm thick. Spongy parenchyma is 3–4-layered, compactly arranged without intercellular space, $55.44\text{--}66.27$ (61.09 ± 0.60) μm thick. Druses can be seen in mesophyll region. Lamina margin is highly bent towards the tip. The hyaline consists of 1–2 rows of thin-walled parenchymatous cells.

Trichomes: The leaf parts of this species exhibit unicellular and multicellular non-glandular trichomes with pointed ends. The number of cells in the multicellular trichomes varies from 3–5, and they are distributed in the midrib, lamina and rachis.

Stomata: Leaves are hypostomatic and show anomocytic as the dominant type and anisocytic as the subtype. Epidermal cells are irregular both adaxially and abaxially. Anticlinal walls are strongly sinuate on both abaxial and adaxial surfaces. Stomatal frequency is $14\text{--}37$ (24.90 ± 2.42) mm^2 . Stomatal length ranges from $26.20\text{--}30.98$ (28.61 ± 0.51) μm . Stomatal index is $20.58\text{--}68.88$ (41.88 ± 5.03).

5. *Leea compactiflora*

Figs. 117 & 118

Midrib: In cross-section, midrib is 1006.42–1929.53 (1468.99 ± 54.69) $\times$ 794.00–1387.86 (1040.67 ± 36.86) μm . Adaxial surface is with acute projections and abaxial surface is wide V-shaped with or without a keel. Epidermis is single-layered, non-papillate with smooth cuticle. Parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the abaxial surfaces are 2–3-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are slightly smaller than adaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–3-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 131.98–314.47 (229.55 ± 10.48) μm . Druses, raphides and starch grains are present.

Rachis: In cross-section, rachis is 2167.91–2488.09 (2346.33 ± 13.16) $\times$ 1864.20–2117.71 (1957.66 ± 13.75) μm . Adaxial surface is U-shaped and abaxial surface is V-shaped. Adaxial rachis groove is 391.81–591.11 (496.13 ± 11.40) μm deep and without protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 2–3-layered and chlorenchymatous. Below the hypodermis, 2–3-layered collenchymatous strata are present. Vascular bundles are collateral, 5 prominent large bundles with small bundles arranged in a ring. Pith is parenchymatous and 858.90–1112.44 (972.07 ± 14.07) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 101.16–139.72 (113.33 ± 3.79) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered and 26.84–41.07 (34.39 ± 0.63) μm thick. Spongy parenchyma is 4–5-layered, compactly arranged without intercellular spaces, 37.17–72.52 (50.89 ± 1.94) μm thick. Druses and raphides are distributed in lamina. Lamina margin is slightly tapering towards the tip. The hyaline portion is 1–3-layered thin-walled parenchymatous cells.

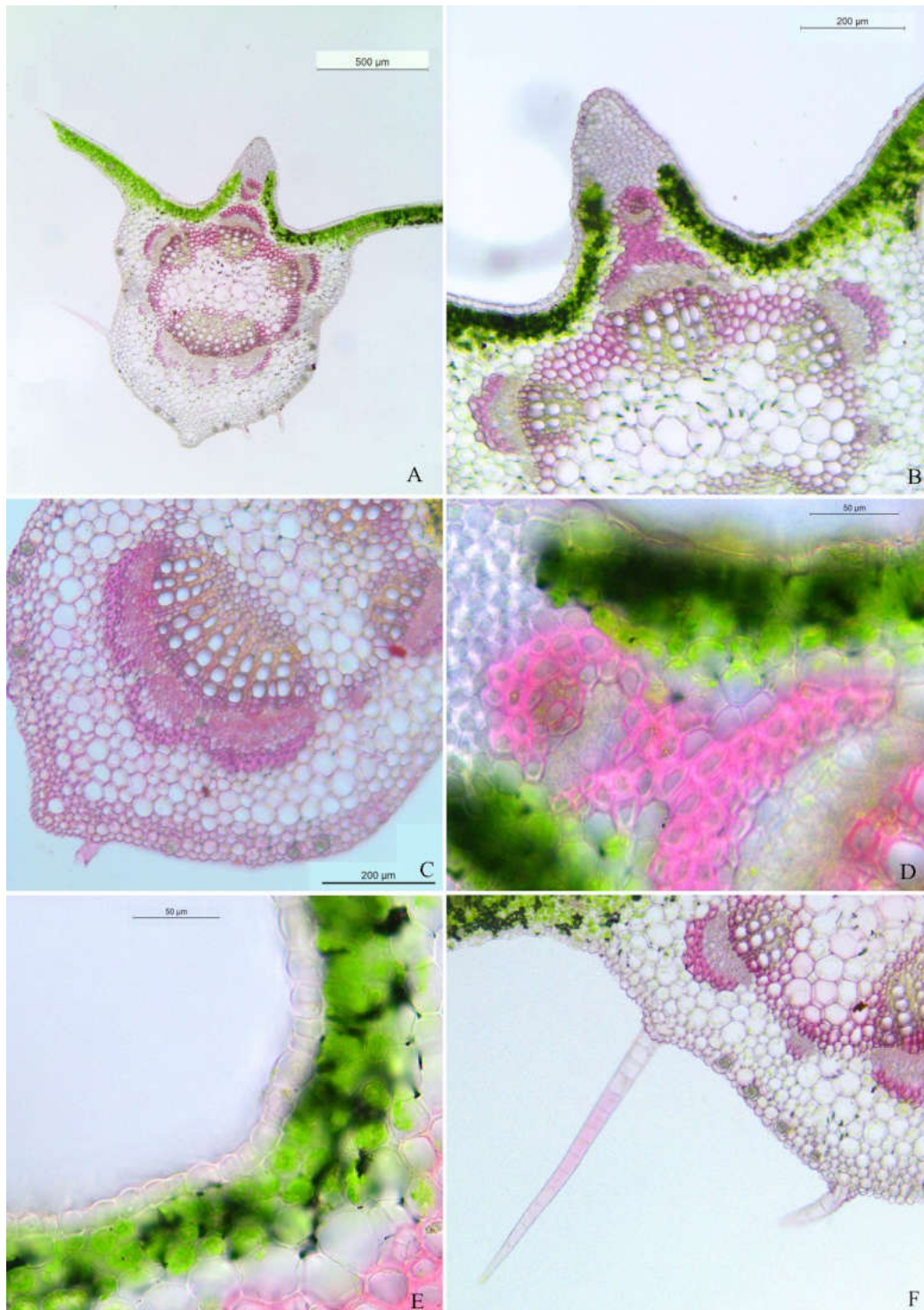


Fig. 117. *Leea compactiflora* Kurz: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Accessory vascular bundle; **E.** Midrib - a portion enlarged showing absence of hypodermis; **F.** Multicellular trichome.

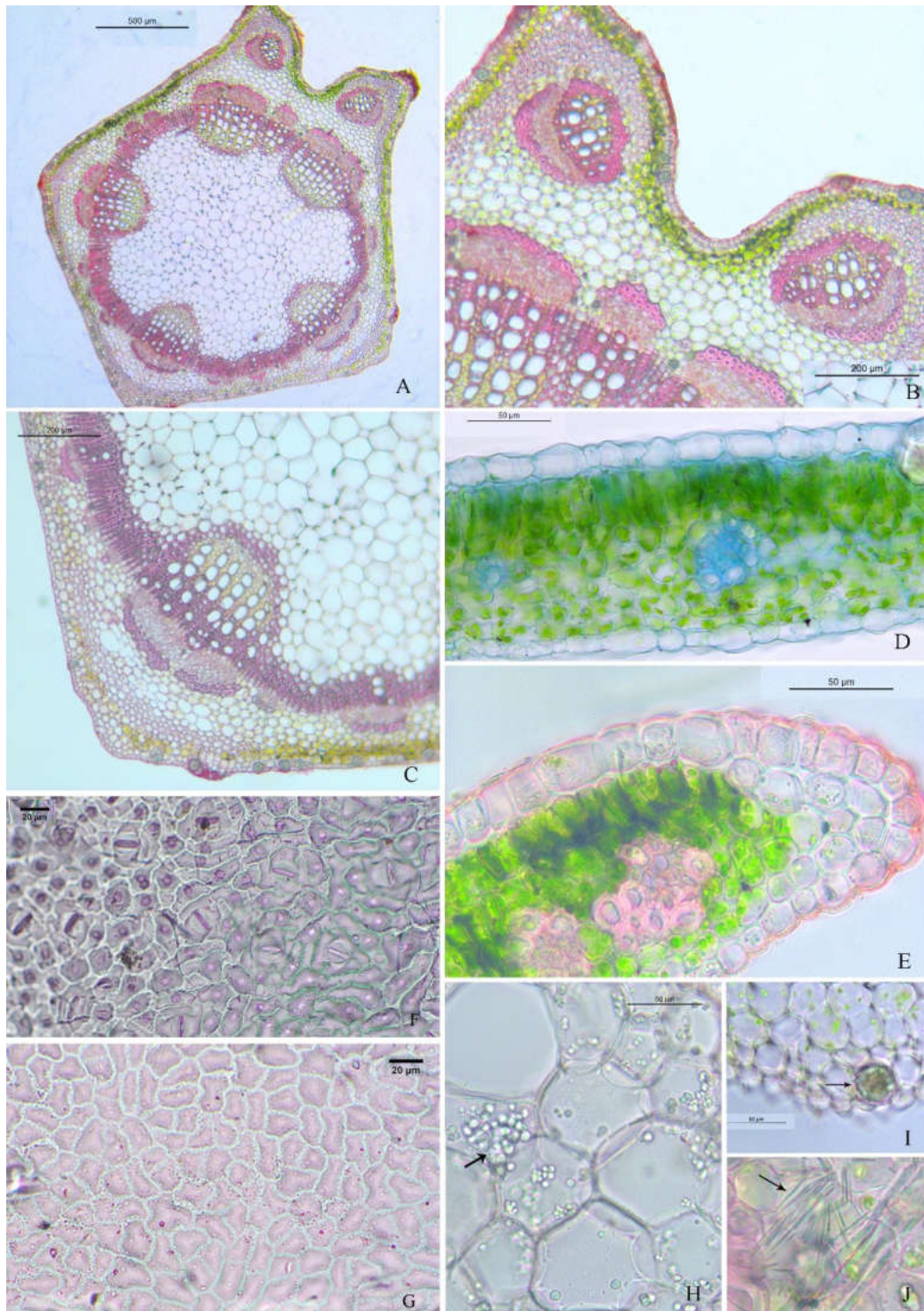


Fig. 118. *Leea compactiflora* Kurz: Transverse section of leaf parts: **A**. Rachis; **B**. Adaxial surface of rachis; **C**. Abaxial surface of rachis; **D**. Lamina; **E**. Leaf margin; **F**. Para-dermal section of abaxial surface of leaf; **G**. Para-dermal section of adaxial surface of leaf; **H**. Starch grains; **I**. Druses; **J**. Raphides.

Trichomes: The leaf part of this species has non-glandular multicellular trichomes with pointed ends. The number of cells in the trichomes varies from 3–15, and they are distributed in the midrib and lamina.

Stomata: Leaves are hypostomatic and shows anisocytic stomata. Epidermal cells are polygonal on both abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy both adaxially and abaxially. Stomatal frequency is 16–24 (18.7 ± 0.87) mm². Stomatal length ranges from 16.74–20.00 (17.92 ± 0.37) µm. Stomatal index is 8.74–13.04 (11.22 ± 0.48).

6. *Leea grandifolia*

Fig. 119

Midrib: In cross-section, midrib is 1689.21–2273.27 (1978.01 ± 32.99) × 1302.08–1678.91 (1448.85 ± 24.83) µm. Adaxial surface is convex and abaxial surface is wide U-shaped. Epidermis is single-layered, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is present. Collenchymatous strata on the abaxial surface are 3–4-layered. The vascular system is represented by collateral vascular bundle consisting of more than six bundles arranged in a ring. Lateral bundles are little smaller than adaxial bundles. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–2-layered. The pith is parenchymatous. The cells are circular or polygonal in shape and arranged without intercellular spaces and the thickness is 226.41–408.99 (323.35 ± 9.21) µm. Druses, raphides and starch grains are distributed in pith and cortex.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 213.31–315.22 (245.73 ± 4.72) µm. Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are round or rectangular. A uniseriate parenchymatous hypodermis is present. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, 32.33–57.27 (47.53 ± 1.36) µm thick. Spongy parenchyma is 7–10-layered, compactly arranged without intercellular spaces, 117.53–189.93 (147.55 ± 3.01) µm thick. Druses are distributed in some cells of epidermis. Small air cavity can be immersed in the lamina. Lamina margin is very slightly bent and tapering towards the tip. Air cavities can be seen in the margin. The hyaline portion consisted of 3–4-layered thin-walled parenchymatous cells.

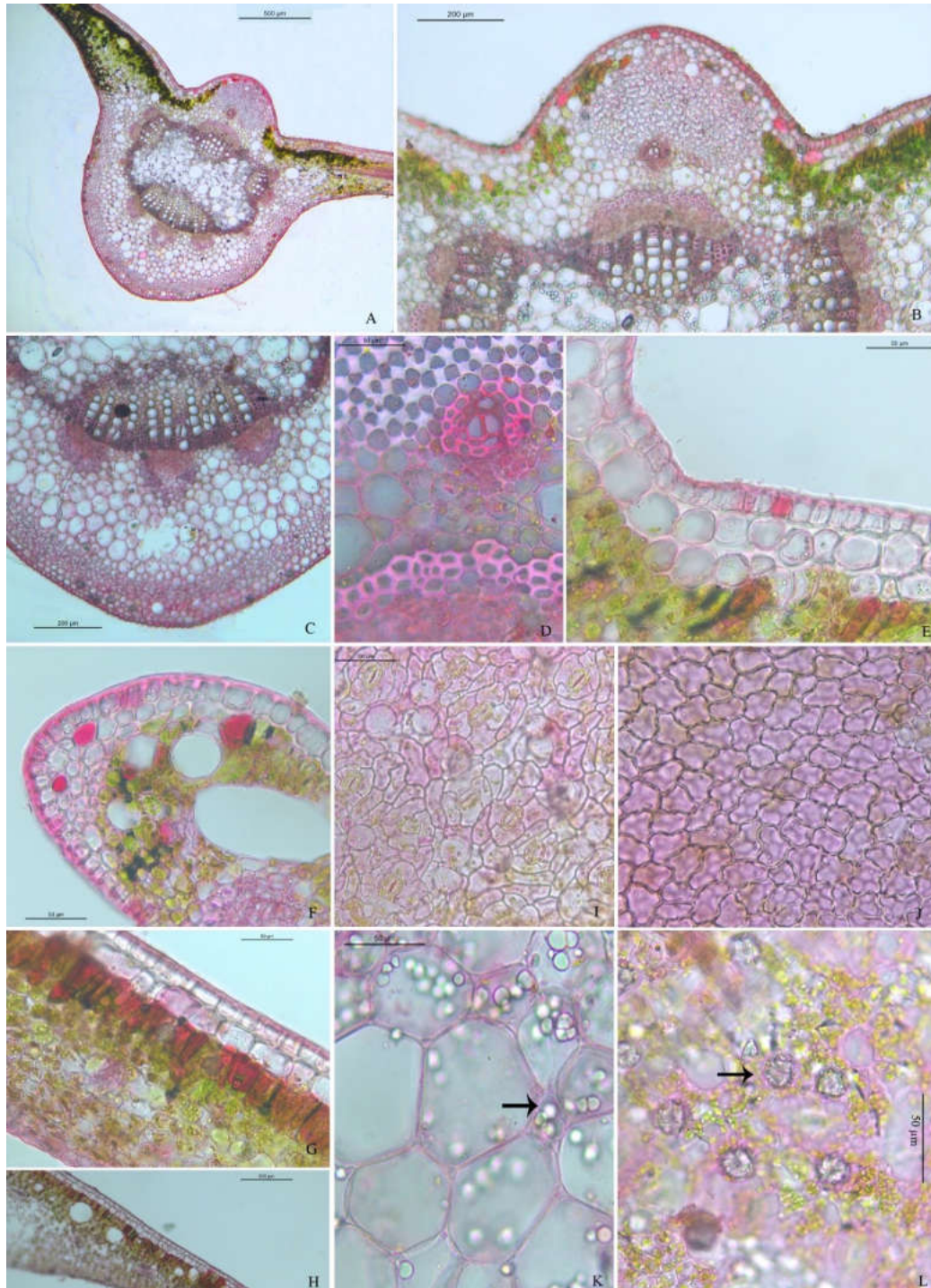


Fig. 119. *Leea grandifolia* Kurz: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Accessory vascular bundle; **E.** Midrib – a portion enlarged showing hypodermis; **F.** Leaf margin; **G.** Lamina; **H.** Lamina showing hypodermis; **I.** Para-dermal section of abaxial surface of leaf; **J.** Para-dermal section of adaxial surface of leaf; **K.** Starch grains; **L.** Druses.

Stomata: Leaves are hypostomatic and dominant type of stomata is anisocytic with anomocytic as subordinate type. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are slightly sinuous on adaxial surfaces and straight to slightly wavy on abaxial surfaces. Stomatal frequency is 16–34 (21.5 ± 1.97) mm². Stomatal length ranges from 21.56–25.79 (23.61 ± 0.48) µm. Stomatal index is 11.11–22.37 (14.89 ± 1.2).

7. *Leea guineensis*

Figs. 120 & 121

Midrib: In cross-section, midrib is 1526.14–2160.18 (1757.99 ± 30.42) × 904.68–1185.93 (1017.48 ± 14.34) µm. Adaxial surface is obconic, slightly dilated below the middle with a keel, and abaxial surface is U-shaped with a keel. Epidermis is single-layered, non-papillate with smooth cuticle. A single parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the abaxial surface are 3–4-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–3-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 191.60–243.19 (221.01 ± 2.44) µm. Druses, raphides and starch grains are present in cortex and pith. Prismatic crystals are seen in the cortex region.

Rachis: In cross-section, rachis is 1765.70–2114.90 (1972.88 ± 20.44) × 1452.79–2353.30 (1676.94 ± 43.82) µm. Adaxial surface is wide U-shaped and abaxial surface is U or V-shaped. Adaxial rachis groove is 233.80–575.29 (350.55 ± 15.39) µm deep without protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 2–3-layered and chlorenchymatous. Below the hypodermis, 3–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous, 659.81–1527.22 (995.69 ± 37.93) µm in thickness. Druses and raphides are present in the cortex and pith.

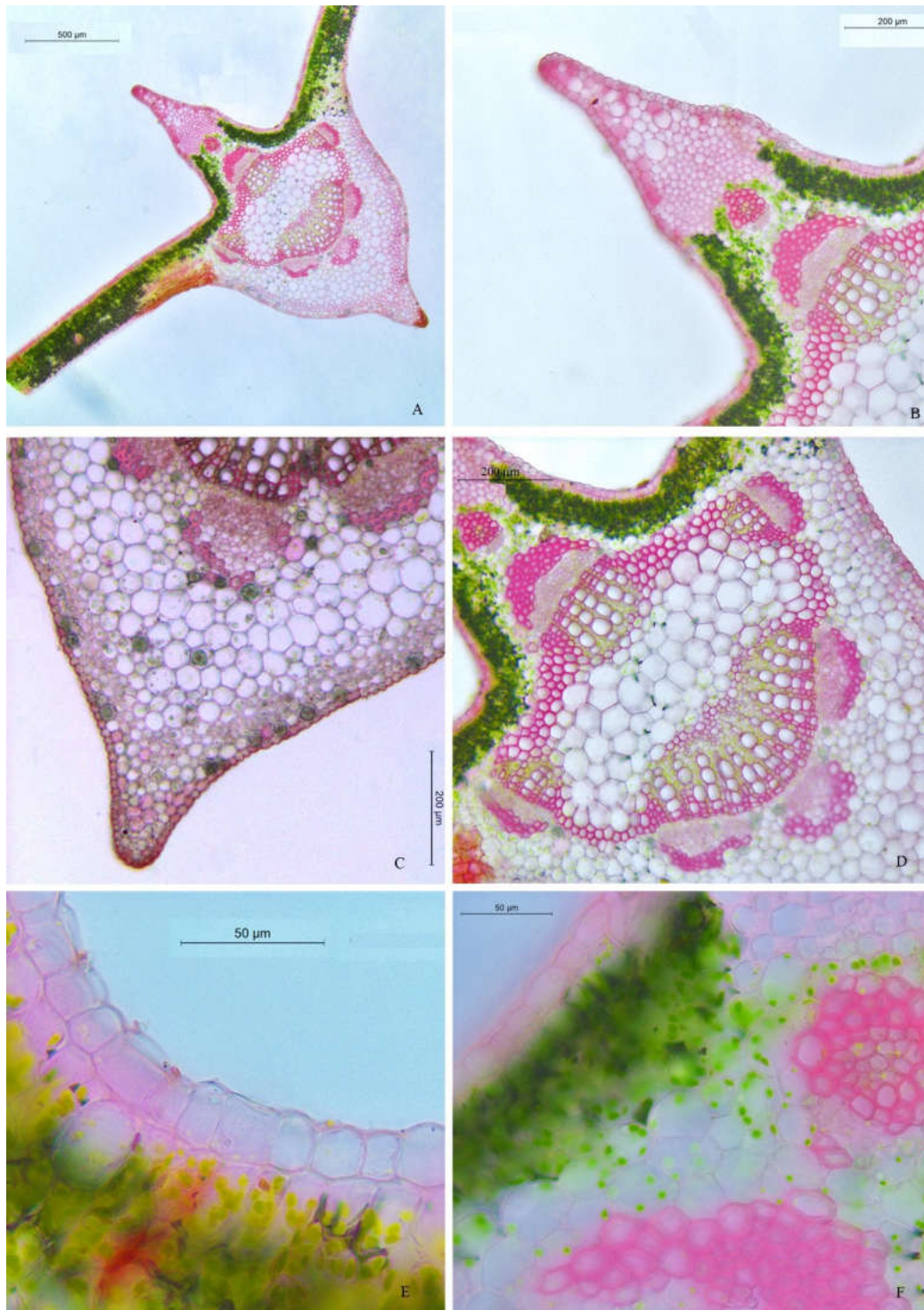


Fig. 120. *Leea guineensis* G.Don: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Midrib – a portion enlarged showing vascular bundles; **E.** Midrib – a portion enlarged showing absence of hypodermis; **F.** Accessory vascular bundle.

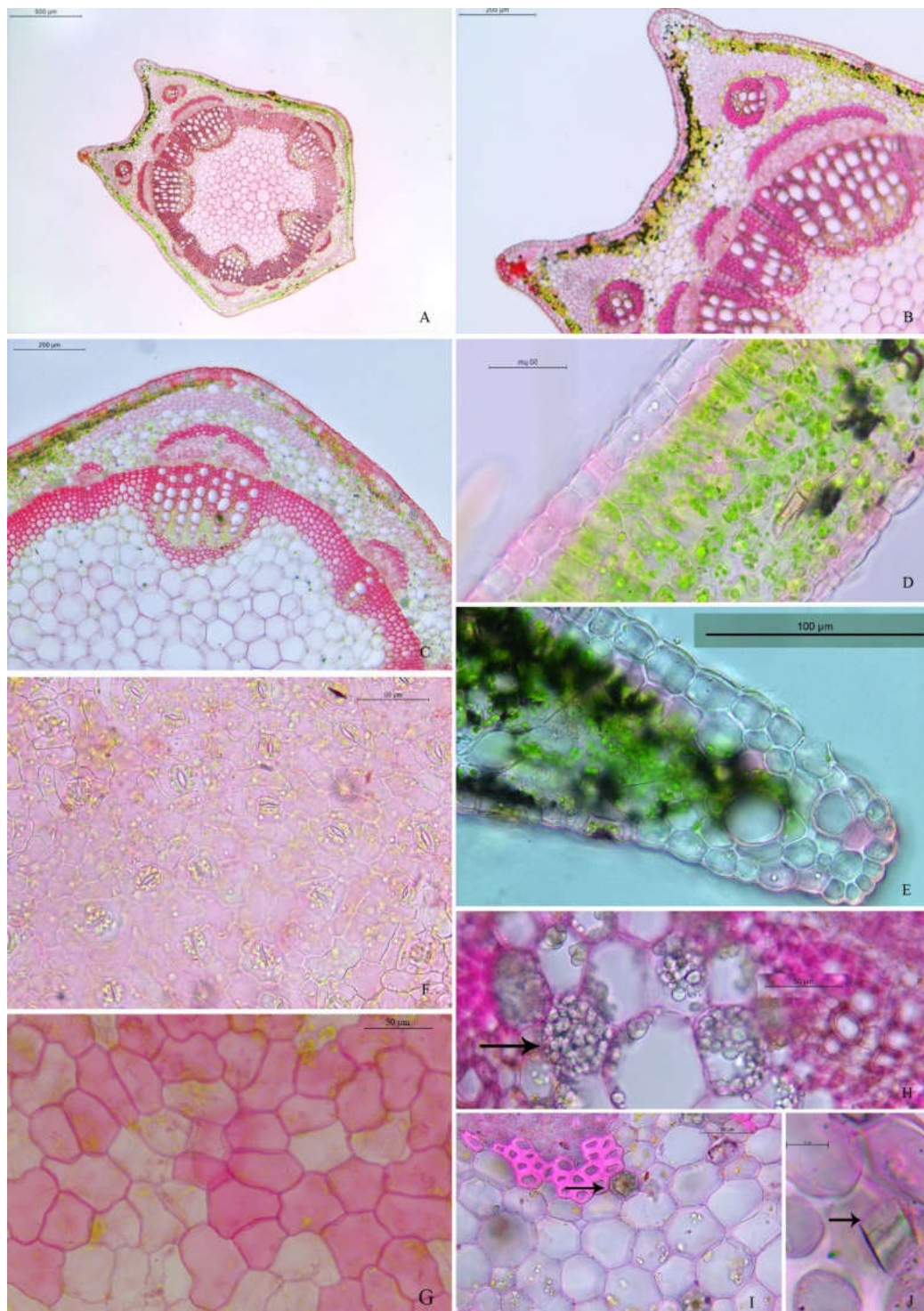


Fig. 121. *Leea guineensis* G.Don: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Starch grains; **I.** Druses; **J.** Prismatic crystals.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 168.42–212.18 (193.87 ± 2.16) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is double-layered, 56.72–82.97 (70.22 ± 1.23) μm thick. Spongy parenchyma is 4–8-layered, compactly arranged without intercellular spaces, 69.92–109.79 (83.35 ± 1.83) μm thick. Druses are distributed in palisade cells. Lamina margin is slightly bent and tapering towards the tip. Mesophyll cells consist of a single layer of palisade and 3–4-layered spongy parenchyma. The hyaline portion consists of 3–4 rows of thin-walled parenchymatous cells.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are polygonal on both abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy both adaxially and abaxially. Stomatal frequency is 14–30 (22.3 ± 1.81) mm^2 . Stomatal length ranges from 17.83–21.75 (19.98 ± 0.39) μm . Stomatal index is 15.38–23.14 (19.21 ± 0.73).

8. *Leea indica*

Figs. 122 & 123

Midrib: In cross-section, midrib is 1329.00–1835.85 (1492.59 ± 25.16) $\times$ 765.53–1268.74 (917.46 ± 21.70) μm . Adaxial surface is convex and abaxial surfaces are V-shaped or U-shaped. Epidermis is single-layered, papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermis is present. Collenchymatous strata on the abaxial surface are 2–4-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are smaller than abaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 2–3-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 248.83–380.64 (292.34 ± 5.9) μm . Druses, raphides and starch grains are distributed in cortex and pith.

Rachis: In cross-section, rachis is $2475.00\text{--}3574.00$ (2929.76 ± 37.68) $\times$ $2269.39\text{--}2919.00$ (2457.29 ± 39.07) μm . Adaxial surface is U-shaped and abaxial surface is wide V or U-shaped. Adaxial rachis groove is $369.21\text{--}581.00$ (468.83 ± 9.27) μm deep without a protrusion. Epidermis is single-layered, papillate, with smooth thick cuticle. Hypodermis is 1-2-layered and chlorenchymatous. Below the hypodermis, 1-2-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and $1317.59\text{--}1618.22$ (1396.47 ± 11.34) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the leaves varies from $169.66\text{--}229.74$ (192.6133 ± 3.04) μm . Epidermis is uniseriate, non-papillate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are round or barrel-shaped. A uniseriate parenchymatous hypodermis is present up to the middle of the leaf. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is mostly 2-layered and single-layered when hypodermis is present, and the thickness ranges between $62.51\text{--}75.23$ (69.06 ± 0.69) μm . Spongy parenchyma is 5-8-layered compactly arranged without intercellular space, $61.89\text{--}92.36$ (74.59 ± 1.29) μm thick. Druses are distributed in some cells of epidermis and mesophyll. Small air cavities rarely noticed in the palisade layer. Starch grains are present in some cells of spongy parenchyma. Lamina margin is very slightly bent towards the tip. The hyaline portion consists 2 rows of thin-walled parenchymatous cells.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy on abaxial surfaces and slightly sinuous on adaxially. Stomatal frequency is 12-27 (18.3 ± 1.60) mm^2 . Stomatal length ranges from $18.78\text{--}22.70$ (21.15 ± 0.3) μm . Stomatal index is $9.09\text{--}22.00$ (15.18 ± 1.08).



Fig. 122. *Leea indica* (Burm.f) Merr.: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Midrib - a portion enlarged showing vascular bundles; **E.** Midrib - a portion enlarged showing absence of hypodermis; **F.** Accessory vascular bundle.

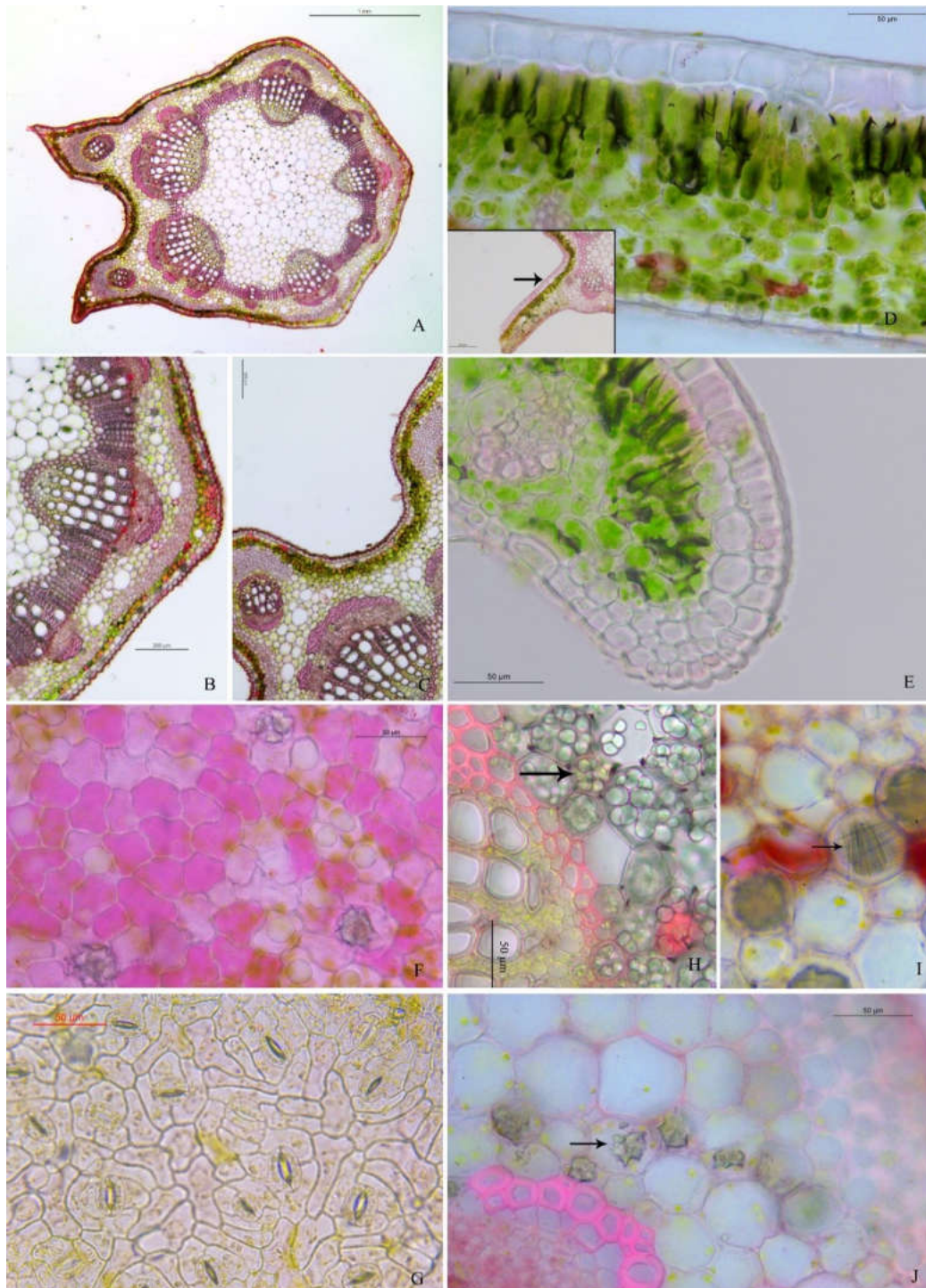


Fig. 123. *Leea indica* (Burm.f.) Merr.: Transverse section of leaf parts: **A.** Rachis; **B.** Abaxial surface of rachis; **C.** Adaxial surface of rachis; **D.** Lamina; **E.** Leaf margin (inset: arrow showing the hypodermis); **F.** Para-dermal section of adaxial surface of leaf; **G.** Para-dermal section of abaxial surface of leaf; **H.** Starch grains; **I.** Raphides; **J.** Druses.

9. *Leea latifolia***Fig. 124**

Midrib: In cross-section, midrib is 2123.27–2633.42 (2317.28 ± 34.44) $\times$ 1716.12–2018.00 (1882.62 ± 22.90) μm . Adaxial surface is convex and abaxial surface is U-shaped with a keel. Epidermis is single-layered, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the abaxial surface are 3–5-layered. The vascular system is represented by collateral vascular bundles consisting of six bundles arranged in a ring. Lateral bundles are smaller than the adaxial bundles. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles 1–3 layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 550.31–887.14 (751.84 ± 28.16) μm . Druses and starch grains are distributed in pith and cortex.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 141.12–168.15 (152.89 ± 1.46) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisades usually single-layered and 32.38–52.32 (41.05 ± 2.51) μm thick. Spongy parenchyma 6–7-layered, compactly arranged without intercellular spaces, 61.12–86.43 (75.00 ± 1.18) μm thick. Druses seen in mesophyll region. Lamina margin is slightly tapering towards the tip. The hyaline portion consists of 2 layered thin-walled parenchymatous cells.

Stomata: Leaves are amphistomatic and show anisocytic stomata mostly. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are straight to slightly wavy on abaxial surfaces and straight on adaxial surface. Stomatal frequency is 19–25 (22.40 ± 0.63) mm^2 . Stomatal length ranges from 18.13–23.12 (19.69 ± 0.47) μm . Stomatal index is 24.17–30.12 (27.48 ± 0.50).

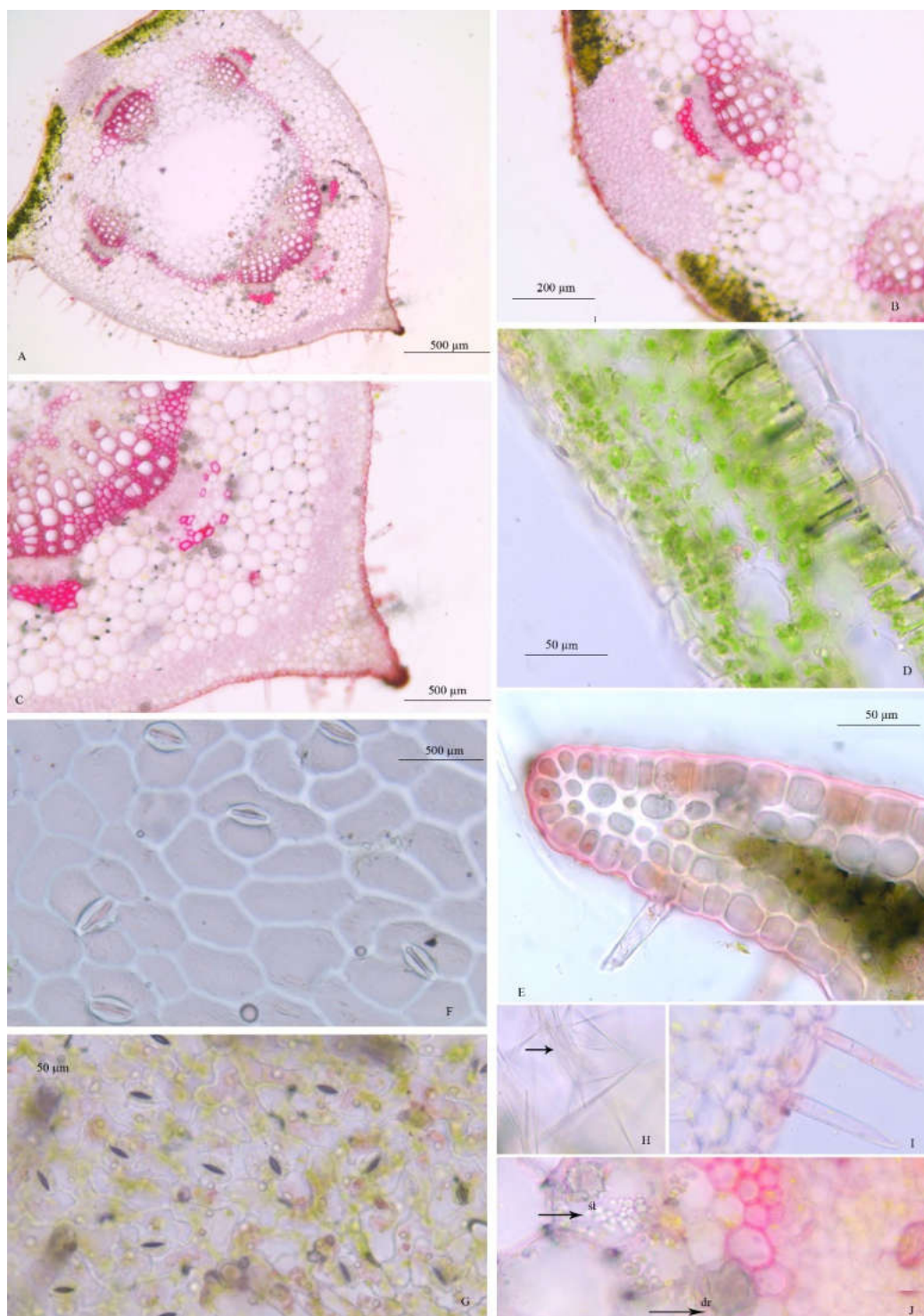


Fig. 124. *Leea latifolia* Wall. ex Kurz: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of adaxial surface of leaf; **G.** Para-dermal section of abaxial surface of leaf; **H.** Raphides; **I.** Trichome; **J.** Druses.

10. *Leea macrophylla***Fig. 125**

Midrib: In cross-section, midrib is 5580.23–6409.11 (6069.09±42.79) × 3144.06–3694.23 (3465.68±22.62) µm. Adaxial surface is convex and abaxial surface is U-shaped with a keel. Epidermis is uniseriate, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is present. Collenchymatous strata on the adaxial surfaces are 4–6-layered. The vascular system is represented by collateral vascular bundle consisting of more than six bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles are 5–6-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 2432.20–3840.11 (3318.04±68.88) µm. Druses are present.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 163.86–247.00 (191.46±4.29) µm. Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is 2-layered, 62.90–89.68 (73.72±1.57) µm thick. Spongy parenchyma 5–8-layered compactly arranged without intercellular spaces, 79.05–119.95 (98.28±1.69) µm thick. Druses are distributed in some cells. Lamina margin is tapering and bent towards the tip. The hyaline portion consists of 4-layered thin-walled parenchymatous cells.

Trichomes: This species exhibits single and two celled trichomes. In two-celled trichomes, the basal cell is shorter and the upper cell is longer. They can be seen in midrib and lamina.

Stomata: Leaves are amphistomatic and show anisocytic stomata. Epidermal cells are polygonal on abaxial and adaxial surfaces. Anticlinal walls are straight both adaxially and abaxially. Stomatal frequency is 28–41 (36.6±1.14) mm². Stomatal length ranges from 18.01–25.45 (21.00±0.70) µm. Stomatal index is 28.04–50.61 (36.08±2.19).

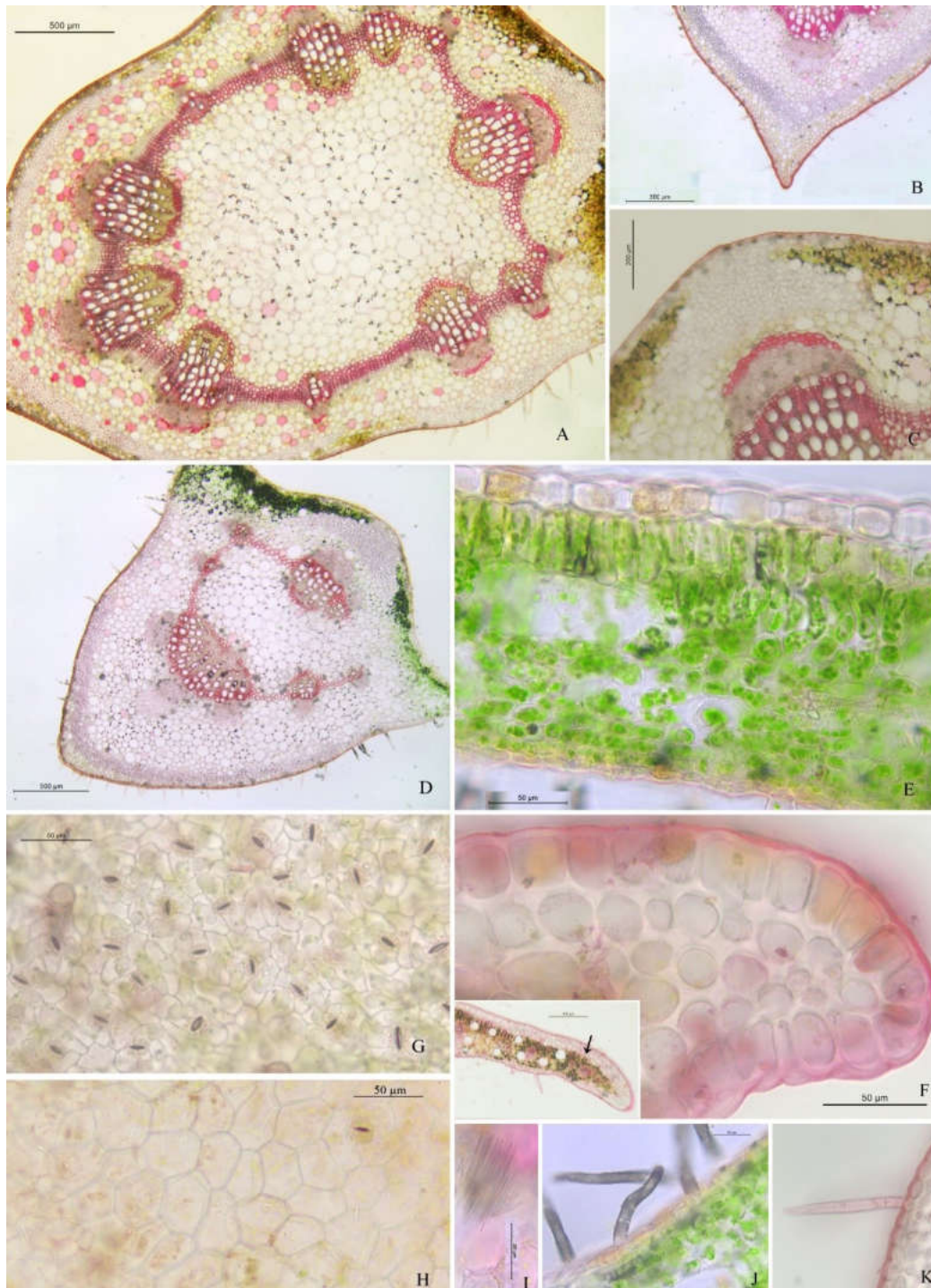


Fig. 125. *Leea macrophylla* Roxb. ex Hornem.: Transverse section of leaf parts: **A**. Midrib; **B**. Abaxial surface of midrib; **C**. Adaxial surface of Midrib; **D**. Secondary vein; **E**. Lamina; **F**. Leaf margin (inset: arrow showing the hypodermis); **G**. Para-dermal section of abaxial surface of leaf; **H**. Para-dermal section of adaxial surface of leaf; **I**. Raphides; **J & K**. Trichomes.

11. *Leea mizoramensis***Figs. 126 & 127**

Midrib: In cross-section, midrib is 1633.82–2053.63 (1823.05 ± 23.73) $\times$ 741.05–991.37 (921.58 ± 10.54) μm . Adaxial surfaces are obconic, dilated below the middle and tapering towards the apex and abaxial surfaces are U-shaped with a keel. Epidermis is single-layered, papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermis is absent. Collenchymatous strata on the abaxial surface are 2–3-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles are 1–2-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 345.16–591.27 (454.82 ± 9.45) μm . Druses are distributed in pith and cortex. Cells of cortex show the presence of starch grains.

Rachis: In cross-section, rachis is 2310.35–2993.73 (2581.73 ± 34.14) $\times$ 2067.19–2912.50 (2314.12 ± 43.50) μm . Adaxial surface is U-shaped and abaxial surface is V-shaped with a keel. Adaxial rachis groove is 554.10–863.27 (642.99 ± 17.15) μm deep without protrusion. Epidermis is single-layered, papillate with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 1–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with many small bundles arranged in a ring. Pith is parenchymatous and 1101.99–1359.59 (1213.79 ± 13.17) μm in thickness. Druses and raphides are dispersed in the ground parenchyma.

Lamina: Leaves dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 78.95–113.27 (98.69 ± 2.08) μm . Epidermis is uniseriate, papillate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are round or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, 23.10–39.98 (29.79 ± 0.93) μm thick. Spongy parenchyma is 3–4-layered, compactly arranged without intercellular space, 34.45–56.63 (44.31 ± 1.19) μm thick. Druses and raphides are distributed in palisade cells. Lamina margin is slightly bent towards the tip. Mesophyll cells consist of single layer of palisade and 1–3-layered spongy parenchyma. The hyaline portion is absent.

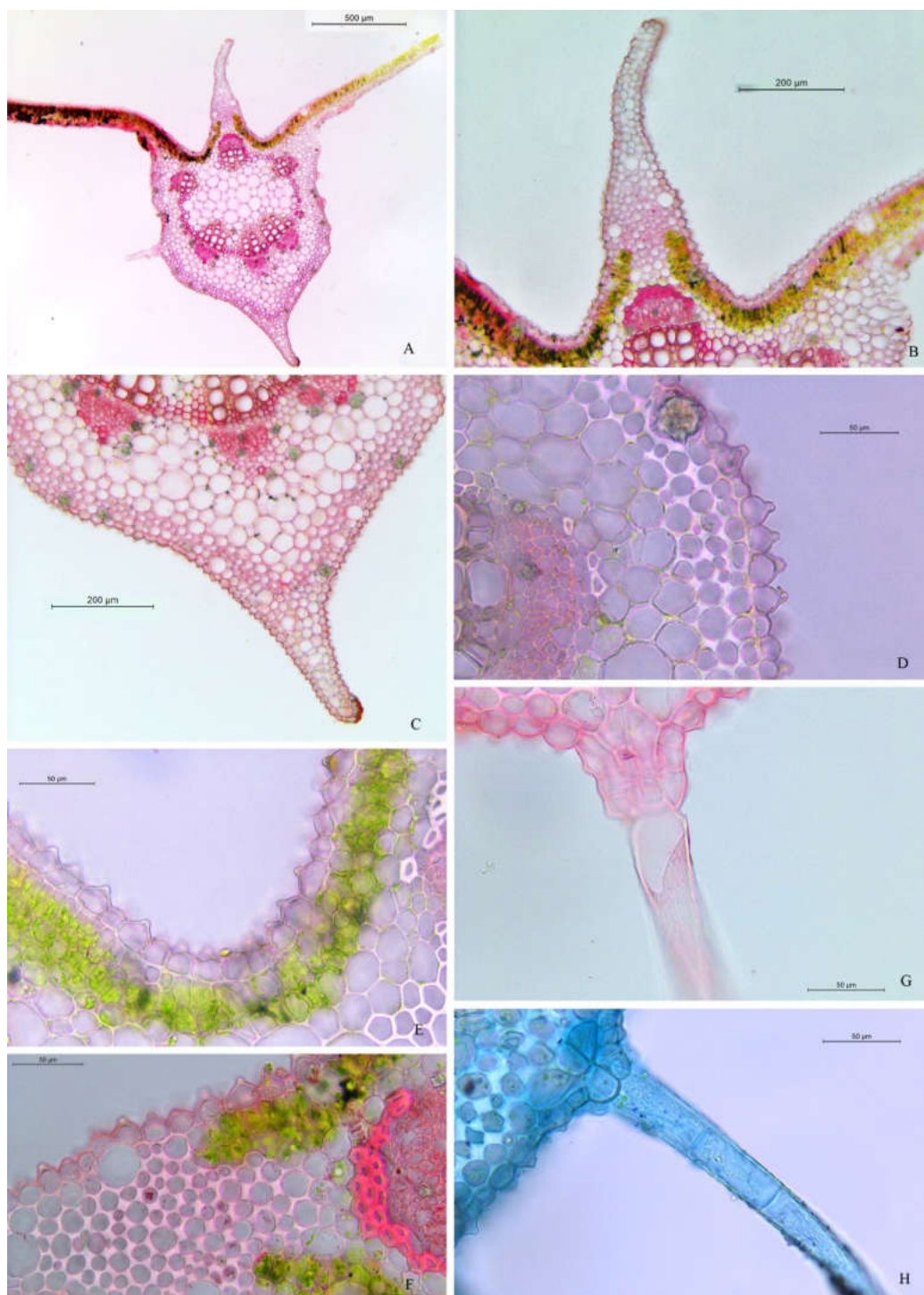


Fig. 126. *Leea mizoramensis* Amrutha & Pradeep: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Papillate epidermis; **E.** Midrib - a portion enlarged showing absence of hypodermis; **F.** Abaxial surface - a portion enlarged showing the absence of accessory vascular bundle; **G.** Unicellular trichomes; **H.** Multicellular trichomes.

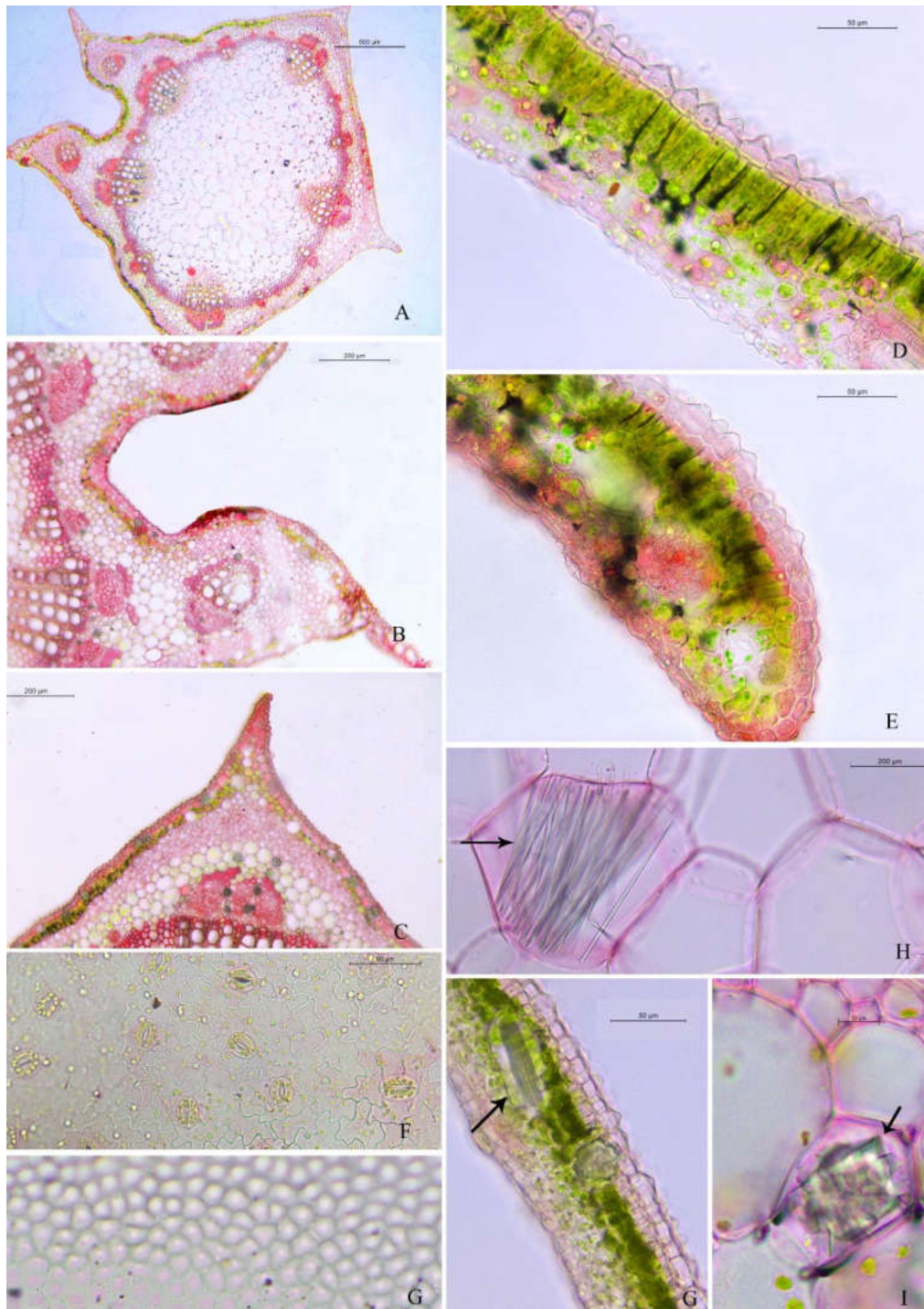


Fig. 127. *Leea mizoramensis* Amrutha & Pradeep: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Raphides; **I.** Druses.

Trichomes: This species shows non-glandular unicellular and multicellular trichomes, distributed in midrib and lamina. All the trichomes have multicellular bases and pointed ends.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are irregular on abaxial surfaces and polygonal on adaxial surface. Anticlinal walls are strongly sinuate abaxially and straight to slightly wavy adaxially. Stomatal frequency is 12–20 (16.7 ± 0.68) mm². Stomatal length ranges from 19.69–24.16 (21.85 ± 0.5) μ m. Stomatal index is 12.50–24.69 (18.42 ± 0.98).

12. *Leea robusta*

Figs. 128 & 129

Midrib: In cross-section, midrib is 1424.75–2109.84 (1629.00 ± 31.98) $\times$ 803.74–1389.93 (957.09 ± 28.09) μ m. Adaxial surface is convex and abaxial surfaces are U-shaped. Epidermis is uniseriate, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the adaxial surfaces are 2–3-layered. The vascular system is represented by collateral vascular bundle consisting of six- bundles arranged in a ring. Lateral bundles are smaller than adaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–2-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 176.23–470.14 (253.55 ± 14.91) μ m. Druses, starch grains and raphides are distributed in pith.

Rachis: In cross-section, rachis is 2146.76–2570.21 (2364.30 ± 21.67) $\times$ 1665.82–1987.72 (1863.97 ± 15.72) μ m. Adaxial surface is wide U-shaped with a small projection and abaxial surface is wide V-shaped. Adaxial rachis groove is 447.66–700.32 (578.12 ± 13.75) μ m deep with a small protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 3–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 727.64–1101.69 (944.63 ± 20.26) μ m in thickness. Druses and raphides are dispersed in the ground parenchyma.

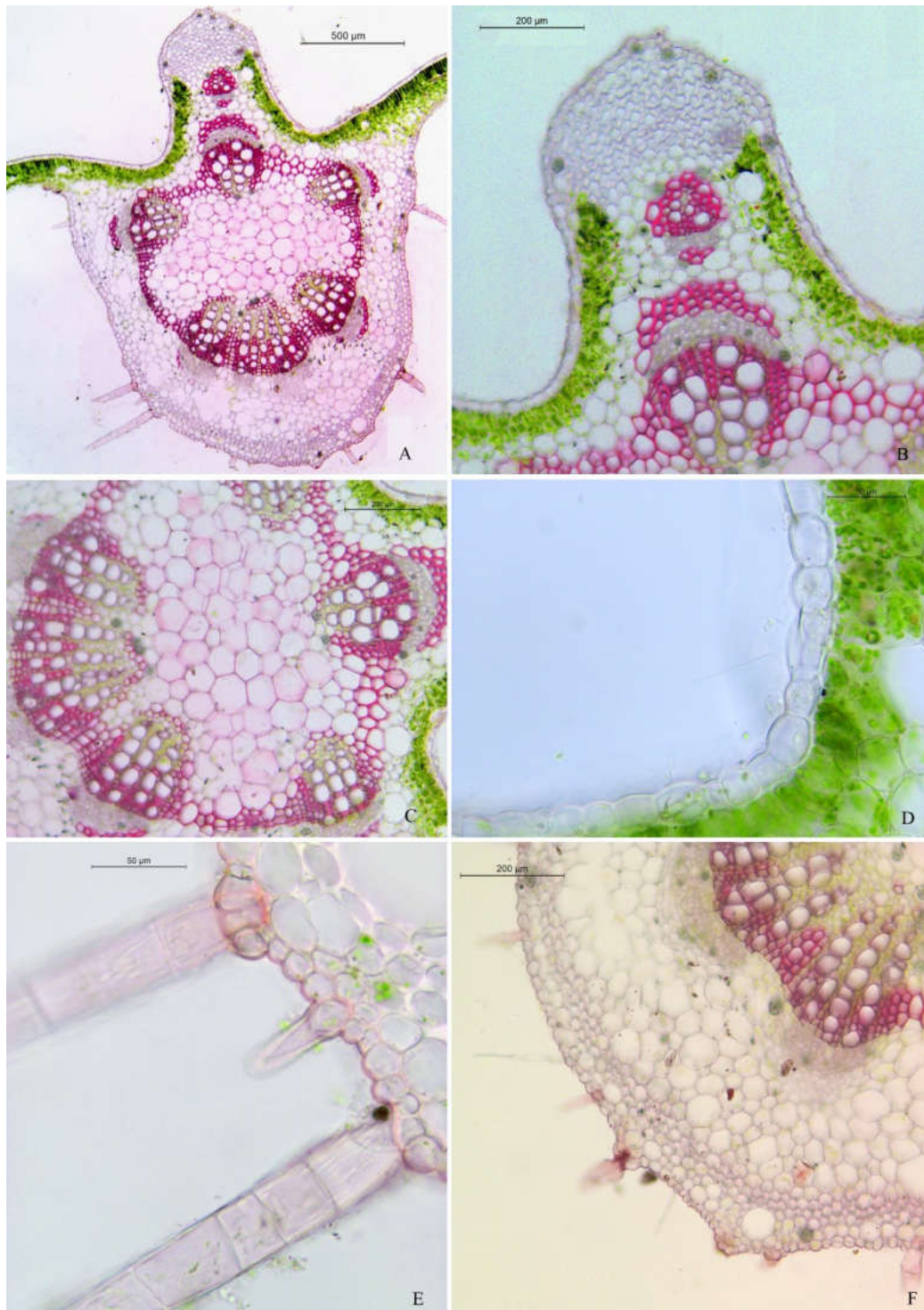


Fig. 128. *Leea robusta* Roxb.: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of the midrib; **C.** Midrib - a portion enlarged showing vascular bundles; **D.** Midrib - a portion enlarged showing absence of hypodermis; **E.** Unicellular and multicellular trichomes; **F.** Abaxial surface of midrib.

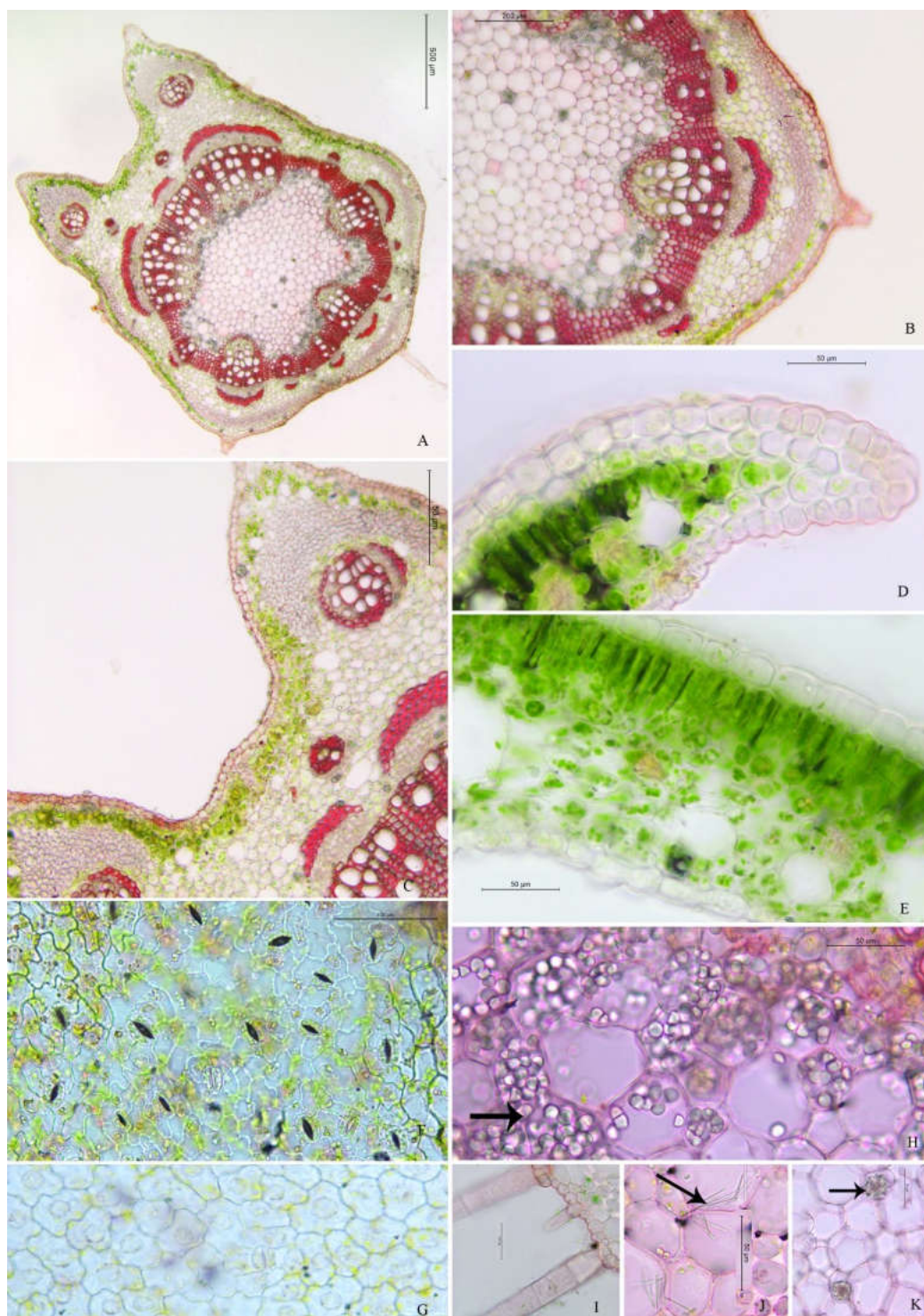


Fig. 129. *Leea robusta* Roxb.: Transverse section of leaf parts: **A.** Rachis; **B.** Abaxial surface of rachis; **C.** Adaxial surface of rachis; **D.** Leaf margin; **E.** Lamina; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Starch grains; **I.** Trichome; **J.** Raphides; **K.** Druses.

Lamina: Leaves dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 135.44–211.39 (160.48 ± 2.95) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are elongated and tubular. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, 32.77–78.20 (55.71 ± 1.99) μm thick. Spongy parenchyma is 4–7-layered, compactly arranged without intercellular space, 54.53–106.40 (68.82 ± 2.18) μm thick. Druses are distributed in palisade cells. Small air cavities occur in the palisade layer. Lamina margin is tapering and sharply bent towards the tip. Mesophyll cells consist of a single layer of palisade and 2–3-layered spongy parenchyma. The hyaline portion consist of three-layered thin-walled parenchymatous cells.

Trichomes: This species shows non-glandular single and multicellular trichomes with pointed end. Trichomes are with or without a multicellular base. It is present on rachis, midrib and lamina.

Stomata: Leaves are amphistomatic and show dominantly anisocytic stomata and rarely anomocytic stomata. The number of stomata is more on the abaxial surfaces than the adaxial. Epidermal cells are irregular on the abaxial surfaces and abaxial surfaces. Anticlinal walls are strongly sinuate on abaxial surfaces and slightly sinuate on adaxial surfaces. Stomatal frequency is 12–16 (18.2 ± 1.4) mm^2 . Stomatal length ranges from 19.69–24.16 (21.85 ± 0.50) μm . Stomatal index is 12.12–27.36 (19.51 ± 1.3).

13. *Leea setuligera*

Fig. 130

Midrib: In cross-section, midrib is 1366.17–1678.42 (1518.39 ± 13.75) $\times$ 712.52–933.21 (783.79 ± 8.06) μm . Adaxial surface is lanceolate and abaxial surface is wide V-shaped with a keel. Epidermis is uniseriate, non-papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the adaxial surfaces are 1–2-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles and abaxial bundle is almost equal sized. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles are single-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 191.27–239.12 (214.92 ± 2.43) μm . Druses are distributed in pith and cortex.

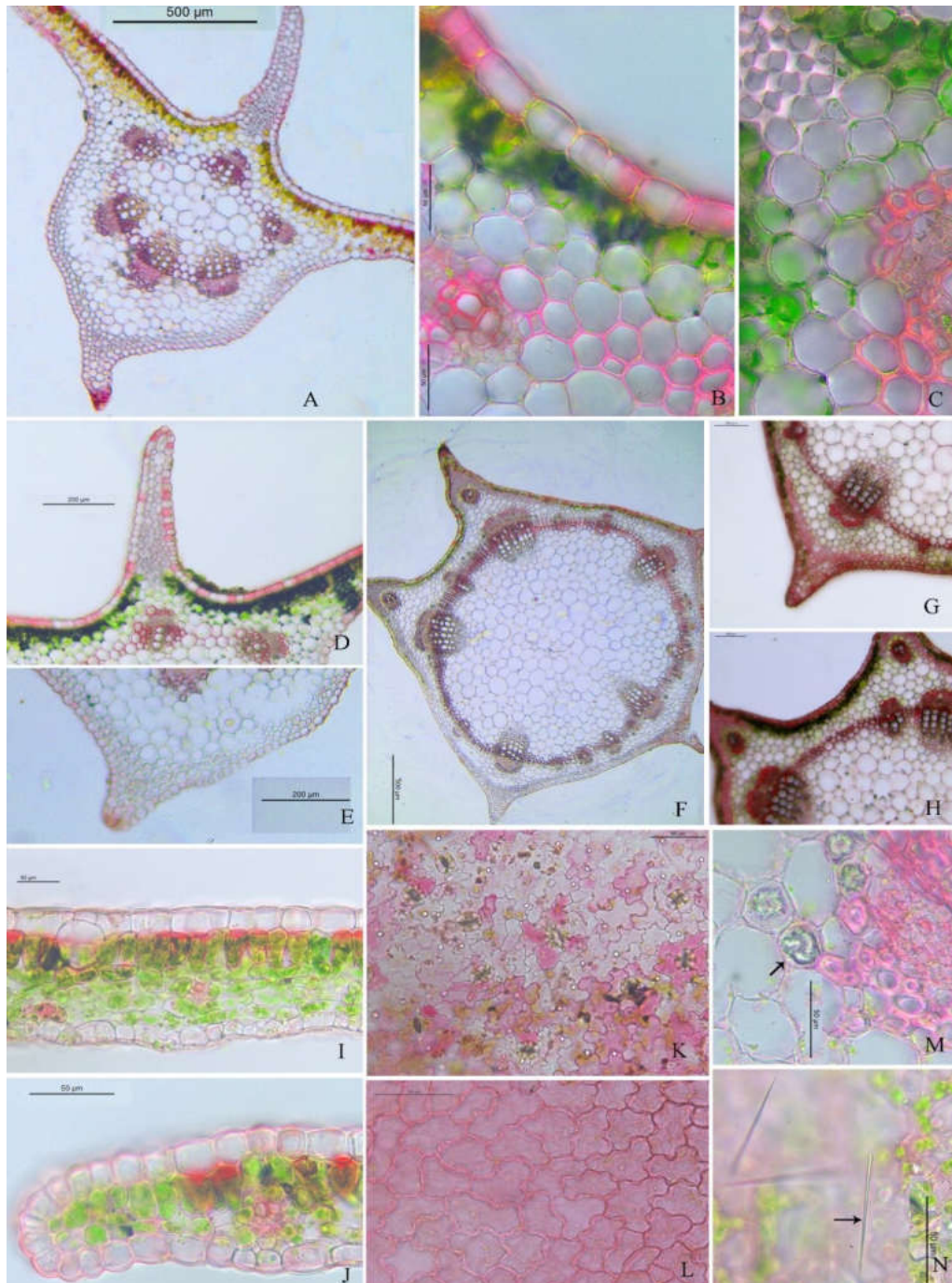


Fig. 130. *Leea setuligera* C.B.Clarke: Transverse section of leaf parts: **A.** Midrib; **B.** Midrib - a portion enlarged showing epidermal cells; **B.** Midrib - a portion enlarged showing absence of hypodermis; **C.** Abaxial surface - a portion enlarged showing the absence of accessory vascular bundle; **D.** Adaxial surface of midrib; **E.** Abaxial surface of midrib; **F.** Rachis; **G.** Abaxial surface of rachis; **H.** Adaxial surface of rachis; **I.** Lamina; **J.** Leaf margin; **K.** Para-dermal section of abaxial surface of leaf; **L.** Para-dermal section of adaxial surface of leaf; **M.** Druses; **N.** Raphides.

Rachis: In cross-section rachis, is $2543.00\text{--}3145.14$ (1518.39 ± 13.75) $\times$ $2113.00\text{--}3913.09$ (2582.46 ± 34.59) μm . Adaxial surface is wide U-shaped and abaxial surface is U-shaped with a keel. Adaxial rachis groove is $619.49\text{--}1002.49$ (740.63 ± 81.83) μm and without protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is Single-layered and chlorenchymatous. Below the hypodermis, 1–2-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with many small bundles arranged in a ring. Pith is parenchymatous and $1238.28\text{--}1601.77$ (1474.79 ± 18.07) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from $94.83\text{--}146.88$ (119.30 ± 2.18) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, $24.05\text{--}38.78$ (30.71 ± 0.53) μm thick. Spongy parenchyma is 2–4-layered, compactly arranged without intercellular space, $30.13\text{--}69.66$ (47.09 ± 2.09) μm thick. Druses are distributed in palisade cells. Lamina margin is straight or very slightly bent and tapering towards the tip. The hyaline portion is absent.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are irregular on abaxial surfaces and adaxial surfaces. Anticlinal walls are strongly sinuate both adaxially and abaxially. Stomatal frequency is 6–14 (9.3 ± 0.73) mm^2 . Stomatal length ranges from $21.63\text{--}27.07$ (24.83 ± 0.47) μm . Stomatal index is $8.57\text{--}24.56$ (16.44 ± 1.53).

14. *Leea sundaica*

Figs. 131 & 132

Midrib: In cross-section, midrib is $1450.82\text{--}1717.33$ (1578.48 ± 14.83) $\times$ $917.91\text{--}1194.77$ (987.25 ± 13.74) μm . Adaxial surface is acute and abaxial surface is V-shaped. Epidermis is uniseriate, papillate with smooth cuticle. A parenchymatous adaxial hypodermal layer is present. Collenchymatous strata on the abaxial surfaces are 2–3-layered. The vascular system is represented by collateral vascular bundle

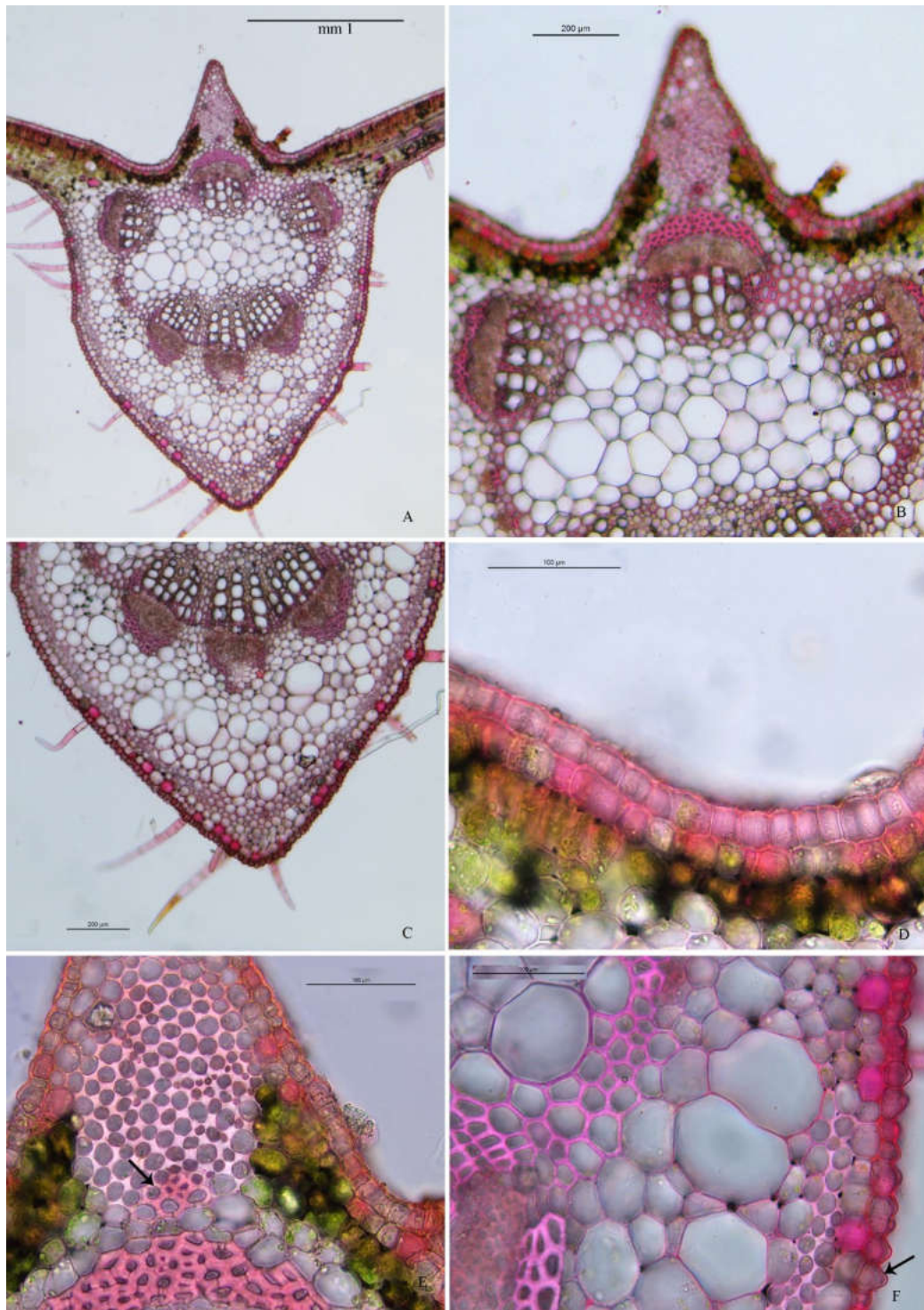


Fig. 131. *Leea sundaica* Miq.: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Midrib - a portion enlarged showing the hypodermis; **E.** Accessory vascular bundle; **F.** Papillate epidermis.

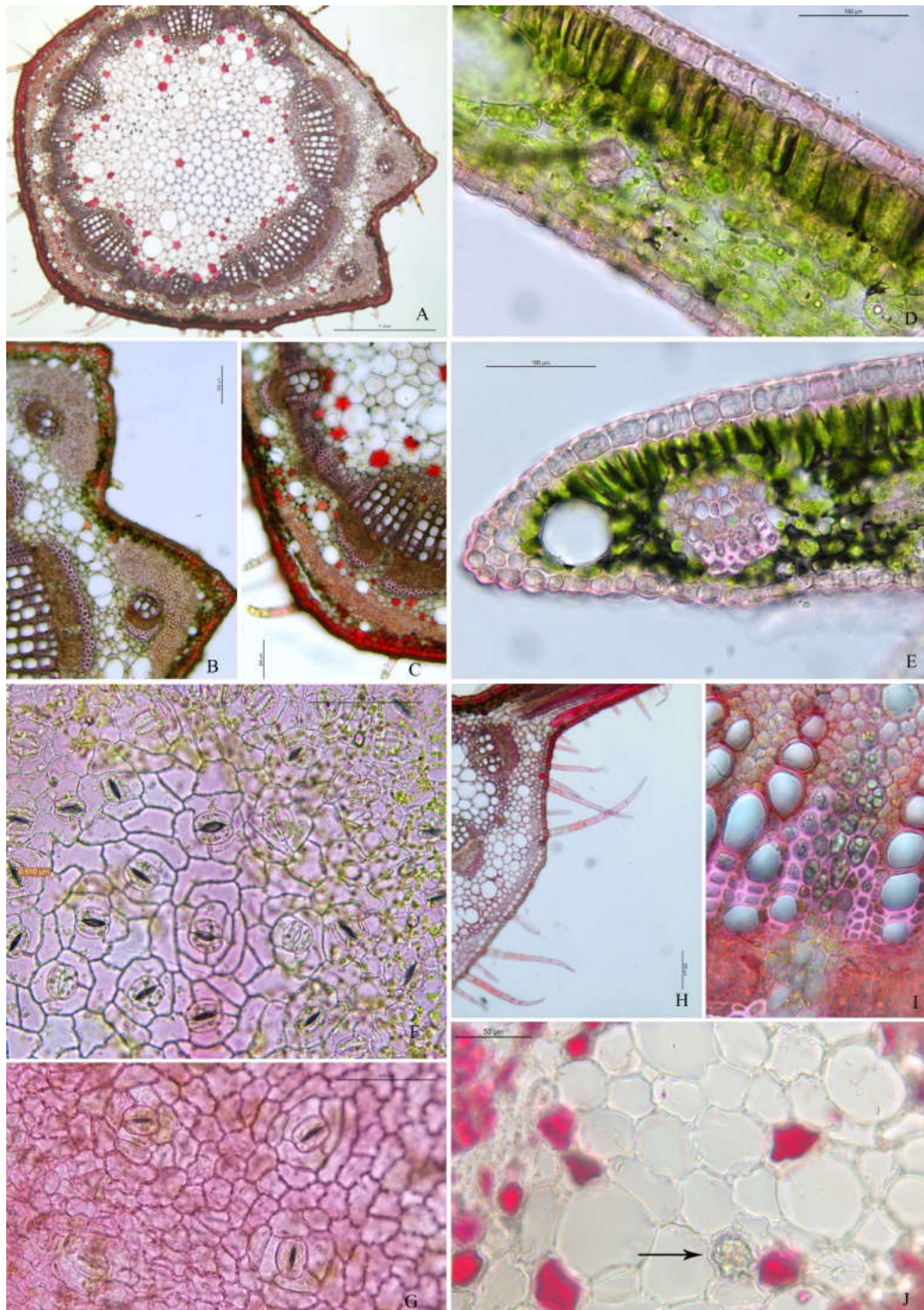


Fig. 132. *Leea sundaica* Miq.: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Trichomes; **I.** Starch grains; **J.** Druses.

consisting of six bundles arranged in a ring. Lateral bundles and adaxial bundle are equal sized. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 2–3-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness of the parenchymatous pith is 217.00–331.99 (295.76±5.83) μm . Druses and starch grains are distributed.

Rachis: In cross-section, rachis is 2672.12–3115.78 (2885.50±18.19) $\times$ 2146.46–2626.33 (2349.79±26.44) μm . Adaxial surface is wide V-shaped and abaxial surface is wide U-shaped. Adaxial rachis groove is 279.90–445.96 (370.82±7.58) μm deep without any protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 3–5-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 1361.34–1738.09 (1527.85±14.66) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 131.04–216.77 (161.55±3.66) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, 30.18–48.49 (39.21±0.79) μm thick. Spongy parenchyma is 5–7-layered, compactly arranged without intercellular space, 62.29–118.85 (82.58±3.01) μm thick. Druses are seen in mesophyll region. Lamina margin is straight and tapering towards the tip. The hyaline portion consists of 2 layers of thin-walled parenchymatous cells.

Trichomes: This species exhibits non-glandular single and multicellular trichomes. Single-celled trichomes are rare; however, multicellular trichomes occur frequently. The trichome has up to 12 cells, which are scattered throughout the rachis, midrib and lamina.

Stomata: Leaves are amphistomatic and show anisocytic stomata. Number of stomata is more on abaxial surfaces than the adaxial surfaces. Epidermal cells are polygonal on both abaxial and adaxial surfaces. Anticlinal walls are straight to

slightly wavy on abaxial surfaces and slightly sinuous on adaxial surfaces. Stomatal frequency is 17–27 (21.9 ± 1.00) mm^2 . Stomatal length ranges from 18.97–23.26 (21.35 ± 0.39) μm . Stomatal index is 12.16–22.68 (15.81 ± 0.99).

15. *Leea trifoliata*

Figs. 133 & 134

Midrib: In cross-section, midrib is 1206.00–1450.21 (1334.96 ± 13.54) $\times$ 700.02–899.86 (821.86 ± 10.93) μm . Adaxial surface is lanceolate and abaxial surface is wide V-shaped with a keel. Epidermis is single-layered, non-papillate with smooth cuticle. Parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the abaxial surface are 1–2-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are slightly smaller than adaxial bundle. Accessory vascular bundle is absent. Sclerenchymatous strata connecting the entire vascular bundles absent. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 100.00–164.192 (124.46 ± 2.99) μm . Druses, raphides and starch grains are present.

Rachis: In cross-section, rachis is 2400.12–2765.21 (2558.30 ± 35.25) $\times$ 1170.20–1865.00 (1809.80 ± 8.62) μm . Adaxial surface is U-shaped and abaxial surface is U-shaped with a keel. Adaxial rachis groove is 638.00–1162.12 (815.90 ± 45.51) μm deep and without protrusion. Epidermis is single-layered with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 3–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 prominent large bundles with small bundles arranged in a ring. Pith is parenchymatous and 846.00–1163.73 (948.05 ± 28.98) μm in thickness. Druses are dispersed in the ground parenchyma.

Lamina: Leaves are dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 91.23–134.24 (113.24 ± 1.98) μm . Epidermis is uniseriate with smooth cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are rectangular or barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered and 23.00–37.08 (29.67 ± 0.58) μm thick. Spongy parenchyma is 4–5-layered, compactly arranged without intercellular spaces, 35.22–82.00 (54.61 ± 2.30) μm thick. Druses and raphides are distributed in lamina. Lamina margin is slightly tapering towards the tip. The hyaline portion consist of 1-layered thin-walled parenchymatous cells.

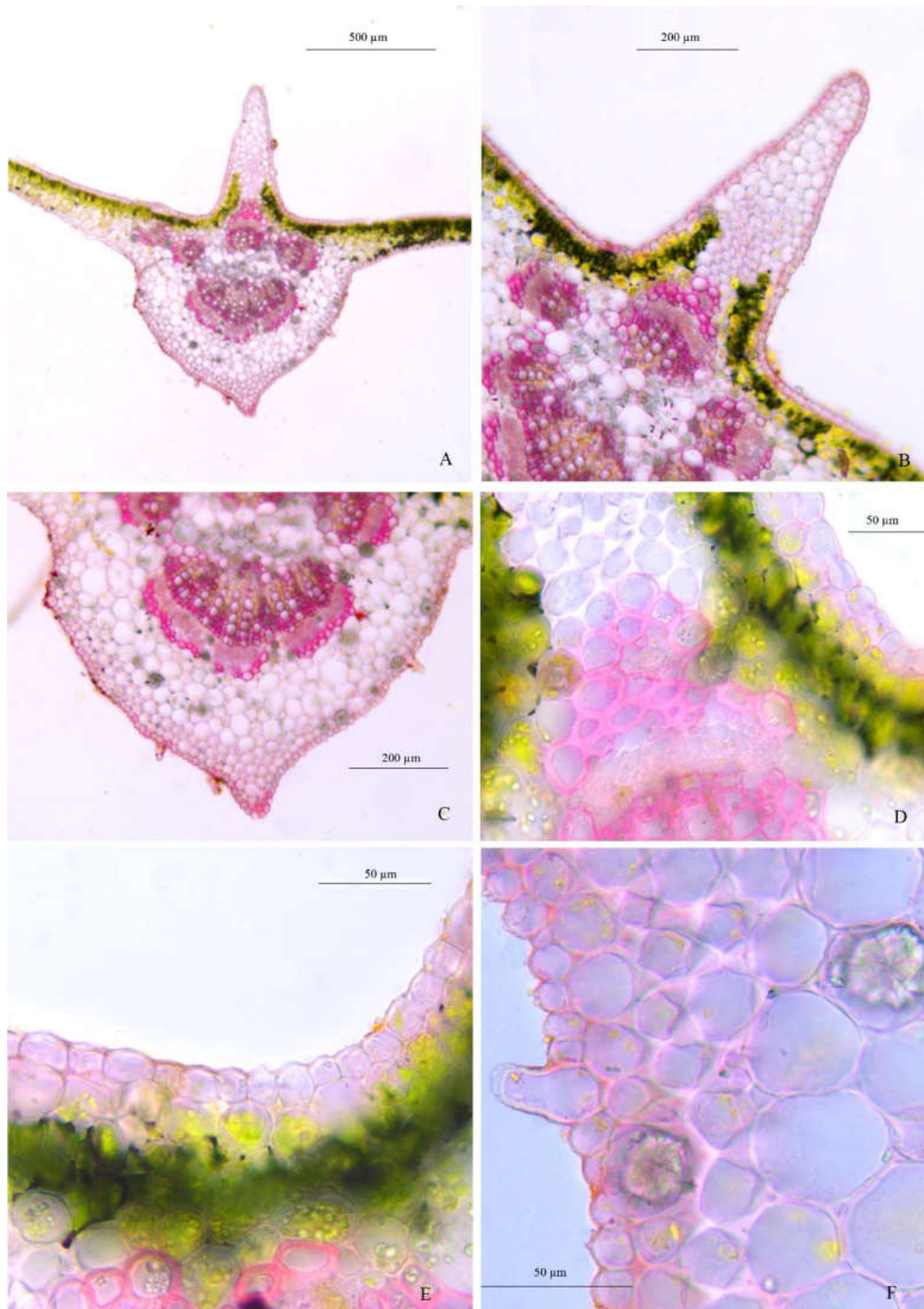


Fig. 133. *Leea trifoliata* M.A.Lawson: Transverse section of leaf parts: **A.** Midrib; **B.** Adaxial surface of midrib; **C.** Abaxial surface of midrib; **D.** Adaxial surface – a portion enlarged showing the absence of accessory vascular bundle; **E.** Midrib – a portion enlarged showing absence of hypodermis; **F.** Unicellular trichomes.

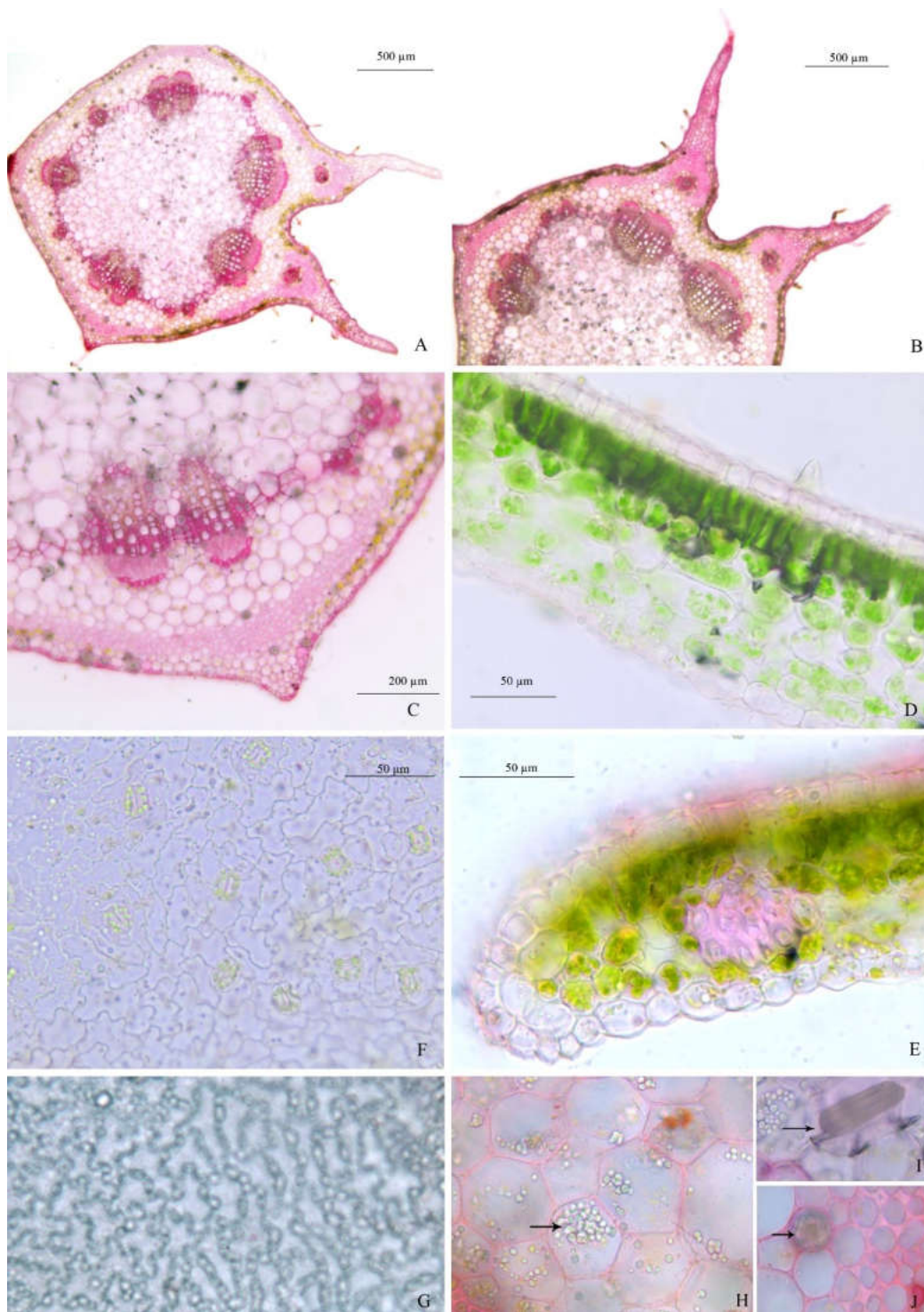


Fig. 134. *Leea trifoliata* M.A.Lawson: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Starch grains; **I.** Raphide; **J.** Druses.

Trichomes: The leaf part of this species has non-glandular multicellular trichomes with pointed ends. The number of cells in the trichomes varies from 1–4, and they are distributed in the midrib, rachis and lamina.

Stomata: Leaves are hypostomatic and show anomocytic stomata. Epidermal cells are irregular on both abaxial and adaxial surfaces. Anticlinal walls are strongly sinuate both adaxially and abaxially. Stomatal frequency is 9–17 (13.80 ± 0.42) mm². Stomatal length ranges from 17.25–21.25 (19.38 ± 0.44) μ m. Stomatal index is 10.71–19.76 (16.08 ± 0.71).

16. *Leea tamdilensis*

Figs. 135 & 136

Midrib: In cross-section, midrib is 1905.40–2199.47 (2065.07 ± 14.18) $\times$ 900.59–1127.41 (1004.41 ± 11.55) μ m. Adaxial surface is slightly dilated below the middle and with a keel and abaxial surface is U-shaped with a keel. Epidermis is single-layered, papillate with smooth cuticle. A single-layered parenchymatous adaxial hypodermal layer is absent. Collenchymatous strata on the abaxial surfaces are 2–3-layered. The vascular system is represented by collateral vascular bundle consisting of six bundles arranged in a ring. Lateral bundles are smaller than the abaxial bundle. Accessory vascular bundle is present. Sclerenchymatous strata connecting the entire vascular bundles are 1–2-layered. The pith is parenchymatous. The cells are circular or polygonal arranged without intercellular spaces and the thickness is 312.52–424.77 (382.09 ± 6.99) μ m. Druses are distributed in pith and cortex. Parenchyma cells of cortex show the presence of starch grains.

Rachis: In cross-section, rachis is 2657.60–3035.76 (2889.72 ± 16.18) $\times$ 2190.90–2389.59 (2305.20 ± 7.60) μ m. Adaxial surface is U-shaped and abaxial surface is V-shaped. Adaxial rachis groove is 722.65–867.34 (809.52 ± 7.23) μ m deep and without protrusion. Epidermis is single-layered, papillate with smooth cuticle. Hypodermis is 1–2-layered and chlorenchymatous. Below the hypodermis, 2–4-layered collenchymatous strata are present. Vascular bundles are collateral, 5 large prominent bundles with small bundles arranged in a ring. Pith is parenchymatous and 1253.11–1424.90 (1357.46 ± 9.09) μ m thick. Druses, starch grains and raphides are dispersed in the ground parenchyma.

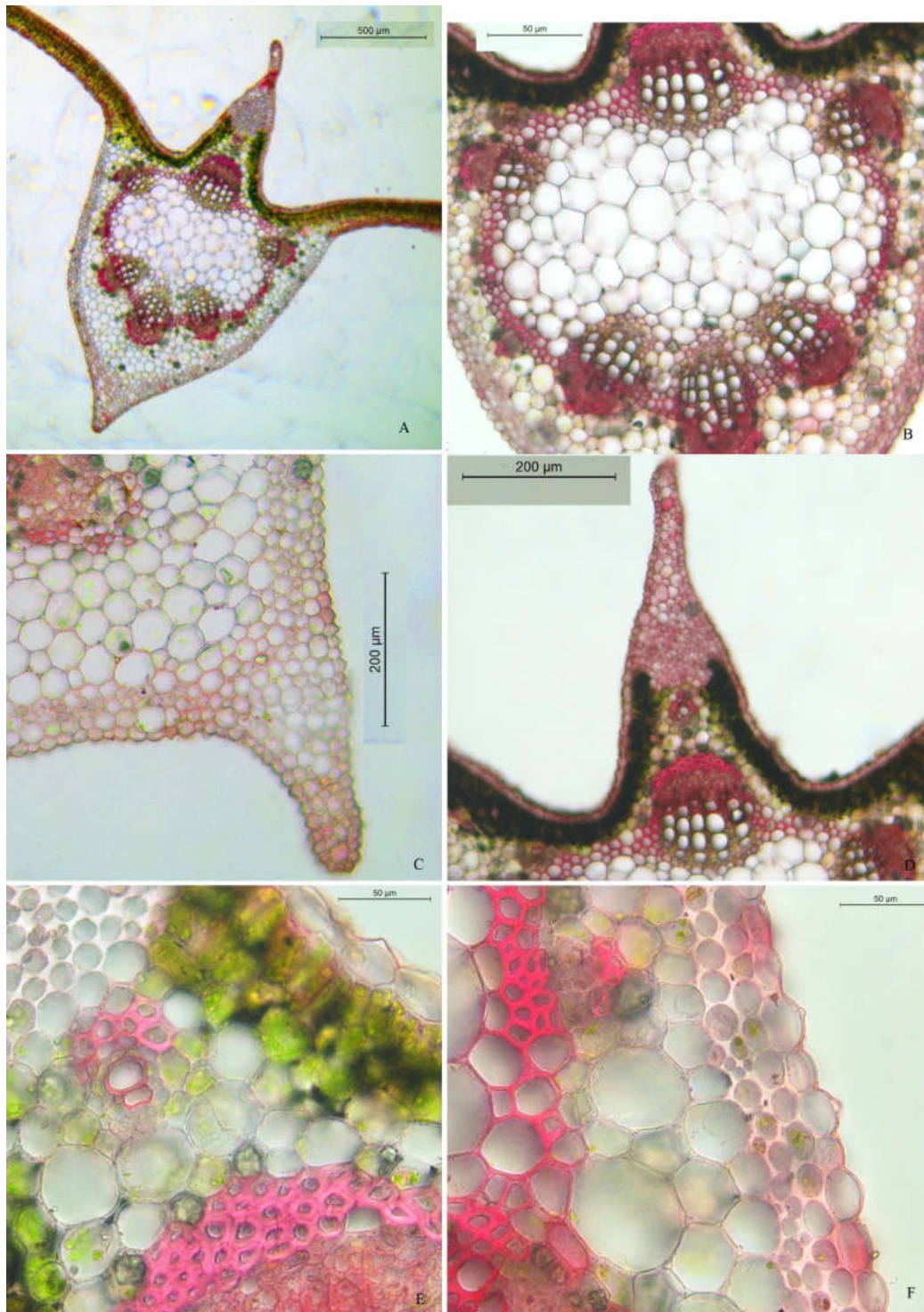


Fig. 135. *Leea tamdilensis* Amrutha & Pradeep: Transverse section of leaf parts: **A.** Midrib; **B.** Midrib- a portion enlarged showing vascular bundles; **C.** Abaxial surface of midrib; **D.** Adaxial surface of midrib; **E.** Accessory vascular bundle; **F.** Papillate epidermis.

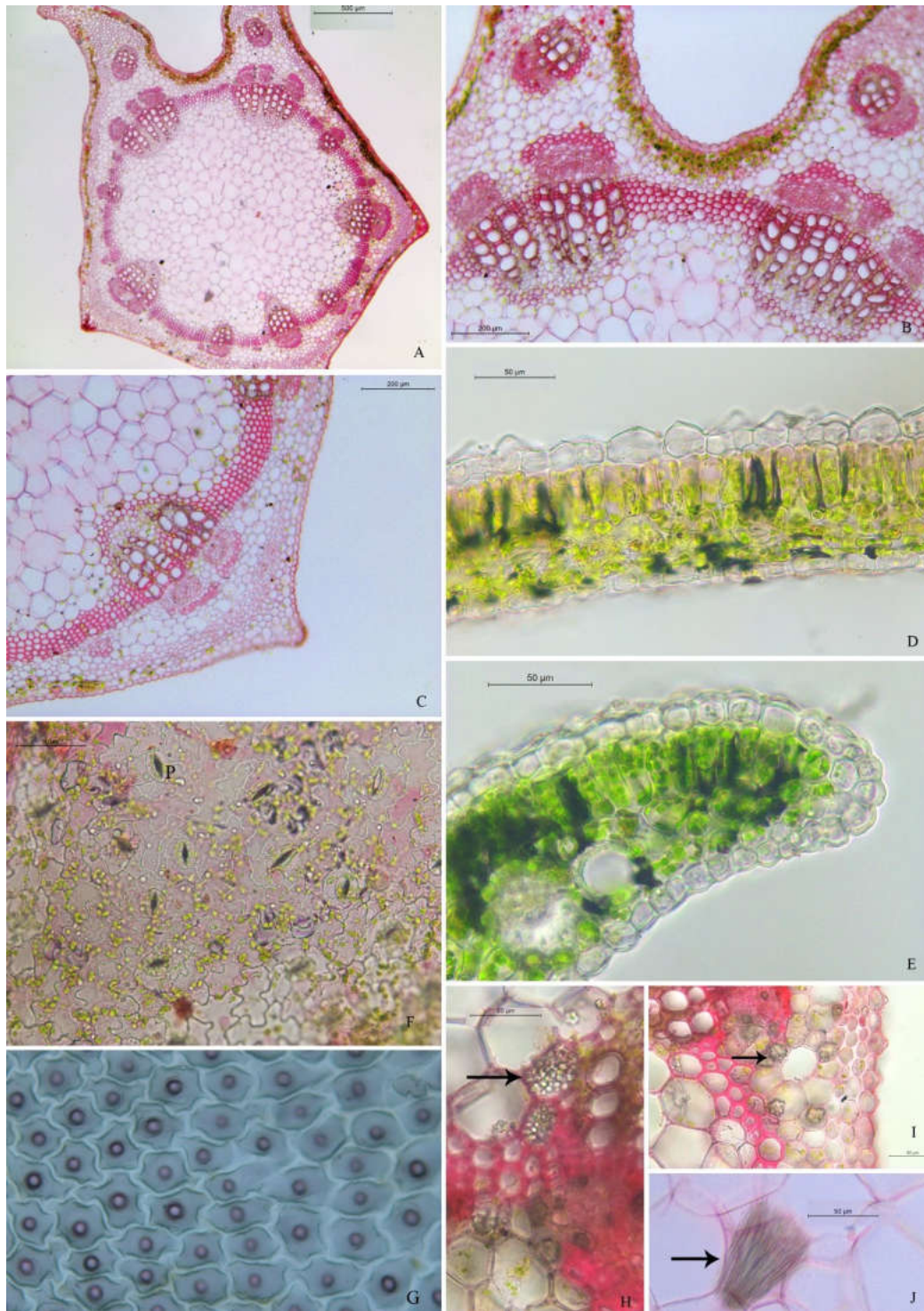


Fig. 136. *Leea tamdilensis* Amrutha & Pradeep: Transverse section of leaf parts: **A.** Rachis; **B.** Adaxial surface of rachis; **C.** Abaxial surface of rachis; **D.** Lamina; **E.** Leaf margin; **F.** Para-dermal section of abaxial surface of leaf; **G.** Para-dermal section of adaxial surface of leaf; **H.** Starch grains; **I.** Druses; **J.** Raphides.

Lamina: Leaves dorsiventral and differentiated into epidermis and mesophyll cells. The thickness of the lamina varies from 93.57–116.33 (116.33 ± 2.45) μm . Epidermis is uniseriate with a thin cuticle. The adaxial epidermal cells are larger than the abaxial cells. Cells are barrel-shaped. Mesophyll is differentiated into palisade and spongy parenchyma. Palisade is single-layered, 33.35–48.73 (41.21 ± 0.83) μm thick. Spongy parenchyma is 3–5-layered, compactly arranged without intercellular space, 32.09–67.03 (44.19 ± 1.72) μm thick. Druses are distributed in palisade cells. Lamina margin is tapering and bent towards the tip. The hyaline portion is very short consisting of a single layer of thin-walled parenchymatous cells.

Stomata: Leaves are hypostomatic and show anisocytic stomata. Epidermal cells are irregular on both abaxial and adaxial surfaces. Anticlinal walls are strongly sinuate abaxially and slightly sinuate adaxially. Stomatal frequency 10–19 (12.08 ± 0.87) mm^2 . Stomatal length ranges from 18.76–22.77 (20.67 ± 0.42) μm . Stomatal index is 11.76–20.21 (15.74 ± 0.93).

Discussion

This study represents the most comprehensive examination of the foliar anatomy, epidermal characters and trichomes in the genus *Leea* in India. In the analysed anatomical features of *Leea*, leaf anatomy was demonstrated to be of high importance for the differentiation and identification of species. Foliar anatomy has been proven to be valuable in taxonomically complex groups (Metcalf & Chalk, 1957). There is evidence of the taxonomic application of plant anatomy, particularly leaf anatomy, at the level of species, genera or families (Retamales & Scharaschkin, 2015; Wosch *et al.*, 2015). Metcalfe and Chalk (1957) defined a description of anatomical features in the family Ampelideae (Vitaceae) and suggested the utility of the anatomy of leaf, wood and young stem as taxonomically important characters. Furthermore, Najmaddin *et al.* (2011a,b) used anatomical characters to compare the species of *Leea* with other members of Vitaceae. It is possible to identify the species using several leaf anatomical and micro-morphological characteristics (Table 2–5).

Comparative anatomical characters

Midrib

The shape of the lamina midrib potentially contributes to the identification of species belonging to *Leea* corroborating the result of Najmaddin *et al.* (2013). This

character has diverse character states that can help to identify species (Table 2). The thickness of the midrib varies among species (Table 2). The epidermis with papillae was seen in some species such as *L. adwivedica*, *L. mizoramensis*, *L. sundaica* and *L. tamdilensis*. On the abaxial surfaces, the collenchymatous strata range from 2–6. Most of the species possess six vascular bundles in the midrib arranged in a ring, with the exception of *L. angulata*, which has four and *L. macrophylla*, which has more than six. Adaxial bundles were generally larger than the two lateral bundles except in *L. asiatica*. Accessory vascular bundles were present in the adaxial surfaces of most of the species and it may be absent in *L. adwivedica*, *L. angulata*, *L. mizoramensis*, *L. macrophylla*, *L. setuligera*, *L. latifolia* and *L. trifoliata*. This character is useful for the identification of species as opined by Najmaddin *et al.* (2013). Sclerenchymatous strata connect the entire vascular bundles was 1–6-layered or it may be absent in some species (*L. adwivedica*, *L. angulata* and *L. trifoliata*). Pith is parenchymatous and thickness varies among species (Table 2). Cellular inclusions like druses and starch grains were distributed in the pith and cortex. By comparing the species of *Leea* with other members of Vitaceae, Najmaddin *et al.* (2013) found that raphides were absent in the midrib of *L. indica* and *L. rubra*, while our study confirmed the presence of raphides in the midrib region. **Fig. 137**

Rachis

In genus *Leea*, the differences found in the rachis contour is a useful diagnostic character to distinguish the species (Table 3). The adaxial and abaxial surface of the rachis varies from V-shaped to U-shaped. Among the species of *Leea*, *L. sundaica* was the only one that possess a wide V-shape adaxial surface. It was wide U-shaped in *L. adwivedica*, *L. guineensis*, *L. robusta* and *L. setuligera*, whereas the remaining species have U-shaped adaxial surfaces. The abaxial surface was V-shaped in *L. angulata*, *L. compactiflora*, *L. guineensis*, *L. setuligera* and *L. tamdilensis*. However, *L. asiatica* and *L. mizoramensis* have a V-shaped adaxial surface with a keel. It was wide V-shaped in *L. indica* and *L. robusta* whereas, a wide U-shaped was seen in *L. compactiflora*, *L. adwivedica* and *L. sundaica*. On the adaxial surfaces, grooves of rachis showed variation in size among species. In *L. aequata* and *L. robusta*, the groove contains extra protrusion, which was absent in the rest of the species.

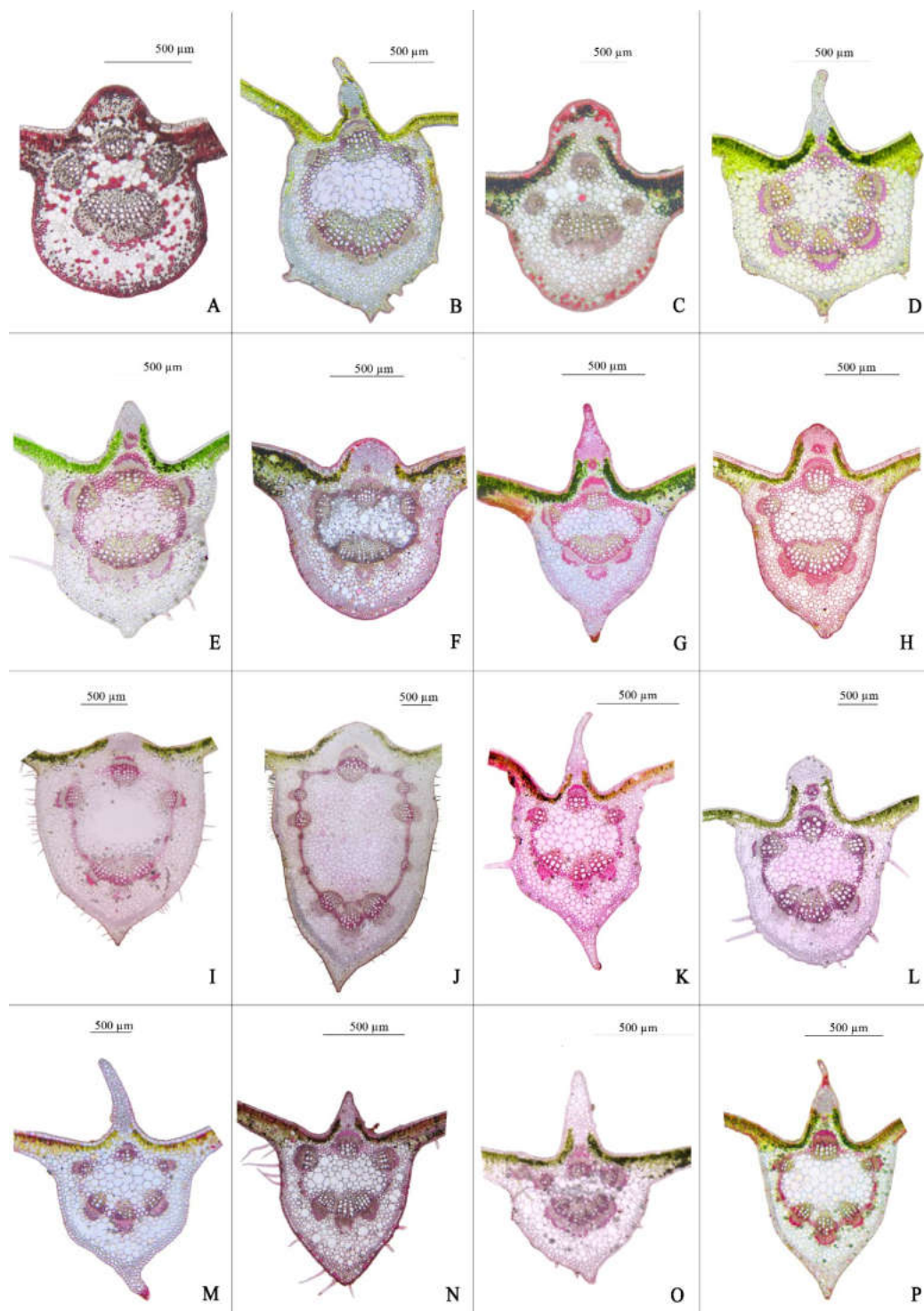


Fig. 137. Midrib of *Leea* L.: **A.** *L. advivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.



Fig. 138. Rachis of *Leea* L.: **A.** *L. advivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. guineensis*; **G.** *L. indica*; **H.** *L. mizoramensis*; **I.** *L. robusta*; **J.** *L. setuligera*; **K.** *L. sundaica*; **L.** *L. trifoliata*; **M.** *L. tamdilensis*.

It has been found that the cellular structure of the rachis was similar in all species studied. All the species investigated exhibit monostратified epidermal cells with or without papillae. The epidermal cells of adaxial and abaxial surfaces were more or less rectangular to oval. Inner to epidermis, chlorenchymatous hypodermis varies from 2–4-layered. Below the hypodermis, 3–5-layered collenchymatous cells, followed by large parenchymatous ground tissue without considerable intercellular space are present. Collenchymatous cells were more on each angle of the rachis. In the rachis, the vascular system consists of a ring of prominent vascular bundles and smaller bundles. The accessory vascular bundle was present in all the species on either side of the grooves in the adaxial surface of the rachis. Pith was parenchymatous and showed variation in thickness among species. **Fig. 138**

Lamina

Leaves were dorsiventral and differentiated into epidermis and mesophyll cells. It is possible to delimit species based on the thickness of the lamina which varies (92.62–245.73 μm) from one species to another. The thickest lamina was found in *L. grandifolia* (213.31–315.22 (245.73 $\pm$ 4.72)) μm whereas the thinnest was observed in *L. aequata* (65.07–112.01 92.62 $\pm$ 2.03)) μm . In all species, epidermal cells were uniseriate on adaxial and abaxial surfaces, with adaxial surfaces being larger than abaxial surfaces. Epidermal cells with papillae are found in *L. mizoramensis* and *L. tamdilensis*, while the rest of the species has smooth epidermal cells. Mesophyll is differentiated into palisade and spongy parenchyma. Mesophyll organization is applicable in taxonomic studies as evidenced by several plant families and genera. Palisade parenchyma made up of vertical, attenuated, and rectangular cells, lies just internal to the adaxial epidermis. The variation found in the palisade layer is useful to distinguish the species of *Leea*. A single-layered palisade was the common type seen in the majority of the species whereas, *L. angulata*, *L. indica*, *L. macrophylla*, and *L. guineensis* exhibit double-layered palisade parenchyma. However, *L. adwivedica*, often displays a 2-layered palisade and occasionally a 3-layered palisade parenchyma. The thickness of the palisade layer varies from 23.48 μm in *L. aequata* and 73.72 μm in *L. macrophylla*. The spongy parenchyma consisted of irregul cells,

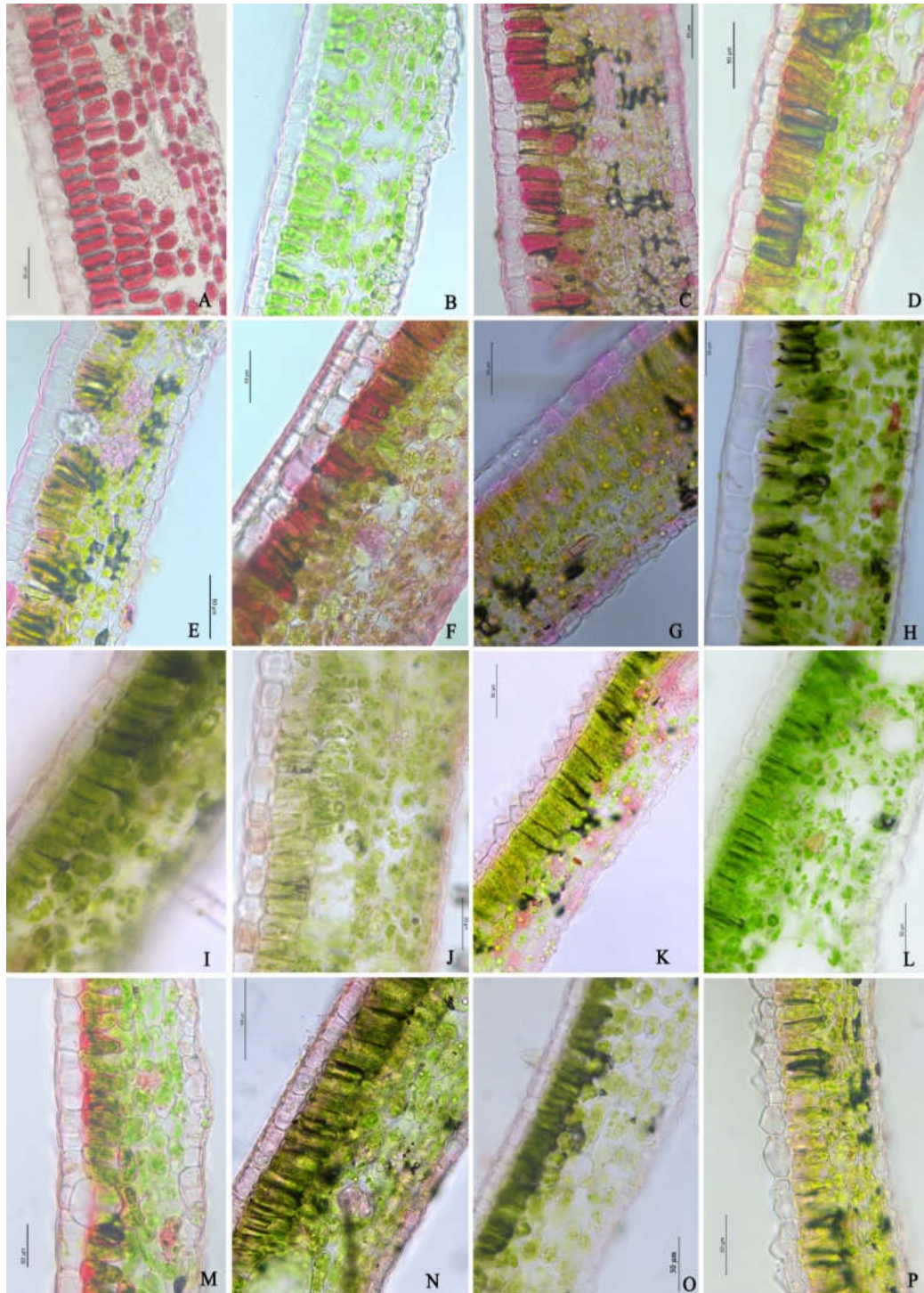


Fig. 139. Lamina of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata.*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.

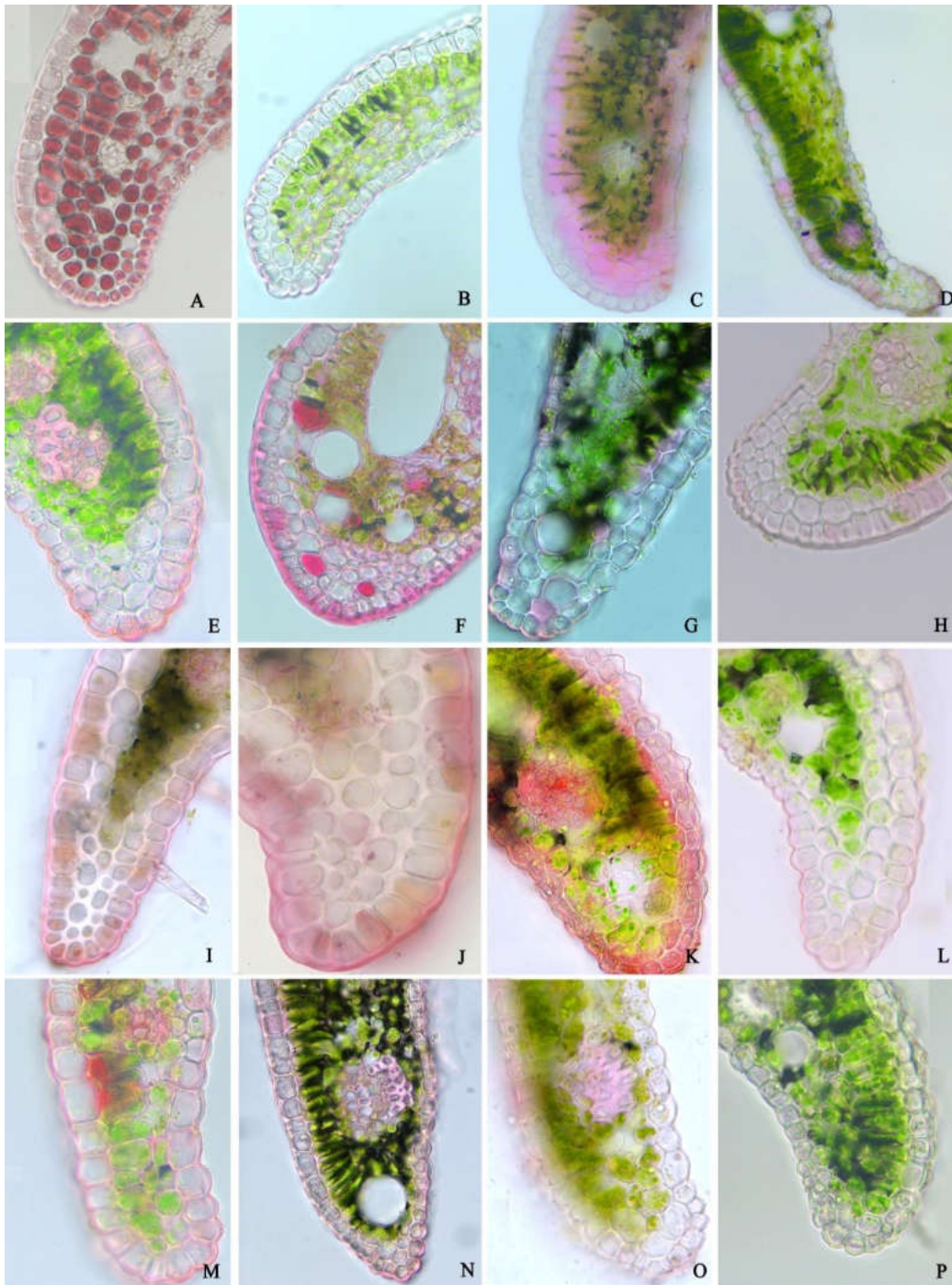


Fig. 140. Lamina margin of *Leea* L.: **A.** *L. advivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.

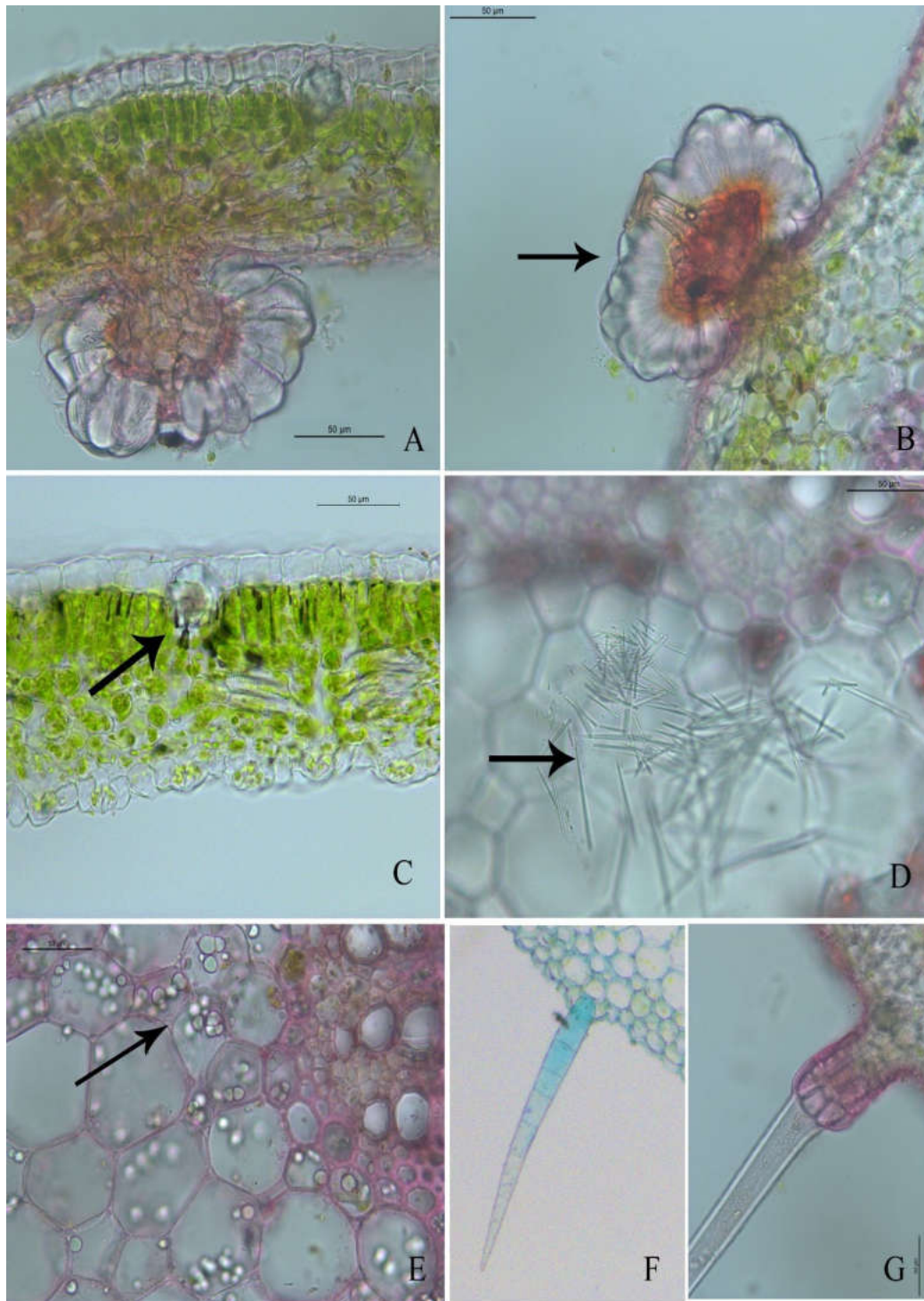


Fig. 141. Cellular inclusions in *Leea* L.: A & B. Pearl gland; C. Druses; D. Raphides; E. Starch grains; F & G. Trichomes.

ranging in shape from round to polygonal. The thickness of the spongy parenchyma ranges from 44.19 μm in *L. tamdilensis* to 147.55 μm in *L. grandifolia* and is composed of 2–10 layers that are compactly organized without intercellular space. Starch grains were immersed in the spongy parenchyma and druses and raphides seen in mesophyll regions and the epidermis. Kannabiran and Prakasam (1994) reported the occurrence of druses and raphides in *Leea*. **Fig. 139 & 140**

Crystals

Calcium oxalate crystals are the most prevalent mineral in plant tissues (Arnott, 1982). It has been shown that these structures regulate the amount of calcium in tissues (Volk *et al.*, 2002), and protect against herbivory and pathogens (Franceschi & Nakata, 2005). These crystals are generally present in Ampelideae and have different shapes and structures (Metcalf & Chalk, 1957). Druses, raphides and prismatic crystals were the different types of calcium oxalate crystals found in *Leea*. Druses (Fig. 141C) and raphides (Fig. 141D) were the most common type of crystal in *Leea* and are distributed in different cells of midrib, lamina and rachis. Raphides were either seen as solitary or clustered. Prismatic crystals were rarely seen in *Leea*, and only noticed in *L. guineensis*. According to Metcalfe and Chalk (1957), the druses in *Leea* are sometimes large and appear as dots. **Fig. 141**

Epidermal characters

Epidermis was uniseriate with smooth cuticle in most species except in *L. asiatica*, where the cuticle is ornamented. The ornamented cuticle has also been observed on other species of Vitaceae, such as *Cissus* (Oliveira *et al.*, 2012). Species such as *L. mizoramensis* and *L. tamdilensis* showed papillae on epidermal cells. Plant defense against pathogens and herbivory may be connected to the role played by papillae. (Voigt, 2014; Retamales & Scharaschkin, 2015). In transverse sections, upper epidermal cells in most taxa were larger than lower epidermal ones and were rectangular or barrel-shaped. Leaves of *Leea* consist of a single layer of epidermal cells. Single-layered epidermis is thought to be usual in vascular plants and is frequently attributed to mesophytic and hydrophytic species. (Dickison, 2000). In some species such as *L. indica*, *L. grandifolia*, *L. macrophylla* and *L. sundaica*, a single layer of hypodermis was present below the epidermis. The layer of cells beneath the epidermal cells is referred to as the hypodermis. It has been suggested that double epidermis or hypodermis is an ecological adaptation to dry conditions.

(Metcalf & Chalk, 1957; Dickison, 2000; Evert, 2006, Retamales & Scharaschkin, 2015). The occurrence of hypodermis in *Leea* may not be connected to a xerophytic habitat since most of the species prefer mesophytic habitats. Leaf epidermal cells were irregular or polygonal. The polygonal epidermal cells were seen in *L. adwivedica*, *L. angulata*, *L. guineensis*, *L. macrophylla*, *L. sundaica*, *L. indica*, and *L. latifolia* and irregular epidermal cells was observed in *L. aequata*, *L. asiatica*, *L. compactiflora*, *L. mizoramensis*, *L. grandifolia*, *L. robusta*, *L. setuligera*, *L. trifoliata*, and *L. tamdilensis*. Various types of anticlinal walls of abaxial epidermal cells were seen (Table 5). The most common type observed was slightly sinuous with thin walls, present in the majority of taxa. Some species possess sinuous cell walls (Fig. 142B, K) whereas others have straight or straight-wavy (Fig. 142F, H). The polygonal epidermal cells usually had straight anticlinal walls with some exceptions (the abaxial surface of *L. compactiflora* and the adaxial surface of *L. sundaica*). Irregular epidermal cells always have sinuate anticlinal walls.

The members of *Leea* have both amphistomatic and hypostomatic leaves, but hypostomatic leaves (stomata on abaxial surfaces only) were more common than amphistomatic leaves (stomata on both adaxial and abaxial surfaces). Species like *L. macrophylla*, *L. robusta* and *L. sundaica* have amphistomatic leaves and all the other species possess hypostomatic leaves. In *Leea* two types of stomatal complex were observed viz., anomocytic and anisocytic and the stomata projected just above the surface of the epidermis. Anomocytic stomata were observed in species with prickled stems (*L. angulata* & *L. adwivedica*) and in *L. asiatica*. This type of stomata has also been prevalent among families. (Metcalf & Chalk, 1957). In a few cases, both types of stomata may be present on the same surface such as in *L. aequata*. In amphistomatic taxa, stomata were more frequent on the abaxial (AB) surface. To some extent, different stomatal types seen in *Leea* can be used to distinguish between taxa. Stomatal density distinctly differs among species (Table 5). The stomatal index showed a variation in abaxial surfaces of leaves among species, the highest stomatal index was calculated for *L. asiatica* (41.88) whereas *L. compactiflora* showed the lowest stomatal index (11.22). The stomatal length varied considerably within the genus *Leea*, the longest stomata were identified in *L. asiatica* (28.61 μm), while the smallest were observed in *L. guineensis* (19.98 μm). **Figs. 142 & 143**

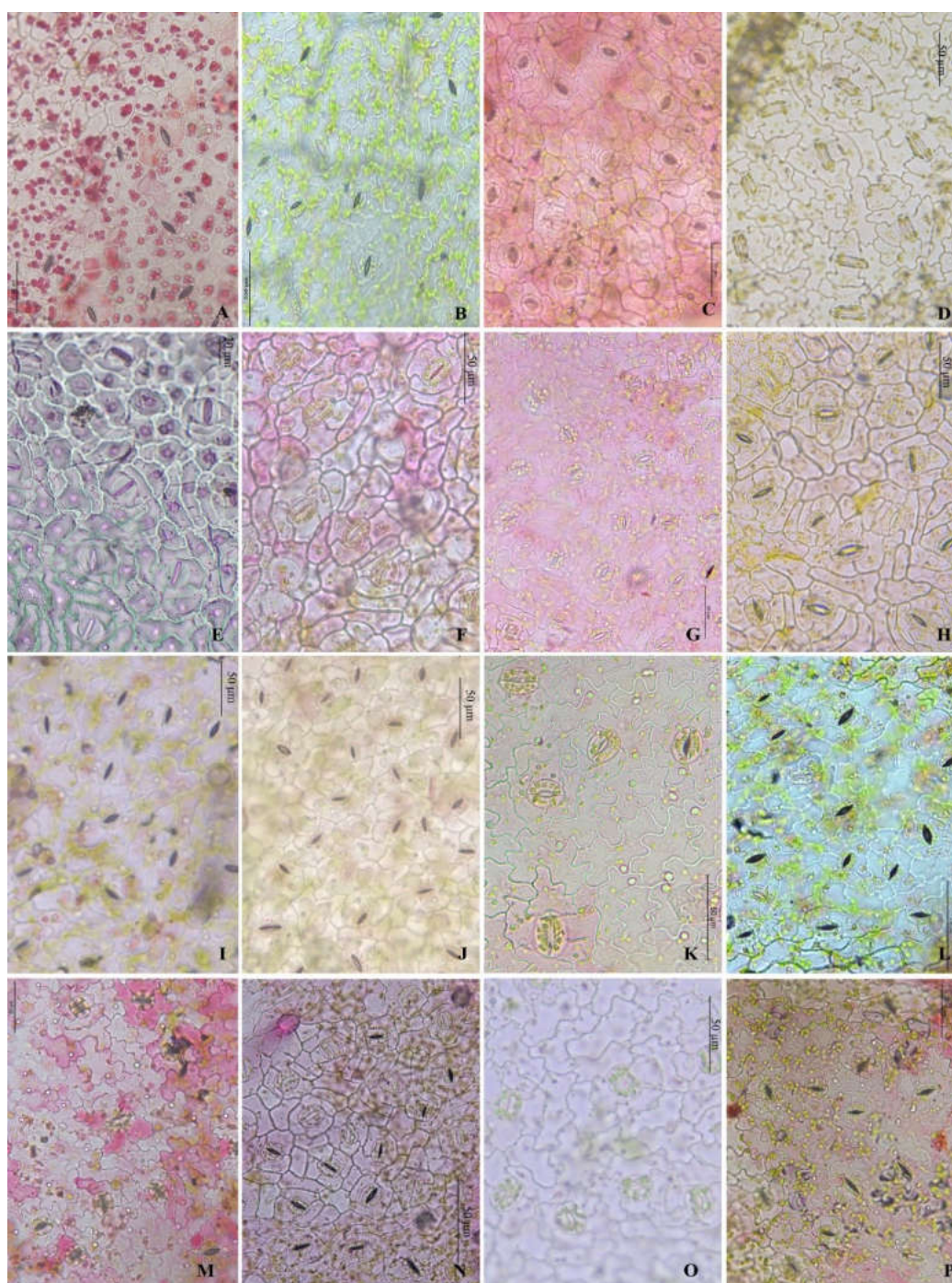


Fig. 142. Abaxial surface of lamina in *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.

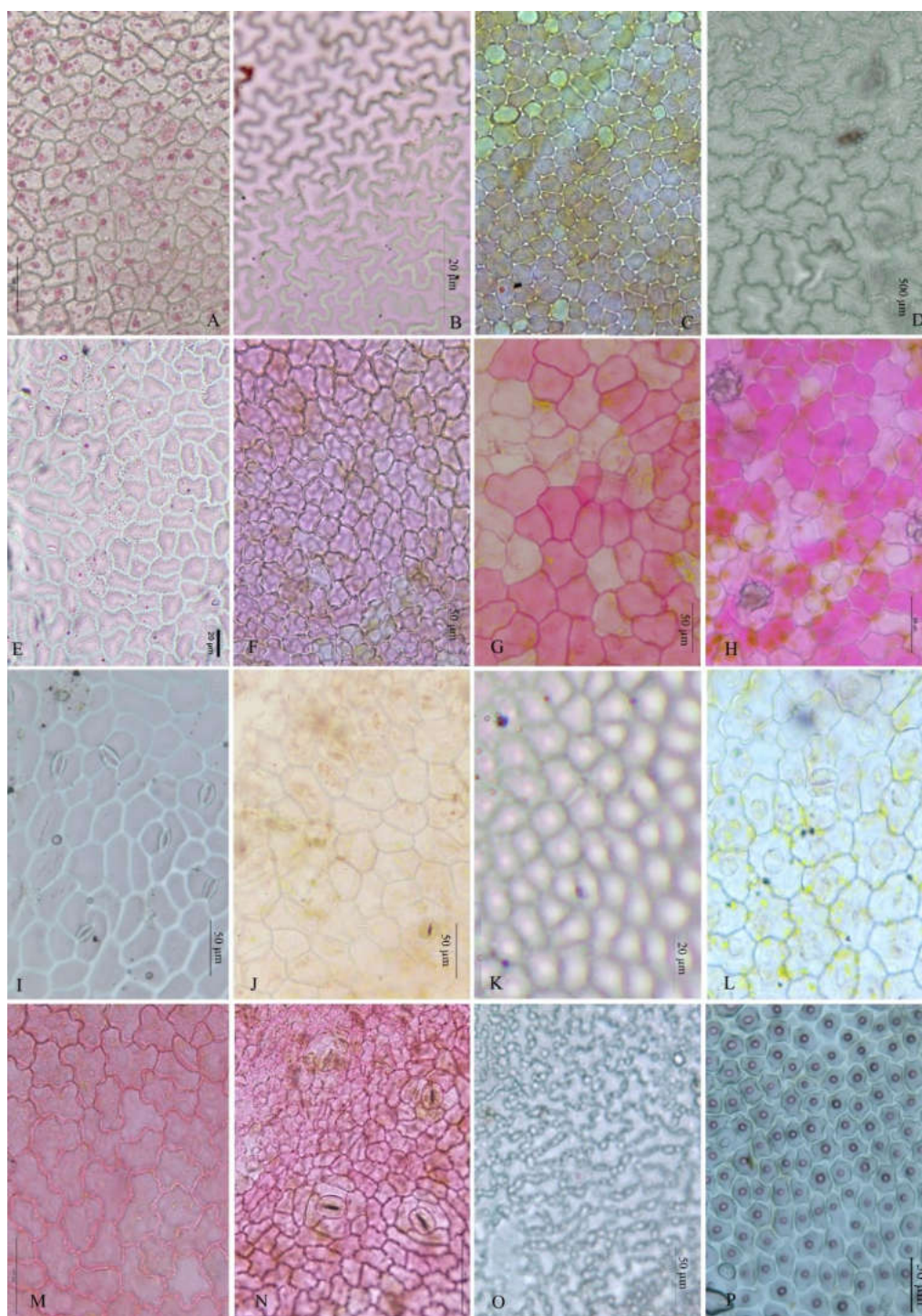


Fig. 143. Adaxial surface of lamina in *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. grandifolia*; **G.** *L. guineensis*; **H.** *L. indica*; **I.** *L. latifolia*; **J.** *L. macrophylla*; **K.** *L. mizoramensis*; **L.** *L. robusta*; **M.** *L. setuligera*; **N.** *L. sundaica*; **O.** *L. trifoliata*; **P.** *L. tamdilensis*.

Trichomes

Micro-morphological characteristics of trichomes shed light on species, genera, tribes, and subfamilies (Ullah *et al.*, 2018a). Hairs on plants are considered as xerophytic adaptations, particularly when they are dense (Evert, 2006). Distribution, densities and types of trichomes present on the vegetative parts of *Leea* vary among species. It is only possible to see non-glandular trichomes in *Leea*, though members of Vitaceae possess glandular trichomes as well. Three types of unicellular trichomes were observed in *Leea viz.*, non-glandular one-celled trichomes, non-glandular two-celled trichomes and non-glandular multicelled trichomes. Non-glandular one-celled trichomes may be thick or thin-walled and conical or aciculate in shape. This type of trichome consists of a multicellular foot or it may be directly originating from the epidermal cell. It can be seen in *L. mizoramensis* etc. Non-glandular two-celled trichomes can be seen in *L. macrophylla*, having thick-walled cells. Here the basal cells are smaller than the upper cells. Non-glandular multicelled trichomes consist of more than two-celled trichomes having pointed ends. The number of cells in the trichomes varies from 3–15 cells. Metcalfe and Chalk (1957) reported the occurrence of simple unicellular, unicellular 2-armed, short-stalked glandular types of trichomes in the family Ampelidaceae (Vitaceae). However, we have observed only the occurrence of non-glandular uniseriate trichomes in *Leea*. Ma *et al.* (2016) documented the occurrence of glandular trichomes in *Vitis* and Wen (2007a) reported the presence of glandular trichomes in the genus *Cissus*, and *Cyphostemma*. Thus, glandular trichomes appear to represent an apomorphic character in Vitaceae, as *Leea* is more primitive in this family.

Fig. 144

Pearl glands

The occurrence of the pearl glands is a unique feature of Vitaceae. These glands have already been described for *Leea*, *Cissus* and *Vitis* (Metcalfe & Chalk, 1957). The anatomy of pearl glands in *L. aequata* consists of 2 parts; small, central cells surround large palisade-like epidermal cells and open to the exterior via a single apical stoma (Fig. 141A & B). These glands were distributed in the lamina, rachis and midrib. Cells of the glands are rich in protein, oils, and sugars (Metcalfe & Chalk, 1957; Paiva *et al.*, 2009).

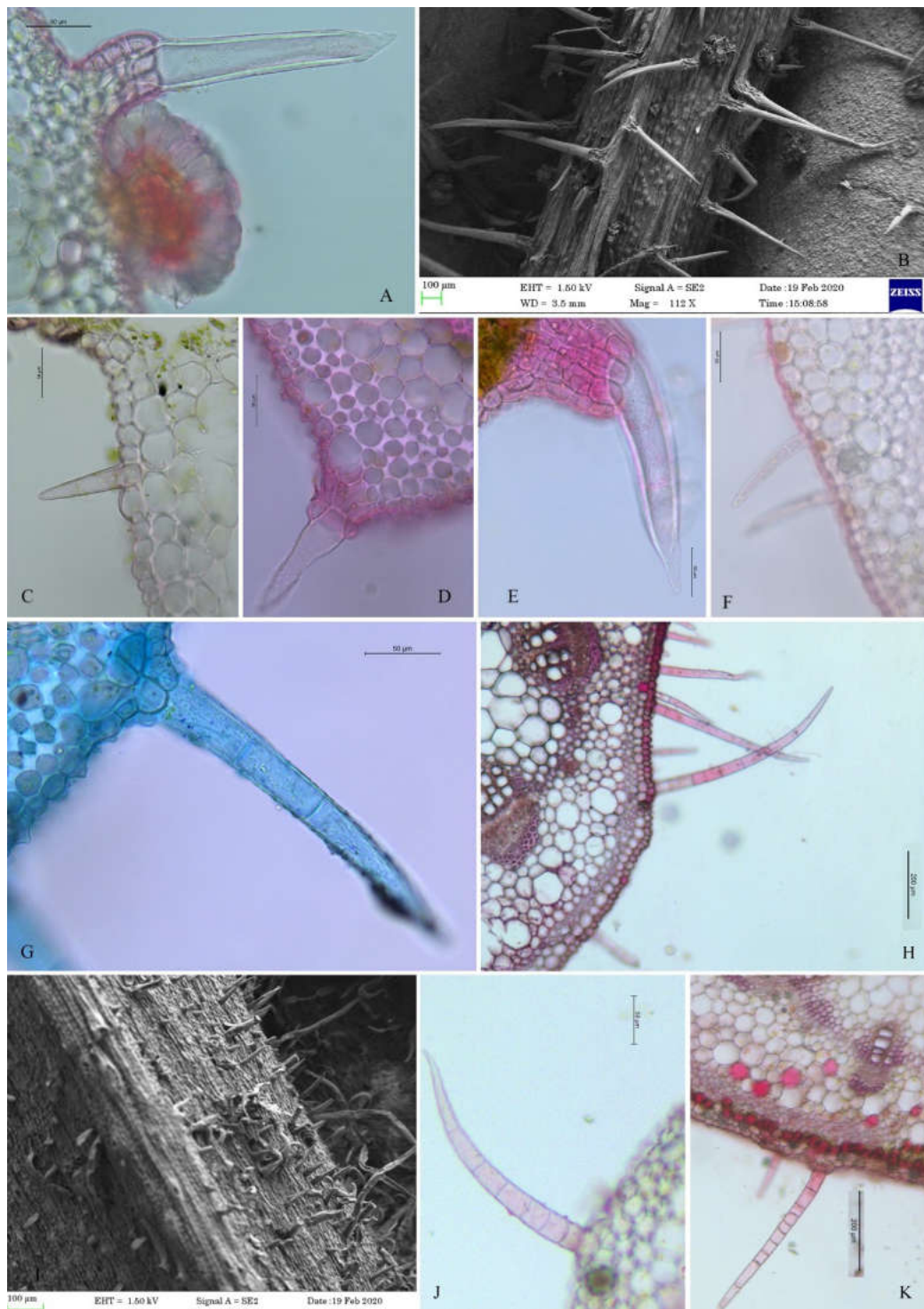


Fig. 144. Trichome diversity in *Leea* L.

Conclusion

It is evident from our results that the anatomical characteristics of leaf organization, cellular organization of midrib and rachis, number of epidermal layers, and vascularization of rachis were constant across all species analysed, thus representing key characteristics of *Leea*. Variations pertaining to the number of palisade parenchyma, the thickness of leaves, shapes of adaxial and abaxial surfaces of midrib and rachis, number of vascular bundles in the midrib, types of stomata, outlines of anticlinal walls of epidermal cells, presence of hypodermis, and accessory vascular bundles in the midrib region contribute to taxonomic delimitations in *Leea*. Despite growing in distinct environments, those characteristics stand out as being persistent even within the species. After analysis of our data, we were able to separate different species based on anatomical characters and support the reinstatement of *L. robusta*, *L. latifolia* and *L. trifoliata*.

Table 2: Comparison of midrib

Sl. No.	Taxa	Length (µm)	Width (µm)	Shape of Adaxial surface	Shape of Abaxial surface	Nature of Epidermis	No of collenchymatous strata on abaxial side	Occurrence of parenchymatous hypodermis	No of vascular bundle	Sclerenchymatous strata	Occurrence of accessory vascular bundle	Thickness of pith (µm)
1	<i>L. aequata</i>	1722.95–2225.08 (2011.55±28.81)	923.63–1478.98 (1206.31±19.29)	Obconic, bulbous from base to above the middle, short and abruptly tapering towards the apex	Wide V-shaped	Non-papillate	3–4 layered	Present	6	1–2 layered	Present	179.9–555.13 (436.91±22.17)
2	<i>L. adawaedica</i>	1002.79–1206.18 (1117.17±13.07)	905.65–1174.17 (987.15±13.12)	Convex	Wide U-shaped	Papillate	3–5 layered	Present	6	Absent	Absent	137.52–192.64 (170.88±11.25)
3	<i>L. angulata</i>	943.58–1133.75 (1006.42±8.89)	652.62–784.70 (727.35±6.67)	Convex	Wide U-shaped	Non-papillate	2–3 layered	Present	4	Absent	Absent	69.56–122.06 (88.08±2.90)
4	<i>L. asiatica</i>	1196.61–1507.72 (1324.23±17.04)	738.08–878.92 (810.90±6.63)	Obconic, slightly dilated below the middle	V or wide V-shaped with a short keel	Non-papillate	1–2 layered	Absent	6	1 layered	Present	142.64–180.02 (167.60±1.7)
5	<i>L. compactiflora</i>	1006.42–1929.53 (1468.99±54.69)	794.00–1387.86 (1040.67±36.86)	Acute	Wide V-shaped with or without a keel	Non-papillate	2–3 layered	Absent	6	1–3 layered	Present	131.98–314.47 (229.55±10.48)
6	<i>L. mizoramensis</i>	1633.82–2053.63 (1823.05±23.73)	741.05–991.37 (921.58±10.54)	Obconic, slightly dilated below the middle and tapering towards apex	U-shaped with a keel	Papillate	2–3 layered	Present	6	1–2 layered	Absent	345.16–591.27 (454.82±9.45)
7	<i>L. grandifolia</i>	1689.21–2273.27 (1978.01±32.99)	1302.08–1678.91 (1448.85±24.83)	Convex	Wide U-shaped	Non-papillate	3–4 layered	Present	6	1–2 layered	Present	226.41–408.99 (323.35±9.21)
8	<i>L. guineensis</i>	1526.14–2160.18 (1757.99±30.42)	904.68–1185.93 (1017.48±14.34)	Obconic, slightly dilated below the middle and with a keel	U-shaped with a keel	Non-papillate	3–4 layered	Absent	6	1–3 layered	Present	191.60–243.19 (221.01±2.44)
9	<i>L. indica</i>	1329.00–1835.85 (1492.59±25.16)	765.53–1268.74 (917.46±21.70)	Convex	V-shaped or U-shaped	Non-papillate	2–4 layered	Present	6	2–3 layered	Present	248.83–380.64 (292.34±5.9)
10	<i>L. latifolia</i>	2123.27–2633.42 (2317.28±34.44)	1716.12–2018.00 (1882.62±22.90)	Convex	U-shaped with a keel	Non-papillate	3–5 layered	Absent	6	1–3 layered	Absent	550.31–887.14 (751.84±28.16)
11	<i>L. macrophylla</i>	5580.23–6409.11 (6069.09±42.79)	3144.06–3694.23 (3465.68±22.62)	Convex	U-shaped with a keel	Non-papillate	4–6 layered	Absent	More than six	5–6 layered	Absent	2432.20–3840.11 (3318.04±68.88)
12	<i>L. robusta</i>	1424.75–2109.84	803.74–1389.93	Convex	U-shaped	Non-papillate	2–3 layered	Absent	6	1–2	Present	176.23–470.14

13	<i>L. setuligera</i>	(1629.00±31.98)	(957.09±28.09)	Lanceolate	Wide V-shaped with a keel	Non- papillate	1- 2 layered	Absent	6	layered	Absent	(253.55±14.91)
14	<i>L. sundaica</i>	1366.17-1678.42 (1518.39±13.75)	712.52-933.21 (783.79±8.06)	Acute	V-shaped	Papillate	2-3 layered	Present	6	2-3 layered	present	191.27-239.12 (214.92±2.43)
15	<i>L. trifoliata</i>	1450.82-1717.33 (1578.48±14.83)	917.91-1194.77 (987.25±13.74)	Lanceolate	Wide V-shaped with a keel	Non- papillate	1-2-layered	Absent	6	Absent	Absent	217.00-331.99 (295.76± 5.83)
16	<i>L. tamulensis</i>	1206.00-1450.21 (1334.96±13.54)	700.02-899.86 (821.86±10.93)	Slightly dilated below the middle and with a keel	U-shaped with a keel	Papillate	2-3 layered	Absent	6	1-2 layered	present	100.00-164.192 (124.46±2.99)
		1905.40-2199.47 (2065.07±14.18)	900.59-1127.41 (1004.41±11.55)									312.52-424.77 (382.09±6.99)

Table 3: Comparison of rachis

Sl No.	Taxa	Length	Width	Shape of Adaxial surface	Shape of Abaxial surface	Grooves of rachis on adaxial surface	Collenchymatous strata	Pith height
1	<i>L. aequata</i>	1954.12–2536.17 (2261.09±38.13)	1507.16–2408.55 µm (1868.69±45.73)	U-shaped with a projection	Wide U or V-shaped	335.91–549.78 (448.92±10.05)	3–4 layered	946.11–1823.38 (1262.83±47.70)
2	<i>L. adarvædica</i>	2375.00–2973.78 (2607.68±33.08)	2141.39–2519.46 (987.15±13.12)	Wide U-shaped	Wide U-shaped	149.73–204.96 (182.75±2.74)	3–5 layered	1093.49–1704.71 (1396.12±32.89)
3	<i>L. angulata</i>	1703.82–2082.08 (1811.30±21.37)	1444.61–1843.61 (1557.16±21.23)	U-shaped	V-shaped	265.06–417.55 (356.11±6.33)	3–4 layered	802.66–1146.77 (906.55±16.89)
4	<i>L. asiatica</i>	2310.39–2617.55 (2495.08±15.81)	2007.00–2469.29 (2264.94±22.36)	U-shaped	V-shaped with a keel	565.19–609.98 µm (593.63±2.11)	1–2 layered	933.98–1112.39 (981.60±6.00)
5	<i>L. compactiflora</i>	2167.91–2488.09 (2346.33±13.16)	1864.20–2117.71 (1957.66±13.75)	U-shaped	V-shaped	391.81–591.11 (496.13±11.40)	2–3 layered	858.90–1112.44 (972.07±14.07)
6	<i>L. mizoramensis</i>	2310.35–2993.73 (2581.73±34.14)	2067.19–2912.50 (2314.12±43.50)	U-shaped	V-shaped with a keel	554.10–863.27 (642.99±17.15)	1–4 layered	1101.99–1359.59 (1213.79±13.17)
7	<i>L. guineensis</i>	1765.70–2114.90 (1972.88±20.44)	1452.79–2353.30 (1676.94±43.82)	Wide U-shaped	V-shaped	233.80–575.29 (350.55±15.39)	3–4 layered	659.81–1527.22 (995.69±37.93)
8	<i>L. indica</i>	2475.00–3574.00 (2929.76±37.68)	2269.39–2919.00 (2457.29±39.07)	U-shaped	Wide V-shaped	369.21–581.00 µm (468.83±9.27)	1–2 layered	1317.59–1618.22 (1396.47±11.34)
9	<i>L. robusta</i>	2146.76–2570.21 (2364.30±21.67)	1665.82–1987.72 (1863.97±15.72)	Wide U-shaped with a small projection	Wide V-shaped	447.66–700.32 (578.12±13.75)	3–4 layered	727.64–1101.69 (944.63±20.26)
10	<i>L. setuligera</i>	2543.00–3145.14 (1518.39±13.75)	2113.00–3913.09 (2582.46±34.59)	Wide U-shaped	V-shaped with a keel	619.49–1002.49 (740.63±81.83)	1–2 layered	1238.28–1601.77 (1474.79±18.07)
11	<i>L. sundatica</i>	2672.12–3115.78 (2885.50±18.19)	2146.46–2626.33 (2349.79±26.44)	Wide V-shaped	Wide U-shaped	279.90–445.96 (370.82±7.58)	3–5 layered	1361.34–1738.09 (1527.85±14.66)
12	<i>L. trifoliata</i>	2400.12–2765.21 (2558.30±35.25)	1170.20–1865.00 (1809.80±8.62)	U-shaped	U-shaped	638.00–1162.12 (815.90±45.51)	1–2-layered	846.00–1163.73 (948.05±28.98)
13	<i>L. tamilditensis</i>	2637.60–3035.76 (2889.72±16.18)	2190.30–2389.59 (2305.20±7.60)	U-shaped	V-shaped	722.65–867.34 (809.52±7.23)	2–4 layered	1253.11–1424.90 (1357.46±9.09)

Table 4: Comparison of lamina

Sl. No.	Taxa	Thickness of the leaf (µm)	Hypodermis	No. of Palisade cells	Thickness of Palisade cells (µm)	No. of Spongy parenchyma	Thickness of Spongy Parenchyma (µm)
1	<i>L. aequata</i>	65.07–112.01 (92.62±2.03)	Absent	1 layered	7.97–29.59 (23.48±0.59)	4–6 layered	30.65–62.11 (46.43±1.76)
2	<i>L. adwivedica</i>	168.17–250.6 (204.40±3.59)	Absent	2 layered, rarely 3	51.46–98.24 (73.18±2.51)	5–7 layered	55.18–125.46 (80.48±3.67)
3	<i>L. angulata</i>	151.51–202.96 (170.61±2.14)	Absent	2 layered	47.37–70.16 (59.69±1.04)	5–6 layered	51.53–84.46 (72.12±1.53)
4	<i>L. asiatica</i>	102.24–185.77 (153.26±3.16)	Absent	1 layered	34.67–986.00 (58.19±1.84)	3–4 layered	55.44–66.27 (61.09±0.60)
5	<i>L. compactiflora</i>	101.16–139.72 (113.33±3.79)	Absent	1 layered	26.84–41.07 (34.39±0.63)	4–5 layered	37.17–72.52 (50.89±1.94)
6	<i>L. mizoramensis</i>	78.95–113.27 (98.69±2.08)	Absent	1 layered	23.10–39.98 (29.79±0.93)	3–4 layered	34.45–56.63 (44.31±1.19)
7	<i>L. grandifolia</i>	213.31–315.22 (245.73±4.72)	Present	1 layered	32.33–57.27 (47.53±1.36)	7–10 layered	117.53–189.93 (147.55±3.01)
8	<i>L. guineensis</i>	168.42–212.18 (193.87±2.16)	Absent	1 layered	56.72–82.97 (70.22±1.23)	4–8 layered	69.92–109.79 (83.35±1.83)
9	<i>L. indica</i>	169.66–229.74 (192.61.33±3.04)	Present	2 layered	62.51–75.23 (69.06±0.69)	5–8 layered	61.89–92.36 (74.59±1.29)
10	<i>L. latifolia</i>	141.12–168.15 (152.89±1.46)	Absent	1 layered	32.38–52.32 (41.05±2.51)	6–7 layered	61.12–86.43 (75.00±1.18)
11	<i>L. macrophylla</i>	163.86–247.00 (191.46±4.29)	Present	2 layered	62.90–89.68 (73.72±1.57)	5–8 layered	79.05–119.95 (98.28±1.69)
12	<i>L. robusta</i>	135.44–211.39 (160.48±2.95)	Absent	1 layered	32.77–78.20 (55.71±1.99)	4–7 layered	54.53–106.40 (68.82±2.18)
13	<i>L. setuligera</i>	94.83–146.88 (119.30±12.18)	Absent	1 layered	24.05–38.78 (30.71±0.53)	2–4 layered	30.13–69.66 (47.09±2.09)
14	<i>L. sundaica</i>	131.04–216.77 (161.55±3.66)	Present	1 layered	30.18–48.49 (39.21±0.79)	5–7 layered	62.29–118.85 (82.58±3.01)
15	<i>L. trifoliata</i>	91.23–134.24 (113.24±1.98)	Absent	1 layered	23.00–37.08 (29.67±0.58)	4–5 layered	35.22–82.00 (54.61±2.30)
16	<i>L. tamulensis</i>	93.57–116.33 (116.33±2.45)	Absent	1 layered	33.35–48.73 (41.21±0.83)	3–5 layered	32.09–67.03 (44.19±1.72)

Table 5: Comparison of epidermis

SL. No.	Taxon	Presence Abaxial Adaxial	Stomatal type	Stomatal Length (μm)	Stomatal Width (μm)	Stomatal no per cm^2	Surface cell	Anticlinal wall shape	Stomatal pore length (μm)	Stomatal index
1	<i>L. aequata</i>	AD -					Irregular	Strongly sinuate		
		AB +	Anisocytic	18.01-22.29 (20.74 $\pm$ 0.4)	16.67-19.51 (18.18 $\pm$ 0.28)	16-21 (18.3 $\pm$ 0.47)	Irregular	Strongly sinuate	10.27-16.79 (13.43 $\pm$ 0.56)	14.04-20.79 (16.99 $\pm$ 0.69)
		AD -					Polygonal	Straight		
2	<i>L. adtwicidia</i>	AB +	Anomocytic	20.20-24.50 (22.85 $\pm$ 0.42)	13.34-18.94 (15.99 $\pm$ 0.57)	16-26 (20.07 $\pm$ 0.96)	Polygonal	Straight to slightly wavy	11.60-17.44 (15.37 $\pm$ 0.57)	14.52-30.26 (22.27 $\pm$ 1.74)
		AD -					Polygonal	Straight		
		AB +	Anomocytic	17.74-23.76 (21.49 $\pm$ 0.57)	16.13-19.93 (17.52 $\pm$ 0.34)	20-26 (22.8 $\pm$ 0.69)	Polygonal	Straight to slightly wavy	11.14-14.72 (13.23 $\pm$ 0.41)	11.17-17.9 (14.29 $\pm$ 0.60)
4	<i>L. asiatica</i>	AD -					Irregular	Strongly sinuate		
		AB +	Anomocytic	26.20-30.98 (28.61 $\pm$ 0.51)	15.30-17.12 (16.54 $\pm$ 0.28)	14-37 (24.90 $\pm$ 2.42)	Irregular	Strongly sinuate	14.39-18.31 (16.26 $\pm$ 0.45)	20.58-68.88 (41.88 $\pm$ 5.03)
		AD -					Polygonal	Slightly sinuate		
5	<i>L. compactiflora</i>	AB +	Anisocytic	16.74-20.00 (17.92 $\pm$ 0.37)	13.28-14.93 (14.14 $\pm$ 0.22)	16-24 (18.7 $\pm$ 0.87)	Irregular	Straight to slightly wavy	12.46-16.38 (14.49 $\pm$ 0.39)	8.74-13.04 (11.22 $\pm$ 0.48)
		AD -					polygonal	Straight to slightly wavy		
		AB +	Anisocytic	19.69-24.16 (21.85 $\pm$ 0.50)	12.80-18.21 (14.99 $\pm$ 0.54)	12-20 (16.7 $\pm$ 0.68)	Irregular	Strongly sinuate	10.67-19.15 14.36 $\pm$ 0.75	12.50-24.69 (18.42 $\pm$ 0.98)
7	<i>L. grandifolia</i>	AD -					Irregular	Slightly sinuous		
		AB +	Anisocytic	21.56-25. (23.61 $\pm$ 0.48)	14.83-17.99 (16.65 $\pm$ 0.29)	16-34 (21.5 $\pm$ 1.97)	Irregular	Straight to slightly wavy	14.73 $\pm$ 0.30 (13.32-15.97)	11.11-22.37 (14.89 $\pm$ 1.2)
		AD -					Polygonal	Straight to slightly wavy		
8	<i>L. guineensis</i>	AB +	Anisocytic	17.83-21.75 (19.98 $\pm$ 0.39)	13.18-17.56 15.49 $\pm$ 0.49	14-30 (22.3 $\pm$ 1.81)	Polygonal	Straight to slightly wavy	8.94-13.75 (11.80 $\pm$ 0.40)	15.38- 23.14(19.21 $\pm$ 0.73)
		AD -					Polygonal	Slightly sinuous		
		AB +	Anisocytic	18.78-22.70 (21.15 $\pm$ 0.37)	14.09-16.83 (15.1y $\pm$ 0.26)	12-27 (18.3 $\pm$ 1.60)	Polygonal	Straight to slightly wavy	14.09-16.83 (15.35 $\pm$ 0.15)	9.09-22.00 (15.18 $\pm$ 1.08)
10	<i>L. latifolia</i>	AD +	Anisocytic				Polygonal	straight		
		AB +	Anisocytic	18.13-23.12 (19.69 $\pm$ 0.47)	13.22-16.23 (14.75 $\pm$ 0.29)	19-25 (22.40 $\pm$ 0.63)	Polygonal	Straight to slightly wavy	12.11-14.21 (12.80 $\pm$ 0.20)	24.17-30.12 (27.48 $\pm$ 0.50)
		AD +	Anisocytic				Polygonal	Straight		
11	<i>L. macrophylla</i>									

		AB	+	Anisocytic	18.01-25.45 (21.00±0.70)	14.51-19.67 (17.28±0.60)	28-41 (36.6±1.14)	Polygonal	Straight	12.34-16.35 (13.67±0.38)	28.04-50.61 (36.08±2.19)
12	<i>L. robusta</i>	AD	+	Anisocytic				Irregular	Slightly sinuate		
		AB	+	Anisocytic	19.69-24.16 (21.85±0.50)	12.80-18.21 (14.99±0.54)	12-16 (18.2±1.4)	Irregular	Strongly sinuate	14.33±0.75 (10.67-19.15)	12.12-27.36 (19.51±1.3)
13	<i>L. setuligera</i>	AD	-					Irregular	Strongly sinuate		
		AB	+	Anisocytic	21.63-27.07 (24.83±0.47)	18.01-21.72 (19.92±0.39)	6-14 (9.3±0.73)	Irregular	Strongly sinuate	11.90-18.84 (15.24±0.79)	8.57-24.56 (16.44±1.53)
14	<i>L. sundaica</i>	AD	+					Polygonal	Slightly sinuous		
		AB	+	Anisocytic	18.97-23.26 (21.35±0.39)	11.69-18.18 (15.83±0.74)	17-27 (21.9±1.00)	Polygonal	Straight to slightly wavy	12.25-16.78 (14.52±0.52)	12.16-22.68 (15.81±0.99)
15	<i>L. trifoliata</i>	AD	-					Irregular	Strongly sinuate		
		AB	+	Anomocytic	17.25-21.25 (19.38±0.44)	13.21-16.22 (15.08±0.38)	9-17 (13.80±0.42)	Irregular	Strongly sinuate	10.28-18.29 (13.08±0.85)	10.71-19.76 (16.08±0.71)
		AD	-					Irregular	Slightly sinuate		
16	<i>L. lamidilensis</i>	AB	+	Anisocytic	18.76-22.77 (20.67±0.42)	13.66-17.98 20.67±0.42	10-19 (12.08±0.87)	Irregular	Strongly sinuate	11.67-15.56 (13.36 ±0.48)	11.76-20.21 (15.74±0.93)

The seed is a developed ovule that contains food reserves and an embryo, enclosed in a seed coat serving as a propagule. The seed characters have long been recognized for their systematic utility and some valuable aspects of seed morphology are size and shape, as well as the colour and surface features of the seed coat (Simpson, 2010). Micromorphological characteristics of seeds are highly helpful for taxonomic identification and delimitation of various plant groups (Ullah *et al.*, 2018b). In Vitaceae, special attention has been made to the application of seed characters in the delineation of allied genera of the family. According to Süssenguth (1953), there are species-specific differences in the configuration of the seed as viewed in the transverse section. Periasamy (1962) found that some genera differ in the growth of chalaza and the number of layers of mechanical tissues of the seed coat. Chen and Manchester (2011) found that Vitaceous seeds can be differentiated to a generic level by comparing certain anatomical and external characteristics.

Besides light microscopy, the invention of electron microscopy opened the way for high-resolution images. Scanning electron microscopy (SEM) involves high magnification with fine details of ultrastructure that are invisible with optical microscopy. While examining seed surface sculpturing and the structure of seed coats, SEM provides significant information while general morphology is less effective (Ullah *et al.*, 2018b).

Here, we carried out a detailed study of seed micro-morphology of the genus *Leea* using a Light Microscope (LM) and Scanning Electron Microscope (SEM). In the present study, we focused on 1) An examination of the seed morphology of all species of *Leea* in India with the aid of both LM and SEM. 2) Providing pertinent data on seed surface morphology to aid in solving taxonomic problems in the genus *Leea*.

Materials and methods

For micromorphological analysis, seeds were investigated through Light microscopy (LM) and Scanning electron microscopy (SEM). For SEM analysis, the

materials were directly mounted on a stub using carbon tape and sputter coated with gold. Micro morphological observations were carried out using Gemini SEM 300 FE scanning electron microscope (ZEISS, Germany) with 1.5 kV voltages at Central Sophisticated Instrument Facility (CSIF), University of Calicut, and at Analytical facility (SITRA), Coimbatore. Multiple accessions of perplexing taxa were examined in order to confirm the consistency of the investigated characters.

The terminology of Periasamy (1962), Ridsdale (1974), and Barthlott (1981) were adopted to describe the seeds.

The results have been presented as mean $\pm$ standard error. The software application SPSS version 20.0 was used to process the quantitative data in order to calculate the minimum, maximum, average, and standard errors. To verify the findings, the data were further subjected to Duncan's multiple range tests as well as one-way Analysis of Variance (ANOVA).

Results

The seed morphological and micro-morphological characters are listed in Table 6. A different view of Light microscopic images of seed is illustrated in figures 145 and 146; seed sculpturing is illustrated in figures 148 and 149. Among the several characters of the seed studied, the characters like seed size, nature of dorsal chalaza, type of sculpturing, the shape of periclinal walls and the nature of anticlinal walls were considered to be the taxonomically most important characters.

Leea adwivedica

Fig. 145A1-A4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 6.61–6.85 (6.76 $\pm$ 0.07) $\times$ 5.32–5.57 (5.47 $\pm$ 0.07) mm, brownish-black when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of seven ingrowths: one along the median plane, two from the raphe, and one at one side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate; cells irregular-polygonal; anticlinal wall depressed; mostly straight, uniformly thickened; periclinal wall flat, rough.

Leea aequata**Fig. 145B1–B4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.98–5.13 (5.04 ± 0.04) $\times$ 3.74–3.91 (3.85 ± 0.05) mm, dark brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing alveolate; cells polygonal; anticlinal wall prominently raised; straight, unevenly thickened; periclinal wall deeply concave, smooth.

Leea angulata**Fig. 145C1–C4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 3.7–3.9 (3.83 ± 0.06) $\times$ 3–3.3 (3.16 ± 0.06) mm, light brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of six ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate or alveolate; cells irregular-polygonal; anticlinal wall slightly raised; straight–slightly wavy, unevenly thickened; periclinal wall shallow concave, rough.

Leea asiatica**Fig. 145D1–D4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.03–4.31 (4.16 ± 0.08) $\times$ 3.35–3.72 (3.50 ± 0.11) mm, dark brown when mature; dorsal chalaza long, linear, not raised (plane); endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing colliculate; cells polygonal; anticlinal wall depressed; straight, uniformly thickened; periclinal wall convex, smooth.

Leea compactiflora**Fig. 145E1-E4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.72–4.91 (4.83 ± 0.05) $\times$ 3.72–3.85 (3.79 ± 0.03) mm, Light brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing slightly reticulate; cells polygonal; anticlinal wall slightly raised; straight, unevenly thickened; periclinal wall flat, smooth.

Leea grandifolia**Fig. 145G1-G4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 3.91–4.22 (4.04 ± 0.09) $\times$ 3.31–3.42 (3.36 ± 0.03) mm, dark brown when mature; dorsal chalaza long, linear, slightly raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing slightly colliculate; cells irregular-polygonal; anticlinal wall depressed; straight-slightly wavy, unevenly thickened; periclinal wall slightly convex, smooth.

Leea guineensis**Fig. 146A1-A4**

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.43–4.78 (4.57 ± 0.10) $\times$ 4.02–4.12 (4.06 ± 0.03) mm, light brown when mature; dorsal chalaza long, linear, not raised (plane); endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing alveolate/reticulate; cells polygonal; anticlinal wall prominently raised; straight, unevenly thickened; periclinal wall deeply concave, finely folded.

Leea indica

Fig. 146B1-B4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.21–4.52 (4.40±0.09) × 3.13–3.42 (3.25±0.08) mm, dark brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing slightly colliculate; cells irregular; anticlinal wall depressed; sinuous, unevenly thickened; periclinal wall slightly convex, smooth.

Leea macrophylla

Fig. 146C1-C4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.12–4.36 (4.27±0.07) × 3.67–3.72 (3.70±0.01) mm, light brown when mature; dorsal chalaza long, linear, not raised (plane); endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing alveolate/reticulate; cells polygonal anticlinal wall prominently raised; straight, unevenly thickened; periclinal wall deep concave, smooth.

Leea mizoramensis

Fig. 145F1-F4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 3.91–4.11 (3.98±0.06) × 3.61–3.72 (3.67±0.03) mm, light brown when mature; dorsal chalaza long, linear, slightly raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the

raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate; cells polygonal; anticlinal wall depressed; straight, uniformly thickened; periclinal wall flat, smooth.

Leea robusta

Fig. 146D1-D4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 3.62–3.82 (3.73±0.05) × 2.95–3.12 (3.01±0.05) mm, light brown when mature; dorsal chalaza long, linear, not raised (plane); endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate; cells polygonal anticlinal wall slightly raised; straight, unevenly thickened; periclinal wall shallow concave, striated.

Leea setuligera

Fig. 146E1-E4

Berry consists of four seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.43–4.69 (4.54±0.07) × 3.72–4.21 (3.98±0.14) mm, light brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing alveolate; cells polygonal anticlinal wall prominently raised; straight, unevenly thickened; periclinal wall deeply concave, finely folded.

Leea sumdaica

Fig. 146F1-F4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 4.31–4.52 (4.45±0.07) × 2.61–3.02 (2.85±0.13) mm, dark brown when mature; dorsal chalaza long, linear, prominently raised; endosperm ruminant, consists of five ingrowths: one along the median plane, two

along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate; cells polygonal; anticlinal wall slightly raised; straight- slightly wavy, unevenly thickened; periclinal wall deeply concave, smooth.

Leea tamdilensis

Fig. 146G1-G4

Berry consists of six seeds. Seeds were wedge-shaped, triangular with smooth angles in cross-section, 3.6–3.9 (3.76 ± 0.08) $\times$ 3.4–3.5 (3.42 ± 0.03) mm, dark brown when mature; dorsal chalaza long, linear, slightly raised; endosperm ruminate, consists of five ingrowths: one along the median plane, two along the raphe, and one on each side of the lateral face surface and three at another side of lateral surface.

Surface sculpturing reticulate; cells polygonal; anticlinal wall slightly raised; straight- slightly wavy, unevenly thickened; periclinal wall shallow concave, rough.

Seed characters

Seed number

The fruit of *Leea* is a berry as that of other genera of Vitaceae. The genus *Leea* showed 4-seeded or 6-seeded, with the latter being the common type. In Indian *Leea*, the majority of the species have six seeded fruits except *L. setuligera* which constantly has four seeds. Usually, all the seed gets mature but occasionally one or two seeds become aborted.

Seed shape

The shape of the seed shows not much difference among different species of *Leea*. Seeds were laterally compressed and normally wedge-shaped. All the studied seeds were triangular with smooth angles in cross-section.

Seed size

The size of the seed showed considerable variation among most of the species studied. It ranges from 6.76–3.73 mm in length, and 2.85–5.47 mm in width.

The length and width of the seeds were divided into different groups. The length groups include Group I (3.5–4.5 mm), Group II (4.6–5.5), and Group III (≥ 5.6). The majority of species belong to Group I, which includes *L. angulata*, *L. asiatica*, *L. mizoramensis*, *L. grandifolia*, *L. indica*, *L. macrophylla*, *L. robusta*, *L. sundaica*, and *L. tamdilensis*. Group II consisted of *L. aequata*, *L. compactiflora*, and *L. setuligera* and Group III consisted only one species, *L. adwivedica*. In Indian *Leea*, the majority of the species belong to the seed length ranges from 3.5–4.5 mm.

The seed width groups include Group I (≤ 3); Group II (3–5); Group III (≥ 5). Group I and Group III contain only one species each, *L. sundaica* and *L. adwivedica* respectively. However, group II includes *L. angulata*, *L. asiatica*, *L. mizoramensis*, *L. grandifolia*, *L. indica*, *L. macrophylla*, *L. robusta*, *L. tamdilensis*, *L. aequata*, *L. compactiflora*, *L. setuligera* and *L. guineensis*.

L. adwivedica has the largest seed, measuring 6.76 mm long whereas *L. robusta* has the smallest seed measuring 3.73 mm long. Seeds show much variation in width, *L. adwivedica* has the widest seed, measuring 5.47 mm whereas *L. sundaica* has the thinnest seed, measuring 2.85 mm. According to the studied species, the most common seed length ranges between 3.5–4.5 mm, and the width is 3–5 mm.

Seed colour

The colour of the seeds was in different shades of brown which included pale brown, dark brown to brownish black. Brownish-black, shiny seeds were seen in *L. adwivedica*. Light brown seeds were found in *L. robusta*, *L. mizoramensis*, *L. setuligera*, *L. compactiflora*, *L. guineensis*, *L. macrophylla*, *L. angulata*, and dark brown seeds occurred in *L. asiatica*, *L. sundaica*, *L. aequata*, *L. grandifolia*, *L. indica* and *L. tamdilensis*. The seed colour does not change after storage and thus can be considered as a significant character.

Dorsal chalaza

The occurrence of a dorsal chalaza is the distinguishing feature of the family Vitaceae. The dorsal chalaza of *Leea* was long and linear. There were three types of

dorsal chalaza were observed *viz.*, flat, slightly raised, and prominently raised. The dorsal chalaza was flat in *L. asiatica*, *L. guineensis*, *L. macrophylla*, and *L. robusta*; slightly raised in *L. grandifolia*, *L. tamdilensis* and *L. mizoramensis* and prominently raised in *L. compactiflora*, *L. setuligera*, *L. indica*, *L. angulata*, *L. adwivedica*, and *L. aequata*.

Endosperm

As in the other members of Vitaceae, *Leea* showed ruminant endosperm. The endosperm in the seed of *Leea* has basically five ingrowths: one along the median plane due to the in pushing of the chalaza, two from the raphe, and one at each lateral face. However, in *L. adwivedica*, an extra infold (Fig. 149I) along the lateral face was noticed.

Fig. 149

Seed sculpturing

The Surface sculpturing patterns play an important role in the delimitation of different taxa. Sculpturing patterns were classified into six types (Table 6) *viz.*, reticulate, slightly reticulate, colliculate, slightly colliculate, alveolate and reticulate/alveolate.

Fig. 147-148

Anticlinal walls

The pattern of the anticlinal wall is quite variable among species. It can therefore be used to identify and differentiate between species. There were three types of anticlinal walls seen in *Leea*; slightly raised, prominently raised or depressed. The species like *L. angulata*, *L. compactiflora*, *L. robusta*, *L. sundaica* and *L. tamdilensis* showed slightly raised anticlinal walls whereas, *L. aequata*, *L. guineensis*, *L. macrophylla* and *L. setuligera* showed prominently raised anticlinal walls. However, in *L. asiatica*, *L. adwivedica*, *L. mizoramensis*, *L. grandifolia* and *L. indica*, anticlinal walls were depressed. In all the species studied, the anticlinal walls are unevenly thickened and straight to slightly wavy.

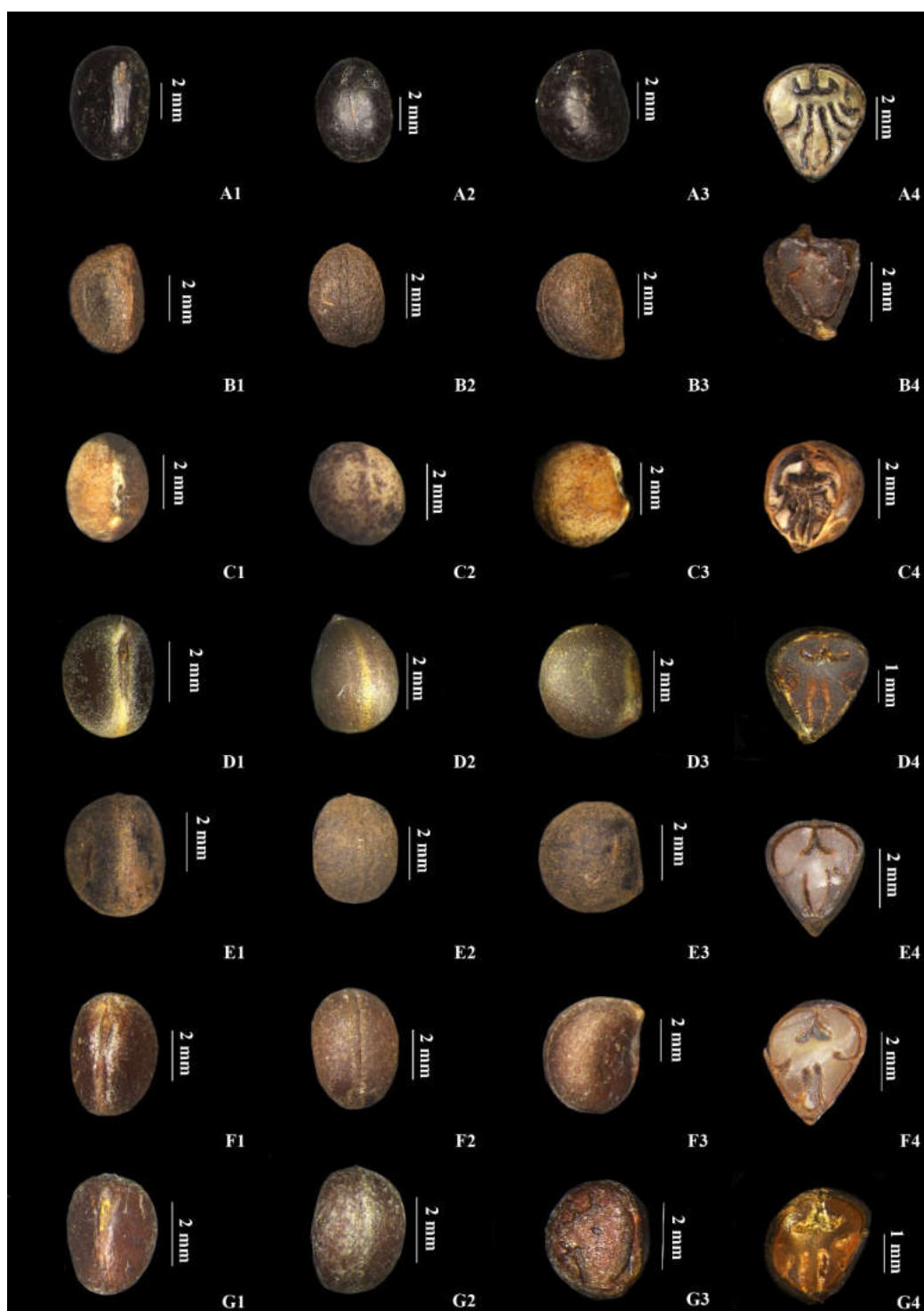


Fig. 145. Seeds of *Leea* L.: **A1-A4.** *L. adwivedica*; **B1-B4.** *L. aequata*; **C1-C4.** *L. angulata*; **D1- D4.** *L. asiatica*; **E1-E4.** *L. compactiflora*; **F1-F4.** *L. mizoramensis*; **G1-G4.** *L. grandifolia*. From left to right, ventral, dorsal, lateral, and transverse sections are shown.



Fig. 146. Seeds of *Leea* L.: **A1-A4.** *L. guineensis*; **B1-B4.** *L. indica*; **C1-C4.** *L. macrophylla*; **D1- D4.** *L. robusta*; **E1-E4.** *L. setuligera*; **F1-F4.** *L. sundaica*; **G1-G4.** *L. tamdilensis*. From left to right, ventral, dorsal, lateral, and transverse sections are shown.

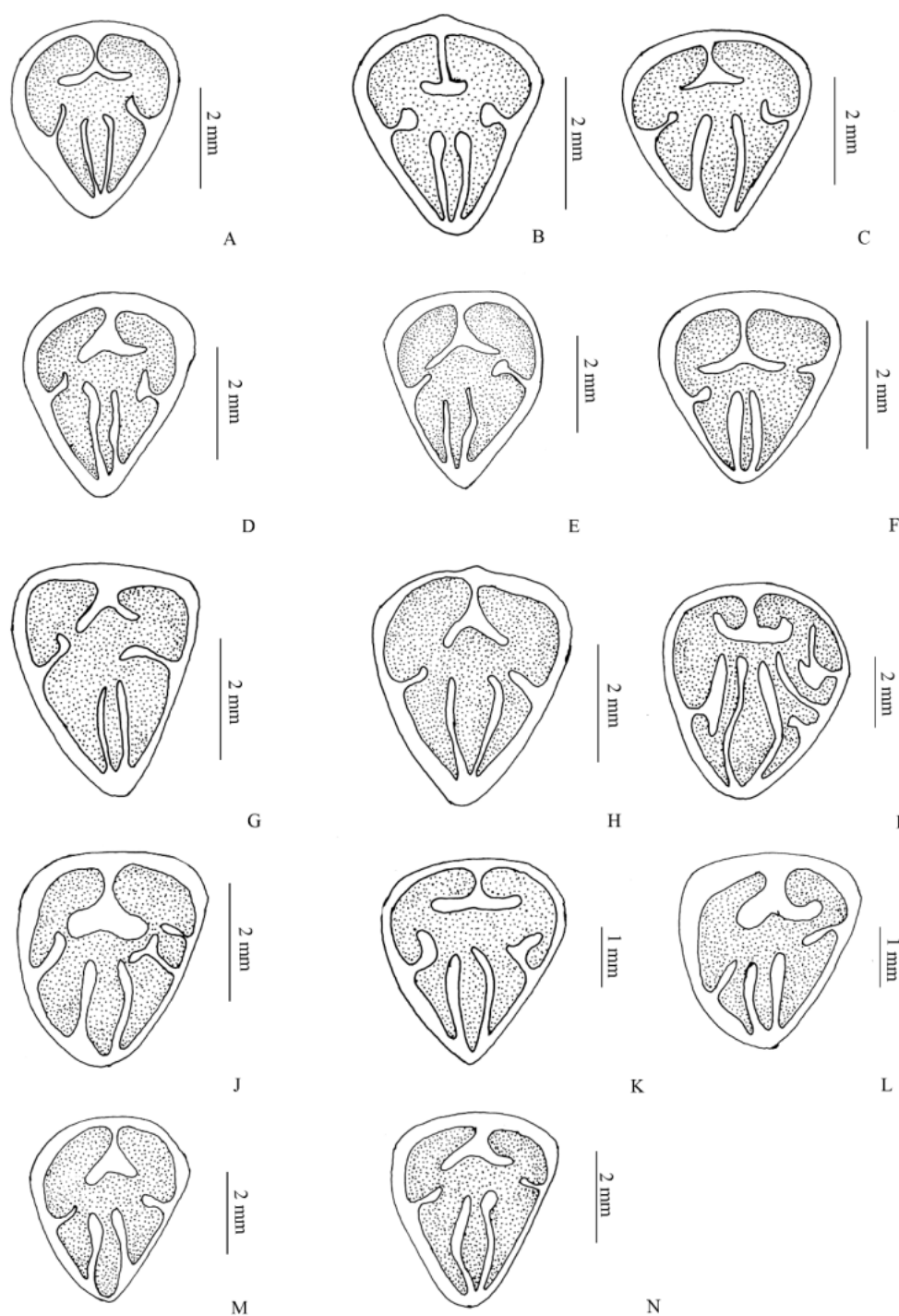


Fig. 147. Cross-sections of seeds of *Leea* L. showing ruminated endosperm: **A.** *L. guineensis*; **B.** *L. indica*; **C.** *L. macrophylla*; **D.** *L. robusta*; **E.** *L. setuligera*; **F.** *L. sundaica*; **G.** *L. aequata*; **H.** *L. compactiflora*; **I.** *L. adwivedica*; **J.** *L. angulata*; **K.** *L. asiatica*; **L.** *L. grandifolia*; **M.** *L. mizoramensis*; **N.** *L. tamdilensis*.

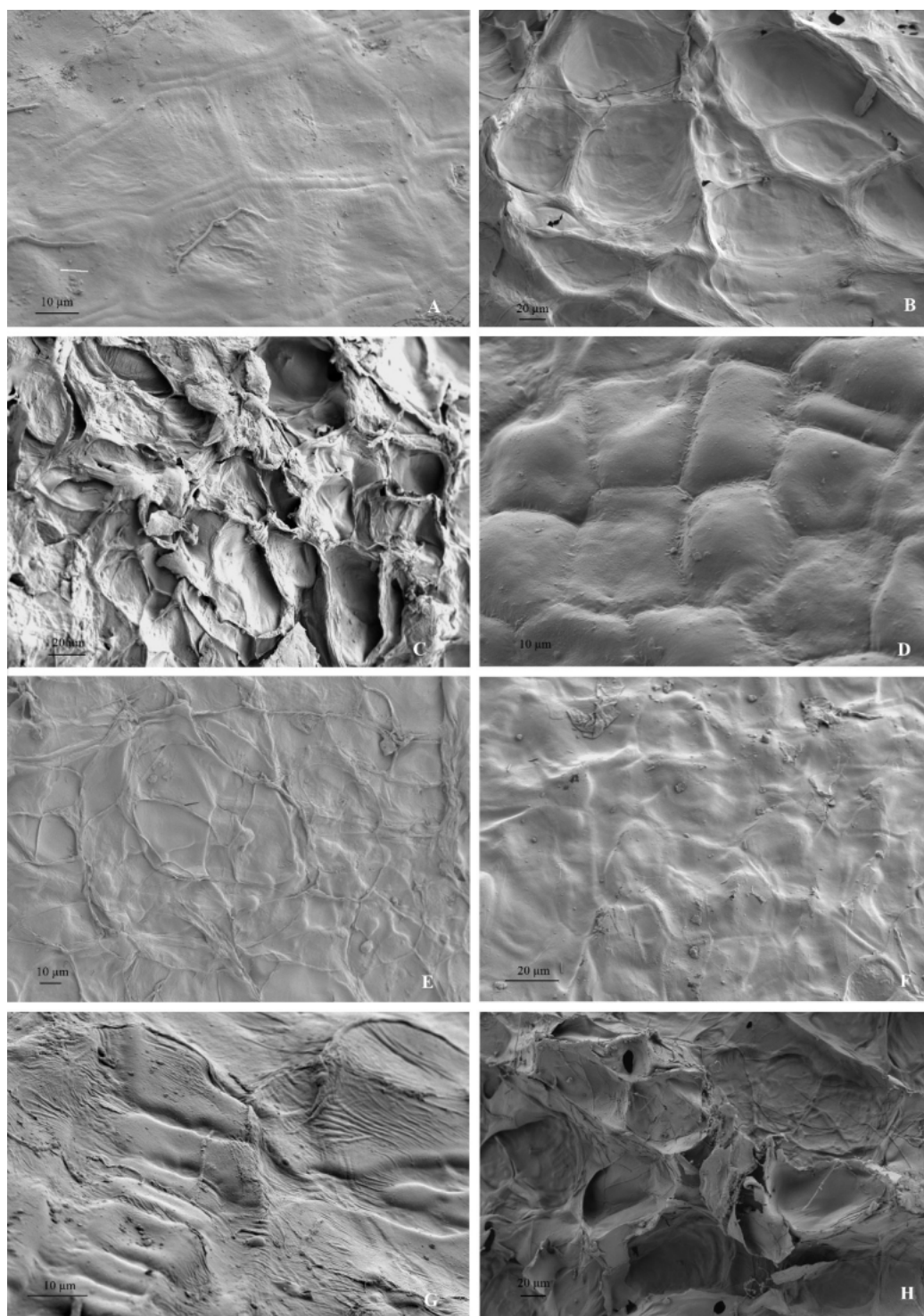


Fig. 148. Surface sculpture of seeds of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; **F.** *L. mizoramensis*; **G.** *L. grandifolia*; **H.** *L. guineensis*.

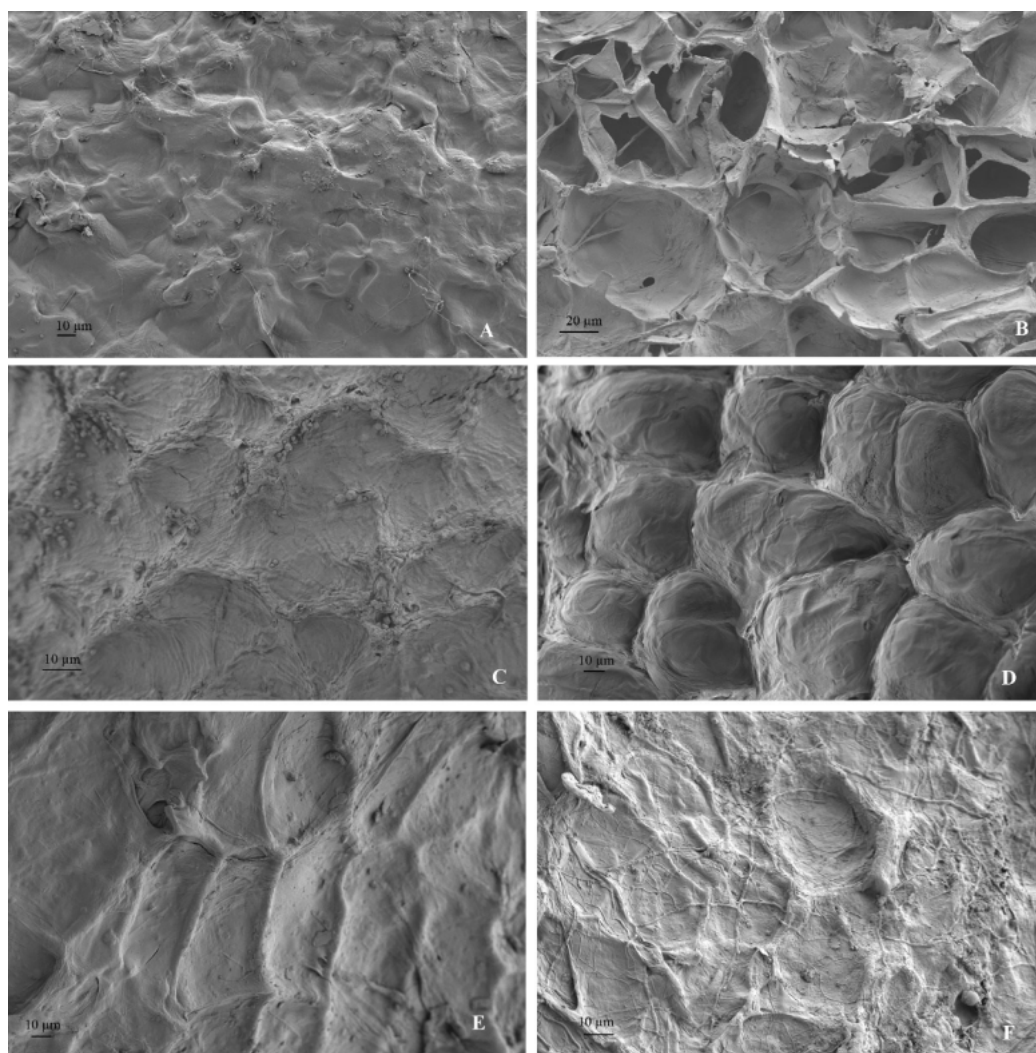


Fig. 149. Surface sculpture of seeds of *Leea* L.: **A.** *L. indica*; **B.** *L. macrophylla*; **C.** *L. robusta*; **D.** *L. setuligera*; **E.** *L. sundaica*; **F.** *L. tamdilensis*.

Outer Periclinal walls

Characteristics of the outer periclinal cell walls are useful for diagnostic purposes. Outer periclinal walls show differences among species. There were five types of patterns observed; flat, convex, deep concave, shallow concave and slightly convex. The flat type was observed in *L. compactiflora*, *L. adwivedica*, and *L. mizoramensis*. Whereas species such as *L. tamdilensis*, *L. sundaica* and *L. robusta* show shallow concave and *L. angulata*, *L. setuligera*, *L. macrophylla*, *L. guineensis* and *L. aequata* show deep concave ericlinal wall. However, in *L. grandifolia* and *L. indica*,

periclinal walls were slightly convex. *Leea asiatica* was the only species that showed convex periclinal walls.

Discussion

Seed morphology is of considerable significance for species delimitation. Between species, an extensive variation in size and sculpturing occurs, which offers significant taxonomic information. The morphology of the seeds' coats is assumed to remain stable and hardly influenced by external factors as the seeds grow and mature inside the fruit. (Gabr, 2018). In the family Vitaceae, very few studies have been carried out on the seed coat and its taxonomic relevance. The seed coat morphological feature in the genus *Leea* is seldom used as a key feature for distinguishing species.

Seeds of Vitaceae are characterized by a pair of ventral infolds and a dorsal chalaza (Periasamy, 1962), Vitaceous seeds are relatively easy to identify. Previous research (Periasamy, *l.c.*; Chen & Manchester, 2011) recognized the potential systematic usefulness of seed characteristics in this family, however, based on a rather small sampling. Periasamy (*l.c.*) discovered variations in chalazal growth and in the number of layers in the mechanical tissues of seed coat among some genera of Vitaceae. Chen and Manchester (*l.c.*) presented a seed survey of 258 species belonging to the 15 genera of Vitaceae. They found that the seeds of *Leea*, *Cissus*, and *Cyphostemma* can readily be distinguished from other members of the Vitaceae by their linear, long chalaza. Our results corroborate with their findings. According to them, laterally compressed and the Y-shaped dorsal infold below the perichalaza, along with a pair of longitudinally arranged rugae is the distinguishing feature of the genus *Leea*. The longitudinal rugae of *Leea* might be unbranched, branched or extensively branched and the endotesta in the rugae is poorly developed.

The present study showed that Indian *Leea* usually had six-seeded fruits except in some species where it is four-seeded. One or more ovules may become aborted but usually, all six or four develop into mature seeds. Seeds were usually laterally compressed and wedge-shaped in *Leea* and were light brown to dark

brown-black. Seed length and width varied across the species studied; it ranged from $3.73\text{--}6.76 \times 3.85\text{--}5.47$ mm. The longest seed (6.76 mm) in *Leea* was found in *L. adwivedica*, while the shortest (3.73 mm) in *L. robusta*.

The endosperm in the seed of *Leea* was ruminant, having basically five ingrowths: one along the median plane due to the in pushing of the chalaza, two from the raphe, and one at each lateral face. The ingrowth is produced by localized meristematic activity of the middle layer of the outer integument which causes the inner layer to be intruded and later the inner layer undergoes some degree of lignification (Ridsdale, 1974). He also pointed out the development of the chalazal ingrowth, to form a median plate, a characteristic feature of *Leea* and not found in any other members of Vitaceae. Extra ingrowths may be present in some species (*L. adwivedica*). The mature endosperm contains fatty reserves and one druses in each cell (Periasamy, 1962; Ridsdale, l.c.).

For the delimitation of species in *Leea*, seed morphology is of considerable importance. Significant differences have been found, for instance, in *L. macrophylla* and *L. robusta*, which were previously considered to be conspecific. They differ considerably in terms of seed characteristics such as seed length and the nature of anticlinal and periclinal walls. However, different ecotypes of *L. robusta* have similar types of seeds. Hence, seed character can be used as supportive data for the delimitation of species in this taxonomically challenging genus with species complexes.

Conclusion

The present study showed that variations in seed morphological and seed surface characters appear to have taxonomic value in distinguishing species of *Leea*. Among the seed characters studied seed shape, size, nature of dorsal chalaza, type of sculpturing, shape of periclinal walls and nature of anticlinal walls were considered to be the taxonomically most important characters. Hence, seed characters can be used to delimit species in this taxonomically challenging genus. Results from the present study are generally in agreement with those of earlier studies especially characters such as the ruminant endosperm of and dorsal chalaza.

Table 6: Comparison of seed characters

Sl. No.	Name of species	shape	Colour	Seed length (mm)	Seed width	Dorsal Chalaza	Surface sculpturing	Anticlinal wall	Periclinal wall
1	<i>L. aequata</i>	Wedge-shaped	Dark brown	4.98-5.13 (5.04±0.04)	3.74-3.91 (3.85±0.05)	Long, linear, prominently raised	Alveolate	Prominently raised	Deeply Concave
2	<i>L. adwivedica</i>	Wedge-shaped	Brownish Black	6.61-6.85 (6.76±0.07)	5.32-5.57 (5.47±0.07)	Long, linear, prominently raised	Reticulate	Depressed	Flat
3	<i>L. angulata</i>	Wedge-shaped	Light brown	3.7-3.9 (3.83±0.06)	3-3.3 (3.16±0.06)	Long, linear, prominently raised	Reticulate/Alveolate	Slightly raised	Shallow concave
4	<i>L. asiatica</i>	Wedge-shaped	Dark brown	4.03-4.31 (4.16±0.08)	3.35-3.72 (3.50±0.11)	Long, linear, not raised (plane)	Colliculate	Depressed	Convex
5	<i>L. compactiflora</i>	Wedge-shaped	Light brown	4.72-4.91 (4.83±0.05)	3.72-3.85 (3.79±0.03)	Long, linear, prominently raised	Slightly reticulate	Slightly raised	Flat
6	<i>L. grandifolia</i>	Wedge-shaped	Dark brown	3.91-4.22 (4.04±0.09)	3.31-3.42 (3.36±0.03)	Long, linear, slightly raised	slightly colliculate	Depressed	Slightly Convex
7	<i>L. guineensis</i>	Wedge-shaped	Light brown	4.43-4.78 (4.57±0.10)	4.02-4.12 (4.06±0.03)	Long, linear, not raised (plane)	Alveolate/Reticulate	Prominently raised	Deeply Concave
8	<i>L. indica</i>	Wedge-shaped	Dark brown	4.21-4.52 (4.40±0.09)	3.13-3.42 (3.25±0.08)	Long, linear, prominently raised	slightly colliculate	Depressed	Slightly convex
9	<i>L. macrophylla</i>	Wedge-shaped	Light brown	4.12-4.36 (4.27±0.07)	3.67-3.72 (3.70±0.01)	Long, linear, not raised (plane)	Alveolate/Reticulate	Prominently raised	Deep Concave
10	<i>L. mizoramensis</i>	Wedge-shaped	Light brown	3.91-4.11 (3.98±0.06)	3.61-3.72 (3.67±0.03)	Long, linear, slightly raised	Reticulate	Depressed	Flat

Seed

11	<i>L. robusta</i>	Wedge-shaped	Light brown	3.62–3.82 (3.73±0.05)	2.95–3.12 (3.01±0.05)	Long, linear, not raised (plane)	Reticulate	Slightly raised	Shallow Concave
12	<i>L. setuligera</i>	Wedge-shaped	Light brown	4.43–4.69 (4.54±0.07)	3.72–4.21 (3.98±0.14)	Long, linear, prominently raised	Alveolate	Prominently raised	Deeply Concave
13	<i>L. sundaica</i>	Wedge-shaped	Dark brown	4.31–4.52 (4.45±0.07)	2.61–3.02 (2.85±0.13)	Long, linear, prominently raised	Reticulate	Slightly Raised	Shallow Concave
14	<i>L. tamdilensis</i>	Wedge-shaped	Dark brown	3.6–3.9 (3.76±0.08)	3.4–3.5 (3.42±0.03)	Long, linear, slightly raised	Reticulate	Slightly raised	Shallow Concave

The tropical genus *Leea* is taxonomically challenging as most of its species possess uniform vegetative and floral characters. However, within species, many taxa exhibit a great deal of variation in habit, leaf characteristics, vestiture, and polymorphism in flower colour often making species circumscription difficult. As a result, a number of synonyms have been recorded especially in widely distributed taxa. Such problems can be tackled by exploring macro morphological and micromorphological characters that are stable and help in elucidating the taxonomy of the genus. Palynology is the study of the morphology of pollen and spores. Palynological characteristics play an important role in the identification, classification, and species delimitation of plants (Ashfaq *et al.*, 2018). According to Simpson (2010), the palynological features of plants have provided important characters for determining their phylogenetic relationships. Although the pollen grains of other members of Vitaceae received good attention, palynological studies on the genus *Leea* are not comprehensive. The few studies available (Najmaddin, 2014; Nair *et al.*, 2018) are based on limited sampling. In this backdrop, a study was undertaken to 1) examine the pollen morphology in detail including its shape, size, and exine ornamentation of *Leea* from India, using light microscopy (LM) and scanning electron microscopy (SEM); 2) assess the role of palynological data in the circumscription and delimitation of species in the genus *Leea*.

Materials and methods

Micromorphology of pollens were investigated through LM & SEM. Pollen grains were stored in 70% alcohol and dehydrated in an ethanol series. The materials were directly mounted on a stub using carbon tape and sputter coated with gold. Micro morphological observations were carried out using Gemini SEM 300 FE scanning electron microscope (ZEISS, Germany) with 1.5 kV voltages at Central Sophisticated Instrument Facility (CSIF), University of Calicut, and at Analytical facility (SITRA), Coimbatore. Multiple accessions of perplexing taxa were examined in order to confirm the consistency of the investigated characters.

The terminology of Walker and Doyle (1975), Punt *et al.* (1994) and Nair *et al.* (2018) were followed to describe pollen characters.

The results have been presented as mean $\pm$ standard error. The software application SPSS version 20.0 was used to process the quantitative data in order to calculate the minimum, maximum, average, and standard errors. To verify the findings, the data were further subjected to Duncan's multiple range tests as well as one-way Analysis of Variance (ANOVA).

Result

The pollen characters of *Leea* are listed in Table 7. Different views of Light microscopic images of pollen and Scanning Electron Microscopic images (SEM) were provided in Figures. 150–152. In order to analyse the morphological characters of the pollen grains *Leea*, both quantitative and qualitative characteristics were recorded, including polar and equatorial diameters, P/E ratios, the number of pores and colpi, pollen shapes, and exine ornamentation.

Leea adwivedica

Fig. 149A

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 39.20 ± 1.14 (37.21–41.16) $\times$ 35.90 ± 0.98 (34.00–37.30), P/E ratio 1.09, prolate spheroidal, ornamentation foveolate, heterobrocheate.

Leea aequata

Fig. 149B

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 40.57 ± 0.95 (38.06–43.43) $\times$ 40.02 ± 2.32 (37.12–44.61), P/E ratio 1.01, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea angulata

Fig. 149C

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 34.59 ± 1.56 (33.23–36.42) $\times$ 34.49 ± 1.16 (32.22–36.10), P/E ratio 1.00, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea asiatica

Fig. 149D

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 40.01 ± 0.29 (39.43–40.41) $\times$ 38.50 ± 0.83 (37.27–40.08), P/E ratio 1.03, prolate spheroidal, ornamentation Microreticulate, heterobrocheate.

Leea compactiflora

Fig. 149E

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 41.04 ± 0.86 (39.40–42.34) $\times$ 41.14 ± 0.93 (40.15–43.00), P/E ratio 0.99, oblate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea grandifolia

Fig. 150A

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 43.90 ± 0.93 (42.16–45.38) $\times$ 43.84 ± 1.19 (42.26–46.18), P/E ratio 1.00, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea guineensis

Fig. 150B

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 37.64 ± 1.15 (35.24–39.11) $\times$ 35.68 ± 1.62 (34.24–37.44), P/E ratio 1.05, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea indica

Fig. 150C

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 45.28 ± 1.16 (43.33–47.16) $\times$ 44.53 ± 0.87 (43.27–46.20), P/E ratio 1.01, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea macrophylla

Fig. 150D

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 48.95 ± 1.22 (47.29–51.34) $\times$ 47.54 ± 1.23 (45.11–49.17), P/E ratio 1.02, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea mizoramensis

Fig. 151C

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 41.30 ± 1.48 (39.39–44.22) $\times$ 42.29 ± 0.86 (41.39–43.11), P/E ratio 0.97, oblate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea robusta

Fig. 150E

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 39.63 ± 0.86 (38.43–41.32) $\times$ 37.52 ± 0.65 (36.22–38.25), P/E ratio 1.05, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea setuligera

Fig. 151A

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 36.24 ± 1.15 (34.22–38.23) $\times$ 36.97 ± 0.26 (36.47–37.33), P/E ratio 0.98, oblate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea sundaica

Fig. 151B

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 42.21 ± 1.06 (34.22–38.23) $\times$ 39.94 ± 1.14 (38.23–42.12), P/E ratio 1.05, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Leea tamdilensis

Fig. 151D

Trizonocolpate, radially symmetrical, isopolar, aperture 3-colporate, 42.28 ± 1.21 (40.21–44.41) $\times$ 41.75 ± 1.20 (40.11–44.11), P/E ratio 1.01, prolate spheroidal, ornamentation microreticulate, heterobrocheate.

Pollen characters

Dispersal unit and size

The pollen grains were shed as monads. Based on the definition of Erdtman (1952), the pollen grains of *Leea* came under the medium-sized category, ranging from $34.59 \times 34.49 \mu\text{m}$ (*L. angulata*) to $48.95 \times 47.54 \mu\text{m}$ (*L. macrophylla*)

Polarity and shape

Pollen grains were radially symmetrical and isopolar in all species that were studied. The outline of the pollen grains in this genus was triangular in the polar view and elliptic in the equatorial view. In *Leea*, the majority of pollen grains were prolate spheroidal, as indicated by the P/E ratio (P/E range: 8/8–8/7) with three

species such as *L. compactiflora*, *L. setuligera*, *L. mizoramensis* having oblate spheroidal (P/E range: 7/8-8/8).

Aperture

All the studied pollen grains were three colporate with colpi extending almost near to the poles. The ectocolpi was very long in all the species and it was apocolpate mostly and very rarely syncolpate. In some species (eg. *L. aequata*) both apocolpate and syncolpate pollen grains were noticed.

The surface of the ectocolpi was ornamented in all the species. There was a narrow margin that may have been ornamented or psilate.

Stratification of exine and ornamentation

In all species, a broad mesocolpium was covering most of the surface area of pollen grains. The ornamentation at mesocolpium was microreticulate in most of the species except in prickle-bearing species (*L. angulata* and *L. adwivedica*) where it was foveolate.

The luminal floors were deep and the shape of the lumen varied from oval, round irregular shape. There was often a waxy deposit plugged into the lumina, especially in the mesocolpium. In the equatorial zone, colpi tend to be deep and wide; as they approach the poles and margins, they tend to be narrower.

Discussion

There was heterogeneity in the size, shape, and ornamentation of pollen grains of the analysed taxa (Table 7). Pollen grains of *Leea* were tricolporate which strongly supports the earlier works (Tarnavski & Patria, 1968; Chen, 2009; Najmaddin, 2014; Gerrath *et al.*, 1990; Nair *et al.*, 2018). The size of the pollen varies from 34.59×34.49 to 48.95×47.54 μm . The smallest pollen was found in *L. angulata* while the largest was in *L. macrophylla*. The shape of the pollen grains was mainly prolate spheroidal except in three species, data corroborate well with the work of Nair *et al.* (*l.c.*).

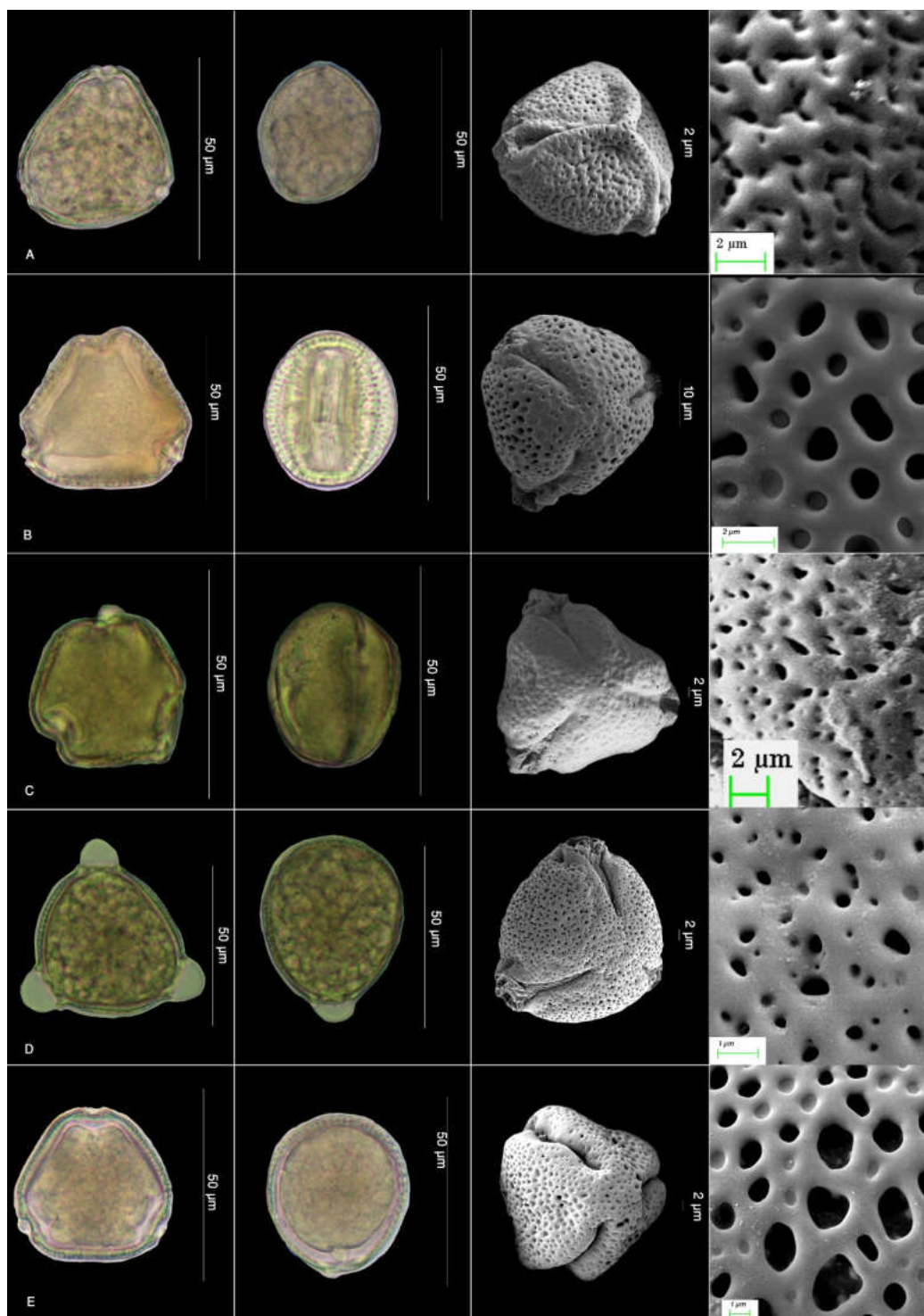


Fig. 150. Pollen grains of *Leea* L.: **A.** *L. adwivedica*; **B.** *L. aequata*; **C.** *L. angulata*; **D.** *L. asiatica*; **E.** *L. compactiflora*; polar view, equatorial view, SEM image and exine ornamentation are presented from left to right.

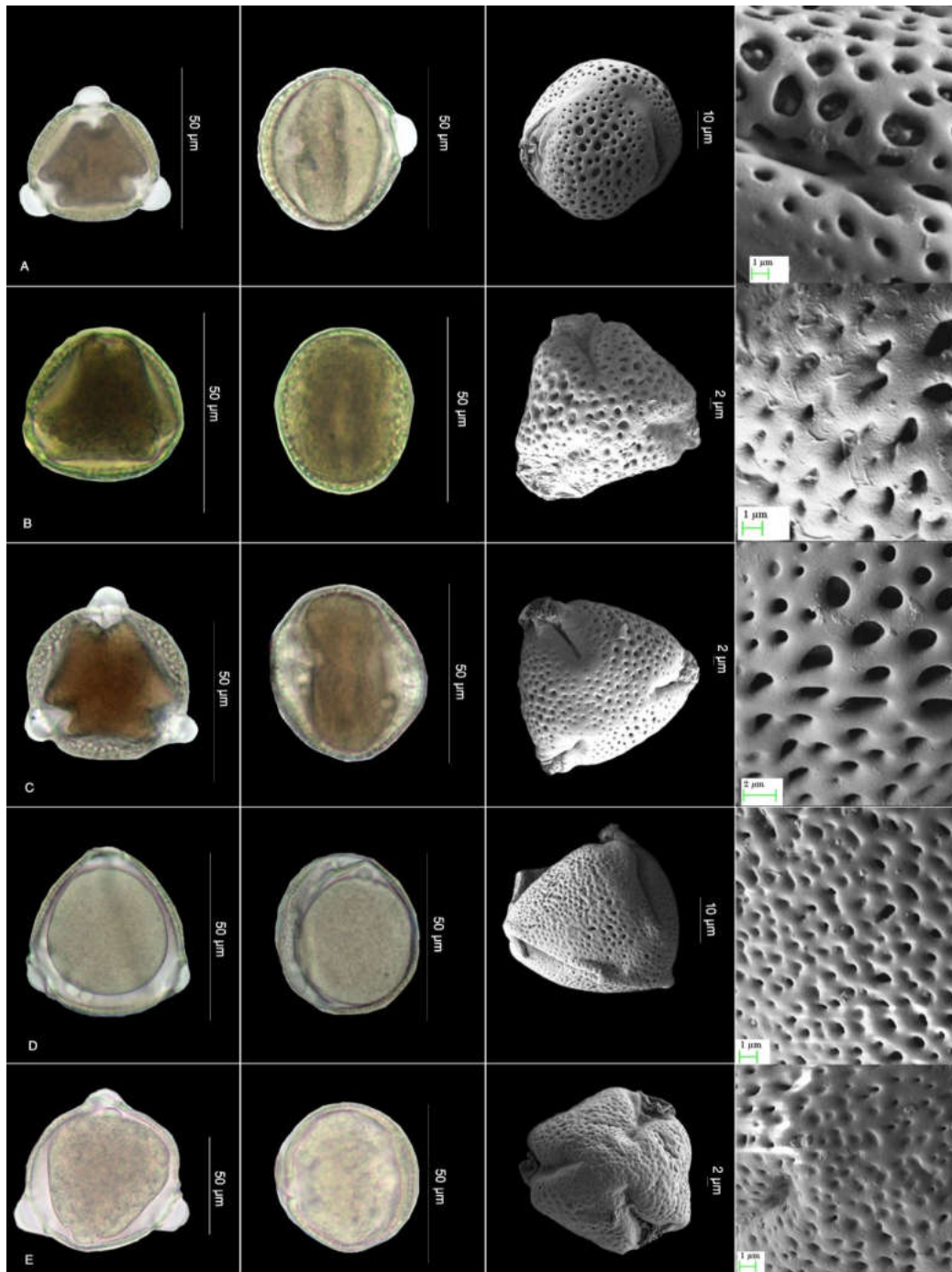


Fig. 151. Pollen grains of *Leea* L.: **A.** *L. grandifolia*; **B.** *L. guineensis*; **C.** *L. indica*; **D.** *L. macrophylla*; **E.** *L. robusta*; polar view, equatorial view, SEM image and exine Erdtman (1962) found that the pollen grains of *L. aequata* were spheroidal and brochi decreased in size and disappeared towards the colpi. However, our study showed that the pollen grain of *L. aequata* was prolate specroidal but the observation on brochi size was in accordance with him. ornamentation are presented from left to right.

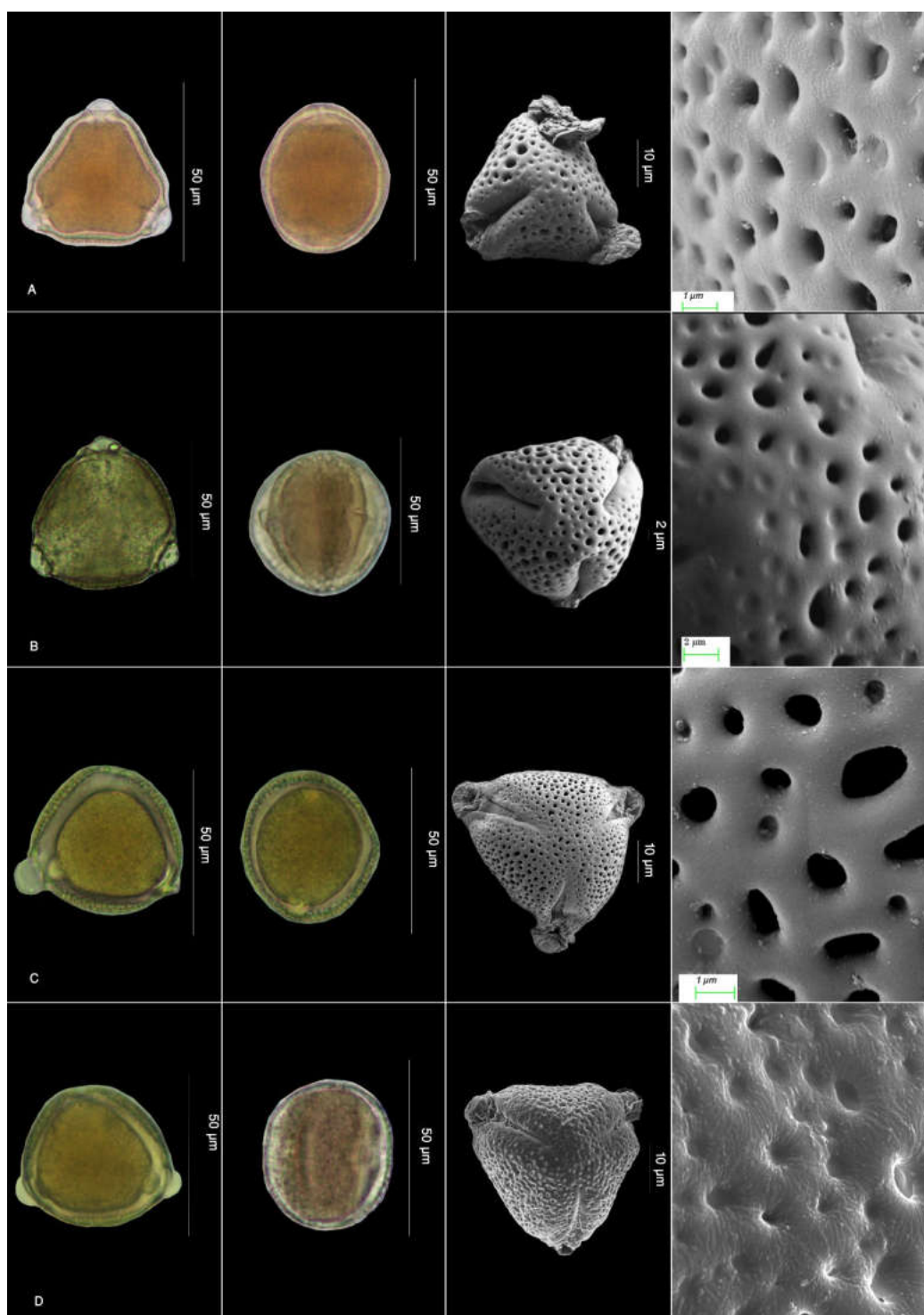


Fig. 152. Pollen grains of *Leea*: **A.** *L. setuligera*; **B.** *L. sundaica*; **C.** *L. mizoramensis*; **D.** *L. tamdilensis*; polar view, equatorial view, SEM image and exine ornamentation are presented from left to right.

Erdtman (1962) found that the pollen grains of *L. aequata* were spheroidal and brochi decreased in size and disappeared towards the colpi. However, our study showed that the pollen grain of *L. aequata* was prolate spheroidal but the observation on brochi size was in accordance with him.

Tarnavski and Patria (1968) have investigated the pollen grains of 31 species of *Leea*. The major findings include pollen grains were tricolporate, suboblate to suprolate in shape, syncolpate and the tectum was reticulate. But our result was no concordance with their attributes except in the nature of aperture. The segregation of two families was deemed necessary by the authors due to the significant differences in pollen characteristics between Vitaceae and Leeaceae. This view was also supported by Ridsdale (1974), Chen (2009) and Najmaddin (*l.c.*).

Based on a comparison of pollen grains *Leea* and Vitaceae, Chen (2009) concluded that species of *Leea* have relatively large and oblate pollen grains that are readily differentiated from Vitaceae pollen grains. However, our study showed that the pollen grains of *Leea* were mainly prolate spheroidal. Najmaddin (2014) conducted comparative palynological studies of members of the Vitaceae [*Cissus quadrangularis* L. & *Cayratia geniculata* (Blume) Gagnep.] and Leeaceae (*L. angulata*). She observed that pollen grains in *L. angulata* were tricolporate and had a triangular shape in equatorial view, in contrast to pollen grains in Vitaceae *s.s.*, which are tricolpate and have a prolate shape.

Nair (1968) found that pollen grains of *L. robusta* and *L. edgeworthii* were tricolporate and shed at a 3-celled stage. Gerrath *et al.* (1990) noted that the pollen grains of *L. guineensis* were triangular in shape and tricolporate. Our result also corroborates with the findings of these earlier workers.

Nair *et al.* (2018) investigated the pollen morphology of ten accessions representing five species of *Leea* from Kerala. They observed that pollen grains of *Leea* were stenopalynous and the features of pollen that appeared to be highly conserved in this genus were 3-colporate, prolate-spheroidal to sub-prolate, and medium-sized with micro reticulate exine ornamentation. They also discovered the close kin of pollen grains of *Leea* and other members of the Vitaceae as opposed to

the observation of previous authors. Using palynological data, they came to the consensus that *Leea* belongs to a subfamily of the Vitaceae, as suggested by the APG system of classification. our results corroborated with them.

Cartaxo-Pinto *et al.* (2021) examined the pollen morphology of representatives of the Ampelopsidae, Cayratieae, and Parthenocisseae tribes in order to evaluate their relationships and reconstruct their evolution of pollen characters based on previously existing phylogenetic hypotheses. Their findings demonstrate that the microreticulate ornamentation seen in members of the Vitaceae is a plesiomorphic trait shared with the sister group Leeaceae.

Our result shows the close similarity between the pollen of *Leea* and other members of Vitaceae. They showed similarity in terms of shape, and exine ornamentation. The present study supports the inclusion of the genus *Leea* as a monogeneric subfamily Leeoideae under Vitaceae based on pollen characteristics. As noted by Nair *et al.* (*l.c.*), the stenopalynous condition in both subfamilies along with some share characteristics is apt to classify the genus *Leea* under the family Vitaceae according to the pollen characteristics.

Conclusion

The genus *Leea* has stenopalynous pollen grains as seen in other members of Vitaceae. It consists of trizonocoporate radially symmetrical isopolar pollen grains. The results demonstrated the aperture number, polarity, and symmetry are consistent within the genus, however, species differ considerably in their polar and equatorial diameters, P/E ratios pollen shape, and exine sculpturing. This study also supports the close similarity in pollen grains of *Leea* and other members of Vitaceae. Hence, the inclusion of *Leea* in the family Vitaceae under the subfamily Leeoideae is justifiable.

Table 7: Comparison of palynological characters

Sl. No.	Taxa	Dispersal unit	Polar axis (µm)	Equatorial axis (µm)	P/E ratio	Shape	Ornamentation	Number of colpi	Polarity
1	<i>L. adwivedica</i>	Monad	39.20±1.14 (37.21–41.16)	35.90±0.98 (34.00–37.30)	1.09	Prolate spheroidal	Foveolate	Tricolporate	Isopolar
2	<i>L. aequata</i>	Monad	40.57±0.95 (38.06–43.43)	40.02±2.32 (37.12–44.61)	1.01	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
3	<i>L. angulata</i>	Monad	34.59±1.56 (33.23–36.42)	34.49±1.16 (32.22–36.10)	1.00	Prolate spheroidal	Foveolate	Tricolporate	Isopolar
4	<i>L. asiatica</i>	Monad	40.01±0.29 (39.43–40.41)	38.50±0.83 (37.27–40.08)	1.03	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
5	<i>L. compactiflora</i>	Monad	41.04±0.86 (39.40–42.34)	41.14±0.93 (40.15–43.00)	0.99	Oblate spheroidal	Microreticulate	Tricolporate	Isopolar
6	<i>L. grandifolia</i>	Monad	43.90±0.93 (42.16–45.38)	43.84±1.19 (42.26–46.18)	1.00	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
7	<i>L. guineensis</i>	Monad	37.64±1.15 (35.24–39.11)	35.68±1.62 (34.24–37.44)	1.05	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
8	<i>L. indica</i>	Monad	45.28±1.16 (43.33–47.16)	44.53±0.87 (43.27–46.20)	1.01	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
9	<i>L. macrophylla</i>	Monad	48.95±1.22 (47.29–51.34)	47.54±1.23 (45.11–49.17)	1.02	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
10	<i>L. robusta</i>	Monad	39.63±0.86 (38.43–41.32)	37.52±0.65 (36.22–38.25)	1.05	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar
11	<i>L. setuligera</i>	Monad	36.24±1.15 (34.22–38.23)	36.97±0.26 (36.47–37.33)	0.98	Oblate spheroidal	Microreticulate	Tricolporate	Isopolar
12	<i>L. sundaica</i>	Monad	42.21±1.06	39.94±1.14	1.05	Prolate	Microreticulate	Tricolporate	Isopolar

13	<i>L. mizoramensis</i>	Monad	(34.22-38.23) 41.30±1.48 (39.39-44.22)	(38.23-42.12) 42.29±0.86 (41.39-43.11)	0.97	spheroidal Oblate spheroidal	Microreticulate	Tricolporate	Isopolar
14	<i>L. tamdilensis</i>	Monad	42.28±1.21 (40.21-44.41)	41.75±1.20 (40.11-44.11)	1.01	Prolate spheroidal	Microreticulate	Tricolporate	Isopolar

Molecular systematics includes a number of methods, which use data from the macromolecules of the species being studied to infer phylogenetic relationships (Simpson, 2010). The use of molecular data for phylogenetic investigations provides new information, which often clarifies broad relationships among taxa (Rossetto *et al.*, 2002). Molecular studies of *Leea* received very little attention, and the only phylogenetic study of the genus was by Molina *et al.* (2013). This work suggested that the genus resolved into four major clades based on ITS and 5S NTS sequence data. The main aim of the present work includes 1) To clarify the phylogenetic relationship within the genus *Leea* 2) To find the position of Indian *Leea* and to check whether the molecular data is useful for species limitations.

Materials and Methods

Taxon samplings

A total of 42 accessions from 15 species of *Leea*, representing the geographic diversity of the genus, were sampled. Additional sequences representing the genus were acquired from the NCBI GenBank database (<http://www.ncbi.nlm.nih.gov>). *Clematicissus angustissima* Planch., *Cissus tweedieana* Planch., and *Cayratia acris* Domin were chosen as outgroups. Table 8 contains a complete list of the samples analysed in this investigation, along with the species that were downloaded from NCBI. The tender leaves were collected from the field and placed in a tea bag before being preserved in silica. Fresh samples were also used that are grown at Calicut University Botanical Garden (CUBG).

Table 8: List of taxa used for the present phylogentic study

No.	Name of the taxa	GenBank Accession number	Voucher specimen
1.	<i>Cayratia acris</i> F.Muell.	AF365985	B.Jakes 9960 (JCT)
2.	<i>Cayratia acris</i> F.Muell.	KT344586	Wen 12183 (US)
3.	<i>Cissus tweedieana</i> Planch.	AY998779	See Rosetto <i>et al.</i> (2002)

4.	<i>Clematicissus angustissima</i> (F.Muell.) Planch.	AY037913	B.Borschman 29.11.1999 (JCU)
5.	<i>Leea aequata</i> L.	Not deposited	Amrutha 164036 (CALI)
6.	<i>L. aequata</i> L.	JN160932	Kessler 3080 (L)
7.	<i>L. aequata</i> L.	JN160937	Wen 7494 (US)
8.	<i>L. aculeata</i> Blume	JN160912	Yap s.n. PUH)
9.	<i>L. aculeata</i> Blume	JN160911	Molina 19 (CHRB)
10.	<i>L. angulata</i> Korth. ex Miq.	Not deposited	Amrutha 164096 (CALI)
11.	<i>L. angulata</i> Korth. ex Miq.	JN160913	Mitchell 5 (CANB)
12.	<i>L. angulata</i> Korth. ex Miq.	JN160914	Wen 10230
13.	<i>L. asiatica</i> (L.) Ridsdale	Not deposited	Amrutha 153226 (CALI)
14.	<i>L. asiatica</i> (L.) Ridsdale	Not deposited	Amrutha 164785 (CALI)
15.	<i>L. asiatica</i> (L.) Ridsdale	Not deposited	Amrutha 164793 (CALI)
16.	<i>L. asiatica</i> (L.) Ridsdale	JN160889	Averyanov <i>et al.</i> 2190 (MO)
17.	<i>L. asiatica</i> (L.) Ridsdale	JN160892	Maxwell 90718 (A)
18.	<i>L. asiatica</i> (L.) Ridsdale	JN160891	Wen 9036 (US)
19.	<i>L. asiatica</i> (L.) Ridsdale	JN160890	Chand 8276 (MICH)
20.	<i>L. compactiflora</i> Kurz	Not deposited	Amrutha 159836 (CALI)
21.	<i>L. compactiflora</i> Kurz	Not deposited	Amrutha 159829 (CALI)
22.	<i>L. grandifolia</i> Kurz	Not deposited	Amrutha 164066 (CALI)
23.	<i>L. guineensis</i> G.Don	Not deposited	Amrutha 164060 (CALI)
24.	<i>L. guineensis</i> G.Don	Not deposited	Amrutha 154235 (CALI)
25.	<i>L. indica</i> (Burm.f.) Merr	JN160972	Fernandes 2031(A)
26.	<i>L. indica</i> (Burm.f.) Merr.	Not deposited	Amrutha 153216 (CALI)
27.	<i>L. indica</i> (Burm.f.) Merr.	Not deposited	Amrutha 153221 (CALI)
28.	<i>L. latifolia</i> Wall. ex Kurz	Not deposited	Amrutha 164791 (CALI)
29.	<i>L. macrophylla</i> Roxb. ex Hornem.	Not deposited	Amrutha 164701 (CALI)
30.	<i>L. macrophylla</i> Roxb. ex Hornem.	JN160927	Wen 7415 (US)
31.	<i>L. mizoramensis</i> Amrutha & Pradeep	Not deposited	Amrutha 164766 (CALI)

32.	<i>L. mizoramensis</i> Amrutha & Pradeep	Not deposited	Amrutha 164782 (CALI)
33.	<i>L. mizoramensis</i> Amrutha & Pradeep	Not deposited	Amrutha 164760 (CALI)
34.	<i>L. mizoramensis</i> Amrutha & Pradeep	Not deposited	Amrutha 159892 (CALI)
35.	<i>L. robusta</i> Roxb.	Not deposited	Amrutha 153202 (CALI)
36.	<i>L. robusta</i> Roxb.	Not deposited	Amrutha 153258 (CALI)
37.	<i>L. robusta</i> Roxb.	JN160928	Wen 7417 (US)
38.	<i>L. setuligera</i> C.B.Clarke	Not deposited	Amrutha 153249 (CALI)
39.	<i>L. setuligera</i> C.B.Clarke	Not deposited	Amrutha 153260 (CALI)
40.	<i>L. sundaica</i> Miq.	Not deposited	Amrutha 164065 (CALI)
41.	<i>L. trifoliata</i> M.A.Lawson	Not deposited	Amrutha 159851 (CALI)
42.	<i>L. tamdilensis</i> Amrutha & Pradeep	Not deposited	Amrutha 153265 (CALI)

DNA extraction, amplification and sequencing

A modified CTAB technique of Doyle and Doyle (1987) was used to extract whole genomic DNA from fresh/silica-dried materials. The procedure adopted for the isolation of DNA is described below:

1. 1 ml 2% CTAB extraction buffer and 2 μ l β -mercaptoethanol per sample was taken in a tube and preheated at 65 °C.
2. Grinded 100 mg of the leaf and added 1 ml of preheated extraction buffer and PVP and taken into a micro centrifuge tube which was labelled.
3. Incubated for 1.30 hr at 65 °C in the heated block. Mixed the sample twice while incubating.
4. Added 500 μ l Chloroform-isoamyl alcohol (24:1) and mixed gently by shaking to obtain a single phase using a vortex.
5. Centrifuged for 10 minutes at 13000 rpm at 4°C on a cool centrifuge.
6. Collected the supernatant and transferred it into a clean 1.5 ml centrifuge tube. Added 600 μ l ice-cold isopropanol and left in the refrigerator overnight.
7. Centrifuged for 10 min at 13000 rpm.
8. Discarded the supernatant and added 500 μ l wash buffer. Agitated to remove the pellet from the bottom. Left for 30 min at room temperature.

9. Centrifuged for 5 min at 13000 rpm at 4°C.
10. The supernatant was removed and the tubes were inverted to allow the remaining wash buffer to drain away and dry the pellet in room temperature.
11. The pellet was then dissolved in 50 to 100 µl of 1X TE buffer, based on the quantity of pellet, mixed well and stored at -20°C.

The extracted genomic DNA was subjected to gel electrophoresis to determine whether the appropriate bands were present or not. For this, 0.75 g agarose was weighed and dissolved in 75 ml 1X TAE (Tris Acetate EDTA) buffer. Agarose was subjected to melting by using a hot air oven until it fully dissolved. It is then transferred into a casting tray and allowed to solidify. After the agarose had solidified it was immersed in a gel electrophoretic apparatus with 750 ml of 1X TAE buffer and Ethidium bromide (2.5 µl/100 ml buffer). 2 µl DNA was mixed with 2 µl 6X gel-loading dye and each of the samples was loaded in the subsequent well. Electrophoresis was performed for 40 min at 120 V. Then the gel was visualized in a UV transilluminator (Fig. 153) and the images were captured in the gel documentation system (Aplegen ENDURO™ GDS Gel Documentation System).

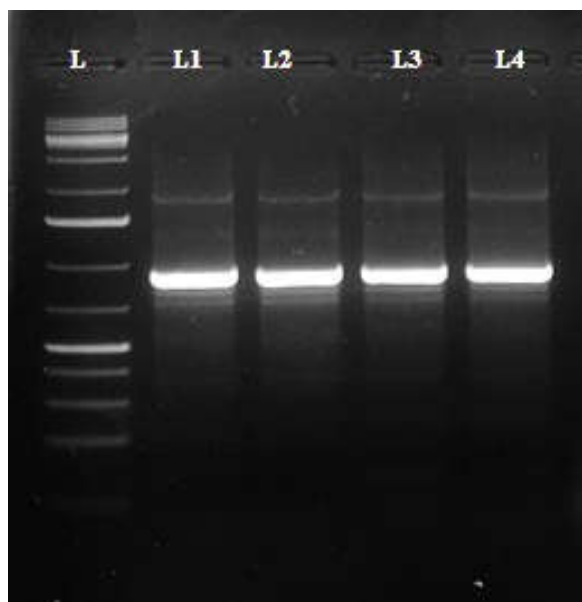


Fig. 153. Gel image of nrITS. L. indicates the bands of 100 kb ladder and L1–L4 shows the PCR products of ITS (approximately 750 bp.)

PCR (Polymerase Chain Reaction) Amplification

Phylogenetic analysis was conducted based on the nuclear ribosomal ITS (ITS1+5.8s+ITS2) sequence with the help of published primers ITS 5P and ITS 8P (Möller & Cronk, 1997; Table 9). PCR was carried out in a total of 25 µl reaction mixture containing 12.5 µl EmeraldAmp® GT PCR Master Mix (TaKaRa Bio, India), 0.25 µl Dimethyl sulfoxide (DMSO), 0.75 µl of each forward (ITS 5P) and reverse primer (ITS 8P), 9.25 µl deionized water and 1.5 µl of template DNA. The amplification of nrITS was done using a thermal cycler (Veriti thermal cycler) using a program consisting of an initial denaturation of 4 minutes at 97° C followed by 35 cycles of 1 minute denaturation (95° C), 1 minute annealing (54° C), 2 minute extension (68° C), ending with final 4 minute extension (72° C). Amplified DNA was visualized on 1.2% agarose gel under a UV transilluminator to check the presence of appropriate bands. The PCR amplification profile is given in Table 11. The composition of the amplification reaction mixture is given in Table 10. Amplified DNA was visualized on 1.2% agarose gel under a UV transilluminator (Fig. 153) to check the presence of appropriate bands 100 bp ladder was used as the molecular standard and sample with clear band were subjected to sequencing.

Amplified PCR products were purified using Exosap-IT PCR Product cleanup reagent (GE Healthcare, Cleveland, USA) and the purified PCR fragments were Sanger cycle sequenced.

Table 9 : Details of DNA region and primers used in the present analysis

Marker	Primer	Sequences 5'-3'	Citation
ITS	ITS-5P	GGA AGGAGA AGT CTA ACA AGG	(Möller & Cronk, 1997)
	ITS-8P	CAC GCT TCT CCA GAC TAC A	

Table 10: Composition of PCR Master mix

Reagent	Composition (μl)
EmeraldAmp® GT PCR Master Mix	12.5
Forward primer	0.75
Reverse primer	0.75
Genomic DNA	1.5
DMSO	0.25
Water	9.25

Total volume of the master mix per sample =25 μl

Table 11. PCR amplification profile**ITS**

97°C- 4 min

95°C- 1 min

54°C- 1 min

68°C- 2 min

72°C- 4 min

} 35 cycles

Sequencing

The sequencing was performed at SciGenom Labs, Cochin, Kerala. PCR products were sequenced using an ABI 3730 automated sequencer and BigDye 3.1 reagents according to normal procedures. (Applied Biosystems, California, U.S.A.) with the primers from the original amplification.

DNA assembling and BLAST

Both the forward and reverse sequences have been assembled and edited using Sequencher v.4.1.4 (Gene Codes Co., Ann Arbor, Michigan, U.S.A.). Similarity of the sequences was checked through BLAST (Basic Local Alignment Search Tool).

Multiple sequence alignment and phylogenetic Analysis

Alignments were made using MUSCLE embedded in Mega v.11 (Tamura *et al.*, 2021). The alignment was thoroughly checked, gaps were interpreted as missing data and characters were given equal weight. phylogenetic trees were inferred using Maximum likelihood (ML) and Bayesian Inference (BI) approaches. ML analysis was performed using IQ-TREE ver. 2.1.2 (Minh *et al.*, 2021) based on the TIM3+G model recommended by Modelfinder (Kalyaanamoorthy *et al.*, 2017) implemented in IQ-TREE. The Akaike information criterion (AIC), which is implemented in the jModeltest tool, was used to find the best fit nucleotide substitution model for the BI analysis (Santorum *et al.*, 2014). The best-fit model was TIM+G. Bayesian analysis implementing Markov Chain Monte Carlo (MCMC) was conducted using MrBayes ver. 3.2.6 (Ronquist *et al.*, 2012). The analysis was carried out for 10,000,00 generations till the standard deviation of split frequency became less than 0.01. The strict consensus tree of both ML and BI trees was generated and visualized in FigTree v 1.4.3 (Rambaut, 2017).

Results

Sequences and alignment

A total of 770 characters were included in this analysis, of which 324 were conserved sites, 275 were potentially parsimony informative and 63 were singletons.

Phylogenetic analysis

Altogether 16 accessions were used in this study. Bayesian analysis generated a topology similar to the strict consensus of the maximum likelihood tree (Fig. 142B). The phylogram skeleton is shown in figure 142A. Both Bayesian and Maximum likelihood tree strongly support the monophyly of the genus *Leea*. Within *Leea* four major clades were resolved *viz.*, Clade I, Clade II, Clade III and Clade IV with a high to moderate support value.

Clade I is the early diverging clade within the genus, represented by a single species *L. asiatica*, which recovered with strong support (BS=100, PP=1). Clade II

accommodates *L. angulata* and *L. aculeata* characterized by spines on stem and branches, with good clade credibility values (BS=87, PP=0.98). Clade III consisted of two species having prominent bracts (BS=91, PP=0.99) viz., *L. compactiflora* and *L. trifoliata*. The clade IV forms the largest clade represented by the majority of the Indian taxa and received strong support (BS=100, PP=1) which further bifurcated into 3 major subclades. The subclade IVa is a highly supported (BS=100, PP=1) monoclade represented by a single species *L. setuligera*. The second subclade IVb consisted of *L. macrophylla* complex but had moderate clade support (BS=87, PP=0.98). This subclade again bifurcated into two groups. The first group contains *L. macrophylla* and *L. latifolia* with good support values (BS=95, PP=0.99) and the second group forms a monophyletic *L. robusta* with moderate support (BS=87, PP=0.98). Subclade IVc is the largest subclade, contains seven species (*L. indica*, *L. guineensis*, *L. sundaica*, *L. aequata*, *L. grandifolia*, *L. mizoramensis* and *L. tamdilensis*) but with low support (BS=79, PP=0.96). This subclade is not well resolved in this ITS based phylogenetic study. This subclade is again bifurcated into two sister clades (c1 and c2) with low support.

Discussion

The present work aimed to solve the complexes in the genus *Leea* and to find the phylogenetic positions of *Leea* based on the nuclear ITS region.

The phylogenetic study based on nuclear ITS region showed that the genus *Leea* is monophyletic as shown by Molina *et al.* (2013). The present study showed that the genus *Leea* was recovered into four major clades, the result was slightly different from the previous molecular study by Molina *et al.* (*l.c.*). The ITS and 5s NTS based study by Molina *et al.* (*l.c.*) identified four major clades. Clade I with single species with free stamens, clade II with spiny species and clade III formed by the plants with relatively larger floral and vegetative dimensions and clade IV with morphologically similar *L. indica*/*L. guineensis* complex as well as morphologically different *L. aequata*, *L. compactiflora*, *L. macrophylla*, *L. robusta* and *L. setuligera*. However, in our result, *L. compactiflora* was resolved into a separate clade (Clade III) and the rest of the Indian species into another clade (clade IV). We have not incorporated any representative from the clade III of Molina *et al.* (*l.c.*) since any of the species in this clade was not present in India.

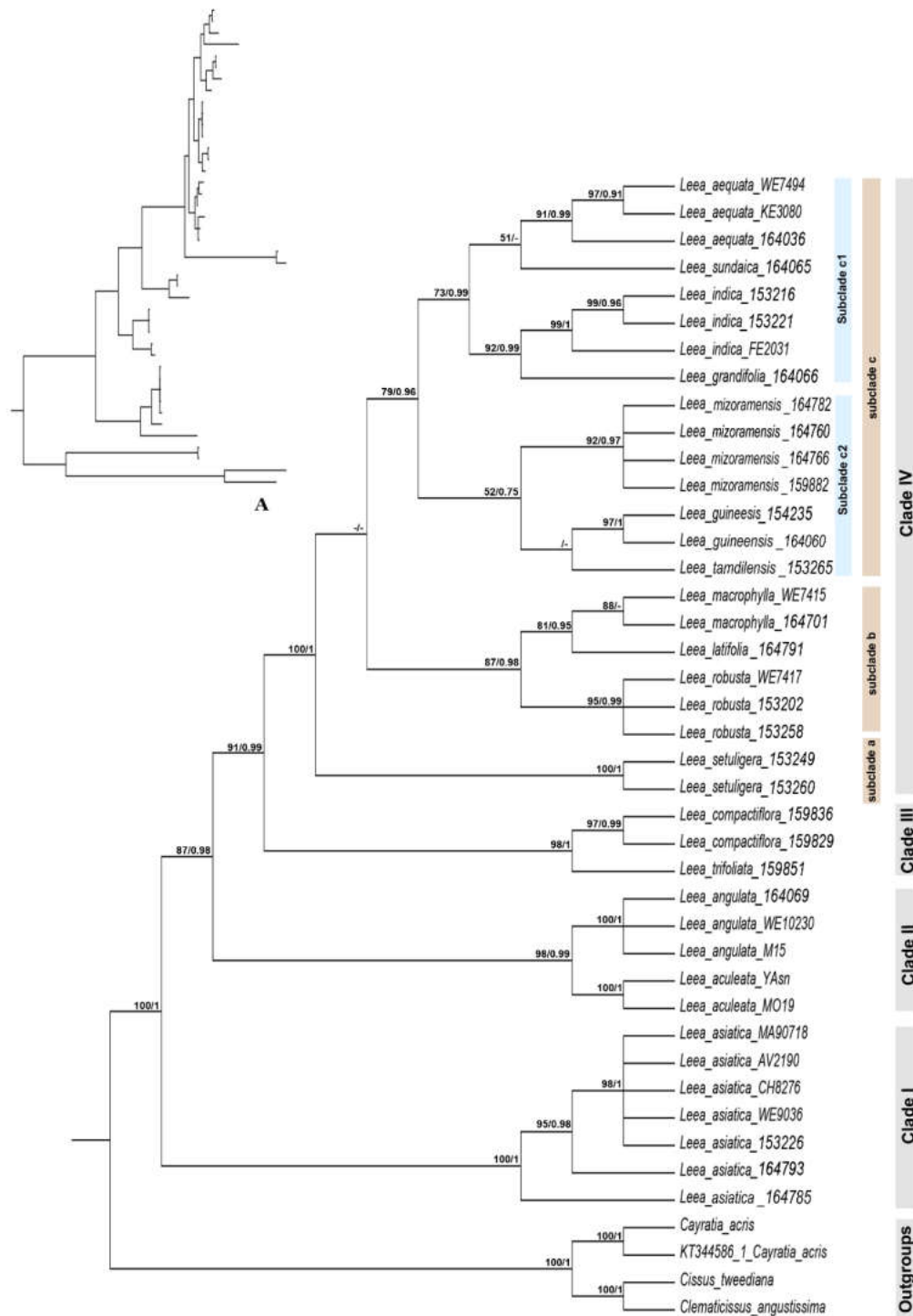


Fig. 154. Strict consensus tree of *Leea* L. inferred from nrITS sequences. Numbers above the branches are maximum likelihood bootstrap (BS) following Bayesian posterior probability (PP). When $\geq 50\%$ (BS) or ≥ 0.75 (PP). ('-' is indicated when the value is below 50% or 0.75).

Clade I, an early diverging clade consisted of a single species, *L. asiatica*, characterized by free stamens, strongly serrate leaflets with close and parallel veins in pinnate leaves, and the anthers open through two longitudinal slits. As pointed out by Molina *et al.* (l.c.), a free stamen is a plesiomorphic character in *Leea*, since Vitaceae do not develop fused stamens. Within this clade I, Molina *et al.* (l.c.) reported two clades corresponding to *L. crispa* L. and *L. aspera* Wall. ex G.Don. According to them, the 'crispa' clade was characterized sharply serrated leaves that are glabrous above, as well as crisped-winged petiole and peduncle. The 'aspera' clade, however, differs in having leaves with scattered appressed hairs between nerves and generally crenate-serrate margins. But during our study, we could collect intermediate forms from Maharashtra, India [*L. asiatica*, Amrutha 164793 (CALI)] having crispation only in the ridges of the stem. In our phylogenetic tree, this intermediate form is nested along with *L. asiatica* from Assam having fully crispate wings. The reproductive characters of all the morphotypes are similar and the crispation is not considered as a constant character and shows continuous variation. Hence, all the morphotypes are treated as a single species (*L. asiatica*) in this work.

Clade II consisted of species having prickles on stems and branches. The species are mostly trees and have narrowly winged petiolar stipules. *Leea angulata* and *L. adwivedica* are two spiny species from India and they mainly differ in the margin of lamina, length of the lower part of floral disc and colour of the young fruits. We consistently failed to amplify *L. adwivedica* due to low DNA quantity, hence it was excluded from the current study. Furthermore, we used the sequence of *L. aculeata* from Molina *et al.* (l.c.) and it forms as a sister to *L. angulata*.

Clade III constituted two species, *L. compactiflora* and *L. trifoliata*. In the previous phylogenetic study by Molina *et al.* (l.c.), *L. compactiflora* was nested along with other Indian species. However, in our study, it was resolved into a separate clade. Both these species in clade III are characterized by the persistent bracts. However, they can be differentiated due to the nature of habit, size and shapes of the bracts, nature of the leaves, the size of inflorescence and the nature of the petiole. Ridsdale (1974) synonymized *L. trifoliata* under *L. compactiflora*. However, morphological characters showed that both the species are distinct and this finding

was also supported by the current molecular study. Hence, we reinstated *L. trifoliata* here.

Clade IV was the largest clade in *Leea* and consisted of majority of Indian species, including *L. indica*, *L. guineensis*, *L. sundaica*, *L. macrophylla*, *L. robusta*, *L. latifolia*, *L. setuligera*, *L. aequata*, *L. grandifolia*, *L. mizoramensis* and *L. tamdilensis*. Moreover, this particular Clade is further resolved into three subclades (Subclades a, b, & c).

Subclade a consisted of a single species, *L. setuligera* with high clade support. This species is the only one having four seeded taxa in India and are characterized by tuberous roots, winged petiolar stipules, setaceous hairs on leaves. In the phylogenetic analysis of Molina *et al.* (l.c.), this species forms a polytomy with two undetermined species from Myanmar and *L. guineensis* s.l. from Africa, Comoros and Madagascar and Mauritius. However, in our study, this species resolved into a separate subclade with high support (BS=100, PP=1).

Subclade b composed of *L. macrophylla* complex. It includes, *L. macrophylla*, *L. robusta* and *L. latifolia*. Ridsdale (1974) synonymised *L. robusta* and *L. latifolia* under *L. macrophylla*. According to Ridsdale all these three species have similar floral characters and show differences only in the pinnation of the leaf. However, upon examination of the live materials and herbarium material all the species show dissimilarities in both the vegetative and reproductive characters and this phylogenetic study supports the reinstatement of *L. latifolia* and also supports the reinstatement of *L. robusta* by Mathew and Umadevi (1993). In the present study *L. latifolia*, which occurs in Maharashtra, India form a sister to *L. macrophylla*.

Subclade c consisted of *L. indica*, *L. guineensis*, *L. sundaica*, *L. aequata*, *L. grandifolia*, *L. mizoramensis* and *L. tamdilensis* and this clade was not fully resolved in the current phylogenetic study. However, this particular clade further bifurcated into c1 and c2. The subclade c1 consisted of *L. guineensis*, *L. mizoramensis* and *L. tamdilensis* having red or creamy flowers and subclade c2 consisted of *L. indica*, *L. aequata*, *L. sundaica* and *L. grandifolia* having greenish-white flowers.

Leea indica is a widely distributed species and has many synonyms. *L. sundaica* is a species with ferrugineous hairs on inflorescence, lower part of leaves

and stem. Ridsdale (1974) synonymized *L. sundaica* under *L. indica* and we reinstated this species as it showed variation in both vegetative and reproductive characters. In the present molecular study, this species showed close affinity with both *L. indica* and *L. aequata*, a species with brown pearl glands on the lower surface of leaves. *Leea grandifolia* is nested sister to *L. indica*. It is an endemic taxon to India having large orbicular leaves. Molina *et al.* (l.c.) were unable to find the position of this species due to the unavailability of material.

Conclusion

The present work is the first phylogenetic study of Indian *Leea* using nrITS. The present molecular study based on the nuclear ITS region shows that the tropical genus *Leea* is a monophyletic genus in the family Vitaceae. In both ML and BI analysis, the Indian *Leea* is resolved into four major clades. The clade I consisted of a single species *L. asiatica*, having the primitive free stamens. Clade II consisted of the species having spines on stem, clade III comprised the species having prominent bracts and the rest of the Indian species were nested in clade IV, which was further resolved into four subclades (a–c). The current work also supports the resurrection of the three species, *L. latifolia*, *L. trifoliata*, and *L. sundaica* and also supports the novelty of newly described *L. mizoramensis*. It also helped to find the position of Indian endemic, *L. grandifolia*, which was not used in the previous molecular study. It was concluded that further sampling of species from around the world and multiple markers based phylogenetic study is required to solve the circumscription of the genus *Leea* and also to propose a valid sectional classification in this genus.

The present investigation on the genus *Leea* L. (Leeoideae: Vitaceae) in India is aimed at preparing a comprehensive account of the genus based on extensive field exploration across the country. Along with live materials, vast collections available in all Indian herbaria were also examined. However, descriptions and anatomical studies of all taxa were based on live collections. The treatment incorporates morphological, micromorphological anatomical and molecular data. The present study documents 17 species of *Leea* occurring in India. Their distribution is mainly concentrated in Northeast India, Peninsular India, and Andaman and Nicobar Islands. The main conclusions of the present research are discussed in detail below.

Taxonomy

1. Field Survey

It was clear from the field data that *Leea* exhibits considerable variation depending on the edapho-climatic conditions of the area. The present treatment records 17 species in India, which include two new species.

1. *Leea adwivedica* K.Kumar
2. *Leea aequata* L.
3. *Leea alata* Edgew.
4. *Leea angulata* Korth. ex Miq.
5. *Leea asiatica* (L.) Ridsdale
6. *Leea compactiflora* Kurz
7. *Leea grandifolia* Kurz
8. *Leea guineensis* G.Don
9. *Leea indica* (Burm.f.) Merr.
10. *Leea latifolia* Wall. ex Kurz
11. *Leea macrophylla* Roxb. ex Hornem.
12. *Leea mizoramensis* Amrutha & Pradeep

13. *Leea robusta* Roxb.
14. *Leea setuligera* C.B.Clarke
15. *Leea sundaica* Miq.
16. *Leea trifoliata* M.A.Lawson
17. *Leea tamdilensis* Amrutha & Pradeep

2. Nomenclature

In consultation with protologues and types of all the names placed under Indian *Leea*, the nomenclature of all the Indian taxa was updated. A detailed taxonomic description, photo plates, distribution map, and key to Indian species of *Leea* were provided for easy identification. Lectotypes were selected for the following 41 names in *Leea* of the world: *Leea acuminatissima* Merr., *Leea agusanensis* Elmer, *Leea aurantiaca* Zoll. & Moritzi, *Leea banahaensis* Elmer, *Leea bulusanensis* Elmer, *Leea congesta* Elmer, *Leea cumingii* C.B.Clarke, *Leea dentata* Craib, *Leea diffusa* M.A.Lawson, *Leea euphlexia* Merr., *Leea forbesii* Baker f., *Leea guineensis* forma. *truncata* Desc., *Leea laeta* Wall. ex Kurz, *Leea longipetiolata* Merr., *Leea longifoliola* Merr., *Leea luzonensis* Elmer, *Leea magnifolia* Merr., *Leea mastersii* C.B.Clarke var. *siamensis* Craib, *Leea manillensis* Walp., *Leea monophylla* Lauterb., *Leea negrosense* Elmer, *Leea nitida* Merr., *Leea parva* Elmer, *Leea pauciflora* King, *Leea philippinensis* Merr., *Leea platyphylla* Merr., *Leea pubescens* Zipp. ex Miq., *Leea pycnantha* Quisumb. & Merr., *Leea sambucina* Willd. var. *biserrata* Miq., *Leea sambucina* var. *heterophylla* Zipp. ex Miq., *Leea sambucina* var. *occidentalis* C.B. Clarke, *Leea schomburgkii* Craib, *Leea serrulata* Miq., *Leea simplicifolia* Zoll. & Moritzi, *Leea sundaica* Miq. var. *fuliginosa* Miq., *Leea talbotii* King ex Talbot, *Leea tenuifolia* Craib, *Leea tetramera* B.L.Burtt, *Leea tetrasperma* Gagnep., *Leea thorelii* Gagnep. and *Leea umbraculifera* C.B.Clarke.

3. New taxa described

During the present study, two new taxa (*Leea mizoramensis* Amrutha & Pradeep and *Leea tamdilensis* Amrutha & Pradeep) were described from Mizoram, India.

4. Reinstatement

Leea sundaica, *L. trifoliata* and *L. latifolia* earlier synonymized under *L. indica*, *L. compactiflora* and *L. macrophylla* were reinstated.

5. New synonyms

Leea talbotii King ex Talbot was reduced into the synonymy of *L. setuligera*, *Leea aequata* var. *villosissima* Hochr. is placed under *L. aequata* and *L. aspera* Wall. ex G.Don under *L. asiatica*.

6. Species complex

Leea macrophylla Roxb. ex Hornem. species complex was studied extensively and re-circumscribed by segregating *L. robusta* and *L. latifolia* from its synonymy.

7. Endemism

The present study revealed 2 species endemic to India. *L. adwivedica* is endemic to the Andaman Islands and *L. grandifolia* is endemic to the Great Nicobar Islands.

8. IUCN status assessment

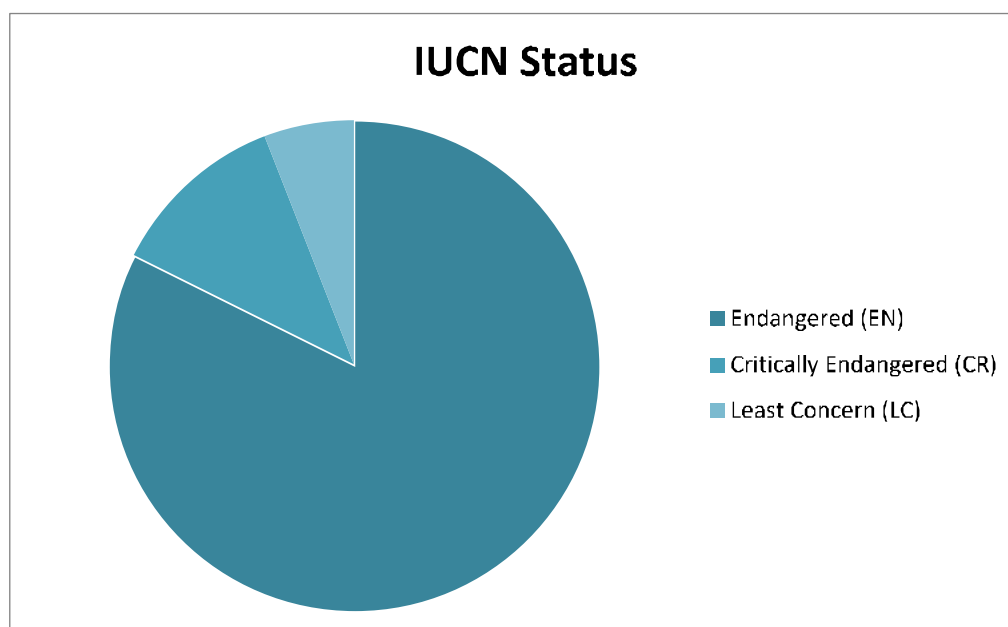
The present study showed that among the 17 species represented in India, eight belong to the Endangered (EN) Category, two under Critically Endangered (CR) and seven under Least Concern (LC) Category (Fig. 155). The lists of the species is given in Table 12.

9. Conservation measures

Calicut University Botanical Garden (CUBG) maintains a total of 50 accessions of 15 species. The plants were able to thrive and show healthy vegetative development and all the species produced flowers and set fruits. *Leea aequata* and *L. robusta* were observed to have natural regeneration, and their seeds grew well and produced young saplings.

Table 12: IUCN status of taxa

Sl. No.	Name of the taxa	Endemic status	IUCN status
1	<i>Leea adwivedica</i> K.Kumar	Endemic	Endangered (EN)
2	<i>Leea aequata</i> L.	-	Least Concern (LC)
3	<i>Leea alata</i> Edgew.	-	Critically Endangered (CR)
4	<i>Leea angulata</i> Korth. ex Miq.	-	Endangered (EN)
5	<i>Leea asiatica</i> (L.) Ridsdale	-	Least Concern (LC)
6	<i>Leea compactiflora</i> Kurz	-	Least Concern (LC)
7	<i>Leea grandifolia</i> Kurz	Endemic	Endangered (EN)
8	<i>Leea guineensis</i> G.Don	-	Least Concern (LC)
9	<i>Leea indica</i> (Burm.f.) Merr.	-	Least Concern (LC)
10	<i>Leea latifolia</i> Wall. ex Kurz	-	Endangered (EN)
11	<i>Leea macrophylla</i> Roxb. ex Hornem.	-	Least Concern (LC)
12	<i>Leea mizoramensis</i> Amrutha & Pradeep	-	Endangered (EN)
13	<i>Leea robusta</i> Roxb.	-	Least Concern (LC)
14	<i>Leea setuligera</i> C.B.Clarke	-	Endangered (EN)
15	<i>Leea sundaica</i> Miq.	-	Endangered (EN)
16	<i>Leea trifoliata</i> M.A.Lawson	-	Endangered (EN)
17	<i>Leea tamdilensis</i> Amrutha & Pradeep	-	Critically Endangered (CR)

Fig. 155. IUCN status of Indian *Leea*.

II. ANATOMY

This is the first investigation that describes the leaf anatomy of *Leea* in India. The leaf anatomy of *Leea* was demonstrated to be of significant importance for the identification of species. Among the anatomical characters, number of palisade parenchyma, the thickness of leaves, shapes of adaxial and abaxial surfaces of midrib and rachis, number of vascular bundles in the midrib, types of stomata, nature of anticlinal walls of epidermal cells, presence of hypodermis, and accessory vascular bundles in the midrib region were considered to be most important for species delimitation. Those features stand out as consistent within the same species, even though they grow in different environments. The present study also revealed the occurrence of calcium oxalate crystals such as druses, raphides, prismatic crystals and starch grains in *Leea*. In *Leea*, the leaves were either amphistomatic or hypostomatic with anomocytic or anisocytic type of stomata. It was also evident from this study that in *Leea* only non-glandular trichomes were present

III. MICROMORPHOLOGY

1. Seed

The present study showed that variations in seed morphological characters appear to have taxonomic value in distinguishing species of *Leea*. Among the seed characters studied, shape, size, nature of dorsal chalaza, type of sculpturing, shape of periclinal walls and nature of anticlinal walls were considered to have taxonomic significance. Therefore, it is possible to use seed characters as supporting data to delimit species in this taxonomically challenging genus. The results from the present study were generally in agreement with those from previous studies especially on the features such as the ruminant endosperm and dorsal chalaza.

2. Pollen

Leea has stenopalynous pollen grains as seen in other members of Vitaceae. Trizonocolporate, radially symmetrical isopolar pollen grains was present in *Leea*. The results demonstrated the aperture number, polarity, and symmetry were consistent within the genus, however, differences in polar and equatorial

diameters, the P/E ratio, the shape of pollens, as well as the exine sculpturing of the studied species were important for species delimitation. This study also supports the close similarity in pollen grains of *Leea* and other members of Vitaceae and supports the inclusion of *Leea* in the family Vitaceae under the subfamily Leeoideae.

IV. MOLECULAR STUDIES

This is the first phylogenetic study of Indian *Leea*. The present molecular study based on nrITS showed that the tropical genus *Leea* is monophyletic. In both Maximum likelihood and Bayesian analysis, the Indian *Leea* was resolved into four major clades. The clade I consisted of a single species *L. asiatica*, having the free stamens. Clade II consisted of the species having prickles on stem and branches, clade III consisted of species with prominent bracts, and the rest of the Indian species were nested in clade IV, which was further resolved into four subclades (a-d). The current work also supports the resurrection of the three species, *L. latifolia*, *L. trifoliata*, and *L. sundaica* and also support the establishment of new species in this genus.

Recommendations

The present work deals with a detailed taxonomic account on the genus *Leea* in India. An integrated approach based on morphology, anatomy, micromolecular, and molecular techniques was used to solve the taxonomy and species complexes in this genus. The recommendations put forward herein are based on comprehensive field-based studies on this genus in India.

After Ridsdale's (1974) revision there was no major work in this genus in the world scenario. Ridsdale's (*l.c.*) carried out an exhaustive work consulting collections of *Leea* available in almost all major herbaria of the world. However, in-depth field surveys and observations on live specimens to understand the variation pattern and habitat preferences of each species are lacking in his treatment. He has synonymized a number of names of previous authors. Upon examining the type materials and protologues, we found that some names cited as synonyms from outside India, not come under the circumscription of currently accepted names. Since we were not able to collect the materials from outside, we could not take a decision on such names. Hence the present work recommends a complete field-based study of *Leea* in other parts of the world to understand the variations in each species. Furthermore, A stable classification of the genus *Leea* at the world level is also recommended since there is no sectional classification for this genus at present.

The present study recognized 17 species in India. The diversity of the genus in India is mainly centered in Northeast India, the Andaman and Nicobar Islands, and Western peninsula and the Western Ghats. However, nothing was known about the diversification of the genus in India. Therefore, the present work recommends studying the divergence of *Leea* in India through molecular dating and ancestral area reconstruction by considering two questions, how did the genus diversify in India? Did the species come from Andaman to Burma to mainland India?

On the field trips, we found that many species of *Leea* (*L. indica*, *L. aequata*, *L. macrophylla*, *L. robusta*, *L. latifolia*) were visited by numerous butterflies including *Thirumala limniace*, *Neopithecops zalmora*, *Eurema hecabe*, *Phalanta phalanta*, *Jamides bochus*, *Graphium terebon* etc. Therefore, we recommend introducing these species to the butterfly garden as host plants. We also found flower colour polymorphism among some species of *Leea*. Therefore, it is recommended to investigate possible reasons for the flower colour polymorphism in *Leea*.

In our field visits to different regions of India, we assessed the threat status of each species and calculated the AOO and EOO. This led to an assessment of the IUCN status of each species, which found 14 to be endangered and 2 to be critically endangered. We recommended taking special consideration for endangered and critically endangered species. The conservation of Island species has also been suggested since two species are endemic to islands. In addition, we recommend predicting the possible habitat of threatened species using ecological niche modelling and reintroducing them into suitable habitats.

In the present study, we used only nuclear ITS marker to construct the phylogenetic tree. Even though it is supported in the species-level resolution, the study suggests to use more markers and more accessions to construct a clearer phylogenetic tree.

Outlook for the future

1. To improve the resolution and support of the *Leea* phylogeny by adding more accessions and more markers.
2. To reconstruct a chronogram and undertake the ancestral area reconstruction and molecular dating.
3. To find the reasons for the higher species diversity of *Leea* in Andaman and Nicobar Islands? Is this related to the climatic history?
4. To trace the evolutionary history of pearl glands, leaf architecture, petiolar stipule, exine ornamentation of pollen and, rumination of endosperm using

ancestral state reconstruction and to evaluate the systematic significance of these characters.

5. Karyomorphological studies of *Leea*.
6. Ecological niche modelling of threatened species in *Leea*.
7. To study the pollination biology of *L. aequata*, *L. macrophylla*, *L. robusta* and *L. latifolia*.
8. Phytochemical analyses and the identification of compounds in *Leea* that cause itching.
9. Nanoparticle synthesis of species of *Leea*.

The further studies addressing all the above requirements will certainly throw more light on the evolution of the genus *Leea*, its phytochemistry, pollination biology, and the role played by each species in a tropical forest ecosystem.

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Appendix – I

List of abbreviations used

Details of the main abbreviations used in the text are given below.

Acc. No.	:	Accession Number
auct. non.	:	<i>auctorum</i> (used for a misapplied name)
c.	:	<i>circa</i> (about)
cm	:	centimetre
comb. nov.	:	<i>combinatio nova</i> (new combination)
et al.	:	<i>et aliorum</i> (and of others)
Ibid.	:	<i>Ibidem</i> (in the same place)
l.c.	:	<i>loco citato</i> (in the place cited)
mm	:	millimetre
n.v.	:	<i>non vidi</i> (not seen)
nom. cons.	:	<i>nomen conservandum</i> (name to be conserved)
nom. illeg.	:	<i>nomen illegitimum</i> (illegitimate name)
nom. Illeg. superfl.	:	<i>nomen illegitimum superfluum</i> (name that is illegitimate because it was nomenclaturally superfluous when published)
nom. inval.	:	<i>nomen invalidum</i> (invalid name)
nom. nud.	:	<i>nomen nudum</i> (naked name)
nom.nov.	:	<i>nomen novum</i> (new name)
p.p.	:	<i>pro parte</i> (in part)
s.coll.	:	<i>sine collectore</i> (without collector)
s. d.	:	<i>sine die</i> (undated)
s.n.	:	sine numero (without collection number)
s.l.	:	<i>sensu lato</i> (in a wide/broad sense)

s.loc.	:	<i>sine loco</i> (without locality)
s.s.	:	<i>sensu stricto</i> (in strict/ narrow sense)
sensu	:	in the sense
sp. nov.	:	<i>species nova</i> (new species)
syn. nov.	:	<i>synonymum novum</i> (new synonym)
typ. cons.	:	<i>typus conservandus</i> (type to be conserved)

Appendix – II

List of Herbaria Cited

1. Agharkar Research Institute, Pune, India (AHMA).
2. Blatter Herbarium, St. Xavier's College, Mumbai, India (BLAT).
3. ZE Botanischer Garten und Botanisches Museum, Freie Universität Berlin Berlin, Germany (B)*.
4. Botanical Survey of India, Andaman & Nicobar Circle, Port Blair, Andaman (PBL).
5. Botanical Survey of India, Arunachal Pradesh Regional Centre Itanagar, Arunachal Pradesh, India (ARUN).
6. Botanical Survey of India, Deccan Regional Centre, Hyderabad, India (BSID).
7. Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya, India (ASSAM).
8. Botanical Survey of India, Sikkim Himalayan Circle, Gangtok, Sikkim (BSHC).
9. Botanical Survey of India, Southern Regional Centre, Coimbatore, India (MH).
10. Botanical Survey of India, Western Regional Centre, Pune, India (BSI).
11. Calicut University Herbarium, Department of Botany, University of Calicut, India (CALI).
12. Central National Herbarium, Kolkata, India (CAL).
13. Gray Herbarium, Harvard (GH)*.
14. Herbarium of the Arnold Arboretum, Harvard (A)*.
15. Kerala Forest Research Institute Herbarium, Peechi, India (KFRI).
16. Meise Botanic Garden Herbarium, Meise, Belgium (BR)*.
17. Missouri Botanical Garden, U.S.A. Missouri. Saint Louis. (MO)*.
18. Museum National d'Histoire Naturelle, Paris. France (P)*.
19. National Herbarium, Leiden University, Leiden, Netherlands (L)*.
20. Natural History Museum, London, England (BM)*.

21. National Museum of Natural History, Smithsonian Institution, Washington, USA (US)*.
22. National History Museum of Denmark, Copenhagen, Denmark (C)*.
23. Rapinat Herbarium, St. Joseph's College, Thiruchirappalli (RHT).
24. National Parks board, Singapore Herbarium, Singapore (SING)*.
25. Royal Botanic Gardens, Kew (K)*.
26. Smithsonian Institution, United States National Herbarium, U.S.A. (US)
27. The conservatory and Botanical Garden, Geneva, Switzerland (G)*.
28. The Linnean Society of London, England, U.K. (LINN)*.
29. The New York Botanical, Bronx, New York. (NY)*.
30. Tropical Botanical Garden Herbarium, Thiruvananthapuram (TBGT).
31. University of Michigan, U.S.A. Ann Arbor, Michigan (MICH)*

* Online accessed Herbarium

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Papers and Posters presented

- **Amrutha A.** & A.K. Pradeep 2023. Taxonomic revision of the *Leea* L. (Leeoideae: Vitaceae) in India. XXXII Annual conference of Indian Association for Angiosperm Taxonomy and International seminar on Advances in Plant Systematics, Biogeography and Biodiversity Conservation. 25th– 27th November 2023. Department of Botany, University of Calcutta. (**Prof. K.S. Manilal Award for best paper in Floristics**).
- **Amrutha A.** & A.K. Pradeep 2022. Diversity and Conservation assessment of the genus *Leea* (Leeoideae: Vitaceae) in India. XXXII Annual conference of Indian Association for Angiosperm Taxonomy and National symposium on “The contribution of Angiosperm Diversity to Human wellbeing and the risks associated with its decline”. 11th–13th November 2022. Department of UG, PG and Research in Botany, Karnatak University's Karnatak Science College, Dharwad, Karnataka.
- **Amrutha A.** & A.K. Pradeep 2022. The genus *Leea* (Leeoideae: Vitaceae) in India. 31st Indian Association for Angiosperm Taxonomy (IAAT) Annual Conference & International Conference on “Documentation, Bioprospecting & Conservation of Biodiversity for Sustainable Development”. 5th –7th April 2022., Dr. D.Y. Patil Unitech Society's, Dr. D.Y. Patil Arts, Commerce and Science College, Akurdi, Pune-44.
- **Amrutha A.** & A.K. Pradeep 2019. “Diversity, Ecology and Endemism of *Leea* L. (Vitaceae) in India.” XLII All India Botanical conference of the Indian

Botanical Society and national symposium on Innovations and inventions in plant science research". 6-8 November 2019. University of Calicut, Kerala, India.

- **Amrutha A.** & A.K. Pradeep. 2018. Preliminary observation on the Genus *Leea* L. (Vitaceae) in India. XXVIII Annual Conference of Indian Association for Angiosperm Taxonomy & International Symposium on Conservation of Angiosperm Diversity: Hidden Treasure of Today & Tomorrow. 29-31 October 2018.

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