# TAXONOMY, SEED MORPHOLOGY AND ECOLOGY OF GREAT HORNBILL DISPERSED RAINFOREST TREES OF THE ANAMALAI PART OF THE SOUTHERN WESTERN GHATS, KERALA

*The Thesis submitted to the*
*University of Calicut in partial fulfilment of the*
*requirement for the award of the degree of*

**DOCTOR OF PHILOSOPHY**
**IN**
**BOTANY**

*by*

**FASILA P K**

Muslim Education Society

**RESEARCH & P G DEPARTMENT OF BOTANY**
**MES ASMABI COLLEGE, KODUNGALLUR, KERALA**
**AFFLIATED TO UNIVERSITY OF CALICUT**
**JUNE 2024**

# CERTIFICATE

This is to certify that the thesis entitled studies on **“Taxonomy, Seed morphology and Ecology of Great Hornbill Dispersed Rainforest Trees of the Anamalai part of the Southern Western Ghats, Kerala”**. Submitted to the University of Calicut by Mrs. Fasila P K in partial fulfillment of the award of the degree of Doctor of Philosophy in Botany is a bonified record of the doctoral research work carried out by her under the supervision and guidance of **Dr. Girija T P**, Assistant Professor and Research guide, Research Department of Botany of our institutions affiliated to University of Calicut. No Part of the present work as formed the basis for the award of any other degree or diploma previously.

P Vemballur **Principal**

Date

# CERTIFICATE

This is to certify that the thesis entitled studies on **“Taxonomy, Seed morphology and Ecology of Great Hornbill Dispersed Rainforest Trees of the Anamalai part of the Southern Western Ghats, Kerala”**. Submitted to the University of Calicut by Mrs. Fasila P K in partial fulfillment of the award of the degree of Doctor of Philosophy in Botany is a bonified record of the doctoral research work carried out by her under my supervision and guidance. No Part of the present work as formed the basis fr the award of any other degree or diploma previously.

P Vemballur

**Dr. Girija T P**
Supervising Teacher

# DECLARATION

I hereby declare that the work presented in the thesis entitled **"Taxonomy, Seed morphology and Ecology of Great Hornbill Dispersed Rainforest Trees of the Anamalai part of the Southern Western Ghats, Kerala"** is based on the original work done by me under the guidance of Dr. Girija T P, Assistant Professor and Head, Department of Botany, MES Asmabi College, P. Vemballur 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.

P. Vemballur **Fasila P K**
28/06/2024

**Dr. Girija T P**
Assistant Professor and Head
Department of Botany
MES Asmabi College
P. Vemballur

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# ABSTRACT

The tropical evergreen forests of Anamalai part of Southern Western Ghats are particularly special as it contains the entire range of natural vegetation rich in species diversity and endemism. The great diversity of this area is due to bioclimatic, physiographic and edaphic factors and also due to the presence of pollinators and seed disperses. The Great hornbill is in proximity of evergreen forests at an elevation from 250 meters to 1500 meters above sea level. According to IUCN Red List Category, Great hornbill is classified as vulnerable (VU) due to habitat loss. The diet of the Great hornbill consists mainly of fruits. Fruits of some important plant species of tropical forest coming under families such as Moraceae, Lauraceae, Myristicaceae, Annonaceae and Meliaceae constitute major part of the diet of hornbill. They feed on large fruits and regurgitate the seeds intact. They deposit a great number of seeds under the nesting tree during breeding season and thus serve as important agent for maintaining the habitat equilibrium of primary forests. They also move over large distances, possibly regurgitating and defecating the seeds far away from the parent tree. The present study attempts to find the mutualistic relationship between Great hornbill and these trees. The plant species selected in the study area belongs to Lauraceae (24 species of 8 genera), Meliaceae (6 species of 5 genera), Myristicaceae (3 species of 2 genera) and Elaeocarpaceae (2 species of genus Elaeocarpus). Some of the recorded species include *Canarium strictum* of family Burseraceae, *Diospyros crumenata* of family Ebenaceae, *Syzygium cumini* of Myrtaceae, *Palaquium ellipticum* of Sapotaceae and *Maesopsis eminii* of Rhamnaceae. These species come under vulnerable or endangered category and are endemic to Western Ghats expect *Maesopsis eminii*, which is an exotic species. A detailed taxonomic study was done for these species and an identification key was prepared. The fruits of these plants were collected in various stages of development up to mature stage. Detailed morphological studies were done, and an identification key based on fruit and seed characters was prepared. Phenology of the selected species was done, and it showed that the fruiting period of these trees corresponds with nesting time of hornbill. Germination experiments were carried out to check the seed viability as well as to

determine if there was any difference in germination in regurgitated vs. fallen (control) seed. Germination was tested ex situ in the rainforest field station at Malakkappara. Study showed marked variations; regurgitated seeds of all the species showed fast germination than controlled seeds. In order to find out the species diversity and sapling diversity, quadrat study was done around the nesting tree (square plots of 0.16 ha) at 8 locations in Vazhachal, Sholayar and Parambikulam forest divisions. Phytosociological parameters as well as saplings and seedling regeneration were noted. The study showed that most species found in these areas are hornbill dependent species. Seedlings of 21 food plants were recorded beneath the nesting tree, more seedlings were found in front of the nest than behind. Most of the seedlings were of *Myristica*, *Persea*, *Palaquium*, *Knema* and *Dysoxylum*. Even though the seeds of many of these species are eaten by various animals like macaque, giant squirrel etc. they crush the seeds while eating and are not efficient seed dispersers. Great hornbill, however, regurgitates the seeds intact and acts as an important seed dispersal agent. Great hornbill and these forest trees maintain a mutualistic relationship.

# സംഗ്രഹം

പശ്ചിമഘട്ടത്തിലെ ആനമല മലനിരകളിൽ കാണപ്പെടുന്ന ഉഷ്ണമേഖലാ നിത്യഹരിത വനങ്ങൾ വളരെയധികം സവിശേഷതകൾ ഉള്ളതാണ്. അതിൽ എടുത്തു പറയേണ്ടതാണ് അവിടുത്തെ അനന്യമായ ജൈവവൈവിധ്യം. ഈ പ്രദേശത്തിന്റെ ജൈവ വൈവിധ്യത്തിനു കാരണം ഇവിടുത്തെ പ്രത്യേക ഭൂപ്രകൃതിയും കാലാവസ്ഥയും തന്നെയാണ്; കൂടാതെ പരാഗണത്തിനും വിത്ത് വിതരണത്തിനും ധാരാളം സാധ്യതകളുമുണ്ട്.

മലമുഴക്കി വേഴാമ്പൽ സമുദ്രനിരപ്പിൽ നിന്നും 250 മീറ്റർ മുതൽ 1500 മീറ്റർ വരെ ഉയരങ്ങളിൽ ഉള്ള നിത്യ ഹരിത വനങ്ങളിലാണ് കാണപ്പെടുന്നത്. ആവാസവ്യവസ്ഥയുടെ നാശം മൂലം IUCN റെഡ് ലിസ്റ്റ് ഇവയെ ദുർബലമായ പട്ടികയിൽ ഉൾപ്പെടുത്തിയിരിക്കുന്നു. ഇവയുടെ പ്രധാന ഭക്ഷണം പഴങ്ങൾ ആണ്. നിത്യ ഹരിത വനങ്ങളിൽ കാണപ്പെടുന്ന മൊറേസി, ലോറേസി, മീലിയേസി, മിറിസ്റ്റിക്കേസി, അനോണേസി തുടങ്ങിയ സസ്യ കുടുംബങ്ങളിലെ ചില സസങ്ങളുടെ പഴങ്ങൾ ആണ് ഇവയുടെ ആഹാരം. ഇവ ഈ പഴങ്ങൾ കഴിക്കുകയും വിത്തുകൾ പുനരുജ്ജീവിപ്പിക്കുകയും ചെയ്യുന്നു. ഇവയുടെ പ്രജനനകാലത്ത് ഇവ കൂടുണ്ടാക്കുന്ന മരത്തിനടിയിൽ ധാരാളം വിത്തുകൾ നിക്ഷേപിക്കുകയും അങ്ങനെ പ്രാഥമിക വനങ്ങളുടെ ആവാസ സന്തുലിതാവസ്ഥ നിലനിർത്തുന്നതിനുള്ള പ്രധാന കണ്ണിയായി പ്രവൃത്തിക്കുകയും ചെയ്യുന്നു. കൂടാതെ വളരെ ദൂരത്തേക്ക് പറക്കാൻ കഴിവുള്ളതു കൊണ്ട് ഇവ മാതൃവൃക്ഷത്തിൽ നിന്നും വളരെ ദൂരത്തേക്ക് വിത്തുവിതരണം നടത്തുകയും ചെയ്യുന്നു. മലമുഴക്കി വേഴാമ്പലുകളും ഈ മരങ്ങളും തമ്മിലുള്ള പരസ്പരബന്ധം കണ്ടെത്താന് ഈ പഠനം ശ്രമിക്കുന്നത്. പഠനത്തിനായി തെരഞ്ഞെടുത്ത സസ്യ ഇനങ്ങൾ; ലോറേസി (8 ജനുസ്സുകളിലായി 24 ഇനങ്ങൾ മീലിയേസി, (5 ജനുസ്സുകളിലായി 6 ഇനങ്ങൾ), മിറിസ്റ്റിക്കേസി, (2 ജനുസ്സുകളിലായി 3 ഇനങ്ങൾ), എല്ലിയോകാർപ്പേസി (2 ഇനങ്ങൾ) എന്നിവയാണ്. ഇത് കൂടാതെ ബർസെറേസി കുടുംബത്തിലെ തെള്ളി, എബനേസീ കുടുംബത്തിലെ കരിമരം, മിർട്ടേസി കുടുംബത്തിലെ സൈസിജിയം സപ്പോട്ടസിയെ കുടുംബത്തിലെ പാലി, റമനേസി കുടുംബത്തിലെ മേയോസോപ്സിസ് എമിനീ എന്നി മരങ്ങളും ഉൾപ്പെടുന്നു. ഈ മരങ്ങൾ എല്ലാം തന്നെ വംശനാശ ഭീഷണി നേരിടുന്ന വിഭാഗത്തിൽ പെടുന്നവയും പശ്ചിമഘട്ടത്തിൽ മാത്രം കാണപ്പെടുന്നവയും ആണ്. തെരെഞ്ഞെടുത്ത ഈ മരങ്ങളിൽ വിശദമായ പഠനം നടത്തുകയും ഒരു ടാക്സോണമി കീ തയ്യാറാക്കുകയും ചെയ്തു. ഇത് കൂടാതെ ഈ മരങ്ങളുടെ പഴങ്ങളുടെ

വിവിധഘട്ടങ്ങൾ ശേഖരിക്കുകയും വിശദമായ പഠനത്തിനൊടുവിൽ ഇവ തിരിച്ചറിയുന്നതിനു വേണ്ടി സ്പീഷീസ് കീ തയ്യാറാക്കുകയും ചെയ്തു. ഈ മരങ്ങളിൽ നടത്തിയ ഫീനോളജി പഠനത്തിലൂടെ ഇവ കായ്ക്കുന്ന ഘട്ടം വേഴാമ്പലിന്റെ പ്രജനന വുമായി പൊരുത്തപ്പെടുന്നതായി കാണാൻ സാധിച്ചു. അത് പോലെ വേഴാമ്പലിന്റെ കൂടിനു താഴെ നിന്നും ശേഖരിച്ച വിത്തുകളും, മരത്തിൽ നിന്നും ശേഖരിച്ച വിത്തുകളും മുളപ്പിച്ചു ഒരു താരതമ്യ പഠനം നടത്തി. വേഴാമ്പൽ കൂടിനു താഴെ നിന്നുള്ള വിത്തുകൾ മരത്തിൽ നിന്നുള്ള വിത്തുകളെക്കാൾ വേഗത്തിൽ മുളച്ചു. മരങ്ങളിലെ വൈവിധ്യം മനസ്സിലാക്കുന്നതിനായി വാഴച്ചാൽ, ഷോളയാർ, പറമ്പിക്കുളം ഡിവിഷനുകളിൽ ആയി 8 വേഴാമ്പൽ കൂടുകൾ കണ്ടെത്തുകയും മരത്തിനു ചുറ്റും 0.16 ഹെക്ടറിൽ പഠനം നടത്തുകയും ചെയ്തു. അവിടെ ഉള്ള മരങ്ങളും തൈകളും രേഖപ്പെടുത്തി. ഈ പ്രദേശങ്ങളിൽ കാണപ്പെടുന്ന ഒട്ടുമിക്ക മരങ്ങളും തൈകളും വേഴാമ്പൽ വിത്തു വിതരണം നടത്തുന്ന ഇനങ്ങൾ ആണെന്ന് പഠനം വ്യക്തമാക്കുന്നു. വേഴാമ്പലുകൾ കഴിക്കുന്ന പഴങ്ങളുടെ തൈകളും (21 ഇനം) കൂടിനു താഴെ കണ്ടെത്തി. ഇതിൽ കാട്ടുജാതി, പാലി, ചോരപാലി കുളമാവ്, വെള്ളകിൽ എന്നിവയുടെ തൈകൾ ആയിരുന്നു കൂടുതലും. ഈ മരങ്ങളുടെ വിത്തുകൾ അണ്ണാൻ, കുരങ്ങ് എന്നിവർ കഴിക്കുന്നുണ്ടെങ്കിലും അവർ വിത്തുകൾ ചവച്ചു നശിപ്പിക്കുന്നതിലൂടെ കാര്യക്ഷമമായ വിത്ത് വിതരണം നടത്തുന്നില്ല. എന്നാൽ വേഴാമ്പലുകൾ ഈ വിത്തുകൾ കേടുകൂടാതെ വിസർജിക്കുന്നതിലൂടെ വിത്തിനെ പുനരുജ്ജീവിപ്പിക്കുകയും ഇതിലൂടെ ഈ മരങ്ങളും വേഴാമ്പലും തമ്മിലുള്ള പരസ്പരബന്ധം നിലനിർത്തുകയും ചെയ്യുന്നു.

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# CHAPTER 1
# INTRODUCTION

## Tropical Rainforests

Rainforests are found in all three tropical regions in the world, America, Africa, and Asia (Whitmore, 1975). Tropical rainforests are well known for their immense biodiversity, especially the forests of the tropics where the annual rainfall is over 2000 millimeter. It is occupying less than 7 % of earth's land surface, but harbors about 50% of species on earth (Wilson, 1988). The tropical rainforest is one of the major vegetation types of the globe (Richards, 1996; Whitmore, 1998).

The vegetation characterization of tropical rain forests is strongly influenced by physiochemical edaphic factors. They have a very unique vegetation structure with tall trees and lianas (woody climbers) dominating the vegetation. With a dense canopy, reaching an average height of 25 meters, the tree cover allows less than 10% of the sunlight to reach the forest floor. The tree diversity of these forests is unmatchable; a single hectare of forests often contains as many as 300 species of trees. The distinct vertical profile present includes emergent trees, sub canopy trees, shrub understory, and ground layer of herbaceous plants and ferns. Each tree in a tropical rainforest supports myriad of other organisms, with their bark and leaf surfaces supporting myriad of smaller organisms not to mention the fungi, lichens and mosses covering every inch of the tree bark. One can find epiphytic ferns and orchids on every other branch of a tree. This enormous plant diversity supports multitude of animals from the soil dwelling tiny bugs to mighty elephants, all of which forms the most complex and diverse habitat on earth.

Being a mega-diversity country, India has its own share of tropical rainforests. In India, these types of forests are present in three locations, in the Eastern Himalaya (North-East India), in Western Ghats (along the west coast) and in Andaman and Nicobar Islands. In Kerala these forests are found along the Western Ghats.

**The Western Ghats**

The Western Ghats is a chain of mountains originating from river Tapti in the North, runs parallel to the west coast for 1600 km before culminating in Kanyakumari in the southern-most tip of Peninsular India. Even though totaling less than 6 percent of total land mass of India, Western Ghats harbors more than 30 percent of all the fauna and flora present in India (Bawa *et al*., 2007). It is recognized as one among the 36-biodiversity hotspot in the World, indicating its importance in biodiversity and endemism.

These mountain ranges have a predominantly tropical climate with distinct variation along north-south, east-west and also along altitudinal gradients. This varied climatic gradation has resulted in all possible types of vegetation ranging from dry deciduous forests to wet evergreen forests with all the possible variations in between. Then there are the most unique forest ecosystems, like the shola grasslands, the cane and bamboo brakes and the Myristica swamps with unparalleled floristic diversity.

The single most important aspect of the diversity of Western Ghats is the high percentage of endemism. As per (Nayar *et al*., 2014), among the 2,253 species which are endemic to India, 1,273 species are exclusively confined to the forests of Western Ghats. In these mountain ranges, the diversity is not evenly distributed, with the southern part of Western Ghats holding some of the floristically richest tracts (Nair, 1991).

The Kerala part of Western Ghats having high rain fall maintains successful forest ecosystem, which covers 22500 km$^2$ (8700 sq m) within the administrative forest areas. The climax forest types, and other forests are represented by only 10 percentage of the Kerala part of the Southern Western Ghats (Nair, 1991). However, the diversity is impressive with 1637 species of endemic flowering plants, of which 263 species are restricted to Kerala (Sasidharan, 2004). Many of the endemic species are vulnerable to extinction. In these forests, the dominant families are Myrtaceae, Meliaceae and Lauraceae, members of which form the characteristic features of the vegetation types.

Plant animal interactions are ubiquitous for maintaining biodiversity. All species are involved in mutualistic and antagonistic interaction with other species. These interactions form a complex network that structure ecological communities (Bascompte & Jordano, 2007). Animals are dependent on plants mainly for pollination and spatial distribution of seeds. In many cases these interactions are highly specialized and mutually beneficial, essential for the existence of the species. Many rain forest trees develop large fruits rich in sugar, lipid, and are very attractive to large avian birds like Great hornbills. Large animals and birds are particularly threatened, with severe decline in population (Dirzo *et al.,* 2014; Ceballos *et al.,* 2015). The fruit eating birds serve as a mobile link connecting various habitat types through dispersal of seeds and are crucial seed transfer agents for maintaining the composition of tree species in the forests of the tropics (Hughes *et al.,* 2002; Sekercioglu, 2006). Anthropogenic impact on forest areas breaks these types of interactions causing the decline of species.

**Dispersal of seed in tropical rain forest**

Regionally, the range expansion and special genetic structure of plant population is determined by the mechanism of seed dispersal (Nathan & Muller-Landaue, 2000; Levin & Murrell, 2003). It is a complex mechanism influenced by several factors such as quantity of fruits available at a particular time, consumption of fruits by frugivores and the production of seeds, seedlings and saplings produced by individual trees. Even though small fruits are consumed by both small and large-bodied dispersers resulting in their seed dispersal, species with large fruits (fruits which are greater than 20 mm in diameter) are solely dependent on a limited number of larger-bodied frugivores for their seed dispersal (Whitington & Treesucon, 1991).

Interestingly a lot of plants have specialized morphological features and characteristics such as colour of fruit, size and shape of fruits and the time of maturation of fruits which increase the likelihood of their seeds being carried away from the parent tree (Tiffney, 1984; Hughes *et al.,* 1994; Griz & Machado, 2001; Willson & Traveset, 2000).

In the tropics, birds and mammals are the principal agents of seed dispersal (Corlett, 1998). Animals are responsible for the seed dispersal of majority (70% to 90%) of the forest plant species (Willson *et al.*, 1989) involving all kind of animals (Levey *et al.*, 1994). Ingestion of fruits by these animals help in seed recruitment and dispersal (Crome, 1975; Floyd, 1989; Mudappa & Raman, 2010; Tadwalkar *et al.*, 2012). Species of Meliaceae, Myrtaceae, Lauraceae, Annonaceae, Euphorbiaceae, Moraceae, Myristicaceae, Sapotaceae and Ebenaceae are dependent on birds for their seed dispersal (Ganesh & Davidar, 2001). The species of Elaeocarpaceae are dependent on frugivores like birds and mammals viz., bats, squirrels, civets, sloth bears, primates, for their seed dispersal.

Birds are important agents of pollination and seed dispersal in plants. They are more efficient in seed dispersal unlike other vertebrates which disperse the seeds in clumps. Birds such as hornbills, pigeons, barbets, mynas are some of the important frugivores in the tropical forests. Hornbills (Bucerotidae) were the heaviest frugivory among them.

**Hornbills as the important seed dispersal agents of rain forest**

In the forests of Africa and Asia, one will never miss hornbills (Bucerotiformes). They easily capture every one's attention with their large body size and peculiar nesting behavior. They can tolerate a broad spectrum of habitats ranging from wet evergreen forests to arid grasslands (Kemp, 1995). They are beautifully colored and have a huge bill often ornamented with a hollow casque (Delacour & Mayr, 1946). The uniqueness of their bill and casque gave them their names. They belong to order Bucerotiformes under the family Bucerotidae (Kemp, 1995; Birdlife International, 2017).

*Buceros bicornis*, more popularly known as Great hornbill is a strikingly beautiful bird with an enormous, hallowed bill with a bright yellow and black casque on top. They can be seen throughout the forests of Southeast Asia. They can easily be distinguished by their huge body size and distinct 'Kok-Kok' sound (Ali & Reply, 1987; Grimmett *et al.*, 2013). In India, they are distributed throughout the foothills of Himalaya, Northeast India and the evergreen forests of Western Ghats. In the Western Ghats, Great hornbills are seen in all the states from Maharashtra to Tamil Nadu

(Naniwadekar *et al.,* 2021). They play an important role in maintaining the equilibrium of the forest ecosystem as dispersers of forest plants. As per the IUCN Red list Category, Great hornbill is classified as vulnerable (VU) due to habitat loss (Datta & Rawat, 2003). In Kerala, they were observed in good numbers from Chimmony, Nelliyampathy, Parambikulam, Periyar, Thekkady and Vazhachal forests (Mudappa & Raman, 2009).

In the forests of the tropics, hornbills are one of the most important seed dispersal agents thanks to their predominantly frugivorous diet (Datta, 2001). They are the seed dispersal agents of fig, lipid rich berries, drupes, and capsular fruit in tropical forests (Kinnaird, 1998; Whitney *et al*., 1998; Holbrook & Smith, 2000; Kitamura, 2000). There are enough studies suggesting that in the tropical regions of Africa and Asia, the forest structure is greatly affected by the seed dispersing behavior of hornbills (Datta, 2001; Kinnaird, 1998; Kitamura *et al.,* 2004). It has been asserted that large hornbills are the sole dispersers of many primary forest species with capsular dehiscent fruits because of their large gap size and ability to split open husks (Leighton & Leighton, 1983; Becker & Wong, 1985; Kannan & James, 2006). Hornbills also move over large distance hence possibly regurgitating and defecating seeds far away from the parent tree with possible beneficial effects on seed germination and survival (Whitney *et al.,* 1998; Holbrook & Smith, 2000). Moreover, hornbills deposit a high density and diversity of seeds around their nesting tree and affect the abundance of seedlings of species in these areas (Figure 1.1.).

Great hornbill's diet predominantly consists of fruits. Many important components of tropical forest coming under families such as Moraceae, Lauraceae, Myristicaceae, Annonaceae and Meliaceae are important diet of hornbill. Hornbills usually ignore the fruits of the members of family Dipterocarpaceae and Fagaceae (species of the former has winged fruits whereas the species of latter produce acorns). They also tend to ignore fruits of shrubs such as members of Annonaceae, Arecaceae and Rubiaceae (Kitamura *et al*., 2011).

**Figure 1.1. Sights of Great hornbills** (*Buceros bicornis*): **A.** Sholayar; **B.** Vazhachal; **C.** Ambalapara; **D.** Nelliyampathy Lilly Estate; **E.** Nelliyampathy Victoria Estate; **F.** Sholyar Power House.

Generally, fruits eaten by these birds are large fruits which are red, purple or black in colour, dehiscent or indehiscent arillate seeds (Kitamura *et al*., 2004). After consuming the fruits, hornbills regurgitate the seeds intact making them perfect agents of seed dispersal (Holbrook & Smith, 2000). Seeds were also dispersed through their faecal matter. *Horsfieldia kingii,* a rare species occurred in the tropical forests of Arunachal Pradesh was successfully dispersed by hornbill (Datta & Rane, 2013). Hornbills prefer fig fruits for diet, 13 different species of figs included in hornbill diet (Pawar *et al.*, 2020). Fruits of many endemic and important tree species of Western Ghats such as *Palaquium ellipticum, Syzygium* sps., *Vitex altissima*, *Buchanania axillaris* were important diet of Great hornbill (Bachan, 2006). During the consumption of fruit, digestive system does not damage the seed and break the seed dormancy thereby enhancing seed germination.

Pattern of distribution of seeds by hornbills is entirely different in breeding season and non-breeding season. During non-breeding period, like all other birds, in the case of hornbills also seed dispersal happened through feeding. During breeding period, they disperse seeds in a completely different manner. The most distinctive characteristic of hornbills is their breeding behaviour. They establish nests in the natural cavities or holes in large trees. Females of most of the hornbill species seal themselves in the nest leaving only a tiny crack through which the male bird provide food till the completion of nesting period. The mother bird and the babies discard the seeds in their faecal matter through the small opening of the nest resulting in a deposition of seeds at the base of the tree. These are called nest midden or seed midden (Kemp, 1995). The seed midden or nest midden is very helpful in determining the diet of hornbills (Kitamura *et al*., 2004).

Even though once commonly distributed along the forests of Western Ghats, the hornbills are now restricted to smaller pockets in the Anamalai Hills of South India largely due to anthropogenic activities like shifting cultivation and hunting (Kannan & James, 1998). This drastic reduction in the population of hornbills critically impacts the seed dispersal in large seeded tree species (Sethi & Howe, 2009). One of the main focuses on this study is to understand the relationship between Great hornbill and their diet fruit, their dispersal and germination percentage.

**Significance of studies of fruit and seed morphology**

Detailed account of seed and fruit morphology is crucial in understanding the taxonomy, breeding biology, ecology, species interaction, endemism and reasons of threat of rain forest tree species. The available forest documentation across our region seldom focuses on detailed aspects of fruit and seed morphology mainly due to the lack of accessibility to different stages especially of the rain forest endemic taxa. The mature fruit of *Cryptocarya anamalayana,* an endangered and endemic tree of Lauraceae was not described by Gamble or any of his perdures until the work of (Bachan *et al.,* 2018). One of the main emphases of this study is to bring out detailed fruit and seed morphology feature of large seeded hornbill dispersed rain forest trees. Among the genus *Litsea* and *Cryptocarya*, information regarding the fruit and seed morphology is scarce. Although vegetative characters of plants are varying with environmental condition, fruit morphology is constant within the genus, their adaptation for different type of dispersal has been helpful to taxonomist to solve the taxonomic problem. The fruit morphology provides information in taxonomy of species and is extensively used in the preparation of diagnostic key. In most of the cases, fruit and seed morphology is restricted to size, color and texture and are related to their dispersal.

**Fruiting phenology and seed dispersal**

Phenology is the study of both vegetative and reproductive phases of plants with their temporal variation over the year (Nanda *et al*., 2011; Luna- Nieves *et al*., 2017). Although the phenological pattern shows variation with climatic factor, especially rainfall and temperature, the phenology of fruit from inhiation to ripening are important for dispersal, reproductive success and survival of plants. The dispersal of fruits and seeds is one of the critical events of the reproductive ecology of plants. Many evergreen forests plants are dependent upon large number of birds and animals for their seed dispersal. The birds take a greater number of fruits during their breeding time. The Great hornbill take large number of different fruits during their nesting period for feeding the mother and chicks. In short, there is correlation between hornbill and fruiting phenology of their diet plants.

**Seed germination**

One of the most difficult aspects of germination studies of rainforest species is the low dormancy of seeds. It is very difficult to keep the seeds for long periods and also, they do not survive long after maturation. One way to overcome this hindrance is to collect the seeds at the right time and plant in suitable manner immediately after collection. Some species, in nursery conditions, may take up to a year to germinate or fail to germinate at all. Moreover, seeds of many forest plants are susceptible to predation and fungal attack, especially if they are planted deep in the soil (Mudappa & Raman, 2010).

In frugivory, the plants get benefitted not only from the dispersal of the seed (Schupp, 1993; Willson & Traveset, 2000) but also from the enhanced rate germination of the seeds when they pass through the digestive tract of an animal (Krefting & Roe, 1949; Rick & Bowman, 1961; Pijl. 1982). The passage of seed through the digestive tract of a frugivores results in the scarification of the seed coat, thus increases the permeability of the coat to gases and water. The germination inhibitors also got removed. Ultimately, the frugivores enhance the possibility of germination and growth of seedling from the faecal material surrounding the seed (Traveset & Verdú, 2002).

Intensive studies on the intricate relationship of seed dispersal agents such as hornbills and seeds dispersed by them in the rainforests can open a deep understanding of the biological and ecological functions of the rainforest ecosystem. These understanding of seed morphology and ecology of hornbill dispersed seed species can contribute for the conservation of threatened hornbills as well as the rainforest ecosystem. This can contribute to restoration activity of such prestigious habitat for future generation.

**Role of Hornbill and other birds in seed germination**

Studies points out that the Western Ghats is one of the important habitats of the hornbills (Datta 1998; James & Kannan, 2009). Except Indian Grey hornbill, the hornbills are restricted to wet forest of Western Ghats among which the Great hornbill is distributed in the wet evergreen or rain forest region (Bachan *et al*., 2011). The forests of Anamalai part of Southern Western Ghats are important stronghold of Great hornbill (Raman & Mudappa, 2003; Bachan, 2006). These forests including the Nelliyampathy, Parambikulam, Vazhachal, Sholayar forests are also important among the three-biodiversity hotspots in Western Ghats (Nayar, 1996) and this area accounts for many rain forest tree species under Lauraceae, Myrtaceae and Meliaceae. The Great hornbill and Imperial pigeons are the 2 avian seed dispersal agents of large seeded wet evergreen species apart from endemic mammals such as Lion tailed macaque, Nilgiri Langur and Malabar Giant squirrel. Among these, Great hornbills form the most important seed dispersal agent being a canopy dweller which has the capacity to consume fruits as large as a wild *Myristica* (*Myristica beddomei*) and require huge quantities of fruits in their diet. Hornbills are found to depend on nearly112 species of plants (Kannan & James, 1997; Bachan 2006; Bachan *et al.,* 2011). This forms the foundation of our study to focus on large seeded rain forest species whose seeds were dispersed by Great hornbill.

**The background of the study**

The study entitled 'Taxonomy, Seed morphology and Ecology of Great Hornbill Dispersed Rainforest Trees of the Anamalai part of the Southern Western Ghats, Kerala' started on July 2014. Great hornbill 'Malamuzhakki vezhambal,' the state bird of Kerala, is well known for its large size and parental caring during nesting season. The male and female bird sacrifices a lot for their chicks. They also act as dispersal agent of rainforest tree species and serve as potential seed dispersers of large seeded plants. A lot of studies were done on the morphology of hornbill, their breeding biology, their fruit preference and feeding behaviour in the Northern Western Ghats. In the Southern Western Ghats, this type of study was scarce and there was a gap in the relationship between Great hornbills and their dispersing seed. They are found in evergreen forests and prefer old tree for their nesting. The most fascinating aspect of the study was that around the nesting sites of hornbill, one would encounter thick forests with endangered, endemic, vulnerable and threatened tree species. The present study was concentrated on seed dispersal of Great hornbill in the breeding season and their role in germination of seeds. With the help of Kadar tribes in the Vazhachal, Sholayar and Malakkappara region and previous studies by Dr. Bachan, different nesting sites were sited. Nesting sites interior to the forest were selected so that a better understanding of the relationship between this great bird and their feeding fruits can be obtained. From the literature and with the help of Kadar tribes, major fruits dispersed by Great hornbills were listed out. During the field studies, there were plenty of sightings of hornbills and their feeding. Owing to the remote locations of the nesting sites, it was very difficult to reach the sites especially during rainy season. Maximum field visits were done during the breeding season in order to collect the seeds regurgitated by Great hornbills. Detailed taxonomic study of the selected species including their seed morphology was done. The germination studies were conducted on seeds collected from hornbill nest midden and seeds collected from parent trees. In all nesting sites, thick forest was observed due to nesting of hornbill. Detailed phytosociological studies were done in selected nesting locations to find out the plant component, their density and diversity. The study revealed that most of the tree components were hornbill dispersed tree species. Saplings and seedlings of hornbill dispersed trees were abundant in the nesting sites. The study points out the mutualistic relationship between this bird and their dispersing seeds.

**Organization of the thesis**

The thesis included 9 chapters. The first chapter consists of Introduction and area of study. A general introduction was given to all subtopics in this chapter. This also includes the background of the study, organization of thesis and objectives fulfilled. Chapter 2 contains the review of earlier works done based on the topic. All available literature was sited and was written in chronological order. Chapter 3, materials and methods, includes the materials adopted for this study and methods include all the methods used to find out problem of the study. Chapter 4 is systematic treatment of the taxa according to the APG 1V system of classification. A detailed family, genus and species key were prepared based on available taxa. Chapter 5, fruit and seed morphology, includes all the morphology of fruit and seed and some quantitative parameters like size, weight, moisture content, pulp weight etc. A detailed taxonomic key was prepared based on the seeds and fruits studied. Chapter 6, seed germination, includes a small introduction, a detailed study of germination of hornbill dispersed tree species. A discussion was also given to this part. Chapter 7, Phytosociological composition of Great hornbill nesting habitat, gives the detailed phytosociological data. This chapter begins with a small introduction, and a detailed discussion of vegetational analysis given at the end of the chapter. Chapter 8 is summary and conclusion, in which general summary and conclusion of the work is given. Chapter 9 consists of recommendations put forward after the completion of the study.

The study attempts to full fill the following objectives.

**Objectives of the study**

1. To understand the taxonomy and phenology of Great hornbill dispersed rainforest in the Anamalai part of Southern Western Ghats.

2. To understand the fruit and seed morphology of Great hornbill dispersed tree species of the Anamalai part of Southern Western Ghats.

3. To understand the germination rate of Great hornbill dispersed rain forest tree species.

4. To understand the habitat and association of Great hornbill dispersed tree species in the nesting site.

**Study Area**

**The Southern Western Ghats**

The Western Ghats extend over 1600 km covering the states of Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat. It comprises one of the mega diversity centres in the world and is also a Biodiversity Hotspot. The Western Ghats with hilly terrain harbors a wide array of bioclimate with corresponding forest types (Pascal, 1982; Ramesh, 2001). It harbors a wide range of species diversity about 7402 species of flowering plants, of which 1270 are endemic (Nayar *et.al*., 2014).

Geographically Western Ghats divided into three distinct subregions (Nair, 1991), Northern, Central and Western regions. The Northern Western Ghats starts in the Maharashtra Sahyadris from the Tapti River to south of Goa with an elevation of 900-1200 m. It is composed of Deccan lava descending steeply to the undulating narrow Konkan coast. The Central Western Ghats extend from Goa to 320 km south to Coorg.

The Southern Western Ghats starts from the Netravathi Valley south of the Southern Canara. It rises abruptly to gneissic bosses such as Nilgiris. The mountain chain continues unbroken after the Palghat Gap throughout the Nelliyampathy – Anamalai hills up to the Mahendragiri peak at the southern tip of the peninsula, consisting of the Southern part of Karnataka, Kerala and Southern Tamil Nadu and covering an area of 7000 $km^2$, rich in biodiversity. Out of 7402 species of flowering plants present in Western Ghats, about 4500 occur in the Southern Western Ghats (Nayar *et al.,* 2014).

The southern ranges of Western Ghats, the Anamalai Hills are important conservation area. It is situated in the southern edge of the Palghat Gap culminating at Anamudi (2695 m), the highest point in the Western Ghats. This region is one of the three important endemic centres of entire Western Ghats mountains (Nayar, 1996; Ramesh & Pascal 1997). The Anamalai Hills cover an area of 6,014 square kilometers (3.3 percent of the total Western Ghats area) in two states, Kerala and Tamil Nadu (Bawa *et al*., 2007). Study of floristic diversity of the Anamalai part of Southern Western Ghats is done by botanists and is still going on. Systematic accounts on the floras of the various protected areas in the region have already been published (Manilal, 1988; Sasidharan & Sivarajan, 1996; Sasidharan, 2002).

The Anamalai hills were considered as one of the most important habitats for the hornbills in the entire Western Ghats, with four hornbill species viz., Great hornbill (*Buceros bicornis*), Malabar Pied hornbill (*Anthraceros coronatus*), Indian Grey hornbill (*Ocyceros birostris*) and Malabar Grey hornbill (*Ocyceros griseus*) being reported from these forests (Bachan 2003, 2006; Mudappa & Raman, 2007).

Interestingly, the abundance of these birds is higher in the forests below 900 m elevation. The highest numbers of Great hornbills are reported to occur in this region (Mudappa & Raman, 2007). The evergreen riverine forests of Vazhachal distributed along the banks of the Chalakudy River contain quite several large trees in which nesting of all the hornbill species except the Indian Grey hornbill has been found (Bachan, 2006).

The present study area includes the Anamalai part of the Southern Western Ghats of central circle of Kerala, covering the Thrissur and Palakkad district. The study area includes Vazhachal, Sholayar and Malakkappara regions of Vazhachal forest division, Nelliyampathy hills of Nemmara division, Sheikalmudi forests of Parambikulam Tiger Reserves (Figure 1.2.).

**Vazhachal forest division**

The area of Vazhachal Forest Division falls in Chalakudy taluk of Thrissur district and Aluva taluk of Ernakulam district. Sholayar, Kollathirumedu, Vazhachal, Charpa and Athirappilly are the various ranges in Vazhachal Forest Division. It comes under the Central circle of Kerala Forest Department, lies between $76^0$ 09' 06'' - $76^0$ 54' E and $10^0$ 07' 08'' - $10^0$ 23' 16'' N. This Division is bound by the Chalakudy Division in the west, Chimmony and Peechi Wildlife Sanctuaries and Nelliyampathy forests of Nemmara Division in the north, forests of Parambikulam Tiger Reserves in the northeast, Indira Gandhi Wildlife Sanctuary and Valaparai forests of Tamil Nadu in the east and the Edmalayar-Pooyamkutty forests of Malayattoor forest division in the south. The division occupies the total forest area of 353.4107 sq. km and is distributed in five ranges, such as 1. Athirappilly Range (95.099 sq. km), 2. Charpa Range (59.975 sq. km), 3. Vazhachal Range (90.643 sq. km), 4. Kollathirumedu Range (29.34 sq. km) and 5. Sholayar Range (78.35 sq. km). The Sholayar Range was the largest Range in the Division with 138.88 sq. km up to 2015-16 and now the Athirappilly Range is the largest in extent since the merging of 60.53 sq. km of Sholayar Range to the Parambikulam Tiger Reserve in 2015-16.

### Topographical features

The study area is situated in the western slope of the Western Ghats with an altitudinal variation of 200 m to 1300 m. The highest peak in the area is Karimalagopuram which is in the Sholayar range. The whole area is hilly and undulating. The eastern part of this region which has many valleys, especially in the Sholayar and Vazhachal region is the major habitat of Great hornbill. The northeast portion of this division Malakkappara, Chandanthodu, Anakkayam, Sholayar, Sheikalmudi, Ambalapara have good evergreen vegetation and support hornbill nesting and feeding trees. The Vazhachal Forest Division composed of distinctive four levels in its area based on the area of the height classes; (i) Highly elevated plateaus of >1000 m in the Malakkappara-Valparai region (mostly Sholayar Range) are the eastern boundary of the Division; (ii) A unique medium elevation (600-1000 m) in the Sholayar-Malakkappara region of which a great extent is in between 800-1000 m. (Sholayar Range, part of Charpa and Vazhachal Ranges); (iii) slightly ascending zone from the (300-600 m) Pokalapara–Vachumaram, Orukombankutty region and low elevation area (Kollathirumedu, Charapa and Vazhachal Ranges); (iv) very low elevation area, lower plains 70-250 m elevation area from the Thumboormuzhi, Kannankuzhi-Athirappilly to Vazhachal region (Athirappilly Range and lower regions of Charpa and Vazhachal Range).

### Geology and soil

Predominantly, the area has crystalline rocks of archaen age which may be of either igneous or metamorphic origin. They consisted mainly of granitic gneisses, charnockites and granites with narrow bands of magnetite quartz and pyroxene granulates (Krishnan, 1974). Soil types vary from deep filler textured soil on the lower slopes and valleys to shallow gravelly soil on the upper slopes. This is probably due to geological erosion resulting in alluvial deposition. The soil properties are also influenced by the nature of vegetation. Areas with less vegetative cover have more laterization resulting in laterite capping, especially in the foothills in some regions (Krishnan *et al*., 1996).

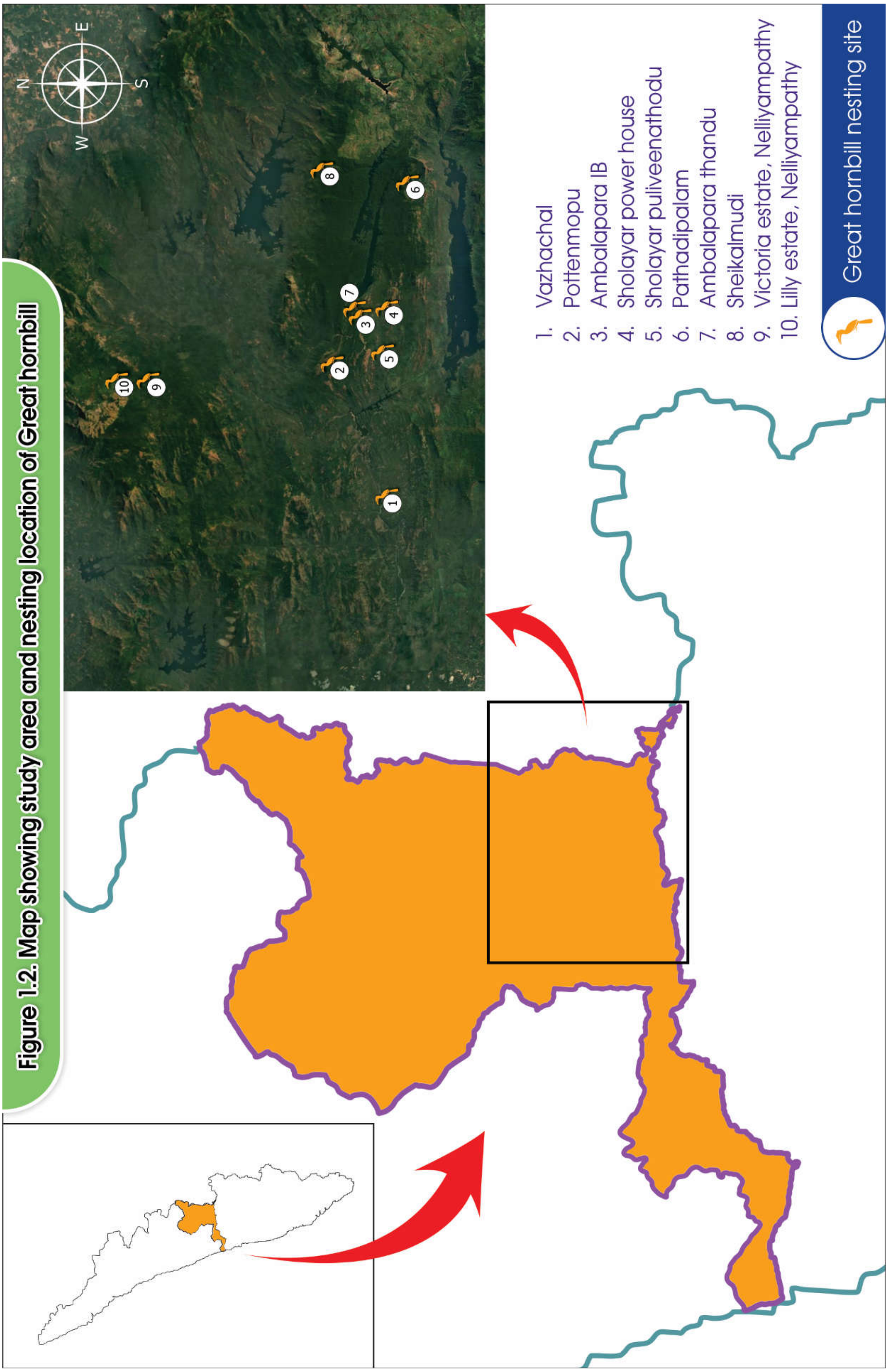


**Figure 1.2. Map showing study area and nesting location of Great hornbill**

**Climate and rainfall distribution**

The area falls in the tropical zone. The forest areas have a temperature range of 16-23$^{o}$ C, and the lower regions have a temperature of >23$^{o}$ C. This area experiences three distinct seasons viz. cold season starts from November to February, hot season starts from March to May and rainy season from June to September. During cold season, deciduous species begin to shed their leaves. During the hot season, the climate will be very hot with maximum humidity. The region receives pre-showers in March and April followed by a short period of dry weather before the onset of southwest monsoon in May or June. Maximum rainfall will be in the month of July. The southwest monsoon is immediately followed by the northeast monsoon. From November onwards, the climate changes to dry weather. This is the usual rainfall pattern of the area. However, recently, both the monsoons have become erratic. The vast stretch of the wet evergreen forests of the locality is the product of the high rainfall, temperature, and the minimum dry period.

**Rivers**

The Vazhachal forest division flourished with Chalakudy river. With a length of 145 km, it is the fifth longest river in Kerala and harbors 2 hydroelectric project. Sholayar hydroelectric project commissioned in 1965 having the reservoir has an area of 8.705 sq.km and Poringalkuthu hydroelectric project commissioned in 1957. Besides the river, Manimaruthuthodu, Anakkayam thodu, Karnathodu, Kannakuzhirhodu, Oolassery-Athirappilly thodu, Chullithodu, Orukkmban thodu, Charpathodu are the main streams in this area.

**Vegetation**

The different type of vegetation is seen in this division in an altitude from 200 m to 1300 m, the rainfall and temperature from 14$^{0}$ C to 36$^{0}$ C. The vegetation is mainly wet evergreen forest. The peculiar anthropogenic disturbance combined with the topographic conditions has led to the formation of other forest types which are degraded stages of evergreen type. The Vazhachal division has a considerable area of wet evergreen forests, about 190 Km$^{2}$. This amounts to roughly half of the total wet evergreen forests in the Kerala part of Anamalai hills (Ramesh & Gurukkal, 2007). Majority of this forest comes under Sholayar and Vazhachal ranges (Table 1.1.).

**Table 1.1. Extend of vegetation -Vazhachal forest division (2015-16)**

| **Sl No** | **Category** | **Extend ha** |
|---|---|---|
| 1 | Natural forest | 29883.800 |
| 2 | Teak plantations | 3780.780 |
| 3 | Teak and Bombax plantation | 1676.420 |
| 4 | Miscellaneous plantations | Merged with natural forests as enrichment planting |
| | **Total** | **35341.000** |

(Source Working Plan Vazhachal 2018-19)

As per the revised classification of forest types of India by (Champion & Seth, 1968), the types of forest seen in the Vazhachal area are West coast tropical evergreen forests (13881 ha.), Tropical semi evergreen forests (1397.7 ha.), Tropical moist deciduous forests (3284 ha.), Reed mixed forests (1804 ha.), High elevation grass lands (184 ha.) and Open degraded area (2857 ha.). The Vazhachal forest possess a large stretch of low elevation riparian vegetation and is dominated by some species like *Syzygium occidentale* (Bourd.) Ghandhi, *Barringtonia acutangular* Gaertn., *Madhuca neriifolina* H.J. Lam, *Humboldtia vahliana* Wight, *Mallotus aureo-punctatus* (Dalz.) Mull.Arg., *Homonoia riparia* Lour., *Hopea parviflora* Bedd., *Ochlandra* sp, *Vateria indica* L., *Ficus* sps. These plants are evergreen species, and the first six species are riparian habitat endemic, and *Hopea parviflora* and *Vateria indica* are important nesting tree for Great hornbills and *Ficus* sp. important fruiting tree (Bachan 2003, 2006).

A total of 1036 flowering plant species, coming under 122 families were enumerated from Vazhachal forest division of which 229 are endemic species and 62 are rare and threatened category. Many of the threatened tree species are hornbill dependent species such as *Cryptocarya anamalayana* Gamble, besides these important forest tree species are also hornbill dependent such as *Palaquium ellipticum (*Dalz.) Baill., *Elaeocarpus tuberculatus* Roxb., *Canarium strictum* Roxb., *Myristica beddomei*

King., *Dysoxylum malabaricum* Bedd., *Actinodaphne wightiana* (Kuntze) Noltie, *Beilschmiedia bourdillonii* Brandis., *Actinodaphne tadulingamii* Gamble, *Knema attenuate* (Hook. f. & Thoms.) Warb., *Syzygium cumini* (L.) Skeels, *Cinnamomum malabatrum* (Burm.f.) Blume., *Diospyros paniculate* Dalzell, *Litsea floribunda* Gamble etc. The highest tree diversity is in the wet evergreen forests in Sholayar Range, followed by the primary low elevation forest in the Vazhachal Range (Figure 1.3.).

The over exploitation of trees like *Canarium* and *Myristica* for minor forest products, forest fire, construction activities is the main reason for the degradation these evergreen forests trees. To conserve the genetic resources, it is essential to identify the plant animal relationship, conserve their habitat. The Vazhachal Forest Division is one of the Important Bird Area and harbor many endemic bird (Stattersfield *et al.,* 1998). (Susanth, 1996) reported 120 species of birds from Vazhachal forest division, which include 8 species of IUCN endangered category. Among the hornbill species the Great hornbill and Malabar pied hornbill comes under this category.

**Parambikulam Tiger Reserve**

Parambikulam tiger reserve is an important protected area within the Anamalai Hills. It is in the Palakkad revenue district and lies between $76^0$ 35’ and $76^0$ 51’ E longitude and between $10^0$ 20’ and $10^0$ 32’ N latitude. The reserve has a total area of 643.66 sq km, of which 390.89 $km^2$ is demarcated as the core area and the remaining 252.77 $km^2$ is the buffer zone. The reserve is bordered by Vazhachal forest division in the south, Chalakudy in the west, Nelliyampathy Ghats continuous to the Palghat gap on the north and Indira Gandhi Wildlife Sanctuary on the east. The altitude ranges from 440 m at Chalakudy river basin to 1438 m at Karimalagopuram. The conspicuous peaks are Kuchimudi (1180 m), Vengoli (1224 m), Pandaravarai (1190 m), Karimalagopuram (1438 m), Sheikalmudi (1210 m) and Peza (1200 m).

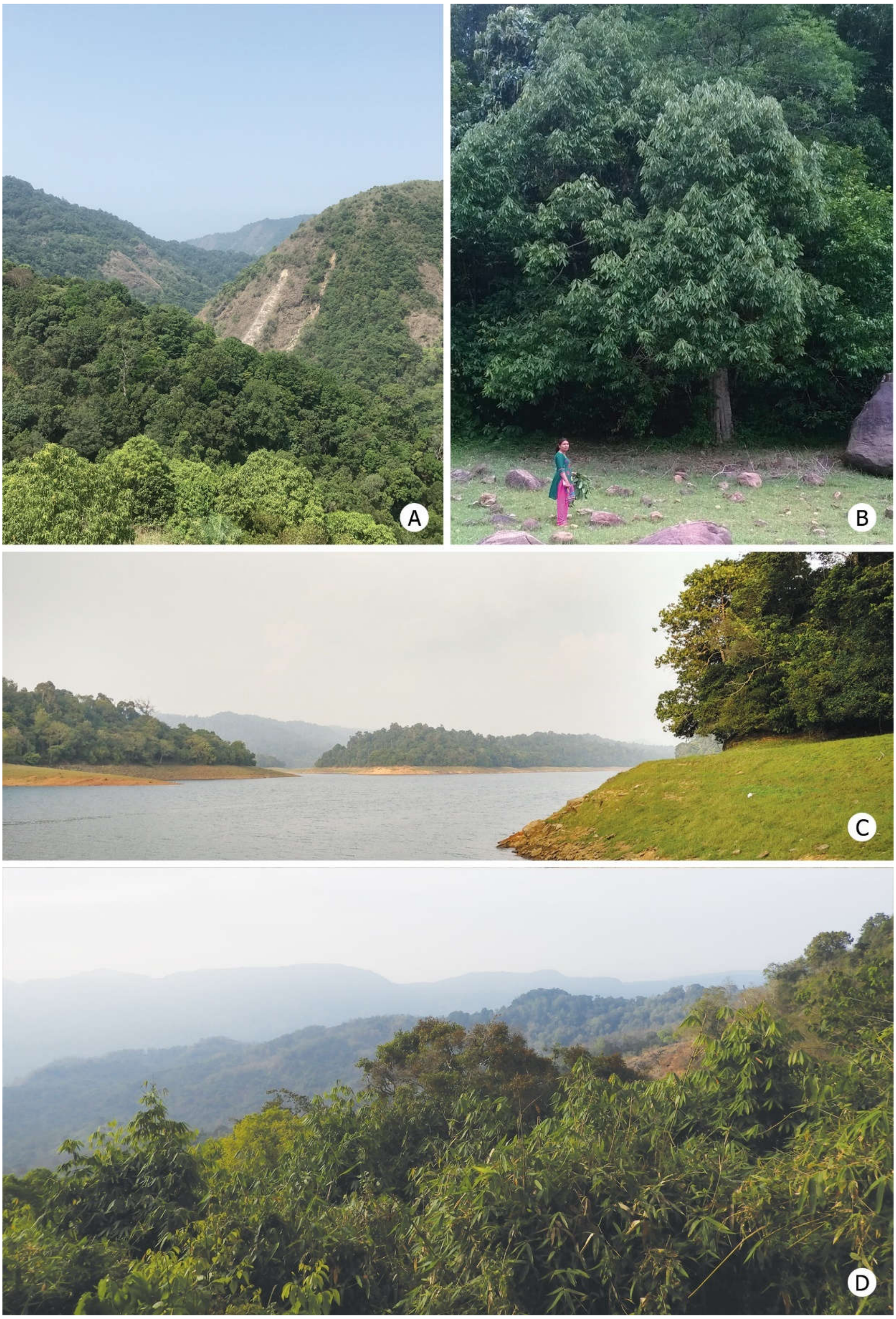

**Figure 1.3. Study Sites: A.** Nelliampathy; **B.** Sholayar Dam Site; **C.** Elamthalachi; **D.** Malakkapara.

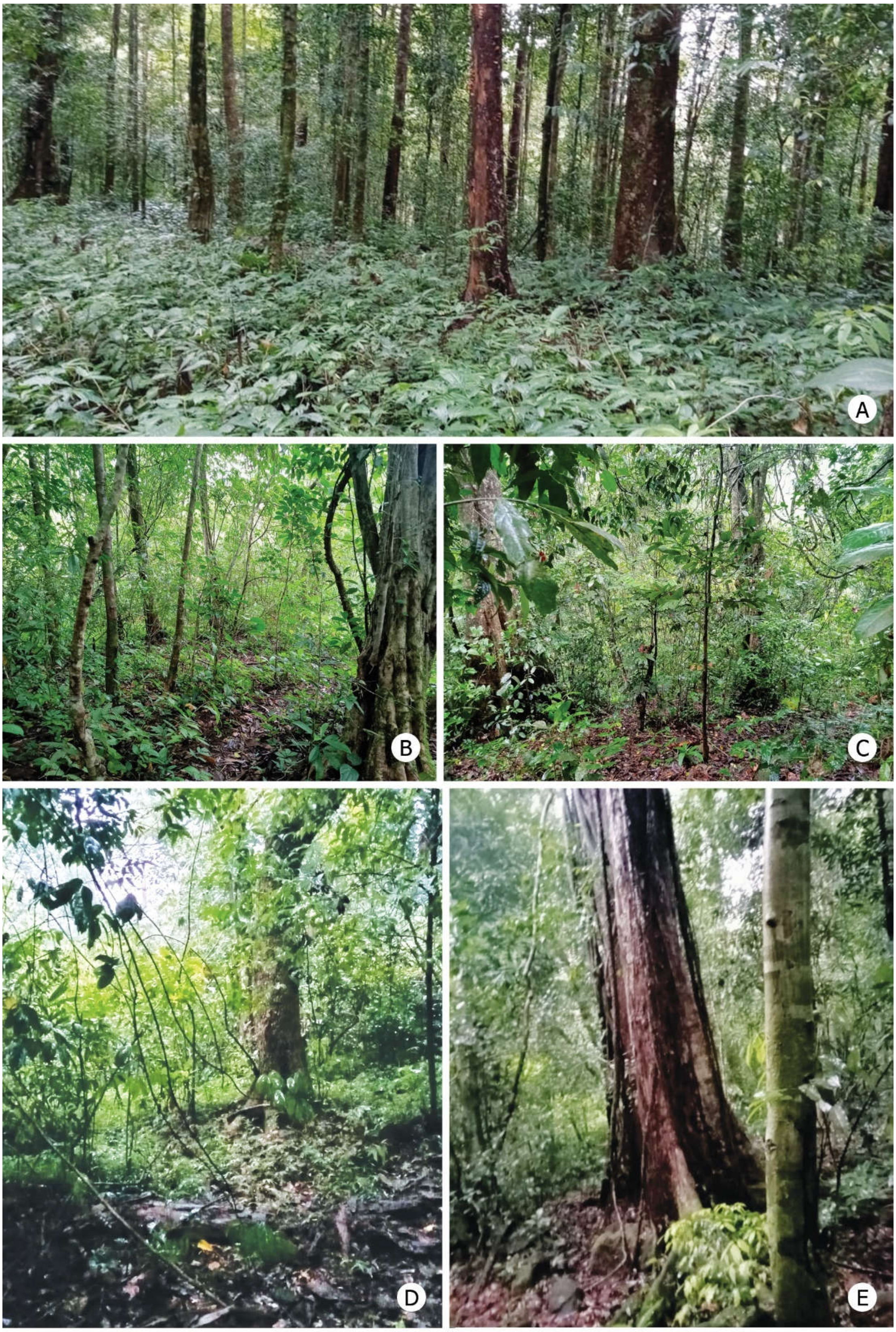


**Figure 1.4. Study sites: A.** Pathadipalam; **B.** Santhampara; **C.** Perumpara; **D.** Swapnamudi; **E.** Chudalamudi

**Topography**

Predominantly, the reserve has a hilly terrain with panoramic valleys in between. One of the characteristic features of the reserve is the presence of marsh lands or Vayals which are scattered throughout the valleys.

**Geology and soil**

The main geological formations in this area are hornblende-biotite gneisses, garnetiferous-biotitegneisses, charnockites that had been intruded by garnitic-ortho-gyneisses and plagioclase porphyry-dykes. Major constituents of the rocks are quartz, biotite, orthoclase and plagioclase feldspar (Krishnan, 1974).

**Climate and rainfall distribution**

Parambikulam Tiger Reserve receives good rainfall, annual rain fall is 1720 mm, most rain is received in the month of June-August, while the eastern part of the sanctuary adjoining to the Tamil Nadu receive most rain in October – November. Even though southwest monsoon is more active, the region gets good showers during northeast monsoon also. The relative humidity is low.

**Vegetation**

Apart from the major vegetation types such as West coast tropical evergreen forest, West coast tropical semi evergreen forests, Southern Moist deciduous forest, Southern dry mixed deciduous forests and teak plantations (Chandrasekharan, 1962; Champion & Seth 1968). Parambikulam has some unique vegetation types. These include cane and bamboo brakes, reed brakes, thorn forests, shola grasslands, and marsh lands (Vayals). Within the reserve, Orukomban range has a good expansion of evergreen forests. West coast tropical evergreen forests are well represented in Sheikalmudi area. Evergreen and semi evergreen forest found along northern and northwestern border, moist deciduous forest mostly in the central portion and small patches of dry deciduous forest in the adjoining part of Tamil Nadu. Plantations are mainly teaks.

The reserve has an impressive floristic diversity (a total of 1432 species of angiosperms belonging to 753 genera under 140 families) featuring about 35 percent of the estimated flowering plants reported from Kerala (Sasidharan, 2002). The evergreen patches of forest in the Orukomban and Karimala ranges are lying continuous with the forests of Vazhachal and Chalakudy divisions. A total of 85 species of threatened plants has been reported from this area (Sasidharan, 2002).

**Nelliyampathy Reserve Forest**

The Nelliyampathy hills $10^0$ 20'-$10^0$48' N & $76^0$30'-$76^0$55' E, are an important part of Nelliyampathy-Anamalai-Palani hills. The region comes under the Chittoor taluk of Palakkad district. The forest area falls under the Nemmara forest division consisting of two forest ranges Nelliyampathy range (20862 ha) and Kollengode range (7000 ha). These hills are surrounded by Palghat gap on the north, Parambikulam Tiger Reserve on the south, Indira Gandhi wildlife sanctuary on the east and Chalakudy forest division on the west. With an elevation of 1633 MSL, this region has a substantial area of primary evergreen forests and constitutes the central part of Southern Western Ghats (Figure 1.4.).

**Topographical features**

Topographically, the area exhibits hilly terrain. The highest peak of this region is Minnamparamala (1,633 MSL) followed by Palakappandimala with an elevation of 1586 MSL, Padagiri with an elevation of 1520 MSL, Pullalamala with an elevation of 1,440 MSL and Karappara with an elevation of 1300 MSL.

**Geology and soil**

Geologically the rock formations of Nelliyampathy are composed of Pre-Cambrian cover (Mani, 1974; Krishnan, 1974). The main rock type is biotic gneiss. Quartz, khondalites and granite are the other rock types seen in this region. The moist tropical conditions prevailing in these areas have caused active metamorphosis of gneiss, resulting in the formation of laterite, generally seen along the foothills. These hills have predominantly red soil mixed with yellow soil. Laterites are generally poor in Iron, Potash, Phosphorous and organic matter, with soil pH ranging from 4.5-7.5 but well drained (Saju. 2015).

**Climate and rainfall distribution**

March to May are the hottest months and December and January are the coldest months. The area has comparatively higher temperature mainly due to the dry winds blowing through the Palakkad gap from the Tamil Nadu plains and also radiating heat from the open rocky hills. The highest temperature in the plains and lower hills goes up to $42^0$ C and in the upper hills is about $32^0$ C. The mercury drops to as low as $8^0$ C in the upper hills whereas in the plains and lower hills the minimum temperature is about $21^0$ C. The average annual rainfall received is 1023−3282 mm ((Balasubramanyan, 1987; Chandrashekara, 1991), most of which is received during the months of June to September. Rainfall distribution varies considerably in different locations.

**Rivers**

The southwest portion of the Nelliyampathy RF drains into Karappara river, the Southeast portion of the Nelliyampathy RF drain into Thekkady river and northern portion of Nelliyampathy RF drain into Pothundy reservoir as Pothundy River.

**Vegetation**

The major forest types seen in this area are West Coast Tropical Evergreen Forest, West Coast Semi Evergreen Forest, Southern Moist Deciduous Forest (3B), Southern Subtropical Broad-Leaved Hill Forest and Southern Montane Wet Grasslands (11A/C1/DS2) (Champion & Seth, 1968).

Evergreen forest of the area is classified as medium elevation type of the *Cullenia exarillata- Mesua ferrea-Palaquium ellipticum* series (Pascal, 1988; Ramesh & Pascal, 1997). Even though much of the forest cover was lost due to the selective felling in the 1950−1986 period (Mathew, 2001) smaller patches remain in inaccessible locations.

**Nesting locations of Great Hornbills Selected for the Study**

During the present study, 8 nesting sites of Great hornbill were selected for the detailed study. Nesting plot 1 near to Vazhachal waterfalls (VNS), Plot 2 at Pottenmopu (PNS 1), plot 3 at Ambalapara IB (ANS), Plot 4 at Sholayar Powerhouse (SPNS 1), Plot 5 at Sholayar Puliveenathodu (SPNS 2), Plot 6 at Pathadipalam (PNS 2), plot 7 at Ambalapara Thandu (ATNS) in Vazhachal forest division and plot 8 at Sheikalmudi (SNS) in Parambikulam tiger reserve. An extensive data collection including regular visit in the nesting season of Great hornbill, collection of regurgitated seeds from nesting tree, vegetational analysis around the nesting tree, regeneration of saplings around the nesting tree were done in these plots. In Nelliyampathy area, 2 nesting sites were selected at Lily estate and Victoria estate region. Regular visits were done in this area also during the nesting season and collected the regurgitated seeds for germination studies. In these two sites, vegetational studies and regeneration of saplings were not conducted because they are located near to roadside along tea plantations.

# CHAPTER 2
# REVIEW OF LITERATURE

**Floristics study**

The Western ghats occupies major evergreen forests, about two- thirds of endemic plants are found here. The Southern Western Ghats has attracted many botanists because of its floristic diversity. The first among the published books on the botany of this region was van Rheede's (1678-1703) monumental work *Hortus Indicus Malabaricus.* It is of great importance as it formed the main source of information about many Indian plants for Linnaeus. He adopted 265 Indian plant names into botanical nomenclature.

As far as Kerala is concerned a series of floras were published from this region starting from *Flora of Calicut* (Manilal & Sivarajan, 1982). *Flora of Cannanore* (Ramachandran & Nair, 1988), *Flora of Silent Valley* (Manilal, 1988), *Flora of Palghat* (Vajravelu, 1990), *Flora of Thiruvananthapuram district* (Mohanan & Henry, 1994), *Flowering Plants of Thrissur Forests* (Sasidharan & Sivarajan, 1996), *Flora of Agasthyamala* (Mohanan & Sivadasan, 2002), *Flora of Pathanamthitta district* (Anil Kumar *et al*., 2005), *Flora of Nilambur* (Sivarajan & Mathew, 1996) and *Flora of Alappuzha District* (Sunil & Sivadasan, 2009). In Kerala, Botanical survey of India, the taxonomy division of the botany department of University of Calicut, and Kerala Forest research institute made useful contribution in flora.

In the Western Ghats the principal plant communities are angiosperms trees. The Anamalai part of Southern Western Ghats consists of evergreen composition mainly consists of trees under the families Lauraceae, Meliaceae and Myrtaceae. The Great hornbills, large frugivory inhabit in the evergreen forests of Western Ghats mainly depend on many species of these family belonging to endangered and vulnerable category for their diets thus serve as an important disperser.

Lauraceae family commonly consists of large trees or shrubs, consists of approximately 53 genera and 2500-3000 species, its diversity described from the neotropics (Meissner, 1864; Pax, 1891; Kostermans, 1957; Hutchinson, 1964; Rohwer, 1993, 1994). In India, the family represents 16 genera and 154 species. In which 11 genera and 89 species confined to South India (Hooker, 1886; Santapau & Henry, 1973). The first major systematic treatment of Lauraceae on a world-wide basis were made by (Nees, 1836; Meissner, 1864). (Kostermans, 1957) has classified the family, and he established a framework for the worldwide revision. Hornbills depended main taxa are *Actinodaphne, Beilschmiedia*, *Cryptocarya, Cinnamomum*, *Litsea*, *Neolitsea* and *Persea*.

The genus *Actinodaphne* Nees was erected by C. G. D. Nees von Esenbeck (1831), comprises about 101 species, distributed from India and Sri Lanka to Myanmar, Thailand, Indochina, Korea, Japan, Malaysia, and the Solomon Islands (Rohwer, 1993; van der Werff, 2001; Julia, 2005). They are frequently found in evergreen, semi-evergreen, and shola forests. In India, the genus includes 15 species and a variety. Lectotypification of *Actinodaphne lantana* an endemic and critically endangered species is designated, and a detailed account of taxonomy and ecology of species was studied (Robi *et al*., 2017)

The genus *Beilschmiedia* Nees is a pantropical genus comprised approximately 200 species (Kostermans, 1995). Among these, eight are found in India (Hooker, 1885). The two species *Beilschmiedia tirunlvelica* discovered from the Western Ghats of Agasthyamala biosphere reserve (Manickam *et al*., 2010), *Beilschmiedia jacobii* from Agasthyamala biosphere reserve of Southern Western Ghats (Robi *et al*., 2016).

The genus *Cryptocarya* R. Br. comprises about 350 species, most of which are confined to tropical Asia. (van der Werff, 2008). In the Indian, the genus is represented by about 15 species, of which 6 are known to be distributed in the Western Ghats of southern India (Hooker, 1886; Gamble, 1935; Santapau & Henry, 1973; Gangopadhyay & Chakrabarty, 2005). In Kerala the genus consists of about 5 species confined to the Southern Western Ghats. *Cryptocarya Sheikelmudiyana* (Fasila *et al.,*

2020) and *Cryptocarya muthuvariana* (Jagadeesan *et al.,* 2021) are the 2 new species recently discovered.

The genus *Litsea* Lam is an important genus of the family lauraceae with nearly 300 species in world (Mabberley, 2008; Bhuniya *et al.,* 2010). There are about 45 species reported from India of which 18 species are endemic to different ecoregions (Bhuniya *et al*., 2010). Many new species were published from the Kerala part of Western Ghats. A new species of *Litsea* from Agasthyamala hills, Southern Western Ghats is described and *Litsea udayani* from Anamalai Phyto geographical zone of Southern Western Ghats (Robi *et al.,* 2015). *Litsea anamalayana* (Robi & Udayan, 2021) discovered from the Nelliyampathy hills of Kerala, *Litsea kakkachensis* (Ganesan, 2011), *Litsea gorayana* (Udayan & Robi, 2017) is described from Agasthyamala Biosphere Reserve of Southern Western Ghats in Kerala. *Litsea indoverticillata (*Robi *et al*., 2017) is recognized from the Malabar Wildlife Sanctuary of Nilgiri phytogeographical zone of Southern Western Ghats. *Litsea manilaliana (*Robi & Udayan, 2021) is described and illustrated from the Wagamon hills in India.

The genus *Cinnamomum* Schaeffer comprises about 200-350 species occurring mostly in the Old-world tropics, particularly in Southeast Asia. In India about 40 species of the genus were recorded and are distributed in Western Ghats, Eastern Himalayas, and Andaman Islands. Among the total 18 species reported from south India, 16 are endemic to Western Ghats region. A new species of *Cinnamomum mathewianum* was reported from the Agasthyamala Biosphere Reserve (Remya Krishnan *et.al*., 2014). *Cinnamomum agasthyamalayanum* a new species reported from Kollam and Thiruvananthapuram district in Kerala (Robi *et al*., 2014), *Cinnamomum gamblei* a new species reported from Nilgiri part of Southern Western Ghats (Geethakumary *et al*., 2017).

The genus *Neolitsea* (Benth. & J.D. Hook.) Merr. comprises evergreen trees and shrubs was established by (Merrill, 1906). The genus is represented by about 80 Indo-Malesian and Eastern Asian species extending to Australia. The revision of *Neolitsea* in Indian Subcontinent recognizes 11 species of which three species have 2 verities each (Chakrabarty, 2020). *Neolitsea cassia* var. *cassia* occurs in Sri Lanka and Peninsular India and disjunct to China, Thailand, Vietnam, Malaysia, and Andaman and Nicobar Islands. Similarly, *Neolitsea foliosa* var. *foliosa* is also disjunct between Peninsular India and Bangladesh while *Neolitsea foliosa* var. *scrobiculata* exhibits distribution between Sri Lanka and Peninsular India and disjunct to Bhutan and Myanmar and Andaman and Nicobar Islands.

*Phoebe* Nees consists of evergreen trees and shrubs distributed in tropical and subtropical Asia with about 75 species (POWO, 2019). (Santapau & Henry, 1973) reported nine species from India and subsequently three more species were described from Arunachal Pradesh (Gangopadhyay & Sarmah, 2007) and Western Ghats. The occurrence of this genus in the Andaman & Nicobar Islands was known when (Rasingam, 2015) reported *Phoebe lanceolata* (Nees) from Little Andaman Island and *Phoebe nicobarica* (Rasingam *et al.,* 2021) from Andaman and Nicobar Island.

The family Myristicaceae, found in the wet lowland tropical forests well known for its significant ecological and ethnobotanical importance worldwide. It comprises of 20 genera, 500 species and ranks among the 10 most diverse and important tree families in this ecosystem (Pascal & Pelissier, 1996).

The genus *Knema* Lour. consists of 93 species is distributed in Indomalaya (Mabberley, 2008). In India the genus is represented by 8 species of which the *Knema attenuata* is the only species endemic to Western Ghats (Nayar *et al.,* 2014; Banik & Bora, 2016). A new species of *Knema*, *Knema flavostamina* is reported from Agasthyamala biosphere reserves of Southern Western Ghats (Govind & Dan, 2020).

The genus *Myristica* R. Br. consists of 4 species with in the Western ghats of which *Myristica malabarica* Lam. comes under Vulnerable B1+ 2c and *M. beddomei sub sp. sphaerocarpa* is listed under endangered category. *Myristica trobogarii* (Govind, *et al*., 2020) reported from Agasthyamala Biosphere reserve of Southern Western Ghats

The family Meliaceae comprises about 50 genera and 1400 species confined to the tropics and subtropics. In India the family represented by 20 genera and 70 species The genera of this family are very important and shows high degree of endemism. The genus *Trichilia* is derived from Greek word ‘tricho’ referring in to 3 lobed fruits. It is an evergreen tree widely distributed in South and East Asia. *Aphanamixis polystachya* (Wall.) Parker is found primarily in Southeast Asia and in the Indian sub-continent.

The genus *Aglaia* Loureiro comprises 120 species distributed in the tropical evergreen forests of Southeast Asian region. It is commonly known as 'Chuvanakil' and is a subcanopy tree endemic to Western Ghats. The species of *Aglaia* used by the tribal people for edible fruits, flowers.

The genus *Dysoxylum* Bl. comprises 80 species (Mabberley, 1997) distributed in the tropical and subtropical zones. In India the genus is represented by 16 species in which 8 species are endemic distributed mostly in Western and Northeastern regions and Andaman & Nicobar Island. It is endemic to Western Ghats of Peninsular India. In Kerala 5 species of *Dysoxylum* are reported of which 3 species confined to the Western Ghats. (Ahamedulla & Nayar, 1986). In Western Ghats various studies have been done regarding the importance of these species to make a large and sustainable forest. A detailed study was done to explore the threat of these species combined molecular assessment of inbreeding with ecological and demographic data. (Ismail *et al.,* 2014). A study of JNTBGRI n threatened plants on Kerala shows that *Dysoxylum malabaricum* facing threat of extinction.

The genus *Diospyros* L. represented by 600 species distributed in Asia, Pacific areas, Africa, America, and Australia. In India the genus represented by 66 species (Wallnofer, 2001). A detailed monograph of this taxa is prepared by Dr. V. Sinong based on gross morphological character, anatomy, embryology, and cytology. It is important taxa provide edible fruit for macaque and hornbills rich in sugar, proteins, and minerals.

*Canarium* L comprises 75 species distributed in the rain forests of tropical Asia, Pacific region, and Africa. *Canarium strictum* contains about 101species commonly known as Black dammar, occurs in tropical moist evergreen and moist mixed deciduous forests. In India it is found in Western Ghats as well as in Eastern Himalayas. Black dammar resin obtained from this plant is considered an important NTFP (Murali *et al.,* 1996)

Myrtaceae, the myrtle family, of the order Myrtales, comprises about 130–150 genera and 5650 species. This family is distributed in tropical and concentrated in America as well as Malesia and Australia. In India the potential region for the distribution of the family is the evergreen forests in the high ranges of the Southern Western Ghats.

The genus *Syzygium c*omprises 52 species from Western Ghats, among them 26 species have been listed under the IUCN Red List category (five species are included under Critically Endangered, and eight species are under the Endangered category). Over exploitation, habitat degradation, irregular phenological events, lower productivity and lesser seedling establishment in the natural habitat are the real factors for the vanishing of the population of most of the species of *Syzygium* (Vinodkumar, 2003). A new endemic species of *Syzygium munnarensis* is reported from Southern Western Ghats of Kerala ( Shareef *et al.,* 2014)

The genus *Elaeocarpus* Linnaeus has more than 360 species distributed in worldwide (Coode, 2007),  of which 25 species reported in India confined to Nort East and Southern India and few species in Andaman and Nicobar Islands. The seeds commonly called 'Rudraksha' literally means in Sanskrit word Rudra synonym of lord Siva, and 'aksha' meaning eye. The family is economically very important as timber, as edible fruits, and traditional medicine. The different part of the plant taken for various diseases like mental disorders, headache, fever, skin diseases and for healing the wounds.

*Palaquium* Blanco distributed in India, Southeast Asia, and Pacific Island (Govaerts *et al*., 2002) consists of 121 species (POWO, 2022) out of which 6 species are reported from India. It forms an important canopy tree of mid elevation evergreen forest (Pascal *et al*., 2004) and widely distributed throughout the Western Ghats and its local vicariant *P. ravii* is restricted to the Anamalai-Palani-Cardamom hill complex (Ramachandran & Swarupanandan, 2006).

**Phenology of tree species**

Phenology is the science that measures the timing of life cycle events. In the case of flowering plants these life cycle events consist of formation of leaf buds, opening of leaf buds, formation of last flower, shedding of flowers, formation of first fruits, maturation of fruits, ripening of fruits, fruit shedding. (Leith, 1974) described phenology is the study of rhythm of repetitive biological events, causes of these events including biotic and abiotic and relationship between different species (Haggerty & Mazer, 2008). Phenology can be different in same species if the species is standing in different population. *Artocarpus hirsutus* showed variation in phenological pattern growing in two different altitudes. Variation among species in their phenology is very important to avoid competition among pollinators and seed disperser (Rachke & Lacy, 1985). From the phenological studies conducted by (Mulik & Bhosale, 1989) showed that this study was very helpful for afforestation, plant management and to understand the relationship between the plants and their pollan and seed disperser. Phenological observation of tree species is an important aid for the seeds collection (Mahadevan, 1991).

Phenological pattern varies with the environment, in evergreen trees the flowering starts during the winter season (Nanda *et al*., 2017). In tropical deciduous forest tree species, the drought stress is not only reflected in terms of the leaf less periods but also evident from the greater seasonal separation between leafing and flowering. In tropical deciduous tree species summer flowering species were abundant (Singh & Kushwaha, 2005).

In evergreen forests flowering starts in January, flower bud initiation at January-February, ripened fruit at April, fruit fall in June (Nanda *et al.,* 2017). In the same genus there may be variation in the pattern of flowering and fruiting. While considering the phenology of trees in tropical forest species shows almost the same phenological pattern because they are less sensitive to temperature photoperiod and more tuned to seasonal shift in precipitation.

**Seed morphology**

The structure and microstructure of seeds, seed size, shape, number, and weight are of profound importance in the systematic studies of angiosperms. In his classical book on seed structure of angiosperms, (Netolitzky, 1926) had admirably summarized our knowledge up to the end of 1923. After a long gap of more than fifty years, Corner published his two volumes on the seeds of the dicotyledons in 1976. (Martin & Barkley, 1961) prepared a comprehensive account for the identification of weed seeds.

Regarding these aspects various studies have been made in the past by a few workers who have established the essence of seed characters in their studies The taxonomic significance of seed morphology, seed and seed coat anatomy, epidermal and surface characters of angiospermic seeds have been investigated largely both in India and abroad (Chuang & Omduff, 1992). A detailed seed morphology of fruits of *Diospyros* species in Thailand was done by (Utsunomiya *et al.*, 1998). They also noticed the intensity of pubescence in young and mature fruit, skin colour differences in young and mature fruit, the volume and colour of mesocarp, type of fragrancy, ability of seed formation in different species, intensity of seed germination. Seed morphology of 10 species belonging to three subgenera of *Nymphaea* occurring in Mexico were studied (Barbosa *et al*., 2000). Among sub genera, the seeds showed marked morphological variation in shape, color, size, ornamentation of sclereids, and trichomes which is used to solve taxonomic dispute in these genera. Besides seed morphology, germination phenology of three monocarpic and polycarpic species of the Apiaceae found in the Eastern Deciduous Forest were studied by (Hawkins, 2007). Study concludes the importance of seed morphology, because these six species differed considerably in mass, shape, and ornamentation. The seed coat morphology and anatomy of *Rhodiola* species and sub species using scanning and light microscopy methods identified three morphological types of seed coats which is used to evaluate their characteristics for use in systematic studies. Considerable variability of seed coat morphology is reported in species and its possible implication for species taxonomy is discussed (Gontcharova *et al*., 2008). The morphological characters of fruits and seeds of all the five *Rauvolfia* species, occurring in South India were analysed and an artificial key provided for the same based on morphological characters like shape, size, colour, and surface features of both the fruits and the seeds. Comparative study revealed that the species can be delimited based on fruit or seed characters and an artificial key is provided for the same (Anil Kumar *et al*., 2011). The seed morphology of eight *Allium* species confirmed the substantial diversity in testa characters (Bednorz *et al*., 2011). To distinguish genera and tribe in the genus *Malcolmia* showed that the genus has 6 species based on stereomicroscopy and SEM of fruit and seed features including seed and fruit shape, size, colour, fruit pedicel size, fruit hair density, seed coat pattern, epidermal cell shape, anticlinal and periclinal cell wall (Kaya *et al*., 2011). The morphological data of *Araticum* fruits, seeds and seedlings can be used to recognize the botanical family and, when associated to other features, to recognize the species in the field (Pimenta *et al*., 2012). The classification of *Silene* species was done based on micromorphology of seeds (Arman & Gholipour, 2013). Morphological variability like fruit width, fruit thickness, seed length, seed width and seed thickness of the fruit and seed of wild cherry (*Prunus avium* L.) implies the possibility to use seed and planting material from different altitudes and ecological and vegetation zones within the studied area (Ballian & Mujagic- Pasic, 2013).

**Hornbill as an important seed dispersal agent**

Frugivory is one of the most dominant dietary niches that terrestrial vertebrates occupy in tropical forests. (Terborgh, 1986) suggested that an animal that has 50% of its total diet comprising of fruits as frugivore and the hornbills are important frugivores of the tropical moist forests. He observed more than 80% of the avian mammalian fauna at Chocha Cashu in Peru comprises of frugivores.

The breeding biology of four sympatric hornbills in Thailand was observed (Poonswad *et al.*, 1987). Earliest account of hornbills of India was obtained from (Ali *et* al., 1987) in their monumental work "*Birds of sub-continent*" which record all the four South Indian hornbill species such as Great hornbill, Malabar Pied hornbill, Malabar Grey hornbill, and the Indian Grey hornbill. While studying the reproductive biology of two species of African hornbill (Stauffer & Smith, 2004) suggesting that reproductive activity and success are related to fruit availability.

Food preferences of the Sulawesi Red-knobbed hornbill during the nonbreeding season were fig species. Out of 24 diet species recorded in their diet, 20 were figs (Suryadi *et al*., 1994). Top slip area, Tamil Nadu (Kannan & James, 1997) recorded the fruit species delivered to the nest inmates and found that 72.9% of the fruits were delivered at nest were figs. The *Ceratogymna* species in Dja Reserve Cameroon, consumed fruits from 25-49 species of tree and lianas in at least 20 plant families included Annonaceae, Moraceae, Euphorbiaceae, Meliaceae, Olacaceae and Myristicaceae (Whitney *et al.*, 1998). The feeding of the Sulawesi Red-Knobbed hornbill showed that 33 species of ripe fruit as its diet species. The five most common diet species included four tree species namely *Horsfieldia brachiate*, *Cananga odorata*, *Syzygium* sps., *Polyalthia grandifolia* and one liana, *Gnetum latifolium* (Kinnaird, 1998). Hornbill research in Thailand by (Poonswad, 2000) experienced that hornbill select 23 genera of large tree selected for nesting, ripe fruits of 139 plant species, from 76 genera and 36 plant families were recorded in the diet of hornbills. The Great hornbills prefer sugar rich fruits like figs and lipid rich fruits of family Myristicaceae and Lauraceae (Mudappa, 2000).

The diet and food resource partitioning of three sympatric hornbills (Great hornbill *Buceros bicornis,* Wreathed hornbill *Aceros undulatus*, and Oriental Pied hornbill *Anthracoceros albirostris*) during the nonbreeding season showed the presence of 49 plant species that comprised over 95 percent of their diet. The occurrence of non-fig fruit was less compared to fig fruit in nonbreeding season because of the availability of non-fig fruits was much lower in the nonbreeding season than in the breeding season (Datta & Rawat, 2003). The food habits of Malabar Pied hornbill (*Anthracoceros coronatus*) in the Athikadavu valley, Western Ghats, India studied by (Balasubramanian *et al.*, 2004) showed the presence of 147 individuals belonging to 18 fleshy fruited trees were recorded in the bird's diet. During the non-breeding period 60% of the diet was figs. During the peak breeding period 98 percentage of food deliveries to nest inmates were fruits belonging to 6 species considered "keystone species" in the riverine forest ecosystem. A study of ( Kannan & James, 2008) noticed 72.9% delivered by parent hornbills to confined nest inmates were figs. Hornbill prefer large seeded fruit plant including single seeded drupe, lipid rich arillate capsule and large canopy trees like *Canarium strictum* and *Phoebe* sp. attract large number of hornbill and they are responsible for facilitate the dispersal of other hornbill food plant species (Naniwadekar *et al*., 2021).

Seed dispersal by hornbills was an interesting topic of researchers and various studies were conducted in this area. The study of (Wunderle Jr., 1997) provides details of the characteristics of animal seed dispersal relevant to tropical forest restoration efforts and discusses their management implications. Seed dispersal by the hornbills

*Ceratogymna atrata, C. cylindricus and C. istulator* (Aves: Bucerotidae) in the Dja Reserve, Cameroon evaluated the taxonomic breadth of plants dispersed, location of seed deposition and effects on seed germination. (Whitney *et al.,* 1998). The movement pattern, resource tracking and potential long distance seed dispersal by two species of *Ceratogymna* hornbills in low and tropical forest of Cameroon (Holbrook & Smith, 2000) suggest that hornbills made large scale movement up to 290 km, which are larger than any movement previously reported for large avian frugivores and *Ceratogymna* hornbills embark on long distance movement, potentially dispersing seeds and contributing to rain forest regeneration and diversity. A detailed documentation about the spatial patterns of seed dispersal, their determinants and consequence for recruitment studied by (Nathan & Muller-Landau, 2000). A study conducted in a moist evergreen forest in Thailand (Kitamura *et al*., 2004) quantified the number of seeds deposited by hornbill and followed the fates of their seedlings for 3 years to evaluate the effectiveness of hornbill seed dispersal at nest trees and they concluded that seed fall and seedlings of species represented in hornbill diets occurred at significantly higher densities in the quadrants in front of nest cavities. Seed dispersal of *Aglaia spectabilis* and *Canarium euphyllum* (Burseraceae) the large-seeded tree species in a moist evergreen forest of Khao Yai National Park in Thailand dispersing seeds were a rather limited set of four hornbill and one pigeon species, that hornbills show high effectiveness in dispersal of this tree species (Kitamura *et al.,* 2004, 2006). A study by (Datta & Rawat, 2008) on the dispersal modes and spatial patterns of 128 tree species in a tropical forest in Arunachal Pradesh, northeast India showed that 54 species were primarily bird-dispersed and seeds of various bird-dispersed tree species belonging to Lauraceae, Rosaceae, Annonaceae, Meliaceae, an important species in hornbill diet. Hornbills also play an important role as seed dispersers of over 80 rainforest tree species in the area, nearly one-fourth of the tree species recorded from the area. Seed dispersal by the Indian Grey hornbill *Ocyceros birostris* in Eastern Ghats, India, (Santhoshkumar & Balasubramanian, 2011) showed that of the 3303 seeds found in the nest middens 55 percent were hornbill's diet species in which 38.6% were *Premna tomentosa*, 19.5% were *Drypetes roxburghii* and 12.7% were *Filicium decipiens*. The presence of intact seeds in the nest middens were indicating that the Indian Grey hornbill is a legitimate seed disperser. The number of individuals of hornbill diet species was significantly higher in front of the nest cavity than behind also confirming the Indian Grey hornbill's role in seed dispersal. To assesses the role Indian Grey hornbill *Ocyceros birostris* as a seed dispersal agent (Osuri *et al.,* 2017) collected seeds from the nest midden and done seed germination trails of hornbill dispersed trees and seedling abundance under nest trees to assess the role of hornbills in seed dispersal and tree regeneration.

The nest site of hornbills is very peculiar. A lot of studies have done this area. The Malabar Grey hornbill prefer nests in open, evergreen forests with dense undergrowth, with the average height of the nest trees was 24 m, and mean GBH was 75 cm (Mudappa & Kannan, 1997). The Great Pied hornbill prefers trees that are more than one meter in diameter at breast height and that achieve an average height of 44 m (Mudappa, 2000). To find out the distribution and abundance pattern of Malabar Grey hornbill and Great hornbill in undisturbed and heavily altered rainforest areas of Southern Western Ghats (Raman & Mudappa, 2003) showed that the abundance of Malabar Grey hornbill declined with altitude and increased with food tree abundance and Great hornbill abundance increased with food tree species richness. Malabar Grey hornbill was sited in disturbed and fragmented forests, while Great hornbill is more vulnerable to habitat alteration. A technical report of the Kerala Forest Department, Vazhachal Forest Division based on a study lead by reports 23 nests of Great hornbills and 4 nests of Malabar Pied hornbill from the region (Prabhu *et al.,* 2005). Based on hornbill distribution and protected areas, five important hornbill conservation landscapes were identified in the Western Ghats (Mudappa & Raman, 2009). They are (Amboli–Goa–Dandeli, Anamalai–Parambikulam–Vazhachal, Nilgiris–Wayanad, Someshwara–Sharavati–Mookambika, Neyyar–Peppara–KMTR, and Periyar) along with key reserved forests (Kottiyoor, New Amarambalam, Vazhachal, Nelliyampathy, Goodarickal, Kulathupuzha– Palode).

The nesting habit of endangered Great hornbill (*Buceros bicornis*) showed that they need mature, large old growth trees for nesting. Trees used by Great hornbills for nests, compared to unused trees, averaged 18.5 m taller, 0.85 m greater in diameter, and emerged more above the forest canopy by 12.7 m. canopy height, canopy cover, and number of large trees >75 cm GBH were greater at nest site (James & Kannan, 2009). A study related with nesting habit of Indian Grey hornbill (Santhoshkumar & Balasubramanian, 2010) suggested that 6 tree species belonging to 5 families were used for nesting; most nests were in *Melia dubia* making it the most preferred nest-tree. All nests were in the riverine habitat and hence protection of riverain habitat is emphasised. A study conducted by (Hata *et al.,* 2015) to evaluate the quality of hornbill habitat in terms of forest habitat and fruit availability throughout the year in Salakphra Wildlife Sanctuary, Kanchanaburi Province, Thailand observed 30 tree families including 81 species on the belt-transects and the dominant species in terms of Important Value Index (IVI) were non-hornbill fruit species, The Fruit Availability Index (FAI) of all fruit species during breeding season is 23.49 % while the FAI of hornbill fruit species is 58.88 %. Great hornbills found in Vazhachal area found to nest on trees greater than 2 m GBH, average tree height ranged 24-40 m with an average of 31 m (Bachan & Anitha, 2017). Great hornbills were found to nest on 18 species of trees. Most nest were located on *Palaquium ellipticum, Dipterocarpus indicus, Terminalia bellerica, Bombax ceiba, Calophyllum polyanthum, Vateria indica, Kingiodendron pinnatum, Cullenia exarillata, Dysoxylum malabaricum, Ficus callosa, Lagerstroemia microcarpa, Lophopetalum wightianum* and *Syzygium cumini.*

The conservation of hornbills and their habitat is very important for the maintenance of ecological balance. Based on their experience with the Great hornbill *Buceros bicornis* in Southwestern India, (Kannan & James, 2006) develop a procedure for designing fruiting phenology studies of tropical flora, especially tree species, with respect to the feeding ecology of hornbills and other. (Bachan, 2006) gave a detailed history of his experience about hornbill studies in Vazhachal forests of Kerala, about the importance of the unique low elevation riparian forest Vazhachal, breeding season of hornbill, specialized nesting and feeding behaviour and maturing of hornbill chicks like all the details about the hornbills are included in it. His study points out that the Great hornbills foraging on as many as 44 species of fruiting trees, including 15-19 species of *Ficus* and other evergreen forest trees. A study of (Mudappa & Raman, 2008) made a detailed conservation status survey across the Western Ghats found that three hornbill species (Malabar Grey, Malabar Pied, and Great hornbills) were recorded across 14 sites in Kerala and Great hornbills were detected 29 times from Chimmony, Goodrickal, Nelliyampathy, Parambikulam, Periyar, Thekkadi, and Vazhachal chiefly in or near wet evergreen forests at elevations from 50 m to 1500 m above sea level. Vazhachal region with all four species of hornbills, this region appears significant particularly in terms of conservation of the Great hornbill. The hunting of hornbill by tribal people effects the dispersal and recruitment large seeded tree species like *Chisocheton paniculatus Dysoxylum binectariferum* and *Polyalthia simiarum* (Sethi & Howe, 2009). This breaks mutualisms between hornbills and their food plants, with the caveat that role redundancy within even small and specialized disperser assemblages renders other tree species less vulnerable to loss of regular dispersal agents. Seasonal migration of Great hornbill *Buceros bicornis* in the high forest areas of Nameri National Park, India, showed the conservation of this species requires the protection of large old growth trees since they migrate to the high forest for nesting (Das, 2014).

**Review of earlier work on seed germination**

The work on exsitu seed germination after defecation of seeds by birds was rare. In fruit frugivory mutualistic relationship the possibility of germination after gut passage and pulp removal is a subject need much research. The frugivores can increase the permeability of seeds to both water and gases by modified their seed coat (Izhaki & Safriel 1990; Barnea *et al*., 1991; Clergeau, 1992.). A study on germination, establishment, and growth of seedlings of tree species primary and secondary species, *Palaquium ellipticum* (primary), *Actinodaphne malabarica* (late secondary) and *Macaranga peltata* (early secondary) in a humid tropical forest at Nelliyampathy the primary species shows limited time for germination (Chandrashekara & Ramakrishnan, 1993). The effect of frugivorous birds on the germination and establishment of seeds of *Cryptocarya alba*, a common tree of the Chilean matorral showed that although the removal of the pericarp of fruits increased germination rate, bird-dispersed seeds loose germination capacity at a higher rate than those dispersed by gravity alone. Seeds dispersed toward dense habitats survived, germinated, and established at a higher proportion than those dispersed in sparse habitats (Bustamante *et al*., 1996). The pulp removal in the gut of frugivorous eliminate germination inhibitors present in the pulp (Traveset, 1998). (Datta, 2001) in PhD studies on "*An ecological study of sympatric hornbill and fruiting patterns in a tropical forest in Arunachal Pradesh*", germination studies conducted in 37 species of regurgitated hornbill diet seed and controlled seed shows that regurgitated seeds show 33 % of germination than controlled seed which showed 30%. In a study conducted in semievergreen forests of Mudumalai Wildlife Sanctuary, Western Ghats Malabar Grey hornbill utilizes 27 different fleshy- fruit species and 16 species have recorded to have regenerated from the midden under nest trees of hornbills (Balaraman & Balasubramanian, 2003). Insitu seed germination experiments done by (Santhoshkumar & Balasubramanian, 2011) in the Grey hornbill defecated seeds of 16 selected plant species showed that 15 species responded enhance germination especially the diet species such as *Syzygium cumini*, *Premna tomentosa*, *Diospyros montana* and *Drypetes roxburghii* showed higher percent of germination after defecation. To examine the effect of seed size and weight on seed germination of *Alangium lamarckii*, (Ahirwar, 2012) conducted germination study to revealed that the large size seeds gave maximum germination followed by medium size and small size seeds characterized by low germination percentage. It is evident that the germination percentage significantly declined with reduction in size and weight of the seeds. (Chama *et al*., 2013) tested the effect of gut treatment by four captive species of avian frugivores in comparison to manually de-pulped seeds and whole fruits on seedling emergence and germination probability of seeds from sixteen plant species in South Africa and determined whether fruit weight of each plant species affected germination patterns. These results suggest that seed de-pulping, neither by gut treatment nor manually improved germination of seeds, irrespective of their fruit weights. Thus, the major contribution of frugivores to forest regeneration may be more confined in transporting seeds away from the mother plant than in germination enhancement. (Gho-Illanes *et al*., 2015) revealed the identity of vertebrate seed dispersers of *Persea lingue*, to distinguish legitimate seed dispersers, pulp consumers and seed predators, and their influence on seed germination. Germination trails were conducted by placing whole fruit seeds on forest floor to establish weather removal of pulp (by rodents, bird or artificially removed) influences germination rate or not. Out of the six bird species feeding on *P. lingue* seeds, none of them defecated intact seeds, out of the five species of rodents four of them left intact seeds. However, pulp removal was an important factor for germination success.

A study conducted (Keshavachandra & Krishnakumar, 2016) in *Gymnacranthera canarica* (King) Warb. a species endemic to the Western Ghats, is found only in *Myristica* swamp. They assess the viability, germination, and storage behaviour of seeds, and it was observed that seeds started to germinate after two weeks of sowing, and germination was also affected by moisture, when moisture was increased a maximum up to 38%, 90 percentage germination was recorded. A decreased germination percentage was observed when the moisture content reached 14.26 ± 2.3, after 70 days of storage, and when the moisture level reduces beyond this level seeds failed to germinate. (Diaz velez *et al*., 2018) conducted the role of avian frugivorous in fruit removal of *Cotoneaster franchetii* (Rosaceae) and compared percentage and speed of germination among seeds obtained from faeces of the native frugivorous *Turdus nigriceps*, from manually de-pulped fruits, and from intact fruits. The germination percentage was higher in seeds from manually de-pulped fruits and seeds from bird faeces were higher than that of intact seeds. Also, percentage of germination and speed of germination were significantly higher in manually de-pulped seeds than that of gut-passed seeds.

Understanding the regeneration status of the species in a population is very essential while comparing the variation among different population of a species. While analysing regeneration some species shows very high natural regeneration (Grubb,1977). The regeneration status of a species was influenced by various factors like temperature, moisture and rainfall, anthropogenic activities and issues related to poor percentage of seed set and poor seed viability and mechanical factors inhibiting seed germination.

**Importance of Vegetational study**

To understand the variation among species the population structure is very important. The study of population structure includes the biometric characteristic like height, girth, and canopy area of the tree and species association in the population (Coates, 1988). A first detailed account of world vegetation obtained from (Muller-Dombois & Ellenberg 1974). Later (Champion, 1936) classified Indian vegetation. (Fosberg, 1961) has given a world vegetation classification based on physiogamy, structure and function. (Rao, 1994) classified India's vegetation based on the floristic composition and other natural factors. Analysing the girth class distribution of a species is also very useful for analysing the stability of the species in the population.

To evaluate the variation among different species association studies are very much important. The species associations are different in different forest types. There are different species composition exhibit in evergreen and semievergreen forests of Kerala. The species association studies in evergreen and semi evergreen forests of Kerala has done by (Champion & Seth, 1968). The evergreen forests of Kerala have *Mesua-Hopea-Palaquium* association. (Pascal, 1988).

Many Great hornbill depend on tree species are medicinally very important and good non timber forest product also. They also form an important element in evergreen forest and maintain ecological stability. Their seed dispersal and germination related with this marvellous bird. Studies shows that there exists a mutualistic relationship between hornbills and trees dispersed by them. So, it is essential to protect hornbills to the existence of forest component of these species.

# CHAPTER 3
# MATERIALS AND METHODS

The literature was reviewed focusing on different subtopics of the study- taxonomy, seed morphology and distribution of large seeded frugivorous trees in the Southern Western Ghats, their ecology, studies on Great hornbill and their nesting habitat. The collected literature was scrutinized to select tree species for the study based on the frugivory, hornbill dependence and seed size. For finding out the location, flowering and fruiting period, various herbaria of Kerala were visited and noted the flowering and fruiting time and locality. This helped for selection of study and sampling locations.

**Collection and preservation of species**

Field trips were conducted at regular intervals in all hornbill nesting forest areas for eight years beginning from 2014. Study area was thoroughly explored, and specimens were collected for the herbarium and laboratory studies during 2014-2022. Specimens were collected usually in flowering or fruiting (generative) stages following the procedures given by (Jain & Rao, 1977) and (Van Balgooy, 1987). Tribesmen, especially of the 'Kadar' which is an endemic tribe of the Anamalai region were sought for field studies in the interior forests and collection of specimens from tall trees. Specimens from fallen twigs in generative stages from tall trees were collected thanks to the browsing habit of arboreal mammals and birds especially Nilgiri langur, Lion tailed macaque, Civets and Hornbills. Fruits and seeds were carefully taken and separately preserved for detailed fruit and seed morphology studies. Fruits in various stages were collected and mature fruits were kept separately for germination process. Field notes including date of collection, locality, altitude, latitude, habit, habitat, flowers, fruits in various stages, important associated species were made during collection. For preservation of specimens, the wet method (Fosberg & Sachet, 1965) using 70% Ethyl alcohol was employed. The herbarium specimens were prepared by dry method following (Vogel, 1987) and deposited in the MES Asmabi College Research Centre herbarium (MESAH). The plant specimens were identified using the

Flora of the Presidency of Madras (Gamble & Fischer, 1915-1936), Flora of British India Vol.1-7 (Hooker, 1872-1887), available monographs, revisions, and other relevant literature. Herbarium specimens were critically reviewed for morphological details and taxonomic identity. Digital images of type sheets were obtained from the Royal Botanic Garden Kew (K), Royal Botanic Garden Edinburg (E) and the de Candolle Herbarium Geneva (G-DC) to confirm the identity of the species. Herbaria such as Calicut University (CALI), Botanical Survey of India, Coimbatore (BSI), Tropical Botanical Garden and Research Institute (TBGT) and Kerala Forest Research Institute (KFRI) Peechi, Centre for Medicinal Plant Research (CMPR) Kottakkal were visited to confirm the identification of some specimens. Citations of taxa were done according to IPNI and POWO (by the Royal Botanic Gardens, Kew). Photographs were taken from the field with Nikon 760 DSLR camera and from the laboratory using stereoscopic microscope Motic SMZ-168 stereomicroscope (Hong Kong, China) and floral images were constructed. The morphological data was developed in detail. The taxonomic and morphological data were presented as correct and legitimate name, author citation and publication information followed by synonym. This was followed by the detailed morphological description, flowering, fruiting, distribution, habitat ecology, IUCN status and specimen examined (Table 3.1.).

**Table 3.1. Species selected for detailed study.**

| Sl No | Name of species | Family | Fruit size |
|---|---|---|---|
| 1 | *Actinodaphne bourdillonii* Gamble | Lauraceae | 1.3–1.5×0.5–8 cm |
| 2 | *Actinodaphne tadulingamii* Gamble | Lauraceae | 1.2–1.3×0.7–0.8 cm |
| 3 | *Actinodaphne wightiana* (Kuntze) Noltie | Lauraceae | 0.8–1×0.8–1 cm |
| 4 | *Actinodaphne* sp. 1. | Lauraceae | Fruit not seen |
| 5 | *Beilschmiedia bourdillonii* Brandis. | Lauraceae | 2–2.7×1-5 cm |
| 6 | *Beilschmiedia wightii* (Nees) Benth.ex Hook.f. | Lauraceae | 2–3×1.2–1.5 cm |
| 7 | *Cinnamomum malabatrum* (Burm.f.) Blume. | Lauraceae | 1.8–2×0.9–1 cm |
| 8 | *Cryptocarya anamalayana* Gamble | Lauraceae | 2.4–5×0.8–1.3 cm |

| | | | |
|---|---|---|---|
| 9 | *Cryptocarya* lawsonii Gamble | Lauraceae | 2.5–3.5 cm long |
| 10 | *Cryptocarya sheikelmudiyana.* A.K.H. Bachan & P.K. Fasila | Lauraceae | 2−2.4×0.8−1 cm |
| 11 | *Litsea bourdillonii* Gamble | Lauraceae | 1.5−1.8×0.8−1 cm |
| 12 | *Litsea coriacea* (Heyne ex Meisner) Hook. f. | Lauraceae | 1.4−1.8×0.8−1 cm |
| 13 | *Litsea floribunda* (Blume) Gamble | Lauraceae | 1.8−2×0.9−1.2 cm |
| 14 | Litsea nigrescens Gamble | Lauraceae | Fruit not seen |
| 15 | *Litsea oleoides* (Meisner) Hook. f. | Lauraceae | 3.8−4×2.4−3 cm |
| 16 | *Litsea stocksii* (Meisn.) Hook. f. | Lauraceae | 2.1−2.5×0.8−1.5 cm |
| 17 | *Litsea wightiana* (Nees) Hook. f. | Lauraceae | 2–2.3×0.7 cm |
| 18 | *Litsea wightiana var tomentosa* (Meisn.) Gamble | Lauraceae | 1.2–1.4×0.6–.8 cm |
| 19 | *Litsea* sp.1 | Lauraceae | 2.3−2.9×1.1−1.2 cm |
| 20 | *Neolitsea cassia* (L.) Kosterm. | Lauraceae | 1−1.2×0.6−0.7 cm |
| 21 | *Neolitsea fischeri* Gamble | Lauraceae | 10−15×10−12 mm |
| 22 | *Neolitsea scrobiculata* (Meisn.) Gamble | Lauraceae | 1.2−1.3×0.7−0.8 cm |
| 23 | *Neolitsea* sp.1 | Lauraceae | Fruit not seen |
| 24 | *Phoebe lanceolata* (Nees) Nees | Lauraceae | 1.3−1.5×0.8−1 cm |
| 25 | *Persea macrantha* (Nees) Kosterm. | Lauraceae | 1.1–1.2×1.4–1.5 cm |
| 26 | *Phoebe wightii* Meisner in DC. | Lauraceae | 1×0.5 cm |
| 27 | *Aglaia malabarica* Sasidh. | Meliaceae | 3.5–4.5×2.7–4 cm, |
| 28 | *Aphanamixis polystachya* (Wall.) Parker | Meliaceae | 2.9–4×2–2.3 cm |
| 29 | *Dysoxylum ficiforme* (Wight) Gamble | Meliaceae | 4.5–5.5×5–6.5 cm |
| 30 | *Dysoxylum malabaricum* Bedd. ex Hiern. | Meliaceae | 5–7×4.4–5.5 cm |
| 31 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | Meliaceae | 2.5–3.6×2.4–2.5 cm |
| 32 | *Trichilia connaroides* (Wight &Arn.) Bentv. | Meliaceae | 1.5–1.7×1–1.2 cm |
| 33 | *Palaquium ellipticum* (Dalz.) Baill. | Sapotaceae | 3–5×1–1.9 cm |

| | | | |
|---|---|---|---|
| 34 | *Knema attenuata* (Hook. f. &Thoms.) Warb. | Myristicaceae | 3.7–5×2–2.4 cm |
| 35 | *Myristica beddomei* King. ssp. beddomei | Myristicaceae | 7–8×4.2–4.5 cm |
| 36 | *Myristica malabarica* Lam. | Myristicaceae | 5–7.5×1.8–3.5 cm |
| 37 | *Elaeocarpus tuberculatus* Roxb. | Elaeocarpaceae | 3–5×2.5 cm |
| 38 | *Elaeocarpus variabilis* Zmarzty | Elaeocarpaceae | 3.3–3.6×1.8–2.1 cm |
| 39 | *Syzygium cumuni* (L.) Skeels | Myrtaceae | 1.5×0.6 cm |
| 40 | *Canarium strictum* Roxb. | Burseraceae | 2.5–5×1.5 cm |
| 41 | *Diospyros crumenata* Thw. | Ebenaceae | 6–9×5–7 cm |

**Collection of Fruits**

Mature fruits were collected from Great hornbill nest midden, trails, forest floor immediately after dispersion and from selected mother plants from different localities of the study area. Only mature fruits and seeds were taken for the study and the seed samples were examined for each specimen. The collected seeds from nest midden and trails were compared with seeds collected from parent plants. The collected fruits and seeds were washed and cleaned well and were examined thoroughly, for morphological illustration. Photographs were taken to understand various features. Preserved preparations were made based on necessity. The fruits and seeds were numbered based on collected nesting locations, date, species etc., and were tagged. Detailed morphological description was prepared for each species supported with photographs for most of the species. Fruits were collected from at least five healthy trees that had fruits ripened at the same time. Fruits from a single tree were collected for *Cryptocarya sheikelmudiyana* and fruits of three species (a new species from the genus *Actinodaphne*, *Neolitsea* and fruits of *Litsea nigrescens*) could not see.

**Figure 3.1. Field study: A & C.** Puliveenathodu; **B.** Santhampara; **D.** Shooting point.

**Morphological characterization of the fruits**

Fruits were examined fresh and kept in FAA for detailed examination. To measure the mass of the fruit, 50 fruits and seeds of each species were weighed in electronic top pan balance (Model -Z-400) and later the average was expressed in grams based on the availability. Sometimes the number was restricted to 20 or even 10. Fruit dry weight in gram were measured by drying the fruit at low constant temperature of 105±3°C for 24 hr and weighed in electronic top pan balance and average expressed. The length of fruit was measured from the apex of the fruit to the base, excluding the peduncle using scale and digital vernier calliper. The mean of fruit length was recorded. Fruit width was recorded by measuring the fruit from the widest middle part using digital vernier calliper and mean was recorded. Moisture content for freshly collected fruits was calculated immediately after cleaning process following recommended protocols of the International Seed testing Association (ISTA, 1999).

The following formula was used to determine moisture percentage of the fruits on wet basis.

$$\text{Moisture percentage} = \frac{\text{fresh weight }(g) - \text{dry weight }(g)}{\text{fresh weight }(g)} \text{x} 100$$

To evaluate Pulp fresh mass per fruit, the weight of pulp was weighed, and the seeds were taken from randomly selected fruits. After that seeds were extracted out and weighed. The average weight of seeds and pulp was calculated separately.

In addition to the measurable variables, fruit characters such as number of fruits observed, type, shape, texture, surface, colour, fruit pedicel length, pubescence, and fruit dehiscence were also documented. Fruit pericarp nature was examined in detail performing transverse and longitudinal sections in the pericarp when necessary. Photographs were taken with Nikon 760 DSLR camera. The descriptive terminologies are used following (Das & Saha, 2006).

**Morphological characterization of the seeds**

The seeds were externally examined for seed general form, number of seeds per fruit, seed size, shape, colour, texture, seed coat nature, presence of aril, presence of endosperm, orientation of embryo, presence or absence of specialized structure, position of hilum and micropyle, and size of embryo. Transverse and longitudinal sections were performed in the seed, using a scalpel blade. The length of seed was measured from the apex of the seed to the base, using scale a grid/ graph paper and digital vernier calliper. The mean of seed length was recorded. Seed width was recorded by measuring the seed from the widest middle part using digital vernier calliper and mean was recorded. Seed fresh mass (g) was measured using electronic top pan balance (Model -Z-400) and later the average was expressed in grams based on the availability. Sometimes the number restricted to below 20. Seed dry weight in gram was measured by drying the seed at low constant temperature of 105±3°C for 24hr (Brasil, 2009). Number of seed and seed weight was calculated following the recommended protocols of the International Seed testing Association rules (ISTA, 1999). Photographs were taken with Nikon 760 DSLR camera. Seeds were observed under both Light Microscope (LM) and observed under stereoscopic microscope Motic SMZ-168 stereomicroscope (Hong Kong, China). The descriptive terminologies were used following (Das & Saha, 2006). A detailed family and species key were prepared based on the fruit and seed morphology of hornbill dispersed trees.

**Phenology of Great hornbill associated tree species.**

Reproductive phenological characters like flowering, fruiting period and distribution were noted during field trips as well as from regional floras, monographs, and herbarium specimens. Herbaria such as Calicut University (CALI), Botanical Survey of India, Coimbatore (BSI), Tropical Botanical Garden and Research Institute (TBGT) and Kerala Forest Research Institute (KFRI) Peechi, Centre for Medicinal Plant Research (CMPR) Kottakkal were visited to examine the phoenological characters of species which were not observed in the field.

**Seed germination of hornbill dispersed rain forest tree species.**

Germination experiments were carried out to determine if there was any difference in germination success of regurgitated vs. control seed. Germination was tested ex situ in the rainforest field station. Mature fruits were collected from Great hornbill nest midden defecated by hornbill, trails, forest floor immediately after dispersion and from selected mother plants. For the present study, 10 nesting location of Great hornbill were selected in which seven was from Vazhachal Forest division, one from Sheikalmudi in Parambikulam Tiger Reserve, and two from Nelliyampathy. These locations were visited during the study period annually in the nesting season from February to April. Only mature fruit and seeds were taken for the study and seed samples were examined for each specimen. The collected seeds from nest midden and along the trails were compared with seeds collected from parent plants. The seeds were identified with the help of tribals and by referring various literatures. The fruits and seeds were numbered and tagged with information on nesting locations, date, species etc. The damaged and insect infested fruits were eliminated. The seeds from the fresh fruit directly collected from the trees were separated by removing the fruit pulp. Seeds were washed well using water and dried using filter paper.

The germination study was conducted for three consecutive years, from 2018 to 2020. For germination study, the procedure adopted by (Mudappa & Raman, 2010) was followed. Plastic grow bags of 10 cm diameter were used. Grow bags were filled with forest soil and seeds were planted. For each species, fifty seeds collected from parent tree and hornbill nest midden were planted simultaneously in separate grow bags. For *Dysoxylum malabaricum*, it was limited to 20. The grow bags were watered regularly. Many rainforest fruits and seeds were prone to predation and fungal attack especially species of Lauraceae if they were planted deep in the soil. Therefore, the seeds of these species were planted in such a way that the seed was partly exposed above the soil surface. Weeding was carried out regularly with utmost care so that the roots of the seedlings were not damaged. The percentage of seeds germinated was recorded by noting seedling emergence in every week up to 9 weeks until all seeds were either germinated or rotted. The germination was confirmed from the emergence of radicle.

The following germination parameters were calculated using the formulas by (Gairola *et al*., 2011)

Germination percentage: (GE)

It is the ratio of number of seeds germinated to the seeds kept for germination.

$$\text{Germination \%} = \frac{\text{No of seeds germinated}}{\text{No of seeds kept for germination}} \times 100$$

Speed of germination = $n1/d1+n2/d2+n3/d3\ldots$

n = Number of germinated seed

d = Number of days

Various germination stages like sprouting of seed, bud appearance, appearance of first leaf and main shoot development were noted. Number of leaves, shoot length and seedling length were also recorded for the first 9 weeks of development.

**Phytosociological composition of Great hornbill nesting habitat**

The breeding period of Great hornbill commenced in February and ended in April. The nesting sites were visited after sealing the nest cavity by mother bird. Regular visit in the months of February-September during the year 2014- 2022 was done (Figure 3.1.). To find the importance of hornbills as a successful seed disperser and to find the quantitative assessment of plant species dispersed by hornbill and associated species in the nest midden, a square plot of 40 x 40 m (0.16 ha) was laid at 8 Great hornbill nesting location (7 plots in Vazhachal-Sholayar region and one plot in Sheikalmudi region) (Table 3.2.). Within each plot, all plants ≥30 cm girth at breast height (GBH) 1.37 m from the ground level was considered as trees. The plot data was analysed for phytosociological parameters like frequency, density, basal area, and IVI to enumerate the plant composition in nesting habitat. To analyse the population structure of tree species in the nesting plot, the girth class of each species were analysed by grouping them into different GBH class. The field data were also analysed for various diversity parameters (Shannon diversity index). The plot data was analysed and compared with each other.

**Table 3.2. Location and details of Nesting Plot studied.**

| Sl No | Nesting location | Nesting tree | Altitude (m) | Latitude | Longitude |
|---|---|---|---|---|---|
| 1 | Vazhachal | *Terminalia bellirica* (Gaertn.) Roxb. | 274 | $76^0$34'7141 | $10^0$29'034 |
| 2 | Pottenmopu | *Vateria indica* L. | 801 | $76^0$71'2256 | $10^0$32'0067 |
| 3 | Ambalapara IB | *Palaquium ellipticum* (Dalzell) Baill. | 820 | $76^0$73'5441 | $10^0$31'4677 |
| 4 | Sholayar Power house | *Vateria indic*a L. | 825 | $76^0$72'6445 | $10^0$30'3004 |
| 5 | Sholayar Puliveenathodu | *Bombax ceiba* L. | 732 | $76^0$72'0858 | $10^0$35'5648 |
| 6 | Pathadipalam | *Calophyllum polyanthum* Wall.ex Choisy | 954 | $76^0$81'1604 | $10^0$28'1188 |
| 7 | Ambalapara thandu | *Mesua ferrea* L. | 865 | $76^0$73'1817 | $10^0$39'5531 |
| 8 | Sheikalmudi | *Tetrameles nudiflora* R.Br. | 1118 | $76^0$82'7927 | $10^0$31'9609 |
| 9 | Victoria estate Nelliyampathy | *Albizia odoratissima* (L.f.) Benth. | 1585 | $76^0$67'2194 | $10^0$49'7452 |
| 10 | Lilly estate Nelliyampathy | *Toona ciliata* M.Roem | 1590 | $76^0$67'0511 | $10^0$49'7452 |

All plants were identified in the field. Species of uncertain identity were later determined using regional floras Flora of Presidency of Madras (Gamble & Fischer, 1915-1936), Flowering Plants of Thrissur Forests (Sasidharan & Sivarajan, 1996.) and thorough comparison with herbarium specimens (CALI, TBGT, KFRI, CMPR). The trees were identified and counted for their numbers, their associated species and their population characteristics were estimated. Structural attributes such as density, frequency, and cover (basal area) were computed for each species following standard phytosociological practices (Curtis & Mclntosh, 1950) and (Misra, 1968) and is given below. Species importance values (IVI) were derived from percentile values of structural attributes (Muller-Dombois & Ellenberg, 1974). Relative Density (RD) and

Relative Frequency (RF) were calculated to elucidate Importance Value Index (IVI), an index to understand the importance of a particular species in a community.

**Density**

Represent the numerical strength of a species in the community.

$$\text{Density } (\text{D}) = \frac{\text{Total number of individuals of the species}}{\text{Total number of quadrats studied}}$$

$$\text{Relative Density } (\text{RD}) = \left(\frac{\text{Density of the individuals}}{\text{Total density of species}}\right) \text{x100}$$

**Frequency**

Frequency is the degree of dispersion of individual species in an area and is expressed in terms of percentage on a number of sapling areas in which the given species occur.

$$\text{Frequency } (\text{F}) = \frac{\text{Number of quadrats in which species occur}}{\text{Total number of quadrats studied}}$$

$$\text{Relative frequency } (\text{RF}) = \left(\frac{\text{Frequency of individuals of species}}{\text{Total frequency of all species}}\right) \text{x100}$$

**Basal Area**

The basal area refers to the ground penetrated by the stem. This is measured at breast height but in buttressed trees the measurement is taken above the buttresses.

$$\text{Basal Area } (\text{BA}) = \frac{(\text{GBH})^2}{(4\pi)}$$

$$\text{Relative Basal Area } (\text{RBA}) = \frac{\text{Total basal area of species}}{\text{Total basal area of all species}} \text{x100}$$

**Important Value index (IVI)**

The important value index (IVI) is a statistical measure of how dominant a species in each community or forest area. The relative value of these three (viz.,) Relative frequency, Relative density and Relative Basal area provide comparative information of each species to the total number of species in the sample or the stand or community. Sum of these 3 relative values gives Importance Value Index (IVI), this is an indication of the overall importance of each species to the community.

Important Value Index (IVI) = RF+RD+RBA

**Species Diversity**

The total number of species present in any ecosystem will indicate the richness in species. While the number of individuals of a species in relation to the total number of individuals of the species denotes the dominance, both these parameters constitute an important aspect of ecosystem structure. There are certain mathematical expressions to find the species diversity, in which Shannon diversity index is used.

**Shannon Diversity Index**

The Shannon Diversity Index (Shannon-Wiener Index) is a quantitative assessment of diversity of different species in a community.

Denoted as $H$, this index is calculated as:

$$\boldsymbol{H = -\Sigma p_i * ln(p_i)}$$

where:

**Σ:** A Greek symbol that means "sum"

***ln*:** Natural log

**$p_i$:** The proportion of the entire community made up of species $i$

The higher the value of $H$, the higher the diversity of species in a particular community. The lower the value of $H$, the lower the diversity. A value of $H = 0$ indicates a community that only has one species.

**Girth class distribution.**

To analyse the population structure and girth class distribution of tree species present in the nesting site each species was analysed and grouping them into different GBH classes: class A 10-30 cm, class B 30.1-60 cm, class C 60.1-90 cm, class D 90.1-120 cm, class E 120.1-150 cm, class F 150.1-180 and Class G >180 cm following (Uma Shankar, 2001). The plot data was analysed and compared with each other.

**Regeneration of hornbill dispersed tree in the nesting habitat**

To elucidate regeneration of plants under the nesting tree, rectangular plot 0.16 ha further divided in to 8 transects each consists of 100 $m^2$, four in centre (T1-T4) and other four marginal transects (T5-T8). The transect facing the nesting hole was considered T1 and two marginals transect connecting the T1 named as T5 and T8 (Figure 3.2.). All the saplings (the individuals with < 30 cm GBH but height >20 cm considered sapling) in the 8 transects were counted and analysed the frequency, abundance, IVI to find the diversity and regeneration status of the of hornbill dispersed trees.

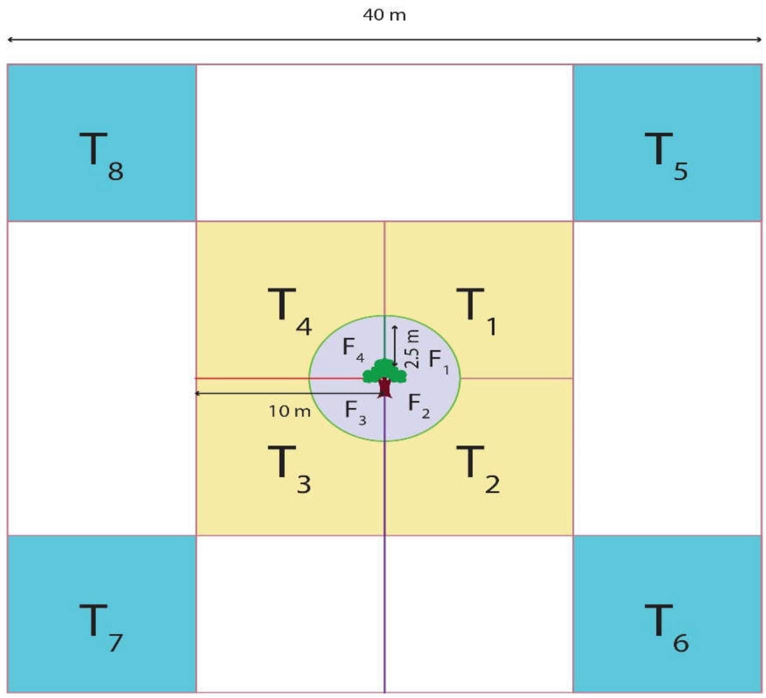


**Figure 3.2. Schematic Diagram of the rectangular plot around the nesting tree**

To enumerate the seedlings under the nesting tree, a circular plot was laid around the nesting tree within 2.5 m radius. This 2.5 m circular plot was then divided into four radial quadrants (F1-F4). Individuals with < 10 cm considered seedlings. Seedling and seed rain (regurgitated dispersed seeds) under each tree was noted. Under each nesting tree seed rain from the hornbill nest observed in a 2.5 m radius, with maximum seed rain occur in area in front of the nest cavity which was considered F1. Number of seedlings in each of these radial quadrants were counted (Figure 3.2.).

# CHAPTER 4
# SYSTEMATIC TREATMENT

**LAURACEAE** Juss.

Gen. Pl. 80. 1789.

**Key to genera**

1a. Terminal bud perulate with imbricate scale ........................................................ 2

1b. Terminal bud without imbricate scale ................................................................ 4

2a. Leaves alternate; anthers 2 celled ................................................. **Beilschmiedia**

2b. Leaves verticillate or sub verticillate; anthers 4 – celled .................................... 3

3a. Leaves penninerved; involucre bract deciduous in flower; fertile stamens 9. ...... ........................................................................................................ **Actinodaphne**

3b. Leaves 3- ribbed; involucre bract early deciduous in flower; fertile stamen 6 .... ................................................................................................................ **Neolitsea**

4a. Anthers extrose; fruit enclosed by accrescent perianth lobe ........... **Cryptocarya**

4b. Anthers introse; fruit not enclosed by accrescent perianth lobe.......................... 5

5a. Perianth form cup- shaped in fruit ...................................................................... 6

5b. Perianth not cup- shaped in fruit................................................................. **Persea**

6a. Leaves opposite or sub opposite rarely alternate usually 3 or more ribbed ......... .......................................................................................................... .**Cinnamomum**

6b. Leaves alternate, penninerved.............................................................................. 7

7a. Leaves not crowded towards the apex of branchlets; inflorescence raceme…..... ..................................................................................................................... **Litsea**

7b. Leaves crowed towards the apex of branchlets; inflorescence cymose panicle .. .................................................................................................................. **Phoebe**

**ACTINODAPHNE** C.G.D. Nees

In Wall., Pl. Asiat. Rar. 2: 61. 1831.

Evergreen tree; outer bark brown, grayish-brown; inner bark pale yellow; terminal bud perulate with imbricate scale; rings of bud scale scar prominent, elliptic-oblong, or lanceolate, pale brown to golden brown rufous tomentose. Leaves simple, verticillate or sub verticillate, in whorls of 4-5 or 6-7, exstipulate; petiole stout or slender, golden-brown densely tomentose; lamina elliptic, ovate-obovate, oblanceolate, elliptic-lanceolate, acute to attenuate at base, acuminate at apex; mid rib slightly raised or channeled above; lateral nerves 7-13 pairs, prominent on upper surface, impressed on lower surface. Inflorescence in axial or lateral racemes, bracteate. Flowers small, unisexual, fragrant. Male flower pale yellow, greenish yellow, rufous tomentose; tepal 6 in 2 whorls of 3 each; stamens in male flower arranged in 3 whorls of 3 each, first and second whorls eglandular and opposite to the perianth lobe, third whorl opposite to the first and glandular; staminodes in female flower is also 9, those of the first and second whorls spathulate or linear, those of the third whorl linear and glandular; anthers 4 celled, introrse; filament densely villous; ovary in female flower is ovoid, half inferior, attenuate to the style, ovule single. Fruit a berry seated on an enlarged or flattened perianth tube.

**Key to the species.**

1a. Lowest pair of main nerve in the leaf lamina usually opposite; ovary glabrous .. **A**.sp. 1

1b. Lowest pair of main nerve in the leaf lamina not opposite, penninerved; ovary sparsely tomentose or fulvous tomentose ........................................................ 2

2a. Leaves oblanceolate, lower surface softy grey tomentose; ovary sparsely tomentose ............................................................................................................ ....................................................................................................**A. bourdillonii**

2b. Leaves elliptic-lanceolate, lower surface fulvous villous; ovary fulvous tomentose ................................................................................................................. 3

3a. Inflorescence in short peduncled cluster, less than 2 cm long; fruit sub-globose with cup-shaped perianth ........................................................ **A. tadulingamii**

3b. Inflorescence long peduncled cluster, 2–4 cm long; fruit depressed globose with paltelliform perianth .................................................................. **A. wightiana**

**Actinodaphne bourdillonii** Gamble, Bull. Misc. Inform. Kew 1925: 129. 1925 & in Fl. Pres. Madras 1231. 1925; C.J. Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 56. 1984; V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 206. 1987; Mani., Fl. Silent Valley 234. 1988; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 389. 1994; N. Mohanan & Sivad., Fl. Agasthyamala 562. 2002; T.S. Nayar *et al.*, Fl. Pl. Kerala 367. 2006.

**Local name**: Eeyoli, Malavirinji.

A medium sized evergreen tree, up to 15 m high; young branchlets golden-brown, densely tomentose when young, greyish-brown when dry; terminal bud scale c.6 mm long, elliptic-oblong, golden-brown, rufous tomentose. Leaves in whorls of 6–7; petiole stout, 0.5–1.3 cm long, golden-brown, densely tomentose, greyish-brown when dry; lamina 5–24×3–6.5 cm, elliptic to elliptic-oblanceolate, acute to attenuate at base, margins entire, acuminate at apex with the acumen 1–1.5 cm long, coriaceous, densely hairy, dark brown above, glaucous silky brown when dry beneath; mid rib slightly raised above, thick, prominent below, golden tomentose on both side; lateral veins 7–9 pairs, prominent, tomentose, golden brown below, impressed above; intercostae sub scalariform on lower surface, obscure on upper surface. Inflorescence 1–1.5 cm long; peduncle fulvous tomentose. Male flower: c.1×0.4 cm, rufous serious, arranged in alternate manner and opposite towards apex; pedicel 0.3–0.6 cm long; bract 2, c.1 cm long, tawny- villous; tepal ovate-elliptic, 2–2.3×0.6–0.9 mm, obtusely acute at apex, pale yellow to golden brown, coriaceous, rufous tomentose without, glabrous within; first whorl of stamen c.7 mm long, anther c.3 mm long, elliptic-ovate, apex truncate, golden brown glabrous, filament c.4 mm long, golden brown; 2$^{nd}$ whorl almost same as that of outer whorl; 3$^{rd}$ whorl of stamen, filament c.2 mm long with 2 small glands attached to the base of the filament, c. 0.5 mm long, orbicular, shortly stipitate. Female flowers: ovary c.1.5 mm long, sparsely tomentose; style c.1.5 mm long, slender, terete, glabrous; stigma irregularly lobed; staminodes linear, apex acute or obtuse, basally villous, first 2 whorls eglandular, 3$^{rd}$ whorl glandular. Fruit 1.3–1.5×0.5–8 cm, sub-globose, seated on pubescent hard perianth cup, green when young, turned to red when mature. Seed 1, c.9×7 mm, hemispherical, pale brown.

**Flowering** & **Fruiting**: Flowering from October to January. Fruiting from February to May.

**Distribution**: *Actinodaphne bourdillonii* is distributed in South India (Karnataka, Kerala and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Idukki, Thrissur, Palakkad and Kozhikode districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests at an elevation ranging from 730-1000 m in the of Southern Western Ghats, associated with *Litsea floribunda* (Blume) Gamble., *Persea macrantha* (Nees) Kosterm*., Myristica beddomei* King., *Litsea oleoides* (Meisn.) Hook.f.

**IUCN status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of October. The buds remained intact, and development was slow. By the first week of November, flowers bloomed randomly all over the tree. By the second week of January, the trees were in full bloom. Dried flowers remained in the tree till the end of February. Green juvenile fruits were formed in the first week of March. Even though the entire tree was in full bloom, only half of the flowers developed fruits. Fruits matured slowly and ripened to black by the end of May. By the first week of June all the fruits were fallen.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Athirumala, *s.die*, ±1000 m, *N. Mohanan* 5117 (TBGT); *ibid*., *N. Mohanan* 8262 (TBGT); Athirumala, 12.3. 2010, *P.S. Udayan et al.* 6630 (CMPR); Kollam district, Shendurney, Pandimotta, 10.02. 2008, *P.S. Udayan et al.* 4635 (CMPR); Idukki district, Adimaly, Karadipara, 24.01.2009, *P.S. Udayan & A.J. Robi 5485* (CMPR); *ibid*., 04 May 2010, *P.S. Udayan et al. 6781* (CMPR); *ibid*., 05.05.2010, *P.S. Udayan et al.* 6793 (CMPR); Ernakulam district, Pindimedu dam, 10.09.1985, *K.K.N. Nair* 3501 (KFRI); Thrissur district, Sholayar, Chandanthodu, 20.04.2010, *P.S. Udayan et al.* 6733 (CMPR); *ibid,* 29.04.2018, *P.K. Fasila et al*. 137481 (MESAH); Palakkad district, Parambikulam, Karimala, 26.05.2010, *P.S. Udayan & A.J. Robi* 6695 (CMPR); Nelliyampathy, Thuthanpara, 12.05.2019, *Fasila et.al* 150558 (MESAH); Kozhikode district, Kakkayam, Urakkuzhi, ±750 m, 20.01.2009, *P.S. Udayan & A.J. Robi* 5423 (CMPR); *ibid*., 20.01.2009, *P.S. Udayan & A.J. Robi* 5425 (CMPR).

**Actinodaphne tadulingamii** Gamble, Bull. Misc. Inform. Kew 1925: 130. 1925 & in Fl. Pres. Madras 1231. 1925; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 392. 1988; Vajr., Fl. Palghat Dist. 402. 1990; Pandura. & V.J. Nair, Journ. Econ. Tax. Bot. 17: 173. 1993; Sivar. & Mathew, Fl. Nilambur 582. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 564. 2002; T.S. Nayar *et al.*, Fl. Pl. Kerala. 369. 2006. **(Figure 4.1.)**

An evergreen tree, 10–20 m high; outer bark rugose; blaze creamy white; young branchlets greenish-brown, brown pubescent when young, greyish-brown when dry; terminal bud 3–4 mm long, elliptic-oblong, rufous tomentose. Leaves in whorls of 5; petiole 1.5–3 cm long, slender, golden brown, fulvous tomentose when young, flat or sulcate above, rounded beneath, slightly pubescent, black coloured when mature; lamina 17–29×5.5–7.5 cm, ovate to obovate, acute at base, margins entire, acuminate at apex with the acumen 1.5–2 cm long, coriaceous, velvety brown, fulvous tomentose on both surface when young, glabrous on upper surface when mature, light green to light brown above, white glaucous velvety below when dry; midrib prominent, highly emergent, impressed or channelled above, prominent below, golden brown tomentose on both surface, glabrous on mature in older leaves; lateral nerves 7–12 pairs, emergent, arching, golden fulvous tomentose on lower surface, obscure on upper surface; intercostae prominent, parallel to scalariform on lower surface, obscure on upper surface. Racemes of 4-6-flowered, c.1 cm long; peduncle small, sub sessile, fulvous tomentose. Male flower: 6–10×c.5 mm, rufous sericeous; pedicel 3–4 mm long; bract 2, c.4×4 mm, obovate, elliptic, rounded at apex, densely silky brown tomentose without, glabrous within; tepals 2–2.8×1.2 mm, ovate, elliptic, with acute apex, brownish-green with out, and greenish yellow within, rufous sericeous without and base of the inner side of tepal; anthers oblong, apex truncate, yellow, glabrous; filament pale light yellow, densely villous at base; first whorl of stamen c. 3.8 mm long, anther c.2 mm long, filament c.1.8 mm long; $2^{nd}$ whorl of stamen c.3.3 mm long, anther c.2 mm long, filament c.1.3 mm long; third whorl of stamen c.2.3 mm long, anther c.1.3 mm long, filament c.1.2 mm long; gland cordate, 1.3 mm long, stipitate, c.0.5 mm long, yellowish. Female flower: ovary globose, c.1.5 mm long, silky pubescent; style c.1.3 mm long, silky pubescent. Fruit sub-globose, 1.2–1.3×0.7–0.8 cm, seated on hard cup- shaped pubescent perianth tube, bright green when young and turned to red when mature. Seed 1, obovate, c.8× 5 mm, brown.

**Flowering & Fruiting**: Flowering from December to January. Fruiting from February to May

**Distribution**: *Actinodaphne tadulingamii* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Idukki, Thrissur, Palakkad, Malappuram, Wayanad and Kannur districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on medium hill slopes at elevations ranging from 800-1000 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Vateria indica* L., *Litsea floribunda* (Blume) Gamble., *Palaquium ellipticum* (Dalz.) Baill., *Cryptocarya lowsonii* Gamble.

**IUCN status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of December. The buds were swollen by the end of the month flowers bloomed randomly all over the tree. By the second week of January, the tree was in full bloom. Dried flowers remained in the tree till the end of March. Green juvenile fruits were formed in the first week of February. By first week of March, the tree was with full of fruits. Fruits matured slowly and ripened to black by the end of April. All the fruits were fallen off by the second week of June.

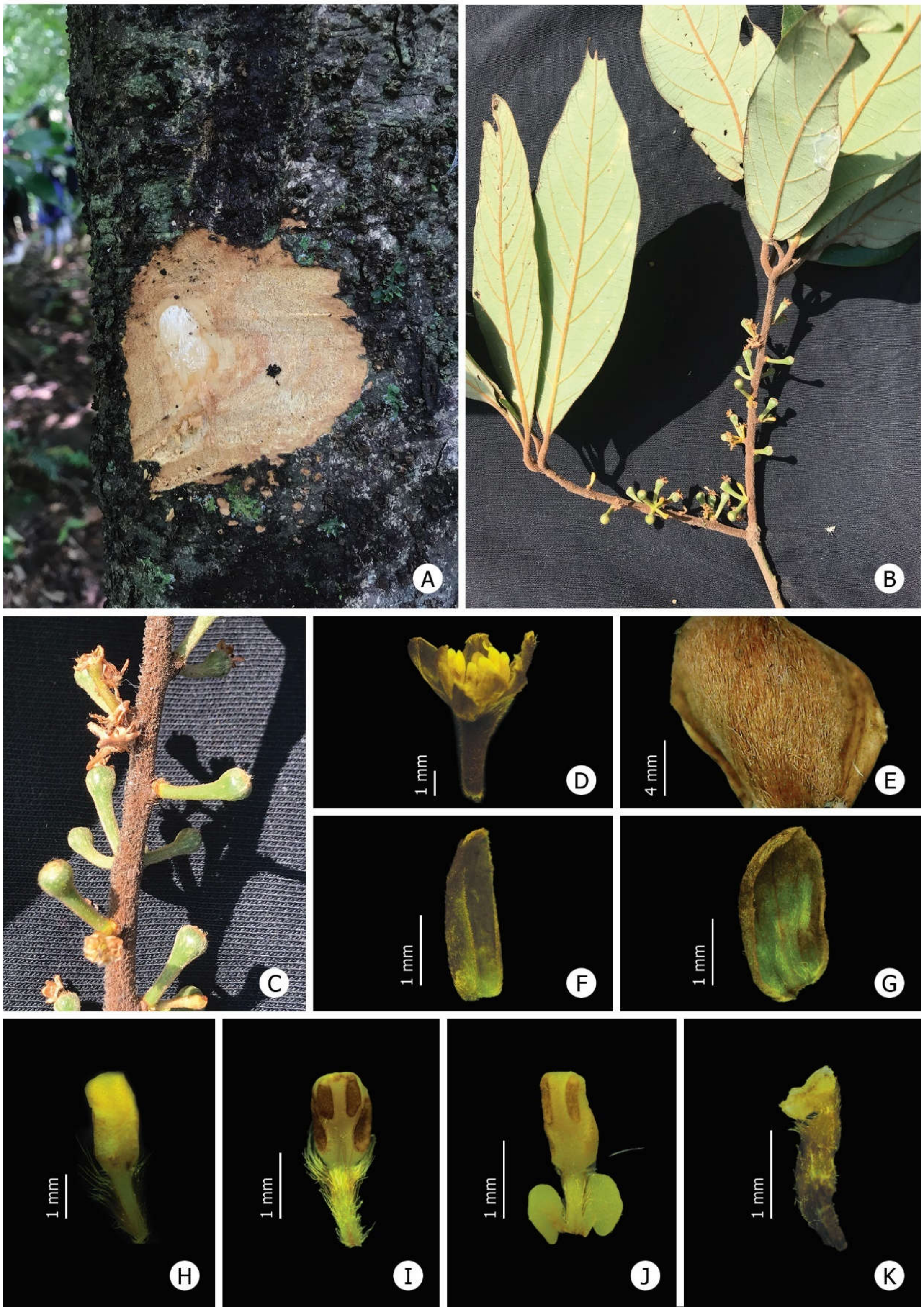


**Figure 4.1.** ***Actinodaphne tadulingamii*** Gamble**: A.** Blaze; **B.** Flowering twig; **C.** Inflorescence; **D.** Flower; **E.** Bract; **F.** Outer tepal; **G.** Inner tepal; **H.** 1st whorl of stamen; **I.** 2nd whorl of stamen; **J.** 3rd whorl of stamen; **K.** Staminode.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Bonaccord, ±700 m, *s.die*., *N. Mohanan* 7961 (TBGT); Kollam District, Arjunkotta, ±100 m, 17.01.1994, 13146 *Jomy Augustine* (CALI); Rosemala, 8.03.2014, *Raj Kumar* 64089 (TBGT); Thrissur district, Sholayar, ±800 m, 01.05.2010, *P.S. Udayan et al.* 5655 (CMPR); *ibid*., ±800 m , 01.03.2011, *A.J. Robi* 29886548 (KFRI); *ibid*., 18.04.2019, 19.01.2020, *P.K. Fasila* 150537, 150571 (MESAH); Malappuram district, Anpumala, 13.11.1982, *Philip Mathew* 33598 (CALI); Ampumala, 24.03.1983, *Philip Mathew* 34039 (CALI); Wayanad district, Chambra peak, 13.01.2018 *P.K. Fasila* 137468 (MESAH); Kannur district, Aralam, 30.07.2009, *P.S. Udayan & A.J. Robi* 6927 (CMPR).

**Actinodaphne wightiana** (Kuntze) Noltie, Regnum veget. 145: 495. 2005.

Actinodaphne malabarica Balakr., Jour. Bomb. Nat. His. Soc. 63: 329.1967: V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 206. 1987; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 392. 1988; Vajr., Fl. Palghat Dist. 402. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 389. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 379. 1996; Anil Kumar *et al*., Fl. Pathanamthitta 422. 2005; T.S. Nayar *et al.*, Fl. Pl. Kerala. 368. 2006.

*Jozoste wightiana* Kuntze, Revis. Gen. Pl. 2: 570 1891.

*Actinodaphne hirsuta* Hook.f. Fl. Brit. India 5: 152. 1886, non Blume 1851; Bourdillon, For. Tr. Travancore. 304. 1908; Rama Rao, Fl. Pl. Travancore. 344. 1914; Gamble, Fl. Pres. Madras 1231. 1925. *A. hookeri* sensu Bedd., Fl. Sylv. t. 296. 1873 p.p., non Meissn. 1864. **(Figure 4.2.)**

**Local name**: Malavirinji, Kambilivirinji

A medium sized evergreen tree, up to 20 m high; bark dark grey or brown; young branchlets, greenish-brown, fulvous tomentose when young or dark brown when dry; terminal bud c.6 mm long, lanceolate, light yellow to brown, rufous tomentose. Leaves in whorls of 4–5, drooping; petiole stout,7–20 mm long, dark brown when dry, tomentose; lamina 7–25×2.5–6 cm, elliptic or elliptic-lanceolate, acute to acuminate at base; margins entire, acuminate at apex with the acumen 1–1.5 cm long, sub coriaceous, glabrous above, villous beneath, coffee brown above, light brown when dry; mid rib flat or channelled above, raised beneath, yellowish, villous on lower surface; lateral nerves 7–13 pairs, raised, arching, villous on lower surface, sunken on upper surface; intercostae scalariform on lower surface, obscure on upper surface. Inflorescence 3–4 cm long, few flowered; peduncle fulvous villous. Male flower c.6.5×7 mm, rufous tomentose; pedicel 3–3.5 mm long, silky tomentose; bracts 2, 6.5–7.8×5.5 mm, elliptic oblong, obtuse at apex, glossy glabrous within, silky brown tomentose without, deciduous; tepals sub equal, 3–3.8×2.8–3 mm, oblong, obtusely acute at apex, pale creamy yellow, fleshy-coriaceous, silky tomentose without, glabrous within; anthers elliptic-ovate oblong, apex truncate, reddish-brown, glabrous; filament pale light green; first whorl of stamen 3–4.3 mm long, anther 1.2–2.5 mm long, filament 1.6–2 mm long; 2$^{nd}$ whorl of stamen 3.8–4 mm long, anther 1.9–2.2 mm long, filament 1.9–2mm long; 3$^{rd}$ whorl of stamen 3.4–3.8 mm long, anther 2–2.2 mm long, filament 1.5–1.7 mm long, with 2 glands attached to base of the filament; gland orbicular, c.0.5×1 mm long, shortly stipitate, c.0.2 mm long. Female flowers: ovary c.1 mm long, densely fulvous tomentose; style c.2 mm long, terete, white silky tomentose; stigma dilated; staminodes outer 2 whorls, c.3.2 mm long, spathulate; 3$^{rd}$ whorl c.3 mm long, linear, with 2 glands at base. Fruit depressed 0.8–1×0.8–1 cm, globose, seated on perianth cup, dark green with white spot when young and turned to purplish black when mature. Seed 1, 5–6 ×6–7 mm, hemispherical, pale brown.

**Flowering** & **Fruiting**: Flowering from October to December. Fruiting from January to April.

**Distribution**: *Actinodaphne wightiana* is distributed in South India (Karnataka, Kerala and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Kottayam, Idukki, Thrissur, Palakkad, Wayanad and Kannur districts.

**Habitat**: The taxon is found in evergreen plain and medium hill slopes at elevations ranging from 400-1000 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Knema attenuata* (Hook. f. & Thoms.) Warb., *Otonephelium stipulaceum* (Bedd.) Radlk., *Vateria indica* L. *Elaeocarpus tuberculatus* Roxb.

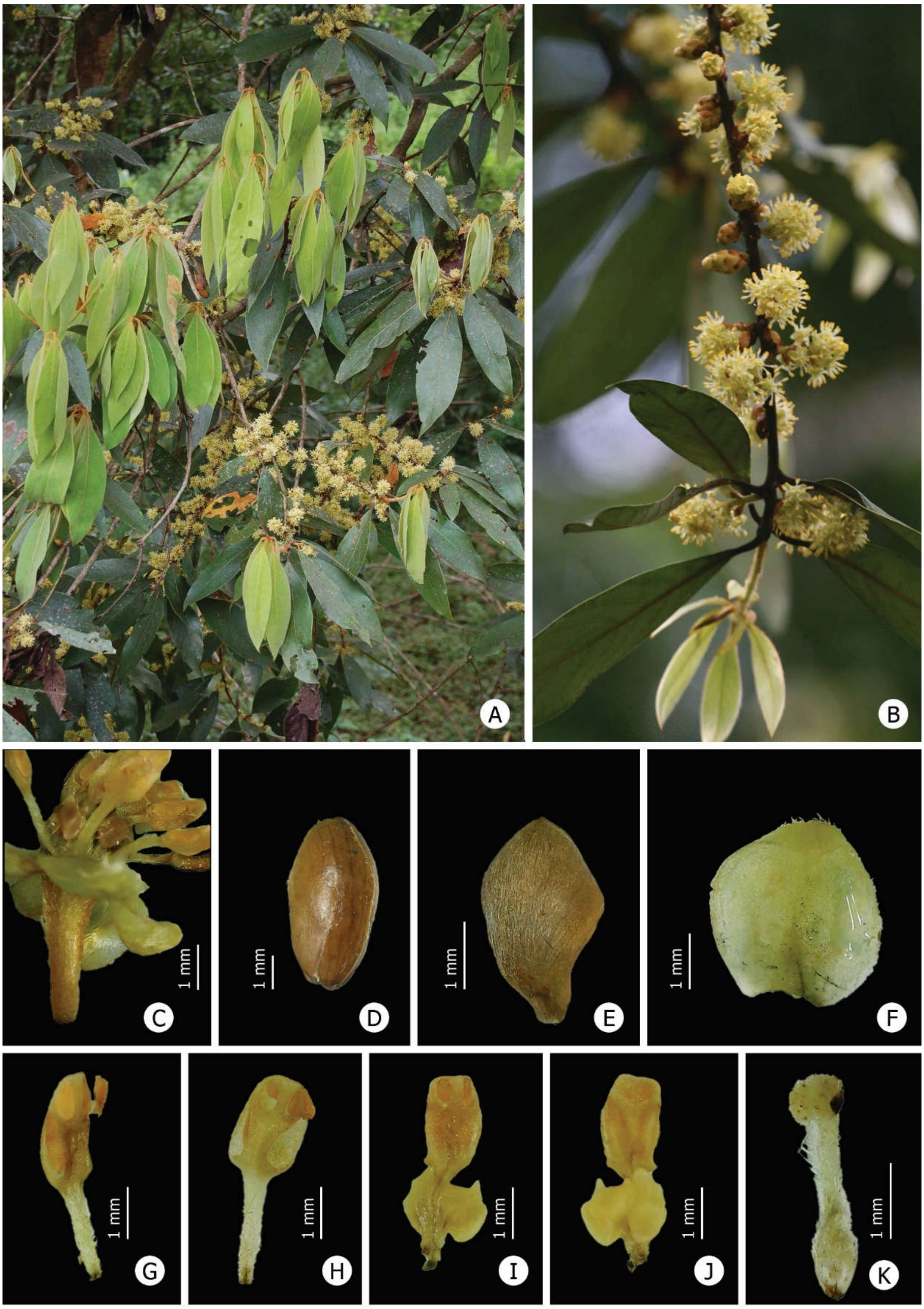

**Figure 4.2.** ***Actinodaphne wightiana*** (Kuntze) Noltie**: A & B.** Flowering twig; **C.** Male flower; **D.** Outer bract inner view; **E.** Inner tepal outer view; **F.** Inner tepal inner view; **G, H, I & J.** Stamens; **K.** Pistil.

**IUCN status**: Least Concern.

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of October. The buds were swollen by the end of the month flowers bloom all over the tree. By the second week of December, the tree was in full bloom. Dried flowers remained in the tree till the end of January. Green juvenile fruits were formed in the first week of January. By first week of March the tree was with full of fruits. Fruits matured slowly and ripened to black by the end of May. All the fruits were fallen off by the second week of June.

**Specimens examined:** INDIA, **Kerala,** Thiruvananthapuram district, Bonnecord, 08.04.2004, *Geetha Kumary,* 33745 (TBGT); Garden site Tvm, 9.08.1984, *N. Mohanan* 1106, 00672 (TBGT); Pottankavu, 2.11.1995, *Deepthi Das* 26238, 16599 (TBGT); Vallakadavu, 1.09.1992, *A. Nazarudheen* 14389, 18260 (TBGT); Kollam district, Shendurney, Kallar, 08 .02.2008, *P.S. Udayan et al.* 4538 (CMPR); *ibid*., 20.01.2010, *P.S. Udayan et al.* 6534 (CMPR); Idukki district, Idukki, Adimali, 13.07.1993, *A. Nazarudheen* 17807, 19928 (TBGT); Malakkappara, 15.03.2009, *P.S. Udayan & A.J. Robi* 5728 (CMPR); PTR, Thekkady, ±800 m, *Jomy Augustine* 41734 (CALI); *ibid*., 8.09.1993, 18.03.2009, *P.S. Udayan & A.J. Robi* 5778 (CMPR); Cheeyappara water falls, 03.05.010, *P.S. Udayan et al.* 6782 (CMPR); Ernakulum district, Below Kathipara, 12.02.1986, *K.K.N. Nair* 3575 (KFRI); Pooyamkutty, Pindimedu Damsite, 11.03.1986, *K.K.N. Nair* 4326 (KFRI); *ibid.*, 7.09.1991, *N. Sasidharan* 5793 (KFRI.); Thrissur district, Vazhachal, Kummatty, ±460 m, 23.03.1979, *N. Sasidharan* 741 (KFRI); Kollathirumedu, ±800 m, 5.08.1988, *N. Sasidharan* 5128 (KFRI); Vazhachal to Sholayar, ±460 m, 26.04.2006, *K.H. Amitha bachan* 98898 (CALI); *ibid*., *P.S. Udayan et al.* 6732 (CMPR); *ibid*., 29.04.2018, *P.K. Fasila 137477* (MESAH); Malakkappara, Perumpara, 10.08.2014, *P.K. Fasila et al.* 137401 (MESAH); Elamthalachi, 29.04.2018, *P.K. Fasila et al.* 137488 (MESAH); Palakkad district, Valiyaparathode, ±1300 m, 2.01.1983, *T. Sabu* 11075 (KFRI); Sispara, ±2200 m, 19.11.1983, *T. Sabu* 11364 (KFRI); Nelliyampathy, Karappara, 11.05.2019, *P.K. Fasila et al.* 150556 (MESAH); Malappuram district, Nadukani, 18.01.1979, *N. Sasidharan 462* (KFRI); New Amarambalam, Onakkapuzha, 11.09.2000, *R. Jayakumar 20372* (KFRI); Kottakkal, AVS Herb garden, 13.11. 2010, *A.J. Robi 7127* (CMPR); *ibid*., 19.08.2010, *A.J. Robi* 6949 & 6950 (CMPR); Wayanad district, Lakkidi, 20.10.1985, *R.T. Balakrishnan* 41734 (CALI); 22.05.2002, Brahmagiri, ±1600 m, *M.K. Ratheesh Narayan* 3093 (CALI).

**Actinodaphne** sp. 1

An evergreen tree, up to 15 m high; young branchlets terete, golden brown, velvety, densely tomentose when young; terminal bud c.4 mm long, lanceolate, or obovate light yellow, densely fulvous tomentose. Leaves in whorls of 4-5; petiole 0.7–1 cm long, stout, flat above, flat or rounded beneath, golden brown, fulvous tomentose; lamina 12.5–20×3.2–5 cm, elliptic to lanceolate, attenuate at base, margins entire, acuminate at apex, thin papery, fulvous tomentose on both surface, dark brown above, golden brown when dry; mid rib prominent, highly raised on upper surface, prominent, flat towards one third of the petiole and slender up to apex on lower surface, golden fulvous tomentose on both surface; lateral nerves 8–9 pairs, lowest pair opposite, emergent, arching, golden, fulvous tomentose on lower surface, obscure on upper surface. Female flowers: c.1×4 mm, fulvous tomentose; pedicel 4–6 mm long, fulvous sericeous; tepals 2–2.3×0.6–0.9 mm, ovate, apex acute, membranous, white to golden brown, 3- nerved, tomentose without; ovary c. 1.2 mm long, glabrous; style terete, up to c.1.5 mm long; stigma irregularly lobed; staminodes 9 in 3 whorls, outer whorl 3, c.2.7 mm long, spathulate, apex acute or obtuse, basally villous, eglandular; 2nd whorl same as that of outer whorl; 3rd whorl c.2 mm long, basally villous with 2 glands at the base of the filament, gland c.0.5 mm long, not stipitate. Fruit not seen.

**Flowering & Fruiting**: Flowering from April to July. Fruiting not seen.

**Distribution:** This taxon is distributed in Thrissur district in Kerala. It is found in Elamthalachi area of Vazhachal forest division.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at elevations 800 m in the Sholayar area. It is a medium sized tree seen associated with *Cryptocarya anamalayana* Gamble., *Schleichera oleosa* (Lour.) Oken., *Mesua ferrea*. L., *Phoebe lanceolata* (Nees) Nees.

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of January. The buds were swollen by the end of the month flowers bloomed randomly all over the tree. By the second week of February, the tree was in full bloom. Dried flowers remained in the tree till the end of March. The fruiting period could not be observed during the study period.

**Specimen examined**: INDIA, **Kerala**, Thrissur district, Sholayar, 20.02.2018, *P.K. Fasila 137471* (MESAH!).

**Notes**

*Actinodaphn*e sp.1 resembles *Actinodaphne bourdillonii* in their leaf shape, number of lateral nerves, but differ from *A. bourdillonii* in their thin papery texture of young leaves and sub ovoid glabrous ovary. Further studies are required to the conformation for the novelty of this species.

**BEILSCHMIEDIA** Nees

N. Wallich, Pl. Asiat.Rar.2:69.1831.

Evergreen tree; bark dark brown, dark green to black outside, pale brown, creamy-white inside; branchlets terate, flattened to terete, glabrous when old, lenticellate; terminal bud small, or elongate, with or without perulate scale, pubescent or glabrous. Leaves simple, alternate, estipulate, penninerved; lamina elliptic to obovate-ovate, obovate to oblanceolate or ovate-lanceolate, elliptic-ovate, elliptic-oblong, or elliptic-lanceolate, acute to apiculate or obtusely acuminate at apex. Inflorescence in axial, terminal or subterminal panicle, bracteate. Flowers small, hermaphrodite; pedicel densely pilose or glabrous; perianth tube short, unequal, deciduous; tepals 6 in 2 whorls of 3; stamens 9, in 3 whorls of 3 each, first and second whorls eglandular, third whorl glandular, anthers 2-celled, introrse in first and second whorls, extrorse in third whorl; ovary superior, sessile, free from the perianth, attenuate to the style; style terete; stigma sub capitate. Fruit a berry. Seed 1.

**Key to the species.**

1a. Terminal bud >5mm long, without coriaceous scale, pubescent; lamina lanceolate, ovate, obovate to oblanceolate or ovate-lanceolate; ovary villous; berry cylindrical, oblong, brown to black when ripe ............................ **B. bourdillonii**

1b. Terminal bud < 5mm long, perulate with coriaceous lanceolate scale, glabrous; lamina elliptic, elliptic-ovate, elliptic-oblong, or elliptic-lanceolate; ovary glabrous; berry ovoid or ellipsoid, purple when ripe .......................... **B. wightii**

**Beilschmiedia bourdillonii** Brandis, Indian Trees. 528. 1906; Gamble, Fl. Pres. Madras 1221. 1925; K.M. Mathew, Fl. Tamil Nadu Carnatic 1357.1982; C. N. Mohanan, Fl. Quilon Dist. 344.1984; C.J. Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 57. 1984; V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 207. 1987; Sasidh. & Sivar., Fl. Pl. Thrissur For. 380. 1996; Sasidh., Fl. Parambikulam WLS 267. 2002; Anil Kumar *et al.*, Fl. Pathanamthitta 423. 2005.

*Beilschmiedia fagifolia* Bedd., Fl. Sylv. t. 263. 1872, non Nees 1831.

**(Figure 4.3.)**

**Local name**: Murakutthi

A large evergreen tree, 16–25 m heigh; bark dark green to black outside, pale brown inside; blaze creamy yellow; branchlets terete, minutely puberulous when young, golden-reddish, golden brown, greyish when dry; terminal bud small, c.3 mm long, without perulate scale, pubescent. Petiole 10–20×2 mm, very slender, slightly twisted, round beneath, flattened above, green, glabrous, blackish when dry; lamina 10–20×5.5–8 cm, elliptic to obovate-ovate, obovate to oblanceolate or ovate-lanceolate, acute to acuminate at base, margins entire, curled inward, acute to apiculate at apex, chartaceous, glabrous, shining above, dark green turning dark greyish to black when dry; mid rib prominent, channelled adaxially, highly emergent abaxially; lateral veins 7–10 pairs, pinnate, prominent on both surface, glabrous; intercostae reticulate, prominent on both surface. Inflorescence in axillary or terminal panicle, 1–3 cm long, fulvous silky tomentose; bracts 2, c.4 mm long, concave, deciduous, silky tomentose without, glabrous on within. Flowers c.5×3.5 mm, pale green to yellow, densely rufous-tomentose; pedicel 2–4 mm long, densely pilose; perianth tube narrowed at the apex; tepal 3.5×2 mm, ovate, acute at apex, densely rufous-tomentose without, appressed pilose within, fleshy-coriaceous, pale green to yellow; stamens of first and second whorls eglandular, c.2.8 mm long, with introrse anther, filament c.1.8 mm long, slender, pubescent with white hairs, anther c.1mm long, ovate, obtuse apex, sparsely pilose without, 2 locular with apical dehiscence; 3$^{rd}$ whorl c.3 mm long, anther c.1 mm long, filament c.2 mm long with 2 globose glands at base; ovary globose, c.1 mm long, villous; styles c.1.2 mm long, slender, pubescent; stigma sub capitate; staminodes c.1 mm long, deeply cordate, villous at base, apex acuminate. Berry 2–2.7×1–5 cm, cylindrical-oblong, green when young, brown to black when ripe. Seed 1, c.1.9×1 cm, obovate, pale brown.

**Flowering & Fruiting**: Flowering from January to February. Fruiting from February to April.

**Distribution**: *Beilschmiedia bourdillonii* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Kollam, Idukki, Pathanamthitta, Thrissur and Palakkad districts.

**Habitat**: The taxon is distributed in evergreen and wet evergreen forests on hill slopes at elevations ranging from 800-1200 m. It is associated with *Litsea floribunda* (Blume) Gamble., *Myristica beddomei* King., *Cullenia exarillata* Robyns., *Mesua ferrea*. L. *Knema attenuata* (Hook. fil. & Thoms.) Warb. etc.

**IUCN Status**: Not evaluated.

**Phenology**.

Flowering only once in year. Flower buds appeared in the first week of January and remained unchanged in appearance till the third week of January. Buds began to open by the fourth week of January and by the end of February flowers were

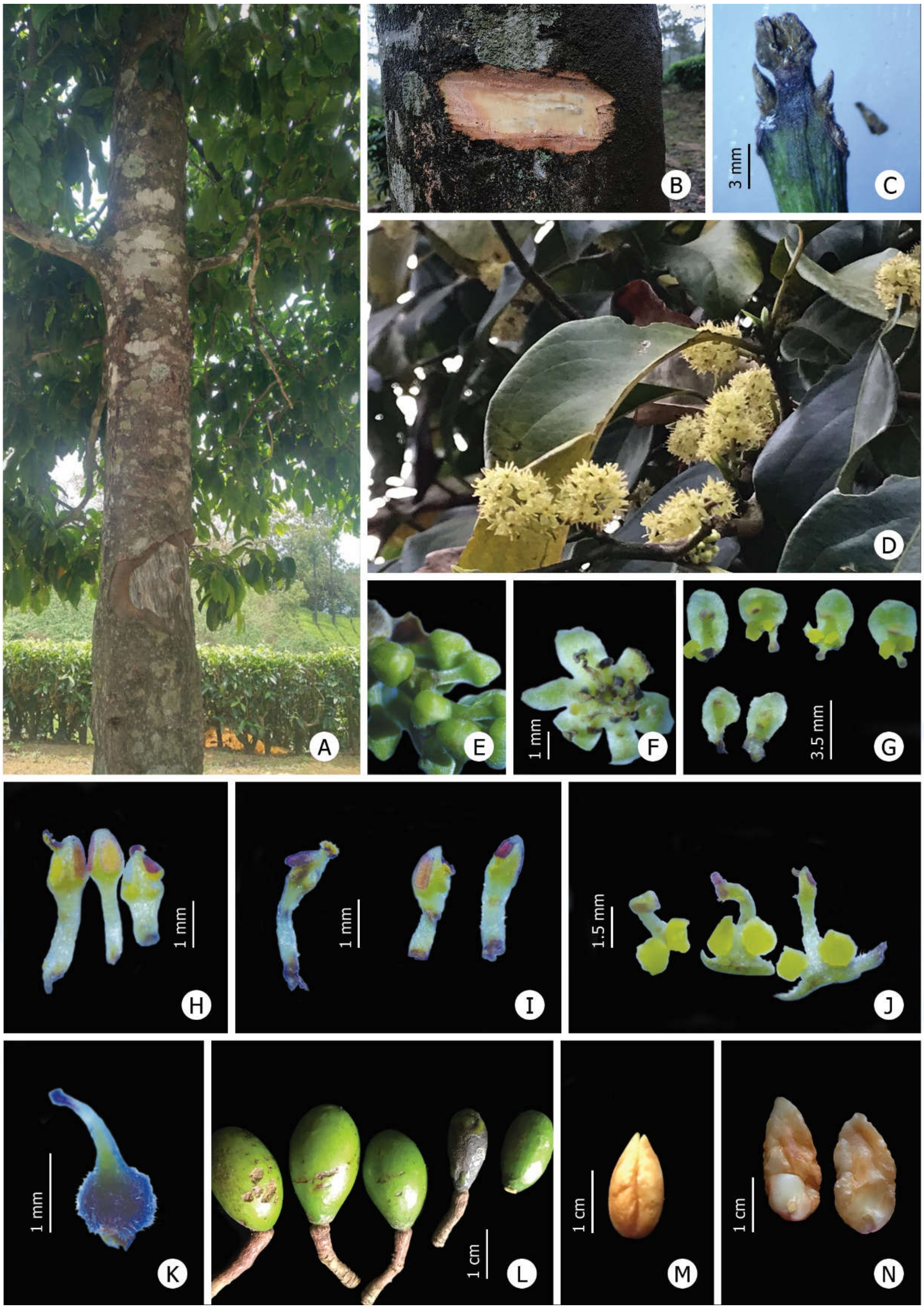


**Figure 4.3.** ***Beilschmiedia bourdillonii*** Brandis**:** **A.** Habit; **B.** Blaze; **C.** Bud scale; **D.** Flowering twig; **E.** Inflorescence; **F.** Single flower; **G.** Tepals with stamens; **H.** 1st whorl of stamens; **I.** 2nd whorl of stamens; **J.** 3rd whorl of stamens; **K.** Pistil; **L.** Fruits; **M.** Seed; **N.** Seed L.S.

bloomed all over the tree. Dried flowers remained in the tree till the last week of March. By the second week of March, green juvenile fruits began to develop. Maturation of fruit was rather fast and became green fruit by the last week of April. Fruits ripened to black and fallen off by the end of May.

**Specimens Examined**: INDIA, **Kerala**, Pathanamthitta district, Karimala, 20.01.1994, *JomyAugustine* 13119 (KFRI); Thrissur district, Peechi, 09.01.1984, *N. Sasidharan & C. Renuka* 3017 (KFRI); Malakkappara, Kasarapara, 20.02.2018, *P.K. Fasila et al.,* 137470*,* 19.04. 2019, 150540 (MESAH).

**Beilschmiedia wightii** (Nees) Benth. & Hook. f., Gen. Pl. 3: 152. 1880; Gamble, Fl. Pres. Madras 1221. 1925; C.J. Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 57. 1984; V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 207. 1987; Sasidh. & Sivar., Fl. Pl. Thrissur For. 380. 1996; Sasidh., Fl. Parambikulam WLS 267. 2002.

*Haasia wightii* Nees, Syst. Laurin. 676. 1836; Meissn. in DC., Prodr. 15(1): 61. 1864; Bedd., Fl. Sylv. t. 298. 1872.

**Local name**: Nagaramaram

A large evergreen tree, up to 25 m tall; bark dark brown, smooth; inner bark creamy-white; blaze dull yellow; branchlets flattened to terete when old, glabrous, lenticellate, blackish when dry; terminal buds 1–1.2×0.4 cm, elongate, perulate with lanceolate scales, glabrous. Petiole 1.5–2 cm long, slender, rounded beneath, grooved above, blackish when dry, glabrous; lamina 7–14×4–6.2 cm, elliptic, elliptic-ovate, elliptic-oblong or elliptic-lanceolate, base acute or attenuate, margin entire, apex obtusely acuminate, glabrous, glossy shining, coriaceous dark green turning dark greyish to black when dry; midrib flattened adaxially, raised and prominent abaxially, yellow to light brown; lateral veins 7–9 pairs, pinnate, prominent, arcuate, glabrous; intercostae reticulate, prominent on both surfaces. Panicles 1.5–5 cm long, glabrous, ebracteate; Flowers c.1 cm long, greenish-yellow; pedicel c.2 mm long; slender, glabrous; tepal c.2.5×2 mm, sub equal, greenish-yellow; stamens in 3 whorls, first and second whorls eglandular, filament c.1 mm long, anthers ovate, acute, 2-locular, glands of inner whorl c.0.5 mm long, stipitate; ovary 1.5 mm long, ovoid, glabrous; style slender;

stigma subcapitate or obtuse; staminodes 3, c.0.5 mm long, cordate, stipitate. Berry 2–3×1.2–1.5, ovoid or ellipsoid smooth, light green when young, purple when ripe. Seed 1, 1.5–2×0.6–1 cm, ellipsoid, pale brown.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from March to June.

**Distribution**: *Beilschmiedia wightii* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Kollam, Idukki, Thrissur, Palakkad, Wayanad, and Kannur districts.

**Habitat**: The taxon is distributed in evergreen and wet evergreen forests on hill slopes at elevations ranging from 1100-1200 m. It is associated with *Aglaia malabarica* Sasidh., *Actinodaphne wightiana* (Kuntze) Noltie., *Turpinia malabarica* Gamble., *Cullenia exarillata* Robyns., *Mesua ferrea* L.

**IUCN Status**: Near Threatened under criteria B2 ab (i,ii,iii,iv).

**Phenology**.

Flowering only once in year. Flower buds appeared in late January and remained unchanged in appearance till the third week of February. Buds began to open by the first week of March and by the last week of March flowers bloomed all over the tree. Flowering continued till the first week of April. By early March, fruits began to develop. By the last week of March and in April, tree was covered with fruits. Fruits ripened to black and fallen off in early May.

**Specimens Examined**: INDIA, **Kerala**, Thiruvananthapuram district, Athirumala, 17.03. 2008, *P.S. Udayan et al*. 04862 (CMPR); Idukki district, Munnar, 29.07.1982, *Nambiar & N. Sasidharan* 1875 (KFRI); Karivepinshola, 03.10.1996, *K.K. Sajeev* 17458 (KFRI); Vellimala, 15.01.1998, *Jomy Augustine* 18492 (KFRI); Mannavanshola, ±1800 m, 31.07.2014, *A.J. Robi* 28100 (KFRI); Kollam district, Rosemala, 24.01.1994, *N. Sasidharan* 10826 (KFRI); Thrissur district, Ponmudi, 17.01.989, *N. Sasidharan* 5271 (KFRI); Palakkad district, Parambikulam, Karimala, 5.05.2017, *P.K. Fasila* 137445 (MESAH).

**CINNAMOMUM** Schaeffer

Bot. Exped. 74. 1760, *nom. cons.*

**Cinnamomum malabatrum** (Burm. f.) Blume, Bijdr. 568. 1826; Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 61. 1984; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu, 2: 208. 1987; Mani., Fl. Silent Valley 234. 1988; Vajr., Fl. Palghat Dist. 403. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 392. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 380. 1996; Sivar. & Mathew, Fl. Nilambur 583. 1997; Anil Kumar *et al*., Fl. Pathanamthitta 423. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 609. 2009.

*Laurus malabatrum* Burm. f., Fl. Ind. 92. 1768.

*Cinnamomum iners* sensu Gamble, Fl. Pres. Madras 1224. 1925, non Reinw. ex Blume 1826.

**Local name**: Vayana.

Small to medium sized evergreen tree, 7–20 m high; outer bark reddish-brown, smooth, or slightly, longitudinally cracked, 5–10 mm thick; blaze pale pink inside; branchlets terete, slightly angular, glabrous. Leaves simple, opposite, estipulate; petiole 1.5–2 cm long, slender, sulcate above, dark greenish to blackish when fresh, blackish when dry, glabrous; lamina 7–20×4–10 cm, elliptic-oblong, oblong or oblong-lanceolate, sub-acute or rounded, slightly oblique at base, margins entire, acuminate or acute at apex, sub coriaceous, glabrous, aromatic, dark green, glossy above, light green, shining white glaucous beneath; midrib flat, 2 opposite lateral nerve, c.5 mm long arise above from the base, terminate at the tip of lamina, glabrous, adaxially, raised, thick and sparsely sericeous abaxially light green to yellow; intercostae thin, scalariform, glabrescent. Inflorescence cymose panicle in the axile of leaves, or at apex, 9–17 cm long, minutely pilose; lateral flowers of cyme opposite or sub opposite. Flowers small, hermaphrodite, c.8 mm long, sparsely sericeous, greenish yellow; pedicel 0.3–0.5 cm long, slender with flattened tip, pubescent; perianth tube short, funnel shaped, c.1mm long; tepal 2–3×1.5–1.8 mm, sub equal, fleshy ovate, acute with dense hairs, coriaceous, light brown to yellow; stamens 9 in 3 whorls of three each, first and second whorls eglandular, outer whorl opposite to outer perianth; anthers c.1.1 mm long, orbicular, 4- lobed, upper lobe small and lower lobe large, dehisced by apical flap; $2^{nd}$ whorl c.2 mm long, anther c.0.9 mm long, glabrous, filaments c.1.1 mm long, villous; $3^{rd}$ whorl glandular, anthers extrorse, oblong, gland stalked; ovary slightly elongated, c.1 mm long, glabrous; style c.1.3 mm long, glabrous; stigma discoid; staminodes 3, 1.2–1.6 mm long; filament villous; anthers cordate and stipitate; gland c.1mm long, stalked, c.0.5 mm long, villous. Fruit a berry, 1.8–2×0.9–1 cm, oblong, pale green at young become deep blue when mature, seated in a cup- shaped perianth tube. Seed 1, c.1.3×0.6 cm, oblong, dark brown.

**Flowering** & **Fruiting**: Flowering from February to March. Fruiting from March to June.

**Distribution**: *Cinnamomum malabatrum* is distributed in South India (Andra Pradesh, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala, it is distributed in all districts.

**Habitat**: It is distributed in low medium and high elevation evergreen wet evergreen forest of Western Ghats at an elevation of 300-1200 m. This is tall evergreen tree found abundantly in its habitat, usually seen associated with *Terminalia paniculata* Roth, *Myristica beddomei* King., *Actinodaphne wightiana* (Kuntze) Noltie, *Schleichera oleosa* (Lour.) Oken etc.

**IUCN Status**: Least Concern.

**Phenology**

Flowering only once in year. Flower buds appeared in early February. Maturation of bud and flowering were rather fast. Buds began to open by the second week of February. By early March all the buds were opened and within a week the tree was in full bloom. Fruits began to develop by the end of March. The fruits were in the perianth lobe by the second week of April and then emerged. Fruits matured slowly and became green. Fruits ripened by the second week of May, by this time the colour of fruits were changed to black. Fruits were fallen off by the end of June.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Chippanchira 3.01. 1993, *M. Abdul Jabbar* 15556 (TBGT); Peroorkada 15.07.2003, *Geetha Kumary* 48401 (TBGT); Nedumangad, 28.06.2005, *Geetha* 49500 (TBGT); Vazhavanthol, 18.02.2009, *Geetha Kumary* 65249 (TBGT); Palode, 19.05.2009, *P.S. Udayan & A.J. Robi* 6040 (CMPR); Way to Karayar, 16.03.2018 *Usha & Deepthy* 92238 (TBGT); Kollam district, Kallar, 16.04.1993, *N. Sasdharan* 10405 (KFRI); Sankhil, 29.12. 2003, *Geetha Kumary* 56088 (TBGT); Cheenikala, 29.12.2003, *Geetha Kumary* 56089 (TBGT); Mayyanad, 30.01. 2004, *Geetha Kumary* 53195 (TBGT); Thenmala, 29.12.2003*, Geetha Kumari* 56070 (TBGT); Cherukara, ±10m, 30.01.2004, *Geetha Kumary* 53200 (TBGT); Malavana 30.01.2004, *Geetha Kumary* 53199 (TBGT); Kottarakkara, 19.01.2007, *Geetha Kumary* 53697 (TBGT); Pandimotta, 10.12.2009, Geetha Kumary 65223 (TBGT); *ibid*., 20.12. 2009*, Geetha Kumary* 65222 (TBGT); Rosemala, 8.03.2017, *Geetha Kumary* 80899 (TBGT) ; *ibid*., 14.04.2012, *Geetha Kumary* 72151 (TBGT); Pathanamthitta district, Sabarimala, 07.04.1995, *Jomy Augustine* 14928 (KFRI); *ibid*., 10.04.1995, *Jomy Augustine* 14979 (KFRI); Idukki district, Kulamavu, ±700 m, 05,02.1980, *Shylaja* 26218 (CALI); Edappalayam, 14.02.1995, *Jomy Augustine* 14819 (KFRI); Peerumedu 13.03.2009, *P.S. Udayan & A.J. Robi* 5718 (CMPR); PTR, Thannikkudi, 18.03.2009, *P.S. Udayan* & *A.J. Robi* 5774 (CMPR); Kuttikkanam, 12.06.2009, *A.J. Robi* 6154 (CMPR); Thrissur district, Peechi, 06.02.1987, *N. Sasidharan* 3934 (KFRI); Vellanimala, 18.03.1980, *N. Sasidharan* 1159 (KFRI); Vazhachal, 20.02.2003, ±230 m, *K.H. Amitha Bachan* 72068 (CALI); 8.03.2013, *Ginu & Salish* 28600 (KFRI); Sholayar, 18.02.2015, *P.K. Fasila* 137429 (MESAH); Malakkappara, 04.04.2015*, P.K. Fasila* 137425 (MESAH); Malappuram district, Nedumkayam, 10.02.1981, *Philip Mathew* 32380 (CALI); Thalichola, 05.02.1982, *Philip Mathew* 33924 (CALI); New Amarambalam, Karimpuzha, 28.04.2000, *R. Jayakumar* 2034 (KFRI); Palakkad district, Anakkalvayal, 14.11.1999 *P. Sujanapal* 1992 (KFRI); Parambikulam, Karimala, 08.03.2007, *P.S. Udayan et al.* 4974 (CMPR); Nelliyampathy, Pulayanpara, 04.06.2010, *P.S. Udayan & A.J. Robi* 6888 (CMPR); *ibid*., 04.06.2010, *P.S. Udayan & A.J. Robi* 6889 (CMPR); Silent Valley, Anawai, 9.05.2019, *P.K. Fasila* 150548 (MESAH); Kozhikkodu district, Peruvannamuzhi, ± 40 m, 02.02.1980, *Shylaja 26215*

(CALI); Perambra, 04.01.1982, *Shylaja* 26239 (CALI); Thiruvambady, 06.01.1982, *Shylaja* 26241 (CALI); Kuttiyadi, ±40 m, 13.05.1983, *Shylaja* 26249 (CALI); Wayanad district, Mananthavady, ±720 m, 17.03. 1981, *Shylaja* 26236 (CALI); Vythiri, ±712 m, 27.02.1980, *Shylaja* 26226 (CALI); Kadiyangadu, ±45 m, 16.02.1981, *Shylaja* 26229 (CALI); Kakkavayal, ±710 m, 17.03.1981, *Shylaja* 26231 (CALI); Sultan Bathery, ±720 m, 17.03.1981, *Shylaja* 26232 & 26233 (CALI); Puthenkunnu, ±720 m, 17.03.1981, *Shylaja* 26235 (CALI); Perya, 24.02.2008, *P.S. Udayan et al.* 4767 (CMPR); Boys Town, 24.02.2008, *P.S. Udayan et al.* 4768 (CMPR).

## **CRYPTOCARYA** R. Br.

Prodr. Fl. Nov. Holland. 402. 1810.

Evergreen tree. Blaze creamy-white. Branchlets terete, greyish-brown, golden-reddish, golden-brown blackish-brown to black, greyish, dark brown when dry, prominently lenticellate or few. Leaves usually simple, alternate, penni-nerved; lamina elliptic to elliptic-oblong, rarely ovate-oblong, obovate to obovate-oblong, cuneate, acute at bae, margins entire, acute to acuminate, apiculate at apex, coriaceous, sub coriaceous, penni-nerved; midrib impressed above and prominently raised below; secondary veins usually sub opposite to opposite, obscure above and prominent below; veinlets prominent, parallel with scalariform intercostae. Flowers small, hermaphrodite in axillary or subterminal cymose panicle; bract and bracteoles early caducous; perianth lobe 6, in two rows of 3 each; stamen 9, perfect in three whorls of 3 each; first and second whorls opposite to the 3 outer perianth lobes, eglandular, third whorl opposite to the inner perianth lobes with 2 glands attached to the base of the filament; anthers 2 celled, 1 and 2$^{nd}$ whorls, anthers introrse, third whorl extrorse, connective often produce; 4$^{th}$ whorl 3 staminodes; ovary inferior, sessile enclosed within in the perianth tube. Fruit drupe, enclose with in the accrescent perianth tube.

**Key to the species.**

1a. Lamina golden reddish-brown, tawny velutinous to fulvous tomentose. ............ .............................................................................................. **C. anamalayana**

1b. Lamina dark green, glabrous, or puberulous when young .................................. 2

2a. Fruits ovoid, lenticillate, without longitudinal striations, acute at apex; seeds ovoid ............................................................................................... **C. lawsonii**

2b. Fruits cylindrical oblong, non lenticillate with 6-11 longitudinal striations, narrowed toward apex; seeds oblong.................................. **C. sheikelmudiyana**

**Cryptocarya anamalayana** Gamble, Bull. Misc. Inform. Kew 1925: 126. 1925 & in Fl. Pres. Madras 1218. 1925; V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 209. 1987; M. Mohanan & A.N. Henry, Fl. Thiruvanthapuram: 393. 1994; M. Gangop. & Chakrab., J. Econ. Taxon. Bot. 29(2): 278. 2005; Bachan *et al.*, Bangladesh J. Plant Taxon. 25(1): 107-111. 2018. **(Figure 4.4.)**

A large evergreen tree, 7–16 m high; bark greyish-brown outside, orange-brown inside; branchlets terete, golden-reddish, golden-brown when dry, tawny velutinous to fulvous tomentose; lenticels few, elliptic-narrow, pale brown. Petiole stout, 6–12×2–4 mm, sulcate above, tawny velutinous or rusty tomentose, blackish when dry; lamina 8–24×4–11 cm, elliptic, obovate to obovate-oblong, obtusely cuneate to sub-acute at base, margins entire, obtusely acute to apiculate at apex, coriaceous, fulvous pubescent, glaucous to glaucescent beneath, dark green glossy above, turning dark brown when dry, pale greyish green above, turning reddish green when dry; mid rib slightly sunken, tawny-tomentose or velutinous above, fulvous to brown tomentose or villous beneath; secondary veins 6-12 pairs, impressed above and highly raised beneath, sub opposite and sub parallel, arcuate and slightly looped towards margins; intercostae scalariform and prominent as midrib, finely reticulate, inconspicuous above, highly raised beneath, percurrent. Panicle 2–6 cm long, rusty, or tawny-velutinous to villous; lateral flowers of the of the cymes subopposite. Flowers c.5 mm long, pale-creamy yellow, densely rufous-tomentose; pedicel c.1 mm long; bracts 2, unequal, persistent, minute, c.3×1.5 mm, ovate-acute, rusty-villous; perianth tube 0.5–0.8×1 mm, narrowed at the top, pale-creamy yellow, fleshy, coriaceous, fulvous silky yellow pubescent; tepal 1.5–2.5×1 mm, golden-brown, ovate, base and apex acute, fleshy-coriaceous, densely rufous-tomentose without, appressed pilose within.

Flowers bisexual; stamens 1–1.6 mm long; anthers 0.5–1.2 mm long, ovate, apex obtuse, 2 locular; filaments 05–1.2 mm long, slender, densely villous; glands c.0.5 mm long, orbicular, sessile; carpel c.3.2 mm long; ovary c.1.5 mm long, ovate-oblong, glabrous, ovule solitary; style c.1 mm long, terete, slender, glabrous; stigma capitate; staminodes c.1.5 mm long, deeply cordate, apex acuminate, shortly stipitate, villous at base. Berry 2.4–5×0.8–1.3 cm, ellipsoid, obovate-oblong, light to bright green when young, glossy black when ripe. Seed 1, 2−3.5×0.5−1 cm, oblong-obovate, obovate-ellipsoid, glabrous, white to light yellow.

**Flowering & Fruiting**: Flowering from December to February. Fruiting from March to May.

**Distribution**: *Cryptocarya anamalayana* is distributed South India (Kerala and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Thrissur districts.

**Habitat**: The taxon is very rare in evergreen and wet evergreen forests on hill slopes at elevations ranging from 680-1200 m in the four locations of Southern Western Ghats. It is a buttressed, top canopy tree seen along the hilltop of wet evergreen forest associated with *Palaquium ellipticum (*Dalz.) Baill., *Melicope lunu-ankenda* (Gaertn.) Hartley., *Cullenia exarillata* Robyns., *Vateria indica* L., *Elaeocarpus tuberculatus* Roxb., *Turpinia malabarica* Gamble., *Litsea oleoides* (Meisn.) Hook.f*, Actinodaphne wightiana* (Kuntze) Noltie, *Litsea floribunda* (Blume) Gamble., *Antidesma montanum* Blume.

**IUCN Status**: Endangered B1+2c.ver. 2.3.

**Phenology**

Flowering only once in year. Flower buds appeared in late December and remained almost unchanged in appearance for three weeks. Flowering only once in a year. Flowers began to appear by early February. By early March, half of the total buds were opened. By the end of March, the tree was in full bloom. Green juvenile fruits began to appear in early April. Maturation of fruit was rather slow, became ripened by the end of May. Colour of fruit changed into black by the second week of May and fruits were fallen by June.

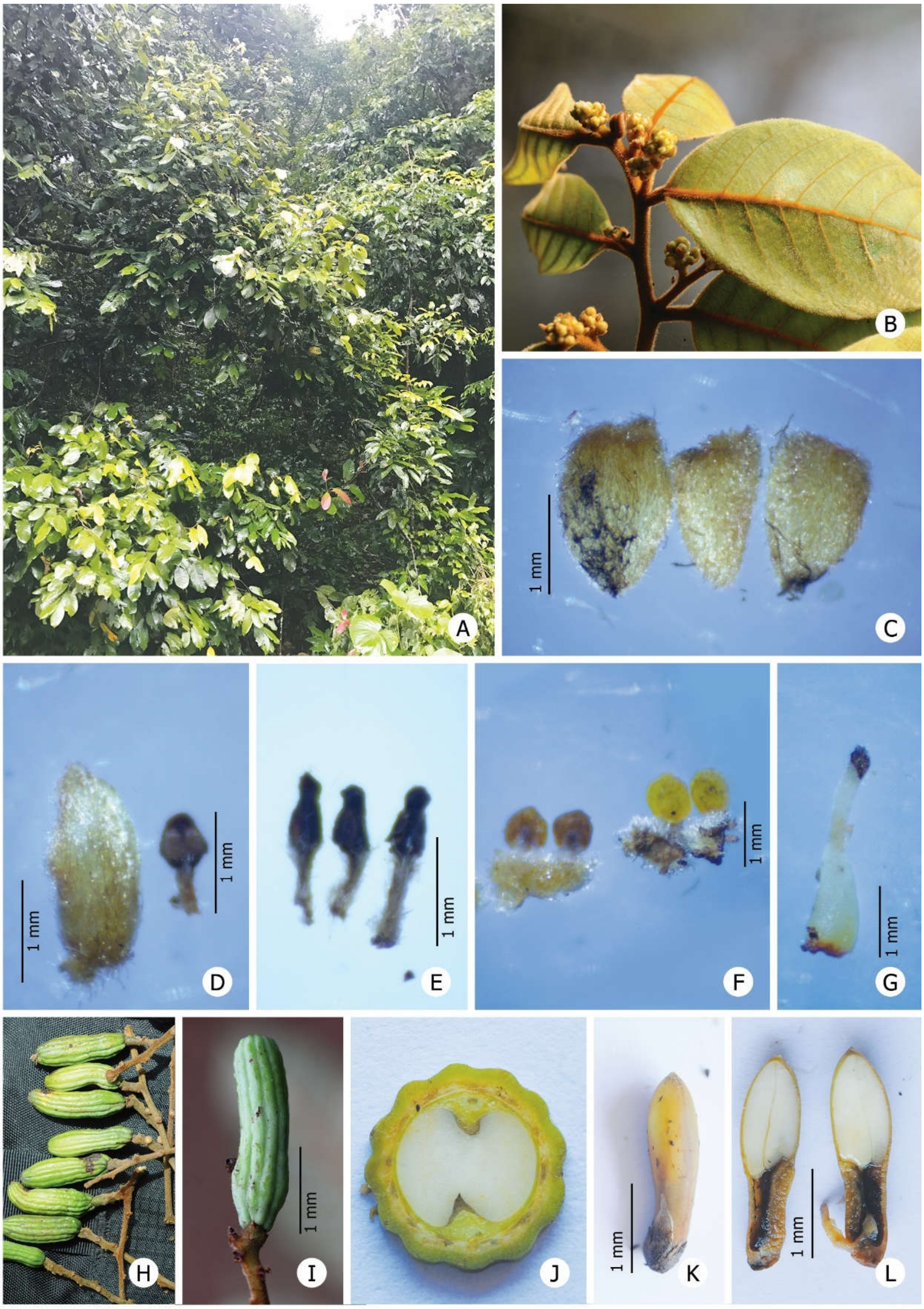


**Figure 4.4.** ***Cryptocarya anamalayana*** Gamble**:** **A.** Habit; **B.** Flowering twig; **C.** Outer whorl of tepals outer view; **D.** Inner whorl of tepals with stamen; **E.** 3rd whorl of stamens; **F.** Stipitate glands; **G.** Pistil; H. Fruits; **I.** Single fruit; **J.** Fruit C.S; **K.** Seed; **L.** Seed L.S.

**Specimens Examined**: INDIA, **Kerala**, Thiruvananthapuram district, Ponmudi, ± 1800 m, 6.11.1984, *Shaji Sebastian* 1495 (CALI); Kollam district, Kallar, 13.04.1993, *N. Sasidharan* 10361 (KFRI); Alvarkurichi, 18.02.1995, *N. Sasidharan* 11419 (KFRI); Thrissur district, Sholayar, Chandanthode, 27.04.2006, *K.H. Amitha Bachan* 98840 (CALI); *ibid.*, 3.04.2015, *P. K. Fasila* 137417 (MESAH); *ibid*., 20.04. 2010, *P.S. Udayan et al.* 6726, 6734 (CMPR).

**Cryptocarya lawsonii** Gamble, Bull. Misc. Inform. Kew 1925: 127. 1925 & in Gamble, Fl. Pres. Madras 1218. 1925; Mani., Fl. Silent Valley 235. 1988.

**(Figure 4.5.)**

**Local name**: Chembalamaram.

Medium sized evergreen tree, 10–12 m high; bark greyish outside, dark brown inside; branchlets terete, greyish-brown, blackish-brown to black, greyish, dark brown when dry, puberulous, prominently lenticellate; lenticels large, oval, pale creamy white. Petiole 0.5–1.2×0.3 cm, stout, grooved above and rounded below, slightly puberulous on young, glabrous on age, blackish when dry; lamina 7.5–22×2–6.5 cm, elliptic, elliptic-oblong, acute at base, margins entire, obtusely acute, acuminate or apiculate at apex, dark brown, narrowly revolute, coriaceous, glabrous, dark green above, pale greenish glaucouscent beneath, pale green to dark green above, reddish brown glaucouscent when dry; midrib highly immersed above, prominently raised below, slightly puberulous; secondary veins 7–10 pairs, highly immersed above, prominent below, glabrous; intercostae parallel and scalariform, prominent below, obscure or immersed above. Panicle 3–7 cm long, yellow tomentose. Flowers c.4×3 mm, fulvous pubescent, pale creamy-yellow; pedicel c.0.5 mm long; bract 2, minute, c.1 mm long, elliptic-obovate, yellow, pubescent; perianth tube 0.8–1×0.8–1 mm, pale creamy-yellow, fleshy coriaceous, adpressed tomentose; tepals 1.8–2×1–1.2 mm, pale-creamy yellow, ovate, acute, or sub-acute at apex, fleshy-coriaceous, puberulous without, appressed pilose within; stamens outer whorl 3, 1.2–1.5 mm long; anthers 0.5–0.7 mm long, ovoid-triangular, obtuse, 2 locular; filament 0.5–0.8 mm long; 2$^{nd}$ whorl c.1.2 mm long, anther c.0.5 mm long, filament c.0.7 mm long; 3$^{rd}$ whorl 1.3–1.6 mm long, anthers 0.5–0.7 mm long, ellipsoid; filament 0.8–0.9 mm long, filaments of all whorls villous at base; glands 0.4–0.7 mm long, ovoid, stalked, stalk c.0.3 mm long, villous at base; ovary c.1.2 mm long, ellipsoid; ovule solitary, c.0.8 mm long; style terete, c.1 cm long, glabrous; stigma simple; staminodes, 1–1.2 mm long, sagittate, shortly stipitate, villous at base. Berry 2.5–3.5 cm long, ovoid to ovoid-oblong, rounded at both ends, longitudinally striate or shallowly ribbed, glabrous, reddish-brown when dry. Seed 1.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from March to May.

**Distribution**: *Cryptocarya lawsonii* is distributed in south India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Palakkad district.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at elevations ranging from 850-2200 m in the Southern Western Ghats. It is a buttressed, top canopy tree seen along the hilltop of wet evergreen forest associated with *Dipterocarpus indicus* Bedd., *Poeciloneuron indicum* Bedd., *Canarium strictum* Roxb., *Artocarpus heterophyllus* Lam., *Neolitsea cassia* (L.) Kosterm etc.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds appeared in early January and remained almost unchanged in appearance for three weeks. Flowers began to appear by early February. By early March, half of the total buds were opened. By the end of March, the tree was in full bloom. Green juvenile fruits began to appear in early April. Fruits were ripened by the first week of May. Colour of fruit changed into black, and fruits were fallen off by the end of May.

**Specimens examined**: INDIA, **Kerala**, Palakkad district, Valiyaparathodu, ±1300 m, 2.01. 1983, *T. Sabu* SV 11075 (CALI); Sispara, ±2200 m, 19.11. 1983, *T. Sabu* SV 11364 (CALI); Silent Valley, Sispara, 08.03.2009, *P.S. Udayan & A.J. Robi* 5704 (CMPR); Attappady, Varadimala, *K.A. Anilkumar* 3428 (CMPR); Nelliyampathy view point, 13.05.2019, *P.K. Fasila* 150566 (MESAH): Meenampara, 18.02.2020, *P.K. Fasila* 150577, 150578 (MESAH).

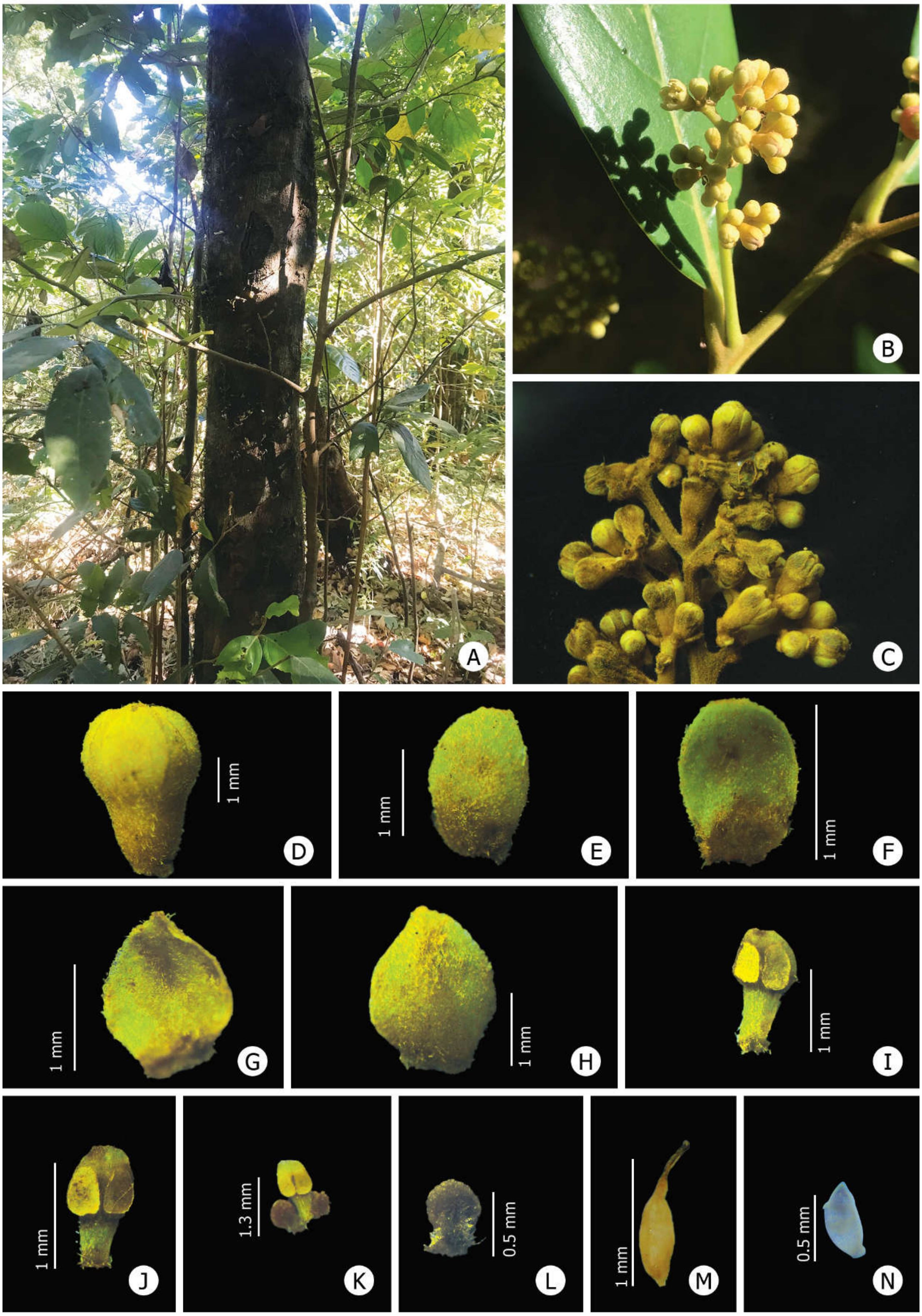


**Figure 4.5.** ***Cryptocarya lawsonii*** Gamble**: A.** Habit; **B.** Flowering twig; **C.** Inflorescence; **D.** Flower bud; **E.** Outer tepal outer view; **F.** Outer tepal inner view; **G.** Inner tepal outer view; **H.** Inner tepal inner view; **I.** 1$^{st}$ whorl of stamen; **J.** 2$^{nd}$ whorl of stamen; **K.** 3$^{rd}$ whorl of stamen; **L.** Gland; **M.** Pistil; **N.** Embryo.

**Cryptocarya sheikelmudiyana.** Fasila *et al*., Taiwania 65(3):265−271.2020.

**(Figure 4.6. & 4.7.)**

Large evergreen tree, 25−35 m high; bark greyish-brown outside, fleshy, brown inside; branchlets terete, greenish-brown when fresh, dark brown, when dry, glabrous, puberulous when young; terminal bud hairy, not covered with leaves; lenticels prominent, oval, pale creamy-white. Petiole 1−1.5 cm long, stout, grooved above, glabrous, greenish when fresh, blackish when dry; lamina 8−20×3−9 cm, elliptic to elliptic-oblong, rarely ovate-oblong, cuneate, rarely acute, slightly oblique at base, margins entire, acute to apiculate, rarely acuminate at apex, sub coriaceous, dark green above, pale greenish-whitish distinctly glaucous beneath, brown above and pale brownish when dry, penni-nerved; midrib impressed above and prominently raised below; secondary veins 7−8, usually sub opposite to opposite except the central pairs, obscure above and prominent below; veinlets prominent, parallel with scalariform intercostae, arcuate, slightly looped towards the margin. Panicle 3.6−9.5 cm long, puberulous; peduncle 0.4−2 cm long, brown, puberulous. Flowers bisexual, c.4×2.5 mm, pale creamy-yellow, fulvous pubescent; pedicel 1–2.5 mm long, pubescent; perianth tube 2−2.5×1.8 mm, pale creamy-yellow, fleshy, coriaceous; tepals c.2×1.2 mm, pale creamy yellow, obovate-oblong, obtusely acute at apex, fleshy-coriaceous, fulvous tomentose; stamens 1.3−1.8 mm long; anthers 0.8−0.9 mm long, ovoid-triangular; filaments 0.4−1 mm long, stout, villous; glands to 0.6×0.4 mm, ovoid, stalked, stalk c.0.2 mm long, hairy; carpel 2.5 mm long; ovary c.1.2 mm long, elliptic-oblong, glabrous, enclosed within the receptacle; ovule solitary; style terete, c.1.2 mm long, glabrous; stigma sub-capitate; staminodes c.1×0.6 mm, triangular-acuminate, shortly stipitate, villous along the middle, on the abaxial side. Berry 2−2.4×0.8−1 cm, cylindrical-oblong, slightly narrowed and truncate at the apex, broader at base, constricted just below the middle, with 6−11 shallow longitudinal ridges, light green when young, black when mature. Seed 1, c.1.8×0.6 cm, oblong, narrowly apiculate at apex, white to light brown when young and reddish brown when mature.

**Flowering & Fruiting**: Flowering from September January. Fruiting from February to April.

**Distribution**: *Cryptocarya sheikelmudiyana* is distributed in wet-evergreen forests of Southern Western Ghats and is so far known only from two locations in the Anamalai landscape near to Valparai plateau Sheikalmudi of Parambikulam Tiger Reserve and high forest area of the Malakkappara in Kerala.

**Notes**: *Cryptocarya sheikelmudiyana* resembles *Cryptocarya lawsonii* Gamble in its leaves, puberulous to tomentose branchlets and large fruits with shallow ridges and *C. stocksii* Meisn. in the oblong fruits. But the new taxon differs from both *C. stocksii* Meisn. and *C. lawsonii* Gamble, being a large, buttressed tree, 25−35 m high, with the elliptic to oblong leaves with acute to apiculate apex, veins strictly limited to 7-8 pairs, tepals fulvous tomentose abaxially, non-lenticellate, longitudinally shallowly-ridged, oblong fruits with a constriction just below the middle.

**Habitat**: The taxon is a buttressed, top canopy tree seen along the hilltops of wet evergreen forests associated with *Cullenia exarillata* Robyns., *Dysoxylum malabaricum* Bedd. ex Hiern., *Alseodaphne semecarpifolia* Nees, *Aglaia malabarica* Sasidh., *Litsea bourdillonii* Gamble, *Phoebe lanceolata* (Nees) Nees.

**IUCN Status**: Critically Endangered

**Phenology**

Flowering only once in year. Flower buds appeared in second week of September and remained almost unchanged in appearance for a whole month. Buds were opened by the second week of October. Flowers bloomed randomly all over the tree. By early December, half of the total buds were opened and within a week the tree was in full bloom. Flowering continued by late December; dried flowers remained on the tree until March. Green juvenile fruits were formed in the first week of January. They matured slowly and ripened to black and fallen off by early April.

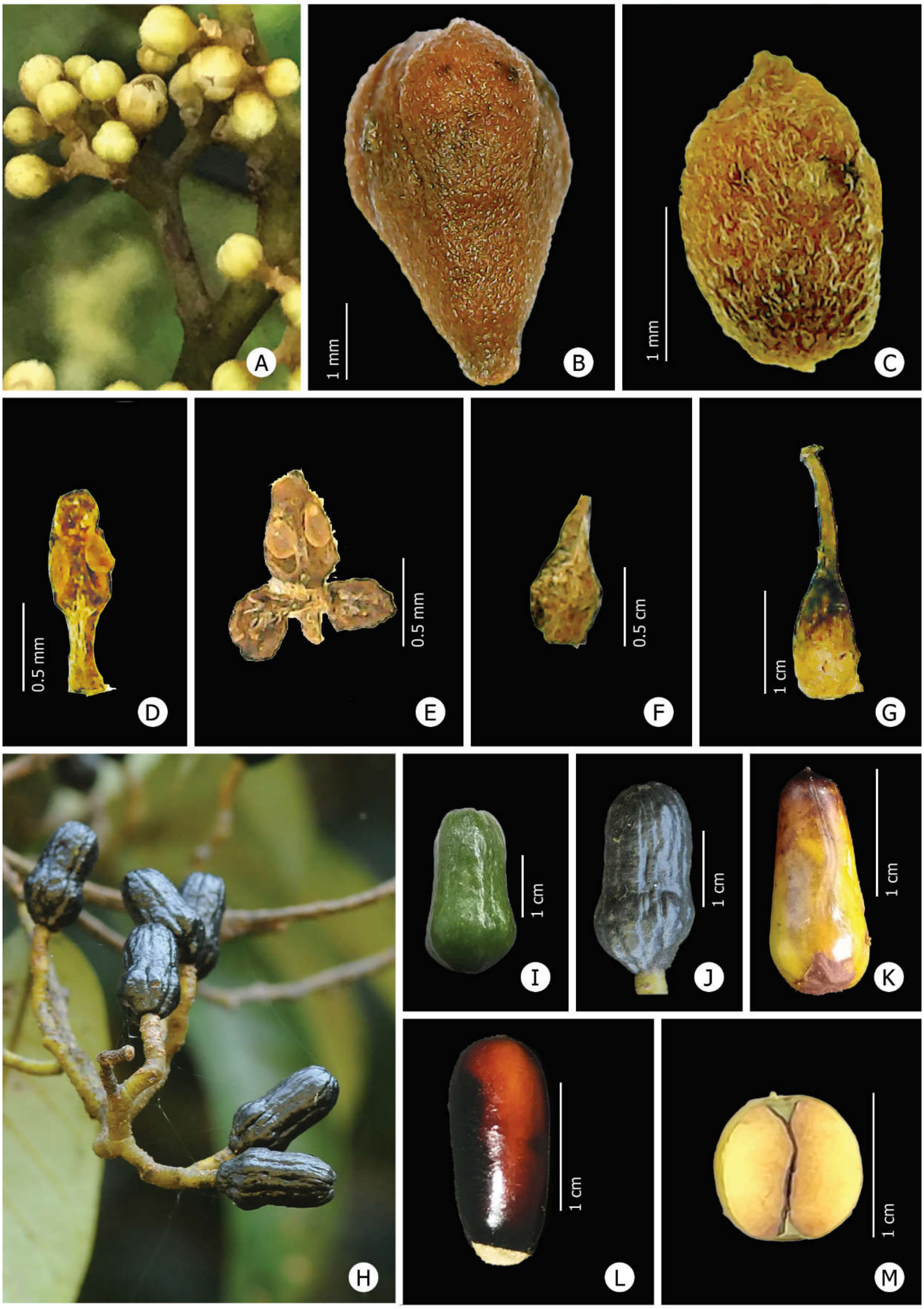


**Figure 4.6.** ***Cryptocarya sheikelmudiyana*** Fasila *et al.,* Taiwania**:** **A.** Inflorescence; **B.** Flower; **C.** Tepal outer view; **D.** 1st whorl of stamen; **E.** 3rd whorl of stamen with glands; **F.** Staminode; **G.** Pistil; **H.** Fruiting twig; **I.** Young fruit; **J.** Mature fruit; **K.** Young seed; **L.** Mature seed; **M.** Seed L.S.

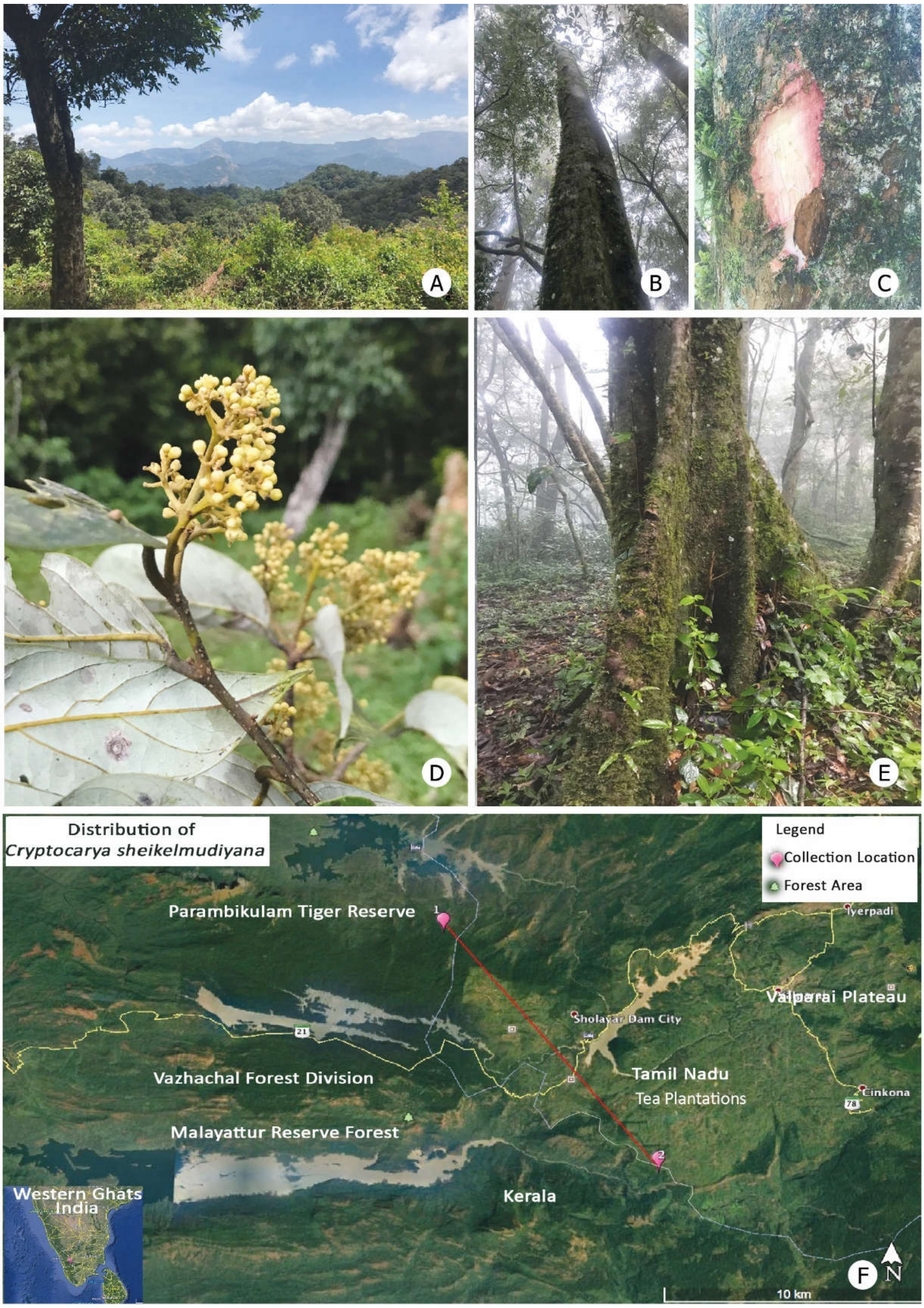


**Figure 4.7. *Cryptocarya sheikelmudiyana* habitat and distribution map: A.** Habitat; **B.** Habit; **C.** Blaze; **D.** Flowering twig; **E.** Buttress; **F.** Distribution map (Google Earth Image 2019).

Additional specimens examined: INDIA. **Kerala**, Palakkad, Parambikulam Tiger Reserve, Sheikalmudi, 76$^{0}$49’33.4” E, 10$^{0}$20’52” N,8, ±1000 m, fruiting twig, 08.01.2019, *K.H. Amitha Bachan & P.K. Fasila* 150532 (IFGTB! KFRI!); High Forest, Malakkappara, Malayatoor Forest Division, 76$^{0}$ 54’17.5” E, 10$^{0}$14’50.5” N, ±1000 m, Fruiting Twig, 22.09. 2018, *K.H. Amitha Bachan & P.K. Fasila* 137498 (MESAH).

**LITSEA** Lamarck

Encycl. 3: 574. 1792, *nom. cons.*

Small to medium sized evergreen tree; outer bark brownish-greyish, smooth, slightly rugose pale brown, inner bark brown, reddish brown, yellowish; blaze creamy white. Petiole stout or slender, tomentose, or glabrous. Leaves simple, alternate or some time opposite, estipulate, penni-nerved; lamina obovate, elliptic, lanceolate, ovate to elliptic, obovate-oblong, elliptic-ovate, oblanceolate, base acute or cuneate, obtusely round, margins entire, apex acute to acuminate, coriaceous, sub coriaceous, fulvous pubescent, mid rib prominent, secondary nerves pinnate, tertiary nerves reticulate or scalariform, highly prominent on lower surface, looped towards the margin, obscure on upper surface. Inflorescence umbel, sessile or subsessile or peduncled in the axillary or lateral clusters. Flowers dioecious; involucre bract 4, deciduous; perianth tube in male flower very small, in female flower funnel shaped; tepals 6, membranous, imbricate, early caducous, equal, or unequal; stamens in male flowers 9 or 12, in four whorls of 3 each; first and second whorls usually eglandular, anther with 2 upper small lobes and large lower lobes, third and fourth row when present glandular; anthers 4 celled, introrse; pistillode rudimentary; staminodes in female flowers same as that of male flower; ovary enclosed with the perianth tube. Fruit berry.

**Key to the species.**

1a. Racemes peduncled........................................................................................3

1b. Racemes sessile or sub sessile ..............................................................................2

2a. Young branchlets, leaves and petiole glabrous; lamina elliptic, elliptic-ovate .... ..........................................................................................................**L. coriacea**

2b. Young branchlets, leaves and petiole fulvous tomentose; lamina obovate to obovate- oblong .......................................................................**L. bourdillonii**

3a. Leaves tomentose or pubescent beneath........................................................... 4

3b. Leaves glabrous beneath........................................................................... 5

4a. Leaves large, 7–28×4.5–10 cm, densely fulvous tomentose, lateral nerves 11–17 pairs; fruit with turbinate perianth tube ........................................ **L. floribunda**

4b. Leaves small, 6–14×3.5–5.5 cm, fulvous tomentose on nerves, lateral nerves 7-8 pairs; fruit seated on cup-shaped perianth tube ............................ **L. wightiana**

5a. Leaves black when dry ................................................................. **L. nigrescens**

5b. Leaves pale brown or reddish brown when dry................................................ .6

6a. Leaves opposite at the end of branchlets; petiole 2.3–3 cm long, thick; berry depressed globose, seated undulate perianth tube ...............................**L. oleoides**

6b. Leaves alternate at the end of branchlets; petiole 0.5–1.5 mm long; berry ovoid or cylindrical globose; perianth cup- shaped...................................................... 7

7a. Young shoots reddish tomentose; leaves oblanceolate, obtuse at apex, thickly coriaceous.lateral nerve 5–8, very strong, tertiary nerve distinct on lower surface; racemes 3–5 cm long. ....................................................................**L.** sp.1

7b. Young shoots glabrous; leaves elliptic-oblong, acute, obtusely acute, or acuminate apex, sub coriaceous, lateral nerve 8–12, slender, tertiary nerve obscure; racemes short 1–2.5 cm long................................................**L. stocksii**.

**Litsea bourdillonii** Gamble, Bull. Misc. Inform. Kew 1925: 131. 1925 & in Gamble, Fl. Pres. Madras 1237. 1925; Mohanan, Fl. Quilon Dist. 347. 1984; V. Chandras. in A.N. Henry *et al.*, Fl. Tamil Nadu 2: 209. 1987; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 394. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 382. 1996; Sasidh., Fl. Parambikulam WLS 269. 2002; Anil Kumar *et al.*, Fl. Pathanamthitta 425. 2005; Bhuinya *et al.*, Bangladesh J. Plant Taxon. 17(2): 183–191. 2010. **(Figure 4.8.)**

Small to medium sized trees, 8–12 m high; outer bark brownish-greyish, inner bark brown; blaze creamy white; branchlets are terete, brownish to black; young shoots are reddish, fulvous, brown-tomentose. Petiole 10–15 mm long, stout, tomentose, dark brown; lamina 8–25×3–9 cm, obovate to obovate-oblong, cuneate at base, margins entire, acute at apex, coriaceous, fulvous pubescent, light green to dark green above and dark brown below when dry; mid rib prominent, fulvous tomentose, reddish brown, on lower surface, slightly raised or flat, tomentose, when young, glabrous on older leaves on upper surface; secondary nerves 7–12 pairs, pinnate, arcute, lowest 4 pairs opposite and closely arranged, highly prominent and fulvous tomentose on lower surface, slender, channelled and glabrous below; tertiary nerves scalariform, highly prominent on lower surface, looped towards the margin, obscure on upper surface. Umbel axillary or lateral clusters of 2–5, pubescent; each umbel 3–4×3 mm, 4–6 flowered. Flowers c.1.6×4 mm, white to yellow, glossy; pedicel short, < c.1 mm long, silky tomentose; involucre bract c.5×3.5 mm, whitish- yellowish, concave, orbicular, imbricate, fleshy, glabrous within, densely brown-sericeous without; perianth tube conical; tepals 1.5–2×1–1.2 mm, white to yellowish, lanceolate or oblong, acute at apex, free, finely silky tomentose without, inner glabrous. Male flowers: stamens yellowish green; filaments slender, villous; first whorl of stamen c.3 mm, anther c.1 mm long, filament c.2 mm long; 2$^{nd}$ whorl c.2 mm long; third and fourth whorls glandular, gland 0.5–0.4 mm long, orbicular, glabrous, white, shortly stipitate; pistillode rudimentary. Female flower: ovary c.0.4 mm long, half inferior, ovoid, glabrous; style c.1.4 mm long, thick, glabrous; stigma dilated; staminodes, outer whorl linear or clavate, 2 inner whorl, 1.5–2.3 mm long, subulate and glandular. Berry 1.5−1.8×0.8−1 cm, oblong, pale green with white spot at young and become reddish brown when mature, seated on cupule like perianth tube. Seed 1, 10–12 mm long, obovate, brown.

**Flowering** & **Fruiting**: Flowering from November to April. Fruiting from March to June.

**Distribution**: *Litsea bourdillonii* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Thrissur, Palakkad, Wayanad districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at medium elevations ranging from 600-1200 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Litsea floribunda* (Blume) Gamble., *Antidesma montanum* Blume., *Myristica beddomei* King., *Cullenia exarillata* Robyns. etc.

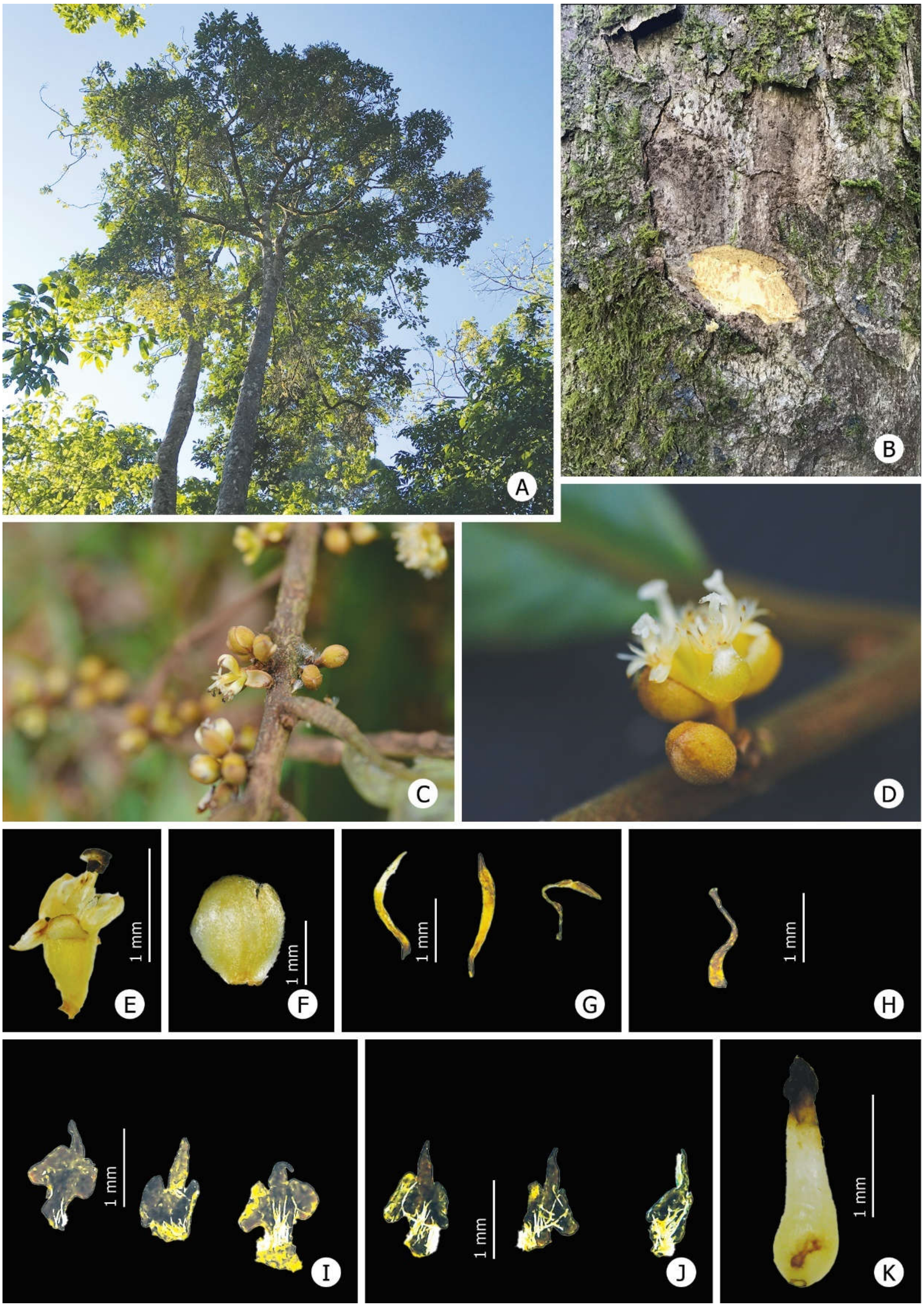


**Figure 4.8.** ***Litsea bourdillonii*** Gamble**: A.** Habit; **B.** Blaze; **C.** Flowering twig; **D.** Inflorescence; **E.** Single flower; **F.** Tepal; **G.** 1st whorl of staminodes; **H.** 2nd whorl of staminode; **I.** 3rd whorl of staminodes; **J.** 4th whorl of staminodes; **K.** Pistil.

**IUCN Status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds appeared in late November and remained almost unchanged in appearance till the end of January. Buds were swollen by First week of February. Flowers bloomed randomly all over the tree. By late March, half of the total buds were opened and within a week the tree was in full bloom. Dried flowers remained on the tree until April first week. Green juvenile fruits were formed in the first week of March and fruiting continued in April. The fruits were within perianth by the last week of March. The emergence of fruits from the perianth tube was slowly. The fruits were completely out of the perianth by the last week of April. Fruits matured slowly and became dark green by the first week of May and ripened to black by the last week of May and fallen off in June.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Agasthyamala, 22.10.2003, *P.S. Udayan et al.* (CMPR); Athirumala, 15.03.2008, *P.S. Udayan et al. 4807* (CMPR); Pandipath, 14.02.2009, *P.S. Udayan et al.* 5658 (CMPR); Ponmudi, 08.02.2012, *Deepthy & Usha* 66190 (TBGT); Kollam district, Shenduruney, Kallar, 30.10.1992, *N. Sasidharan* 10042 (KFRI); Idukki district, Devikulam, 12.12.1970, *M. K. Sreedharan Nambiar* 174 (CALI); Vellimala, 11.12.1994, *Jomy Augustine* 14337 (KFRI); Pambadum shola, ±1800 m, 22.01.2009, *P.S. Udayan & A.J. Robi* 5465 (CMPR); *ibid.*, 28.11.2018, *P.K. Fasila 150521, 137426* (MESAH); PTR Thannikudi, Ummikuppankudi, 17.03.2009, *P.S. Udayan & A.J. Robi* 5766 (CMPR); Thannikudi, 18.03.2009, *P.S. Udayan & A.J. Robi* 5576 (CMPR); Ernakulam district, Pindimedu dam, 10.09.1985, *K.K.N. Nair* 3501 (KFRI); Thrissur district, Sholayar, ±700 m, 21.04.1981, *N.G. Nair* 1752 (KFRI); *ibid.*, ±725 m, 12.12.1988, *N. Sasidharan* 5243 (KFRI); *ibid.*, 22.03.1989, *N. Sasidharan* 5368 (KFRI); 29.01.2015, Pathadipalam, *P.K. Fasila* 137406 (MESAH); 4.04.2015, Ambalapara, *P.K. Fasila* 137422 (MESAH); Palakkad district, Parambikulam, Karimala, 07.05.2015, *P.K. Fasila & K.H. Amitha Bachan* 137454 (MESAH); Nelliyampathy, Pulayanpaara, 05.06.2010, *P.S. Udayan & A.J. Robi* 6892 (CMPR); Wayanad district, Thirunelly 24.07.1984, *R. T Balakrishnan* 40308 (CALI).

**Litsea coriacea** B. (Heyne ex Nees) Hook.f., Fl. Brit. India 5: 166. 1886; Gamble, Fl. Pres. Madras 1236. 1925; Mani., & Sivar., Fl. Calicut 251. 1982; Mohanan, Fl. Quilon Dist. 347. 1984; C.J. Saldanha & B.R. Ramesh in Saldanha, Fl. Karnataka 1: 66. 1984; V. Chandras. In A.N. Henry *et al*., Fl. Tamil Nadu 2: 209. 1987; Mani., Fl. Silent Valley 236. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 395. 1988; Vajr., Fl. Palghat Dist. 404. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 394. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 382. 1996; Sivar. & Mathew, Fl. Nilambur 586. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 569. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 425. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 610. 2009: Bhuinya *et al*., Bangladesh J. Plant Taxon. 17(2): 183–191. 2010.

*Tetranthera coriacea* Heyne ex Nees in Wall., Pl. As. Rar. 2: 66. 1831; Nees, Syst.

Laurin. 522. 1834; Miq., Fl. Nederl. Ind. 951. 1855; Meissn. in DC., Prodr. 15: 186. 1864. **(Figure 4.9.)**

**Local name**: Kanayooran, Maravettithali

Small to medium sized trees, 12–14 m high; outer bark greyish, inner bark reddish-brown; blaze creamy white; lenticels round or oval, creamy yellow; branchlets terete, glabrous, grey-brown when dry. Petiole 8–15 mm long, slender, glabrous, blackish-green; lamina 11–18×3.8–4.7 cm, elliptic, elliptic-ovate, acute or cuneate at base, margins entire, acute to acuminate at apex, sub coriaceous, glabrous, dark greenish or black above, brown below when dry; midrib prominent, puberulous on lower surface, slightly raised or flat, glabrous on upper surface; secondary nerves pinnate, 7–9 pairs, opposite at base, highly prominent below, slightly puberulous, immersed or obscure on upper surface; tertiary nerves reticulate, prominent on abaxially, obscure adaxially. Umbel sessile or sub sessile, axillary of leaves or leaf scars, in cluster of 5–6, pubescent; each umbel 4–3×3 mm, 4–5 flowered. Flowers c.3.2×3 mm, white, silky pubescent, glossy; pedicel c.2 mm long, densely silky tomentose; involucre bract 4–6 mm long, obovate, fleshy, within glabrous, without silky tomentose. Perianth tube conical; tepals c.3×1.8 mm, white to yellowish, lanceolate or oblong, acute at apex, free, finely silky tomentose without, inner glabrous. Male flowers: stamens yellowish-green, filaments slender, villous; first whorl of stamen c.2 mm long, anther c.0.5 mm long, with 2 upper small lobes and large lower lobes, filament c.1.25 mm long; 2$^{nd}$ whorl c.1.3 mm long, anther c.0.5 mm long, filament c.0.8 mm long; third whorl c.2 mm long, lobes almost equal, anther c.0.5 mm long, filament c.1.5 mm long, glandular, gland c.0.4×4 mm, cordate or orbicular, glabrous, white, shortly stipitate; pistillode rudimentary. Female flower: ovary c.1.5 mm long, ovoid, pubescent; style 1–1.3 mm long, thick, glabrous; stigma dilated; staminodes 1.5–2 mm long, outer whorl linear or clavate, and 2 inner whorl subulate and glandular. Berry 1.4−1.8×0.8−1 cm, ovoid, greenish-white spot at young, and turned to red when mature, seated in a cup-shaped perianth tube. Seed 1, c.1.25×0.6 cm, oblong, dark brown.

**Flowering** & **Fruiting**: Flowering from December to March. Fruiting from April to May.

**Distribution**: *Litsea coriacea* is distributed in South India (Karnataka, Kerala and Tamil Nadu). In Kerala it is distributed in all districts.

**Habitat**: The taxon is widely distributed in semi evergreen and evergreen forests on low elevations ranging from 200-1200 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Litsea bourdillonii* Gamble, *Myristica beddomei* King, *Cullenia exarillata* Robyns, *Diospyros crumenata* Thw., *Actinodaphne wightiana* (Kuntze) Noltie, *Glochidion ellipticum* Wight.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds appeared in late December and remained almost unchanged in appearance till the end of January. Buds were swollen by February. Flowers bloomed randomly all over the tree. By late March, half of the total buds were open and within a week the tree was in full bloom. Dried flowers

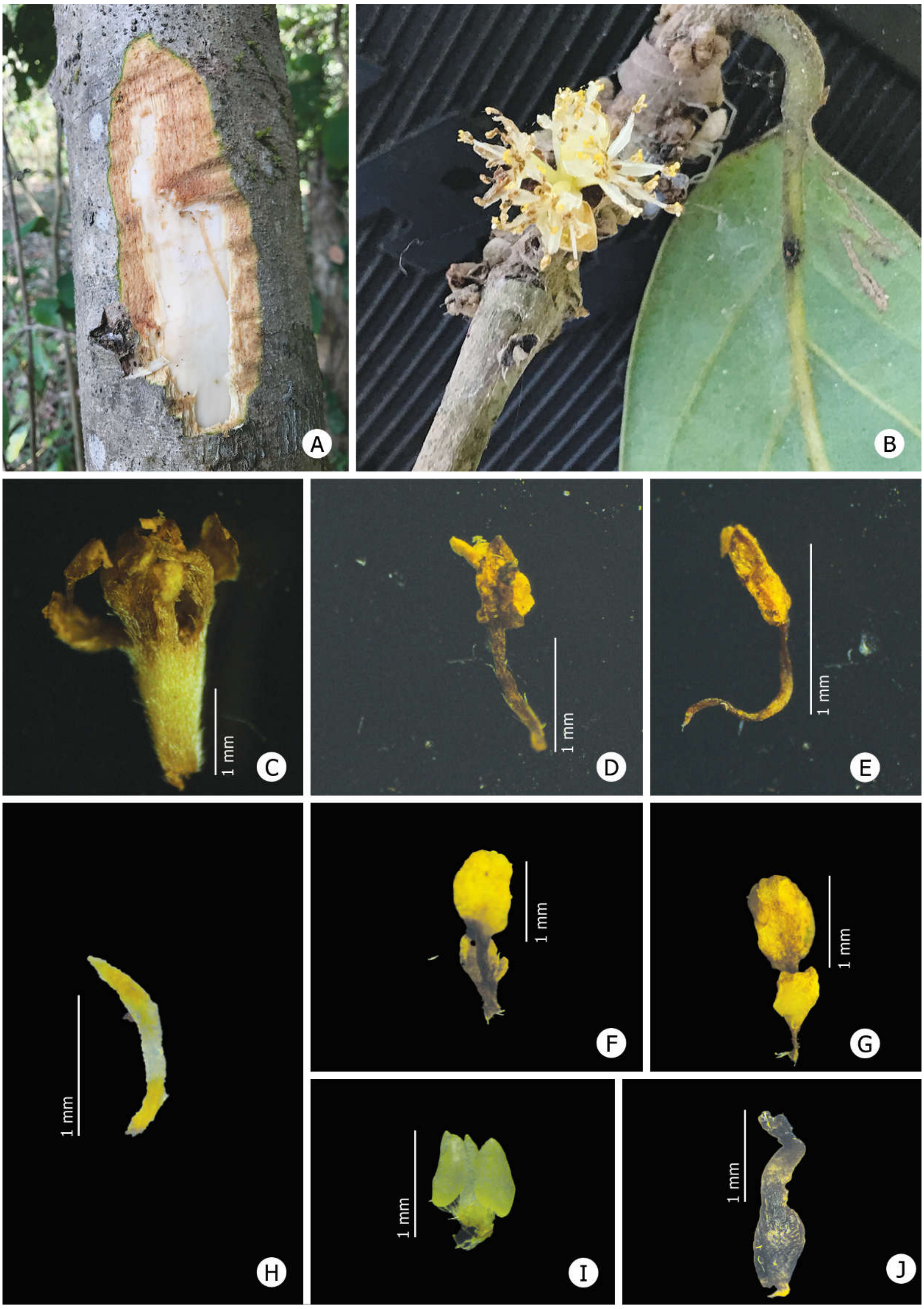


**Figure 4.9.** ***Litsea coriacea*** B.(Heyne ex Nees) Hook.f.**:** **A.** Blaze; **B.** Flowering twig; **C.** Female flower; **D.** 1$^{st}$ whorl of Stamen; **E.** 2$^{nd}$ whorl of stamen; **F.** 3$^{rd}$ whorl of stamen outer view; **G.** 3$^{rd}$ whorl of stamen inner view; **H & I.** Staminode; **J.** Pistil.

remained on the tree until March. Green juvenile fruits were formed in the first week of March and fruiting continued in April. The fruits were within the perianth by the last week of March. The emergence of fruits from the perianth tube was slow. The fruits were completely outside the tube by the second week of April. Fruits matured slowly and ripened to black by the second week of May and fallen off in June.

**Specimens examined**: IINDIA, **Kerala**, Thiruvananthapuram district, Bonnacord, 23.12. 1988*, N. Mohanan* 7942 (TBGT); Garden site, 9.05.1990, *C. Anikumar* 2509 (TBGT); Karamanayar, 17.09.1991*, N. Mohanan* 10746 (TBGT); Ponmudi, 14.11.1996, *N. Ravi* 31786 (TBGT); Kulathupuzha, 09.04.1997, *T. Shaju* 33636 (TBGT); Mankulam, 27.06. 2001, *T. Shaju* 46121 (TBGT); Kottukal, 22.07.2004, *Geethakumary* 55012 (TBGT); Kollam district, Palaruvi, ±450 m, 10.11.1984, *E.N. Vanaja* 2867 (CALI); *ibid.*, ±450 m, 10.11. 1984, *M.V. Sowmini* 1267 (CALI); Kottarakkara, ±175 m, 19.08.1986, *V. Usha* 3374 (CALI); *ibid.*, ±50 m, 19.08.1987, *T.G. Jaisonlal* 4572 (CALI); Kulathupuzha, 07.02.2008, *P.S. Udayan, et al.* 4504 (CMPR); Alappuzha district, Vallikkavu, ±10 m, *C.N. Sunil* 2479 (CALI); Kottayam district, Peringulam, Vellapara, 01.04.2009, *A.J. Robi* 5887 (CMPR); Wagamon hills, Vellikulam, 03.04.2010, *A.J. Robi 6757* (CMPR); *ibid.*, 04.10. 2010, *A.J. Robi* 6974 (CMPR); Idukki district, Vellakadavu, Periyar tiger Reserve, ±600 m, 30.04.1994, *N. Sasidharan & Jomy Augustine* (KFRI); Kurisumala, 1.06.1998, *S.D. Biju 3844* (TBGT); Thrissur district, Vazhachal, ±350 m, 22.03.1979, *N. Sasidharan 724* (KFRI); *ibid.*, ±350 m, 08.01.2019, *P.K. Fasila 150529* (MESAH); Karanthodu, 25.12.2018, *P.K. Fasila* 150525 (MESAH); Ambalapara, Pathadipalam Sholayar, 04.04.2015, *P.K. Fasila* 137428*,* 137436 (MESAH); *ibid.*, 03.01.2018, *P.K. Fasila* 137461 (MESAH); Palakkad district, Kudukki, Silent valley, 9.05.2019, *P.K. Fasila & K.H. Amitha Bachan* 150547 (MESAH); Malappuram dist, Nadukani, Way to Gudallur, 18.01,1979, *N. Sasidharan* 457 (KFRI); Nedumkayam, 29.01.1981, *Philip Mathew 28749* (CALI); *ibid.*, 06.05.1981, *Philip Mathew* 28450 (CALI); Gudallur, 07.05.1982, *Philip Mathew 33197* (CALI); Nadukani, Nilambur, ±600 m, 30.10. 1986, *V.M. Naseem Bhanu* 3818 (CALI); Nilambur, ±600 m, 30.10.1986, *E.V Sowmya 1788* (CALI); *ibid.*, ±500 m, 30.10.1986, *V.J. Jessy* 2489 (CALI); New Amarambalam, Panapuzha, ±450 m, 12.05.1999, *R. Jayakumar* 21520 (KFRI); CU

Campus, 25.08.1987, *C.J. Scaria* 5111(CALI); *ibid.*, 16.06.1989, *A.V. Remavathy* 4317 (CALI); *ibid.*, 08.07.1989, *V.N. Ushakumari* 4810 (CALI); *ibid.*, 12.08.1989, *Betzy K. Mathai*. (CALI); *ibid.*, 02.10. 1989, *Solly George 3201* (CALI); *ibid.*, 15.11.1989, *A. Mini* (CALI); *ibid.*, 14.01.1990, *N.K. Mini* 2501 (CALI); *ibid.*, 02.03.1990, *Beena T. Cheriyan* 2801 (CALI); *ibid.*, 13.07. 1990, *K. Aravind* 1341 (CALI); *ibid.*, 14.12.1990, *A. Yusuf* 2137 (CALI); Kottakkal, AVS Herbal Garden, 22.12.2009, *A.J. Robi* 6519 (CMPR); *ibid*., 22.12.2009, *A.J. Robi* 6520 (CMPR); Wayanad district, Wayanad, ±900 m, 18.11.1985, *P. Geetha* 6633 (CALI); *ibid.*, ±900 m, 23.11.1985, *A.K. Valsa* 7182 (CALI); Lakkidi, ±900 m, 18.11.1985, *M.P. Anitha* 5636 (CALI); *ibid.*, ±900 m, 16.12.1985, *Breezy George* 7611 (CALI); Kannur district, Kottiyur, 28.10.1991, *T. Rajasree* 2766 (CALI); Aralam to Meenmutty, 21.02.2008, *P.S. Udayan et al.* 4711 (CMPR); Nedumpoyil, 24.02.2008, *P.S. Udayan et al.* 4755 (CMPR); *ibid*., 24.02. 2008, *P.S. Udayan et al.* 4759 (CMPR).

**Litsea floribunda** (Blume) Gamble, Fl. Pres. Madras 1238. 1925; Mohanan, Fl. Quilon Dist. 347. 1984; C.J. Saldanha & B.R. Ramesh in Saldanha, Fl. Karnataka 1: 66. 1984; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 210. 1987; Mani., Fl. Silent Valley 236. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 395. 1988; Vajr., Fl. Palghat Dist. 405. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 394. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 382. 1996; Sivar. & Mathew, Fl. Nilambur 587. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 569. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 425. 2005; Bhuinya *et al*., Bangladesh J. Plant Taxon. 17(2): 183–191. 2010.

*Cylicodaphne floribunda* Blume, Mus. Bot. Lugd.-Bat. 1: 387. 1851.

*Tetranthera wightiana* auct. non Nees: Beddome, Fl. Sylv. S. India t. 293. 1873.

*Litsea wightiana* Hook.f., Fl. Brit. India 5: 177. 1886. **(Figure 4.10.)**

**Local name**: Pattuthali

Small to medium sized evergreen tree; 10–20 m heigh; outer bark greyish-brown, smooth, brittle, inner bark dark brown; blaze light-brown; lenticels few, horizontal; branchlets terete, puberulous, rather slender; young shoots reddish-pubescent, dark green to blackish above, golden-brown below when dry; young leaves reddish, densely fulvous tomentose. Petiole 13–20×2–3 mm, stout, tufty tomentose, golden-brown to dark- brown; lamina 7–28×4.5–10 cm, ovate to elliptic, oblanceolate, clustered towards the apex, acute or obtuse at base, margins entire, slightly incurved on lower surface, obtusely acute or acute at apex, coriaceous, fulvous pubescent, yellowish above, dark brown below when dry; midrib raised, golden-brown on abaxially, slightly impressed adaxially, pubescent on both surface; secondary nerves pinnate, 11–17 pairs, opposite in base up to 4 pairs, prominent, looped towards the margin, pubescent on abaxially, highly impressed on adaxially golden brown; tertiary nerve distinct, and scalariform on abaxially, obscure on adaxially. Inflorescence up to 5–8 cm long, tomentose; each umbel 5–6×5 mm, 6–8 flowered; peduncle 5–15 mm long, fulvous tomentose. Flowers, c.7×6 mm, white to yellowish, glossy; pedicel c.3 mm long, pubescent; involucre bract c.10×8 mm, whitish-yellowish, concave, fleshy, without glabrous, within white, silky tomentose; tepals 3–4×1.5–1.8 mm, white to yellowish, free, in one row, lanceolate or oblong, acute at apex, without fulvous tomentose, within glabrous. Male flower: stamens white, filaments villous; first whorl of stamen c.4 mm long, anther c.1.2 mm long, filament c.2.8 mm long, 2 upper lobes small, lower lobes large; 2$^{nd}$ whorl c.3 mm long, anther c.1mm long, filament c.2 mm long; third and 4$^{th}$ whorls glandular with 2 stalked gland, c.3 mm long, anther c.1 mm long, filament c.2 mm long; gland 0.8–1 mm long, obovate, glabrous, shortly stipitate, white; pistillode minute, c.0.5 mm long, fulvous pubescent. Female flower: ovary c.0.1 mm long, ovoid, glabrous; style thick, c.0.5 mm long, glabrous; stigma irregularly lobed or discoid; staminodes same as stamens of male flower, outer whorl clavate or linear, 2 inner whorls subulate and glandular. Berry 1.8−2×0.9−1.2 cm, ovoid, or cylindrical globose, pale green with white spot at young and become reddish brown when mature, seated in a brown coloured turbinate perianth tube. Seed 1, 1.1–1.3×0.7–0.8 cm, oblong, dark brown.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from April to May.

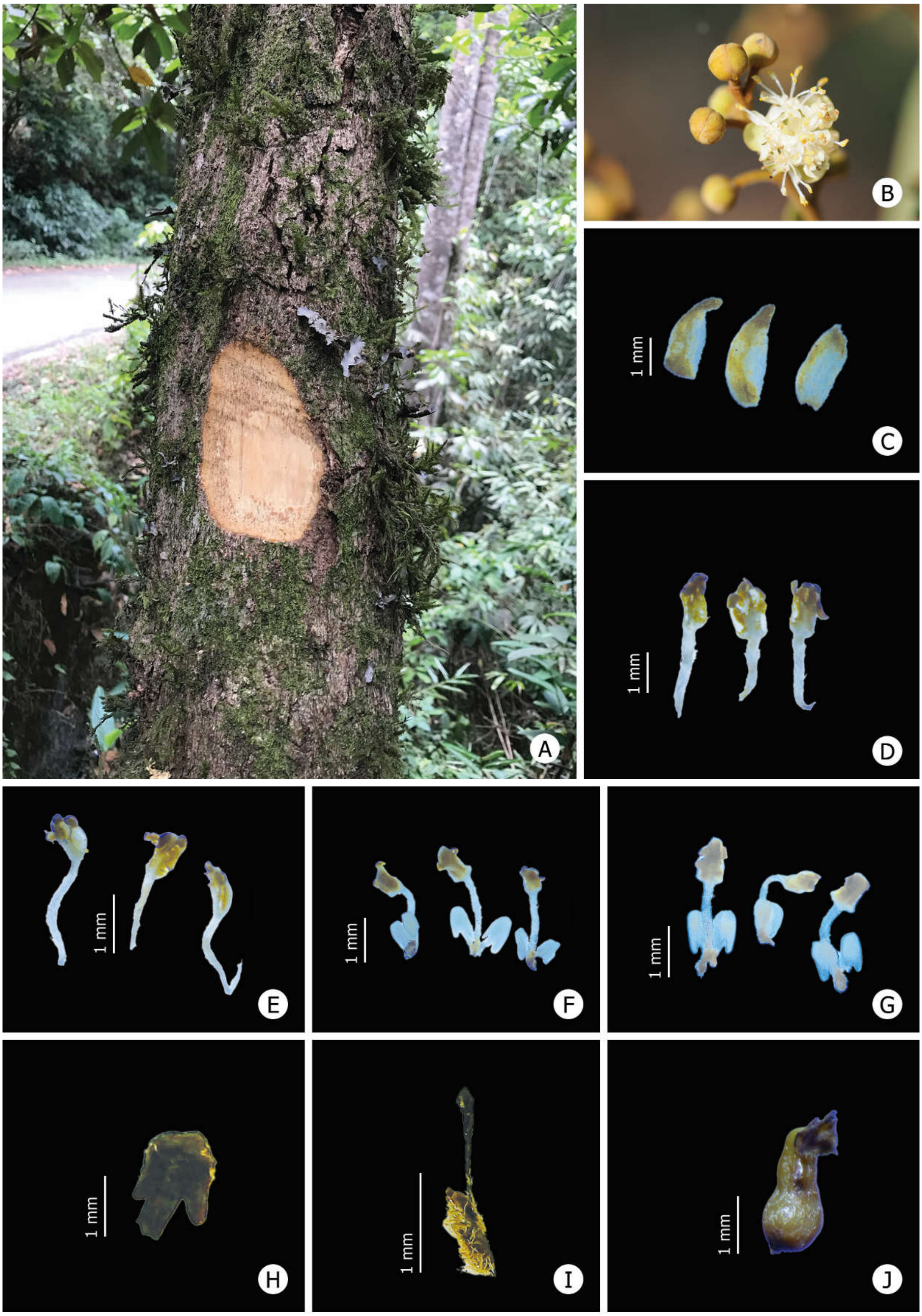


**Figure 4.10.** ***Litsea floribunda*** (Blume) Gamble**: A.** Blaze; **B.** Flowering twig; **C.** Tepals; **D.** 1st whorl of stamens; **E.** 2nd whorl of stamens; **F.** 3rd whorl of stamens; **G.** 4th whorl of stamens; **H.** Gland; **I.** Rudimentary pistil; **J.** Pistil.

**Distribution**: *Litsea floribunda* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala, it is distributed in Palakkad, Kollam, Idukki, Pathanamthitta, Malappuram, Kannur, Trivandrum, Thrissur and Wayanad districts.

**Habitat**: Distributed in evergreen and wet evergreen rain forest areas of the Western Ghats in an altitude range from 500-1200 m. It is a medium sized tree seen associated with *Litsea bourdillonii* Gamble., *Palaquium ellipticum* (Dalz.) Baill, *Cullenia exarillata* Robyns., *Diospyros crumenata* Thw.

**IUCN Status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds appeared in early January and remained unchanged in appearance for a whole month. Buds began to open by the second week of February and by March first week the tree was in full bloom. By first week of April, green juvenile fruits appeared. The fruits were within the perianth by the last week of April. Fruits slowly emerged from the perianth tube and was completely outside by the first week of May. Fruits matured by the first week of May. Fruits were ripened to black and were fallen off by the second week of June.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Pongalapara, ±1400 m, 07.02.1988, *N. Mohanan* 9525 (CALI); Agasthyamala, ±1700 m, 14.10.1988, *N. Mohanan* 4408 (TBGT); Ponmudi, ±900 m, 17.01.1989, *N. Sasidharan* 5280 (KFRI); *ibid.,* 09.02. 2018, *Deepthy & Usha* 93508 (TBGT); Bonocord, ±100 m, 03.12.2003, Geetha Kumary 49487 (TBGT); *ibid.,* 28.08.2010, *Deepthy & Usha* 64416 (TBGT); Idukki district, Kalvarimala Periyar Tiger reserve, ±1750, 18.09.1981, *N. Sasidharan & Jomy Augastine* 13862 (KFRI); Border shola, ±2100 m 24.02.1995, *S.D. Biju* 34592 (TBGT); Eravikulam shola to Poovar ±900 m, 2.05.1995, *S.D Biju* 37456 (TBGT); Memala, 29.11. 1996, 1100 m *N Ravi & N Mohanan* 31843 (TBGT); Bison valley 17.03.1998, *S.D Biju* 37948 (TBGT); Pampadumshola N.P, 28.11.2018, *P.K. Fasila* 150515 (MESAH); Thrissur district, Sholayar, ±700 m, 2.04.1981, *K.K.N. Nair* 1761 (KFRI); *ibid., K.H. Amitha Bachan*

99179 ±700 m (CALI); *ibid.,* 30.04.2018, *P.K. Fasila* 137483 (MESAH); Pathadipalam, 29.01.2015, *P.K. Fasila* 137407 ±870 m (MESAH); 26.12.2014, Swapnamudi, *P.K. Fasila* 137402 ±765 m (MESAH); Malakkappara, Kasarapara, 23.09.2018, *P.K. Fasila* 137496 (MESAH); 19.04.2019, 150538 (MESAH); Palakkad district, Dam site S.V., ±1100 m, 25.02.1982, *K.S. Prasannakumar* 10283 (CALI); *ibid.,* 14.01.1993, *E.S. Santhosh Kumar*, 15928 (TBGT); Aruvanppara, 12.01.2003, *A. Nazarudheen* 15827 (TBGT); Parambikulam, Pandaravari, 06.12.2008, *A.J. Robi* 5315 (CMPR); Poochappara, 07.03.2009, *P.S. Udayan & A.J. Robi* 5691 (CMPR); Sispara, 08.03.2009, *P.S. Udayan & A.J. Robi* 5713 (CMPR); Walakkad, 08.03.2009, *P.S. Udayan & A.J. Robi* 5703 (CMPR); Silent valley, 12.01.1993, *E.S. Santhosh Kumar* 15564 (TBGT; *ibid.*, 22.04.2018, *P.K. Fasila* 137475 (MESAH); Malappuram district, Nadukani, 02.10.1981, *Philip Mathew* 28794 (CALI); New Amarambalam, ±1800 m, 16.12.1999, *R. Jayakumar* 21330 (KFRI); New Amarambalam, Erumala, ±1500 m, 12.02.2000, *R. Jayakumar* 21392 (KFRI); *ibid.*, ±1700 m, 06.12.2000, *R. Jayakumar* 21710 (KFRI); Kozhikode district, Kakkayam, 25.03.2008, *P.S. Udayan et al.* 4868 (CMPR); *ibid.,* 25.03. 2008, *P.S. Udayan et al.* 4890 (CMPR); Wayanad district, Thariyode R F, 21.10. 1984, *R.T. Balakrishnan* 40698 (CALI); Wayanad, ±740 m, 11.12.1997, *K. Shyjan* 60131 (CALI); Pakshipatalam, 30.10.2007, *Kulloli & Rama Sabu* 61503 (TBGT) ; *ibid.*, 26.03.2009, *P.S. Udayan & A.J. Robi* 5820 (CMPR); Pookode, ±720 m, 11.12.1997, *P.S. Sijimol* 59633 (CALI); *ibid.*, ±720 m, 11.12.1997, *Lincy Antony* 59736 (CALI); *ibid.*, ±740 m, 10.04.2001, *A.K. Pradeep* 70553 (CALI); Soochipara, ±780 m, 11.12.1998, *K.B. Bindhu* 62049 (CALI); *ibid.*, ±800 m, 11.12.1998, *K. Sinitha* 59441 (CALI); Perya, Theerthakundu, 07.04.2009, *P.S. Udayan & A.J. Robi* 5855 (CMPR); 30.10.2007 *Kalloli & Ram Sabu* 61503 (TBGT).

**Litsea nigrescens** Gamble, FI. Pres. Madras 1236. 1925; Ahmedullah & M. P. Nayar End. PI. Ind. Reg. 1: 66. 1986; V. Chandras. in A. N. Henry *et al.*, FI. Tamil Nadu 2: 211. 1987.

*Tetranthera panamanja* sensu Wight, Ic. t. 1836. 1852, non Buch. -Ham. 1830.

Small to medium sized evergreen tree, 10–20 m high; branchlets terete, black-brown, glabrous. Petiole 1–1.5 cm long, stout or slender, grooved above, glabrous, blackish when dry; lamina 8–16×2.5–6 cm, ovate to elliptic, obtusely round at base, margins entire, acute at apex, thick coriaceous, glabrous, blackish above, greyish below when dry; midrib raised on abaxially, slender channelled on adaxially, glabrous, black on dry; secondary nerves 8–12 pairs, raised, slender, arcute on lower surface, spacing c.0.5 cm long in smaller leaves, 2–2.5 cm long in larger leaves, glabrous, obscure on upper surface; tertiary nerve not distinct. Inflorescence in the axile of leaves or along branches. Male raceme in panicle, 2–6 cm long, glabrous; each raceme 3×4–5 mm, silky tomentose, 6-flowered; peduncle c.5 mm long, pubescent. Flowers c.5×3 mm, greenish to whitish, silky pubescent, glossy; pedicel c.0.5 mm long, silky tomentose, involucre bract 3×3–4 mm, concave, fleshy, silky tomentose without, within glabrous. Perianth tube conical, c.0.5 mm long, silky tomentose; tepals 1.5–2×1.2–1 cm, ovate to lanceolate, apex obtuse to acute, coriaceous, silky tomentose on upper surface, inner glabrous, creamy-whitish to greenish. Male flowers: anthers oblong, apex acuminate, or obtuse, yellowish to brown; filaments short hairy; the outer 2 whorls, stamens c.1.3 mm long, anther 0.7–1 mm long, filament 0.3–0.5 mm long, 2 upper lobes slightly smaller than lower lobe; third whorl glandular, anther c.1 mm long, filament c.0.2 mm long; gland 0.5–0.8 mm long, orbicular, puberulous, shortly stipitate, white; pistillode rudimentary. Female flower not seen. Fruit not seen.

**Flowering & Fruiting**: Flowering from September to February. Fruiting from March to June.

**Distribution**: *Litsea nigrescens* is distributed in South India (Kerala and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala, it is distributed in Thrissur.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of high elevations ranging from 900-1200 m in the of Southern Western Ghats. It is a large sized tree seen associated with *Melicope lunu-ankenda* (Gaertn.) Hartley., *Aglaia barberi* Gamble., *Schleichera oleosa* (Lour). Oken., *Phoebe lanceolata* Nees.

**IUCN Status**: Vulnerable under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds appeared in the last week of October and remained almost unchanged in appearance by the third week of December. Buds began to open by early January. Flowering was sparse. Fruiting could not be observed during the study period.

**Specimens examined**: INDIA, **Kerala**, Thrissur district, Malakkappara, High Forest Myladumpara, 23.09.2009, *P.K. Fasila* & *K.H. Amitha Bachan* 150507 (MESAH).

**Litsea oleoides** (Meisner) Hook. f., Fl. Brit. India 5: 175. 1886; Gamble, Fl. Pres. Madras 1236. 1925; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 397. 1988; Vajr., Fl. Palghat Dist. 405. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 395. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 383. 1996; Sivar. & Mathew, Fl. Nilambur 587. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 571. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 425. 2005.

*Tetranthera oleoides* Meisn. in DC., Prod. 15(1): 195.1864. **(Figure 4.11.)**

**Local name**: Matthi

Large evergreen trees, 10–30 m high; outer bark 8–10 mm thick, brown, smooth, slightly rugose, inner bark light brown; blaze creamy-white to light-brown; lenticels few, oval, pale-brown; branchlets sub terete, slightly rugose, greyish or blackish when dry. Petiole 2.5–3 cm long, slender, grooved above, glabrous, yellowish, blackish when dry; lamina 7–15×4–5.5 cm, elliptic, elliptic-oblong, or lanceolate, acute, rounded or narrowed at base, margins entire slightly incurved on lower surface, obtuse, acute at apex, thickly coriaceous, yellowish brown above, brownish red below when dry; midrib prominent on abaxially, slender, on adaxially, yellow to light-brown on lower side, prominent gradually channelled towards the tip on upper surface; secondary nerves pinnate, 7–10 pairs, slightly raised on lower surface, obscure on upper surface; tertiary nerve random reticulate. Racemes 2–6 cm long, up to 7 flowers in one umbel; peduncle c.6×1.2 mm, tomentose. Flowers 6–8×4–6 mm, yellow or greenish-white, glossy, pubescent; pedicel 7–8 mm long, silky tomentose;

involucre bract, 8–9×9 mm, orbicular, fleshy, without silky tomentose, within glabrous, deciduous in flower. Perianth tube conical; tepals c.4×2 mm, white to yellowish, broad-lanceolate, acute at apex, thick, brown fulvous tomentose without, within glabrous. Male flowers: stamens yellowish-green, filaments slender, villous; first whorl anther c.2 mm long, filament 4–4.2 mm long; second whorl same as that of first whorl of stamen; third whorl stamen c.3.2 mm long, anther c.0.7 mm long, filament c.2.5 mm, with 2 small glands at base; gland 0.6–1×0.5 mm, orbicular, puberulous, shortly stipitate, white; pistillode rudimentary. Female flower: ovary c.1mm long, globose, glabrous; style thick, c.1mm long; stigma capitate, papillose; staminodes: outer 2 whorls linear or clavate, inner whorl subulate and glandular, c.2 mm long. Berries 3.8−4×2.4−3 cm, depressed globose or hemispherical, subtended by the undulate perianth tube, red with white spots on mature, pale green to dark green, when young. Seed 1, 1.5–2.25 cm, hemispherical, light brown.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from February to April.

**Distribution**: *Litsea oleoides* is distributed in South India (Kerala and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala, it is distributed in Idukki, Palakkad, Kollam, Pathanamthitta, Malappuram, Kannur, Trivandrum, Thrissur and Wayanad districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on high elevation ranging from 800-1400 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Myristica beddomei* King., *Elaeocarpus tuberculatus.,* *Dysoxylum malabaricum* Bedd. Ex. Hiern in Hook., *Canarium strictum* Roxb., *Hydnocarpus alpina* Wight.

**IUCN Status**: Vulnerable under criteria B1ab (iii)+2ab (iii)

**Phenology**

Flowering only once in year. Flower buds appeared in early November and remained unchanged in appearance for a whole month. Buds began to open by second week of December and flowers bloomed randomly all over the tree. By the

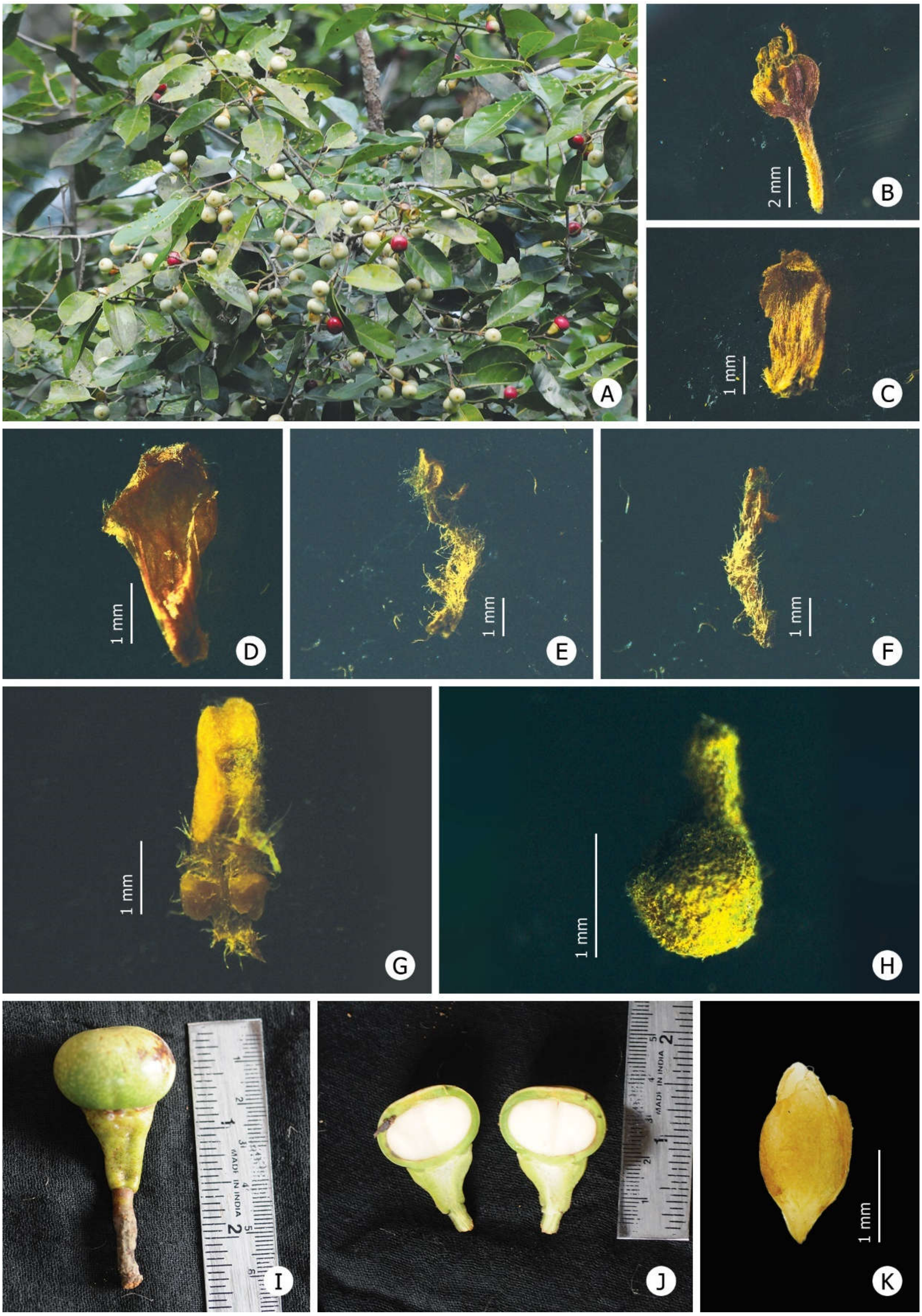


**Figure 4.11.** ***Litsea oleoides*** (Meisn.) Hook. f.**:** **A.** Habit; **B.** Flower; **C & D.** Tepal outer and inner view; **E.** 1st whorl of stamen; **F.** 2nd whorl of stamen; **G.** 3rd whorl of stamen; **H.** Pistil; **I.** Fruit; **J.** Fruit L.S; **K.** Embryo.

second week of January, the entire tree was in full bloom. Flowering continued till January last. Fruits were formed by the first week of February. The fruits were within the perianth by the last week of February. The emergence of fruits from the perianth tube was slow. The fruits were completely out of the perianth by the second week of April. Fruits matured slowly and ripened to pink by first week of April. By the last week of April, the ripened fruits were fallen.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Bonaccord, 25.04.1990, *N Mohanan 8*24742 (TBGT); Attayar, 18.05.1991, *N Mohanan* 10830 (TBGT), Kollam district, Kallar, Shendurney Wild life Sanctuary, ±800 m, *N. Sasidharan* 10766 (KFRI); Idukki district, Kokkara, Periyar Tiger Reserve, ±1000 m, 12.07.1993, *N. Sasidharan & Jomy Augustine* 12022 (KFRI); Thekkady, Periyar Tiger Reserve, ±700 m, 16.10.1993, *N. Sasidharan & Jomy Augustine* 12518 (KFRI); Mannavan chola, 21.04.1994, *A Nazarudeen* 20723 (TBGT); Anamudi, 24.02.1997, *S D Biju* 34570 (TBGT); Pambadum shola, 23.01.2009, *P.S. Udayan & A.J. Robi* 5477 (CMPR); *ibid*., 05.05.2010, *P.S. Udayan et al.* 6790 (CMPR); Thrissur district, Sholayar, ±700 m, 12.08.1981, *N.G. Nair* 49 (KFRI)*;* 3.04.2015, *P.K. Fasila* 137412 (MESAH) *ibid.,* 3.04.2018, *P.K. Fasila* 137482 (MESAH); *ibid;* 18.04. 2019, *P.K. Fasila* 150536 (MESAH), *ibid*; Palakkad district, Nelliyampathy, ±800 m, 25.04.1984, *Sasidharan & Swarup* 3110 (KFRI); *ibid*., 31.05.2008, *P.S. Udayan et al.* 5091 (CMPR); Parambikulam, Sheikalmudi, 20.04.2019, *P.K. Fasila,* 150542 (MESAH); Nelliyampathy, 11.05.2019, *P.K. Fasila* 150555 (MESAH); *ibid;* 19.01.2020, *P.K. Fasila* 150574 (MESAH); Malappuram district, Thalichola, 05.02.1982, *Philip Mathew* 33098 (CALI).

**Litsea stocksii** (Meisn.) Hook.f., Fl. Brit. India 5: 176. 1886; Gamble, Fl. Pres. Madras 1236. 1925; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 211. 1987; Mani., Fl. Silent Valley 237. 1988; Vajr., Fl. Palghat Dist. 406. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 395. 1994; Bhuinya *et al*., Bangladesh J. Plant Taxon. 17(2): 183–191. 2010.

*Cylicodaphne oblonga* Meisn. var. *stocksii* Meisn. in DC., Prodr. 15(1): 205. 1864. *Cylicodaphne wightiana* var. *glabrescens* Meisn. in DC., Prodr. 15(1): 205. 1864. *Cylicodaphne myristicae folia* var. *acutata* Meisn. in DC., Prodr. 15(1): 205. 1864.

Litsea s*tocksii* (Meisn.) Hook.f. var. *glabrescens* (Meisn.) Hook.f., Fl. Brit. India 5: 176. 1886; Gamble, Fl. Pres. Madras 1236. 1925; C.J. Saldanha & B.R. Ramesh in Saldanha, Fl. Karnataka 1: 69. 1984.

*Litsea stocksii* (Meisn.) Hook.f. var. *acutata* (Meisn.) Hook.f., Fl. Brit. India 5: 176. 1886.

*Litsea vartakii* M.R. Almeida in J. Bombay Nat. Hist. Soc. 86(2): 180. 1989, nom. superfl. *Litsea josephii* S.M. Almeida, Fl. Sawantwadi 1: 364. 1990, nom. superfl.; Londhe in N.P. Singh et al., Fl. Maharashtra state, Dicot. 2: 831. 2001. **(Figure 4.12.)**

**Local name**: Varikkeera

Small to medium sized evergreen tree, 10–15 m high; bark brown; branchlets terete or sub terete, glabrous, dark brown to black when dry. Petiole 0.5–20×2–3 mm, slender or stout, glabrous, sulcate above, dark brown to black when dry; lamina 5–18×1.5–6 cm, elliptic obovate, oblong, or lanceolate, acute or narrowed at base, margins entire, slightly incurved on abaxially, acute, obtuse, obtusely acute or acuminate at apex, coriaceous, dark greenish to brownish above, yellowish-brown to light-brown glaucescent below when dry; midrib elevated, dark brown on lower side, slightly impressed on upper surface, glabrous on both surface; secondary nerves pinnate, 8–12 pairs, slender, arcute, raised on lower surface, obscure or slightly channelled on upper surface, glabrous; tertiary nerve obscure or reticulate, slightly visible on lower surface. Racemes in the axile of leaves or along branches, 1.5–4 cm long, pubescent; each umbel 3–4×3 mm, 6–8 flowered; peduncle 0.5–10 mm long, pubescent; Flowers 2–4×1–3 mm, white to yellowish, glossy, fulvous pubescent; pedicel c.1 mm long, pubescent; involucre bract 3.7–6×3–4 mm, concave, imbricate, fleshy, within glabrous, without white silky tomentose, whitish-yellowish, deciduous in flower. Perianth tube conical; tepals 1.2–1.5×1–1.2 mm, white to yellowish, free in one whorl, ovate, lanceolate or oblong, acute at apex, membranous, fulvous tomentose on without, within glabrous. Male flower not seen. Female flower: ovary c.1 mm long, ovoid, glabrous; style c.1 mm long, thick, glabrous; stigma irregularly lobed or discoid; staminodes, outer 2 whorls 1.2–1.5 mm long, clavate or linear, inner whorl 1.1–1.4 mm long, subulate, glandular, gland white, non stipitate. Berry

2.1−2.5×0.8−1.5 cm, ovoid or ellipsoid, pale green with white spot at young, reddish brown when mature, seated in a brown-coloured cupule like perianth tube. Seed 1, 1.5–1.8×0.7–1 cm, oblong, dark brown.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from February to June.

**Distribution**: *Litsea stocksii* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed Wayanad, Idukki, Thrissur, Palakkad, and Thiruvananthapuram districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of high elevations ranging from 900-1200 m in the of Southern Western Ghats. It is a large sized tree seen associated with *Melicope lunu-ankenda* (Gaertn.) Hartley*, Aglaia barberi* Gamble*, Schleichera oleosa* (Lour). Oken*, Phoebe lanceolata* Nees.

**IUCN Status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in a year. Flower buds appeared in early November and remained almost unchanged in appearance for a whole month. Buds began to open by the first week of December and flowers bloomed randomly all over the tree. By first week of January, all buds were opened and within a week the tree was in full bloom. Flowering continued till the end of January. Green fruits appeared by the second week of January. The fruits were within the perianth by the last week of February. The fruits slowly emerged from the perianth tube and were completely outside by the second week of March. Fruits matured into black and fallen off by the last week of April.

**Specimens examined:** INDIA, **Kerala**, Trivandrum district, TBGRI campus, 23.11.1996, *S. Suresh,* 27819 (TBGT); Kallar, 18.12.1997, *Abdul Jabbar* 41276 (TBGT); Kollam district, Pathanapuram, 18.12.2003*, Deepthy & Geetha* 53116 (TBGT); Malavana, 30.01.2004, *Geetha & Deepthy* 53194 (TBGT); Thrissur

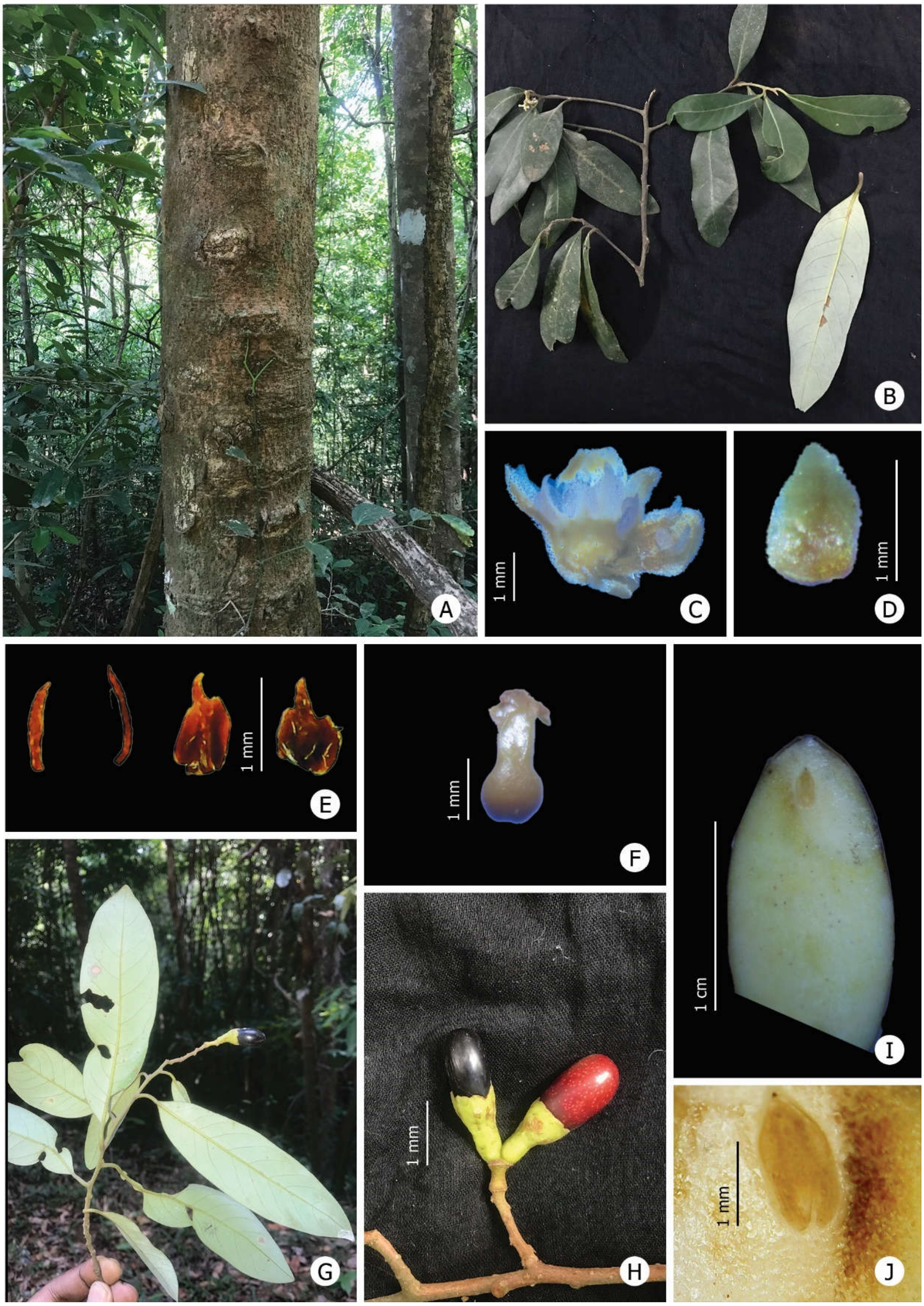


**Figure 4.12.** ***Litsea stocksii*** (Meissn.) Hook.f.**:** **A.** Habit; **B.** Flowering twig; **C.** Flower; **D.** Tepal; **E.** Staminodes; **F.** Pistil; **G.** Fruiting twig; **H.** Ripened fruit; **I.** Seed L.S; **J.** Embryo.

district, Sholayar, Chandanthodu, 03.03.2020, *P.K. Fasila & K.H. Amitha Bachan* 150581 (MESAH); Palakkad district, Valliyaparathode, ±1350 m, 25.05.1982, *K.S.* Prasannakumar SV10386 (CALI); Sheikalmudi, 23.01.2017, *P.K. Fasila & K.H. Amitha Bachan* 137499 (MESAH); *ibid* 20.04. 2019, 150543, 150544 (CALI); Silent Valley, Sirendri, 10.05.2019, *P.K. Fasila & K.H. Amitha Bachan* 150552 (MESAH); *ibid*., Pathenthodu, 10.05.2019, *P.K Fasila & K.H. Amitha Bachan* 150549 (MESAH); Nelliyampathy, Karimala, 13.05.2019, *P.K Fasila & K.H. Amitha Bachan* 150565 (MESAH); Malappuram district, Kedakkamala, New Arambalam R.F, 11.04. 1999, *R. Jayajumar* RJ20380 (KFRI).

**Litsea wightiana** (Nees) Hook.f., Fl. Brit. India 5: 177. 1886; Gamble, Fl. Pres. Madras 1238. 1925; C.J. Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 70. 1984; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 211. 1987; N. Mohanan & Sivad., Fl. Agasthyamala 572. 2002; Sasidh., Fl. Parambikulam WLS 271. 2002; Bhuinya *et al*., Bangladesh J. Plant Taxon. 17(2): 183–191. 2010.

*Cylicodaphne wightiana* Nees in Wall., Pl. Asiat. Rar. 2: 68 & 3: 31. 1831; Wight, Icon. Pl. Ind. orient. t. 1833. 1852; Dalz. & Gibs. Bombay Fl. 222. 1861.

*Tetranthera wightiana* Wall. in Num. List. 1830.

**Key to the varieties**

1a. Leaves elliptic to elliptic-elliptic ovate, thickly coriaceous, blackish above when dry, leaf scar prominent, 3 mm long; petiole 1cm long; racemes 4–6 cm; berries 2–2.3 x 0.7 mm, sub-globose; fruiting perianth cup-shaped ............... var. ***wightiana***

1b. Leaves obovate or oblong, coriaceous, greenish brown above when dry, leaf scar not prominent; petiole 1.5–2 cm long; racemes 4–8 cm long; berries 12–14 mm x 6–8 mm, ellipsoid; fruiting perianth obconic..................................var. ***tomentosa***

**Litsea wightiana** (Nees) Hook f. var. *tomentosa* (Meisn.) Gamble, FI. Pres. Madras 1238. 1925; Ahmedullah & M. P. Nayar, End. PL Ind. Region 1: 66. 1986.

*Cylicodaphna wightiana* Nees var. *tomentosa* Meisn. in DC., Prod. 15(1): 200. 1864.

Small to medium sized trees, 10–15 m high; outer bark brownish-black; inner bark yellow; blaze yellowish-brown; lenticels few horizontal; branchlets terete, light brown; young shoots rusty tomentose; leaf scar small, oval. Petiole 1.5–2 cm long, slightly twisted, densely pubescent, dark-brown when dry; lamina 6–14×3–5.5 cm, obovate or oblong, acute at base, margins entire, slightly recurved, obtusely acute or shortly acuminate at apex, coriaceous, glabrous, greenish-brown above, reddish-brown below when dry; mid rib prominent, fulvous tomentose on lower surface, prominent, channelled, glabrous, on upper surface; secondary nerves 4–7 pair, pinnate, arcute, highly prominent, fulvous tomentose, on lower surface, immersed, slender, glabrous below; intercostae reticulate, fulvous tomentose on lower surface, faint on upper surface. Racemes axillary or lateral clusters 4–8 cm long; each umbel 6–8×6–8 mm, 4–6 flowered, fulvous tomentose; peduncle 3–5 mm long, stout, brown, tomentose. Flowers c.3.5×4 mm, creamy yellow, silky tomentose, glossy; pedicel 1.5–2 mm long, thick, densely silky tomentose; involucre bract c.5.2×5 mm, green, concave, orbicular, thickly coriaceous, within glabrous, without densely brown, tomentose, deciduous in flower. Perianth tube turbinate, 1.5–2 mm long, green, silky tomentose, merging into pedicel; tepals 2.5–3×1.5 mm, creamy white to yellowish, imbricate, oblanceolate, acute, silky tomentose without, within glabrous. Male flowers: stamens yellowish green, filament slender, villous, outer 2 whorls of stamens 1.5–1.8 mm long, anther 5–7 mm long; inner 2 whorls 1.2–2 mm long; gland c.1 mm long, ovate, sessile, glabrous; pistillode rudimentary. Female flower: ovary c.1.3 mm long, ovoid, glabrous; style c.4 mm long, thick, glabrous; stigma discoid; staminodes, outer 2 linear, inner 2 clavate, c.2 mm long. Berry 1.2–1.4×0.6–0.8 cm, ellipsoid, pale green when young, purple at maturity seated on obconic perianth tube. Seed 1, 1−1.3×0.6 cm, elliptic oblong, white, glabrous.

**Flowering** & **Fruiting**: Flowering from November to January. Fruiting from February to June.

**Distribution**: *Litsea wightiana* var. *tomentosa* is distributed in South India (Karnataka, Kerala, Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Palakkad, Idukki, and Thiruvananthapuram districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests and shola forests of high elevations ranging from 800-1800 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Litsea floribunda* (Blume) Gamble., *Vateria indica* L., *Maesa indica* (Roxb.) A.DC., *Dysoxylum ficiforme* (Wight) Gamble, *Syzygium laetum* (Buch. Ham.) Gandhi.

**Phenology**

Flowering only once in year. Flower buds appeared in early November and remained almost unchanged in appearance for a whole month. Buds began to open by the first week of December and flowers bloomed randomly all over the tree. By the first week of January, all buds were opened and within a week the tree was in full bloom. Flowering continued till the end of January. Green fruits appeared by the first week of February. The fruits were within the perianth by the last week of February. The fruits slowly emerged from the perianth tube and were completely outside by the second week of March. Fruits developed slowly, matured to green. The fruit became ripened by the last week of May and became black. The fruits were fallen off by the second week of June.

**Specimens Examined**: INDIA, **Kerala**, Idukki district, Njamakkad, Munnar, ±1850 m, 29.07.1992, *Nambiar & Sasidharan* 1871 (KFRI); Mangaldevi, Periyar Tiger Reserve, ±1375 m, 30.07.1993, *N. Sasidharan & Jomy Augustine* 12183 (KFRI); Poovar, 2.08.1997, *S.D. Biju* 32471 (TBGT), Athirumala, 29.01.2001, *K. Radha Krishnana* 43402 (TBGT); Pongalapara, 14.11.1991, *N. Mohanan* 10934 (TBGT); Nelliyampathy, 28.11.2018, *P.K. Fasila* 150514 (MESAH); Malappuram district, Ganiyamala, New Arambalam R.F, 12.02.1999, *R. Jayakumar RJ* 21323 (KFRI); Mukuruthi, New Arambalam R.F, 09.05.1999, *R. Jayakumar RJ* 21552 (KFRI).

**Litsea wightiana** (Nees) Hook. f. in Benth. & Hook. f., Gen. Pl. 3: 162. 1880, p.p, var. *wightiana*; Gamble, Fl. Pres. Madras 1238. 1925; N. Mohanan & Sivad., Fl. Agasthyamala 572. 2002.

*Cylicodaphne wightiana* Nees in Wall., Pl. Asiat. Rar. 2: 68. 1831. **(Figure 4.13.)**

**Local name**: Pattuthali, Manjakudala

Small to medium sized trees, 10- 20 m high; bark smooth, brownish black; branchlets terete, brownish to black coloured; young shoots are rusty tomentose; leaf scar prominent, c. 3×3 mm, round or oval. Petiole c.1 cm long, stout, round below, prominent and raised above, densely puberulous, dark brown to black when dry; lamina 6.5–10×3.5–5.5 cm, elliptic, elliptic ovate; acute to cuneate at base, margins entire, slightly puberulous, curved inwards, obtuse, acute or rounded at apex, thickly coriaceous, brown to black above, dark or golden brown below when dry; mid rib prominent, highly emerged, c.2 mm broad near to the petiole, fulvous tomentose, on lower surface, prominent near to the petiole then gradually immersed, glabrous; secondary nerves 7–8 pair, pinnate, highly prominent, fulvous tomentose on lower surface, immersed, glabrous below; intercostae reticulate, highly prominent, fulvous tomentose on lower surface, immersed or obscure on upper surface. Racemes in the axile of leaves or terminal up to 4–6 cm long; each umbel 6–8×5–8 mm, 4–6 flowered, brown, tomentose; peduncle 3–4 mm long, silky tomentose. Flowers c.7×4 mm, white to yellow, glossy, tomentose; pedicel short, <1 mm long, silky tomentose; involucre bract c.5×3.5 mm, concave, orbicular, within glabrous, without densely white tomentose, deciduous in flower. Perianth tube turbinate; tepals membranous, free, 1.5–2×1–1.2 mm, white to yellowish, lanceolate or oblong, acute, finely silky tomentose without, within glabrous. Male flowers: stamens yellowish-green, filaments slender, villous; outer 2 whorls of stamen 2–2.3 mm long; inner 2 whorls 1.5–2.5 mm long, glandular, gland 8–9 mm long, orbicular, sub sessile or sessile, glabrous; pistillode c.0.8 mm long, rudimentary. Female flower: ovary c.1.3 mm long, ovoid, glabrous; style c.2.5×1.2 mm, thick, glabrous; stigma capitate; staminodes, outer 2 linear and inner 2 clavate, 1.5–2.3 mm long. Berry 2–2.3×0.7 cm, oblong, pale green with white spots on young become pink when mature, seated on cup like perianth tube. Seed 1, 1–1.2×.6 cm, obovate, brown.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from February to June.

**Distribution**: *Litsea wightiana* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Idukki, Kannur and Palakkad districts.

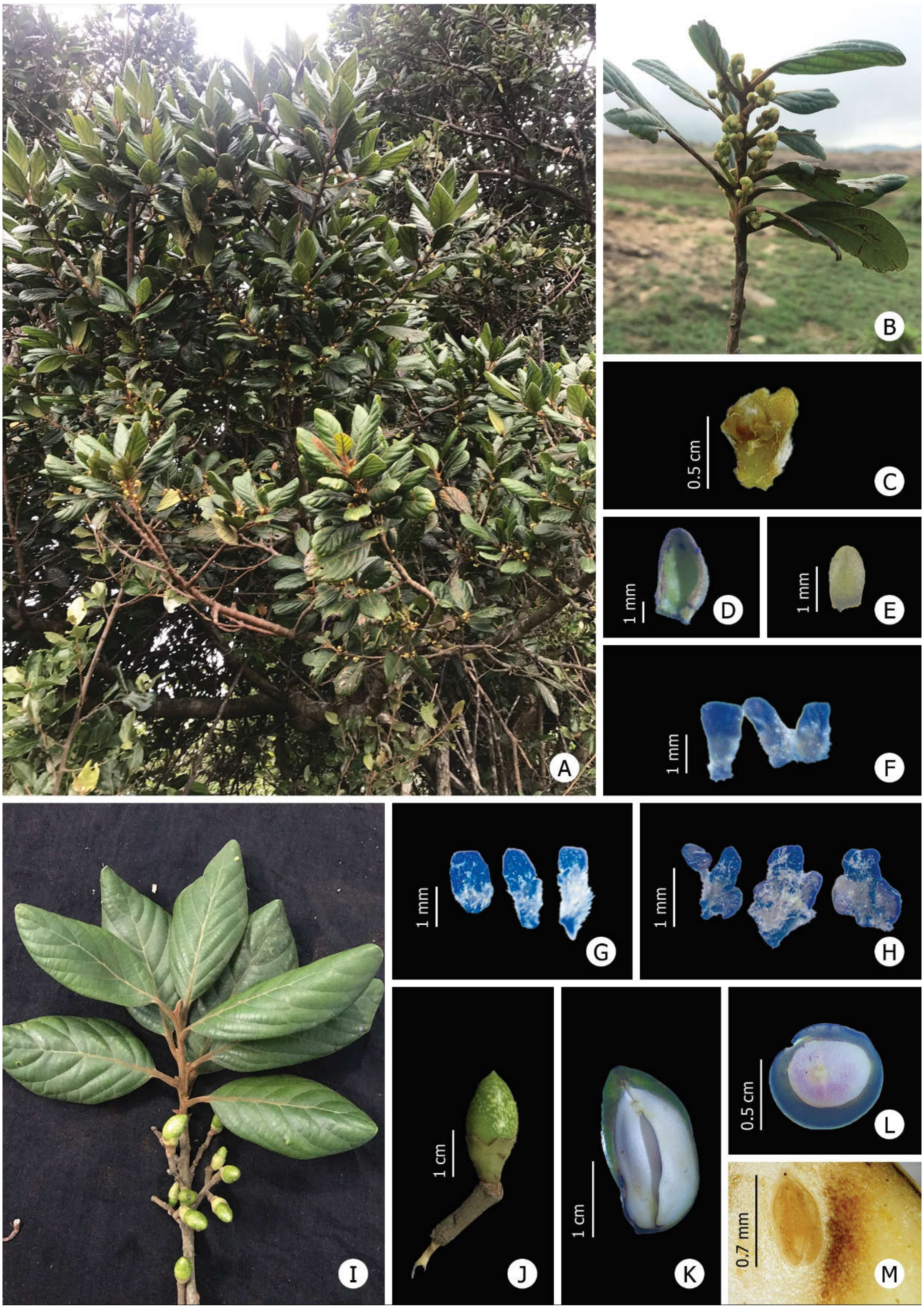


**Figure 4.13.** ***Litsea wightiana*** (Nees) Hook**:** **A.** Habit; **B.** Flowering twig; **C.** Flower; **D.** Bract; **E.** Tepal; **F.** 1st whorl of stamens; **G.** 2nd whorl of stamens; **H.** 3rd whorl of stamens; **I.** Fruiting twig; **J.** Fruit; **K.** Fruit L.S; **L.** Fruit C.S; **M.** Embryo.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of high elevations ranging from 900-1800 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Litsea floribunda* (Blume) Gamble., *Vateria indica* L., *Maesa indica* (Roxb.) A.DC., *Cinnamomum sulphuratum* Nees, *Symplocos* sps.

**IUCN Status**: Near Threatened under criteria B2 ab (i,ii,iii).

**Phenology**

Flowering only once in year. Flower buds appeared in early November and remained almost unchanged in appearance for a whole month. Buds began to open by the first week of December and flowers bloomed randomly all over the tree. By first week of January, all buds were opened and within a week the tree was in full bloom. Flowering continued till the end of January. Green fruits appeared by the first week of February. The fruits were within perianth by the last week of February then fruits slowly emerged from the perianth tube and were completely outside by the second week of March. Fruits developed slowly, matured to become green. The fruit became ripened by the last week of April and became black and fallen off by the second week of May.

**Specimens Examined**: INDAI, **Kerala**, Palakkad district, Nelliyampathy, Karimala, 13.04. 2019, *P.K. Fasila* 150560 (MESAH); *ibid*., 18.02.2020, *P.K. Fasila* 150576 (MESAH).

**Litsea** sp.1 **(Figure 4.14.)**

Small to medium sized evergreen tree, 12-25 m high; outer bark greyish-brown, smooth, brittle; inner bark dark brown; blaze light brown; young branchlets terete, lenticellate; young shoots reddish, pubescent. Petiole 0.5–1.3×1–3 mm, stout, pubescent when young, glabrescent on age, golden-brown to dark brown or black when dry; lamina 7–14×3–4 cm, elliptic, oblanceolate, acute or narrowed at base, margins entire, slightly incurved on lower surface slightly puberulous, obtuse at apex, coriaceous, glabrous, yellowish-brown to dark brown above, greenish yellow to reddish brown below when dry; midrib raised, dark brown on lower side, prominent at the base, gradually slender and obscure to the tip on upper surface puberulous when young, glabrescent on age; secondary nerves pinnate, 5–8 pairs, prominent, thick, arcute slightly looped towards the margin, golden brown to dark brown, impressed on upper surface, puberulous on both surface when young, glabrescent on age; tertiary nerve distinct and reticulate on lower surface, obscure on upper surface. Inflorescence racemes in the axile of leaves or along branches, 3–5 cm long, pubescent; peduncle 5–20 mm long, fulvous tomentose. Flowers c.5×3 mm, white to yellowish, glossy; pedicel c.2 mm long, pubescent; involucre bract 5–6×4 mm, whitish- yellowish, imbricate, concave, fleshy, within glabrous, without tomentose, deciduous in flower. Perianth tube conical; tepals c.2×1 mm, membranous, lanceolate, or oblong, acute at apex, fulvous tomentose without, within glabrous, white to yellowish. Male flower: stamens of 1$^{st}$ and 2$^{nd}$ whorls eglandular; 3$^{rd}$ whorl glandular, white, anthers 4 celled and introrse, filaments villous; pistillode minute. Female flower: ovary c.1 mm long, ovoid, glabrous; style thick, c.2.5 mm long, glabrous; stigma irregularly lobed or discoid; staminodes 1.8–2.5 mm long, inner c.1.2 mm long. Berry 2.3−2.9×1.1−1.2 cm, ovoid, or cylindrical-globose, pale green with white spot at young, become reddish brown when mature, seated in a brown-coloured cupule like perianth tube. Seed 1, 1.5–2×0.7–0.8 cm, oblong, light brown.

**Flowering** & **Fruiting**: Flowering from November to January. Fruiting from February to April.

**Distribution**: This taxon is distributed in Palakkad district in Kerala. It is found in Nenmara forest division of Nelliyampathy area.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of high elevations ranging from 1100-1800 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Litsea wightiana* (Nees) Hook., *Elaeocarpus variabilis* Zmarzty, *Neolitsea cassia* (L.) Kosterm., *Dysoxylum ficiforme* (wight) Gamble.

**Specimen examined**: INDIA, **Kerala**. Palakkad district, Nelliyampathy, Karimala, *P.K. Fasila* & *K. H. Amitha Bachan* 150575 (MESAH).

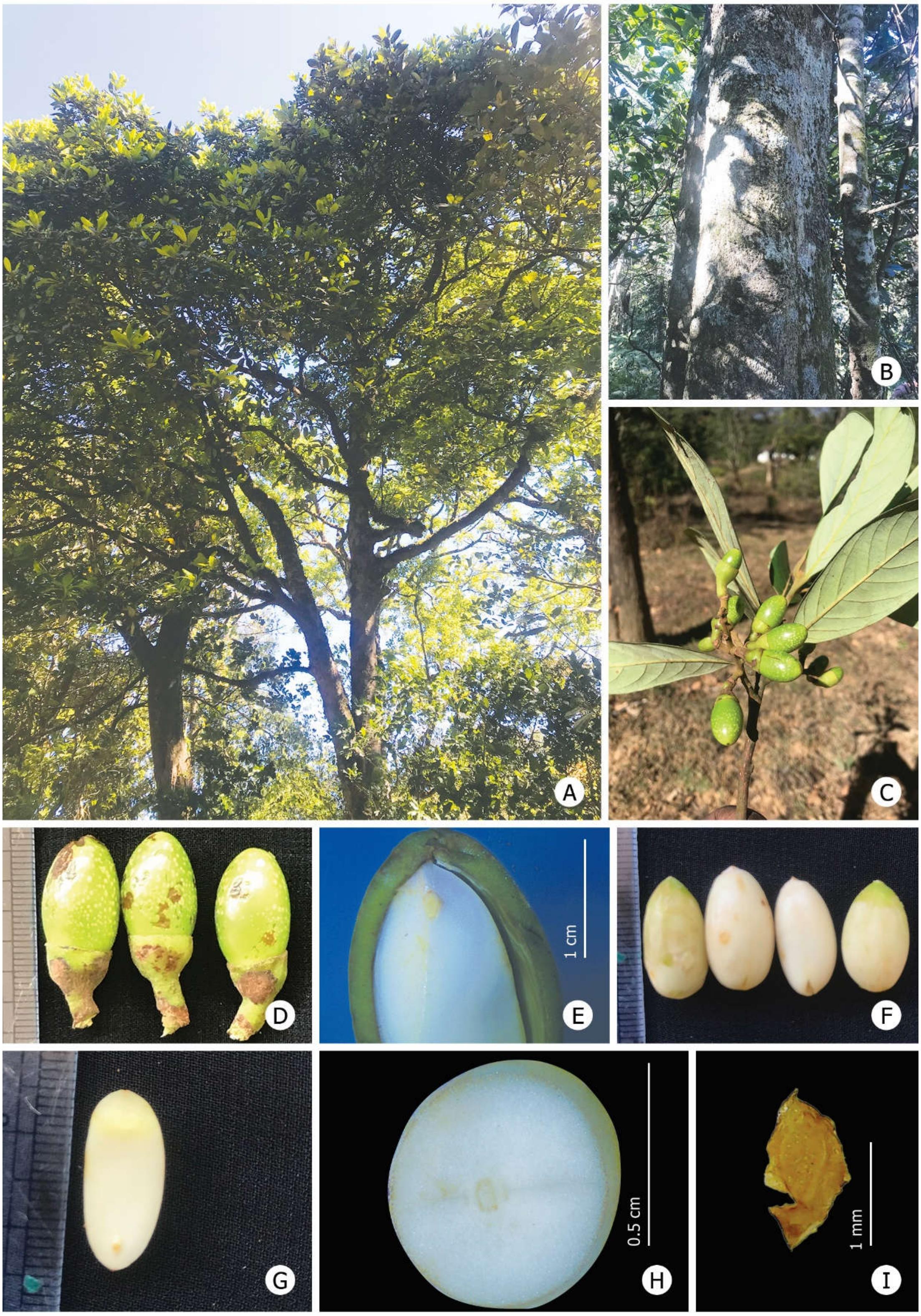


**Figure 4.14.** ***Litsea*** sp.1**: A.** Habit; **B.** Bark; **C.** Fruiting twig; **D.** Fruits; **E.** Fruit L.S; **F.** Seeds; **G.** Seed L.S; **H.** Seed C.S; **I.** Embryo.

**Notes:**

*Litsea* sp.1 resembles to *Litsea stocksii* in alternate leaves, petiole length, ovoid shape of berry, shape of the perianth cup, but differ from *L. stocksii* colour of young shoots, shape of lamina, lamina apex, coriaceous leaves, number of lateral nerves, tertiary nerve distinct and racemes length. Further studies are required for the novelty of this species.

**Phenology**

Flowering only once in year. Flower buds appeared in early November and remained almost unchanged in appearance for a whole month. Buds began to open by the first week of December and flowers bloomed randomly all over the tree. By first week of January, all buds were opened and within a week the tree was in full bloom. Flowering continued till the end of January. Green fruits appeared by the first week of February. The fruits were within the perianth by the last week of February. The fruits slowly emerged from the perianth tube and were completely outside by the second week of March. Fruits developed slowly, matured to become green. The fruits were ripened to black by the last week of April and were fallen off by the second week of May.

**NEOLITSEA** (Benth. & J.D. Hook.) Merr.

Philipp. J. Sci. 1, Suppl. 56. 1906, *nom. cons.*

Evergreen tree. Leaves simple alternate, opposite or whorled at apex, estipulate, triple nerved; terminal buds perulate with imbricate scales; lamina elliptic, elliptic-ovate, lanceolate, acute, or cuneate at base, obtuse, acute to acuminate at apex, chartaceous to sub coriaceous, areolate; intercostae reticulate-areolate, scalariform, prominently scrobiculate. Flowers dioecious; inflorescence axillary or sub axillary, sessile umbel with small bracts at their base; involucre bract 4, deciduous; perianth lobe 4, in two whorls; stamens in the male flower 6, opposite to the perianth, those of the outer whorl eglandular, those of the inner whorl with 2 glands at their base; anthers 4 celled and introrse, upper lobes small and lower lobes large; staminodes of female flowers 6, arranged as stamens. Fruit a berry.

**Key to the species**

1a. Leaves and branchlets fulvous tomentose ......................................... .**N. fischeri**

1b. Leaves and branchlets glabrous .......................................................................2

2a. Leaves lanceolate, lateral nerves 2–3 pairs, basal pair reach half of the lamina, intercostae reticulate-areolate; fruiting perianth disc shaped ................**N. cassia**

2b. Leaves elliptic to ovate, lateral nerves 4–5 pairs, basal pair reach ¾ of the lamina, intercostae scrobiculate; fruiting perianth cup-shaped ......................................3

3a. Petiole 1.8–2.8 cm long; inflorescence in cluster of 5–9, umbel 4–5 flowered, flowers sparsely sericeous ..................................................................**N. foliosa**

3b. Petiole 2–4 cm long; inflorescence in clusture of 2, umbel 5–7 flowered, flowers thickly sericeous ........................................................................... **N.** sp.1

**Neolitsea cassia** (L.) Kosterm., J. Sci. Res. (Jakarta) 1: 85. 1952; Mohanan, Fl. Quilon Dist. 348. 1984; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 211. 1987;V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 397. 1988; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 396. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 383. 1996; N. Mohanan & Sivad., Fl. Agasthyamala 573. 2002.

*Laurus cassia* L., Sp. Pl. 369. 1753.

*Litsea zeylanica* Nees, Amoen. Bot. Benn. Fasc. 1: 58. t.5. 1823; Hook. f., Fl. Brit. India 5: 178. 1886.

*Neolitsea zeylanica* (Nees) Merr., Philipp. J. Sci. Suppl. 1: 57. 1906; Gamble, Fl. Pres. Madras 1239. 1925; Vajr., Fl. Palghat Dist. 406. 1990. **(Figure 4.15.)**

**Local name**: Keezhambazham, Venkana

A small tree, 5–8 meter high; bark grey outside, pale yellow inside; blaze pale cream; branchlets terete, slender, silvery sericeous near apex, brownish black on dry; terminal bud scale 2×1.5–2 mm, glabrous. Petiole 1–2 cm long, slender, sulcate above, glabrous, blackish when dry; lamina 4.5–13×1.5–4 cm, lanceolate, acute at base, margins entire, slightly recurved, acute to acuminate at apex, chartaceous to sub coriaceous, areolate glaucous beneath, glossy glabrous above, dark green turning brown when dry, midrib prominent, glabrous on both surface, slender, channelled above; lateral nerves triple nerved, from the base, 3–4, impressed above, highly raised beneath, 2 basal lateral nerve prominent, slightly arcute, reaching half of the lamina, other lateral veins 1–2 pairs, very faint, curved; intercostae reticulate-areolate. Umbels 5–6 flowered in each cluster, c.4×4 mm; yellowish-green, bracts c.4×2 mm, orbicular, concave, without coriaceous, within sub coriaceous, pubescent without, within glabrous, caducous. Male flower: c.6×4 mm, pale creamy, whitish-yellow, densely pubescent; peduncle short, c.0.3 mm long; pedicel sub sessile, c.1 mm long, hairy; tepal c.3×2 mm, pale green to yellow, free, ovate, hirsute at base, acute at apex, densely villous without; outer and inner whorls of stamens 2–2.2 mm long, anther c.1 mm long, oblong or ovate, filament 1–1.2 mm long, hirsute at base, pink coloured, glandular in inner whorl; glands c.1.2 mm long, stacked, orbicular; pistillode c.1.2 mm long, linear. Female flower: c.3×2 mm, ovary ovoid, glabrous, c.0.8 mm long; style short, c.0.3 mm long, slender, glabrous; stigma large, peltate white hairy; staminodes linear or linear clavate, < 1 mm long, inner with 2 glands at base. Berry c.1×1 cm, globose, seated on disc like flat perianth cup of c.5 mm long. Seed 1, 1−1.1×0.6−0.7 cm, elliptic ovate-oblong, glabrous, light brown.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from April to May

**Distribution**: *Neolitsea cassia* is distributed in South India (Andra Pradesh, Karnataka, Kerala, and Tamil Nadu). In Kerala it is distributed in Thiruvananthapuram, Kollam, Idukki, Thrissur, Palakkad, Malappuram, Wayanad and Kannur districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on medium and high elevations ranging from 800-1200 in the of Southern Western Ghats. It is a medium sized tree associated *Litsea floribunda* (Blume) Gamble., *Actinodaphne tadulingamii* Gamble., *Myristica beddomei* King., *Dysoxylum malabaricum* Bedd. ex. Hiern in Hook. etc

**IUCN Status**: Lower Risk/least concern.

**Phenology**.

Flowering only once in year. Flower buds appeared by the second week of January and remained almost unchanged in appearance till the first week of February. Buds

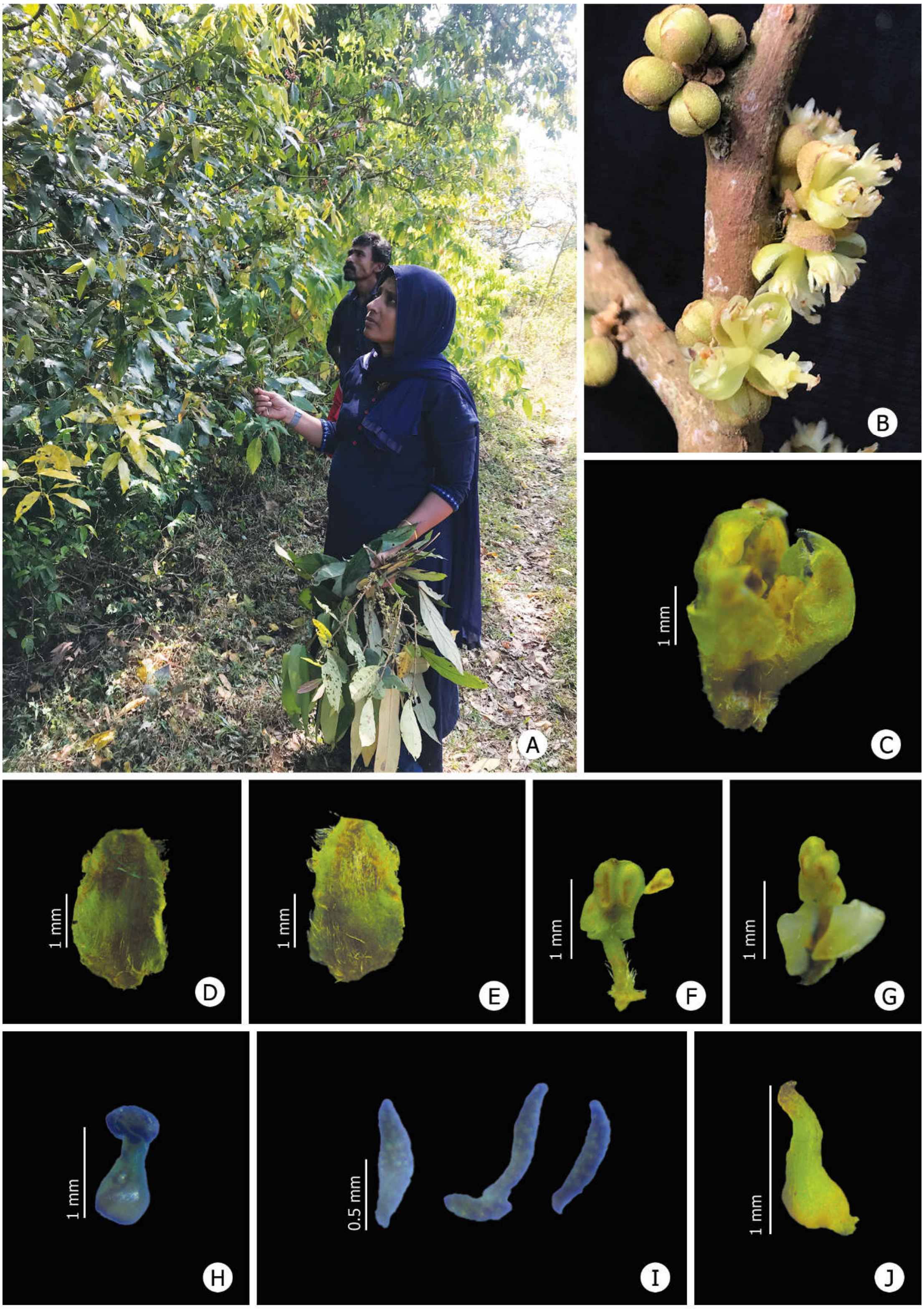


**Figure 4.15.** ***Neolitsea cassia*** (L.) Kosterm.**:** **A.** Habit; **B.** Flowering twig; **C.** Single flower; **D.** Outer tepal; **E.** Inner tepal; **F.** 1st whorl of stamen; **G.** 2nd whorl of stamen; **H.** Pistil; **I.** Staminodes; **J.** Rudimentary pistil.

began to open by the third week of February. By the third week of March, the tree was in full bloom. Green juvenile fruits began to develop by the first week of April. Dried flowers remained in the tree till the first week of April. Fruits matured by the last week of April and became pink. They ripened to black and fallen off by the second week of May.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Bonaord, ±700 m, 23.04.1992, *N. Mohanan* 11088 (CALI); Pongalapara, ±1400 m, 14.05.1980, *N. Mohanan* 9683 (TBGT); Athirumala, ±1000 m, 30.03.1989, *N. Mohanan* 5114 (TBGT); Nadukanipara, 16.03.2008, *P.S. Udayan et al.* 4813 (CMPR). Idukki district, Mannavan shola, Methappu, ±2100 m, *K Kishor Kumar* 17696 (KFRI); Pambadumshola NP, 23.01.2009, *P.S. Udayan et al.* 5469 (CMPR); *ibid*, 28.11.2018, *P.K. Fasila et al*. 150517 (MESAH); Palakkad district, Silent Valley NP, Poochappara, 5.03.2009, *P.S. Udayan et al.* 5679 (CMPR); Walakkad to Parathode, 9.03.2009, *P.S. Udayan et al.* 5711 (CMPR); Thrissur district, Sholayar, Mudiyanpara, ±1250 m, 22.03.1983, *N. Sasidharan* 5379 (KFRI); *ibid*, 17.01.2020, *P.K. Fasila et al*. 150570 (MESAH); Malappuram district, Erumala, New Amarambalam R.F, 25.01.1999, *R Jayakumar* RJ 21312 (KFRI); Kedakkamala, New Amarambalam R.F, 2.02. 1999, *R. Jayakumar* RJ 21372 (KFRI).

**Neolitsea fischeri** Gamble, Bull. Misc. Inform. Kew 1925: 132. 1925 & Gamble, Fl. Pres. Madras 1239. 1925; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 212. 1987.

**Local name**: Varimaram

A medium sized tree, 7–10 m high; bark greyish black outside, reddish brown inside; blaze yellow; branchlets terete, fulvous tomentose, golden brown when dry; terminal bud fulvous tomentose. Petiole 1–2.5×2 mm, thick, flattened, dark brown when dry; lamina 10–17×3.5–7.5 cm, elliptic, elliptic-ovate, acute or cuneate at base, margins entire, obtuse at apex, coriaceous, glossy, glabrous on both surface, golden brown above and dark brown below when dry, midrib prominent, thickly fulvous tomentose beneath, slender and glabrous above; lateral nerves 3–4, arise c.1 cm above the base, the lower pair reach third fourth of the lamina, the other pairs curved and arcute slightly looped towards the margins, slender, glabrous above, thick, highly elevated, fulvous tomentose beneath; intercostae scalariform, prominent below, inconspicuous above. Inflorescence in axillary or extra axillary, shortly peduncled cymose cluster, bracts c.5 mm long, orbicular, concave. Male flowers: c.3×2 mm, yellowish-green, densely tomentose; pedicel c.1 mm long, pubescent; tepal c.3×2 mm, ovate, acute at apex, thin, villous on outer surface, light green to yellow; stamens on outer whorl opposite to outer perianth c.1.2 mm long; anther c.0.6 mm long, oblong, apex acute; filament 0.5–0.6 mm long, slightly pubescent at base; inner whorl with 2 stipitate orbicular gland at base; pistillode ovoid. Female flower: c.3 mm long; tepals c.2×1 mm, ovate, acute at apex; ovary c.1.5 mm long, ovoid, pubescent; style short, slender, glabrous; stigma peltate, white papillose; staminodes linear or linear-clavate; inner whorl with 2 glands at base of the filament. Berry 10−15×10 −12 mm, globose or obovoid, seated on perianth tube. Seed 1, globose, brown coloured.

**Flowering & Fruiting**: Flowering from August to October. Fruiting from November to January.

**Distribution**: *Neolitsea fischeri* is distributed in South India (Kerala & Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Idukki district only.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on high elevations ranging from 1200-2200 in the of Southern Western Ghats. It is a medium sized tree associated *Litsea floribunda* (Blume) Gamble., *Cinnamomum verum* Presl., *Maesa indica* (Roxb.) A. DC, *Drypetes wightii* (Hook. f.) Pax & Hoffm. in Engl. Sp., *Polygonum* sp.

**IUCN Status**: Vulnerable B1 ab (iii)+2 ab (iii).

**Phenology**.

Flowering and fruiting were not observed for this species in the field. The herbarium records of the species were examined from the Herbarium of Kottakkal Arya Vaidya

Shala (CMPR). The specimen contained flowers and it was noted that the specimen was collected during the last week of November.

**Specimens Examined**: INDIA, **Kerala**, Idukki dist, Devicolam, ±2000 m, 01.12.1910, A. *Meebold* 13695 (K!); Mannavanshola, Kanthallur, ±2000 m, 25.02.1998, *K. Kishor Kumar* 18137 (KFRI); Pambadumshola NP, ±1800 m, 23.01.2009, *P.S. Udayan & A.J. Robi* 5468 (CMPR); Palakkad dist, Nelliyampathy, ±1800 m, 28.11.2018, *P.K. Fasila & K.H. Amitha Bachan* 150519 (MESAH).

**Neolitsea scrobiculata** (Meisner) Gamble, Fl. Pres. Madras 1240. 1925; Mohanan, Fl. Quilon Dist. 348. 1984; C.J. Saldanha & B.R. Ramesh in Saldanha, Fl. Karnataka 1: 70. 1984; V. Chandras. in A.N. Henry *et al*., Fl. Tamil Nadu 2: 212. 1987; Mani., Fl. Silent Valley 237. 1988; Vajr., Fl. Palghat Dist. 406. 1990; M. Mohanan & A.N. Henry, Fl Thiruvananthapuram 397. 1994; Anil Kumar *et al*., Fl. Pathanamthitta 426. 2005.

*Litsea scrobiculata* Meisner in DC., Prodr. 15: 223. 1864.

*Litsea zeylanica* sensu Hook. f., Fl. Brit. India 5: 178. 1886, p.p., non Nees 1823.

**(Figure 4.16.)**

**Local name**: Mulakunari

A medium sized evergreen tree, 7–16 m high; bark greyish-black outside, reddish brown inside; blaze pale cream; branchlets terete, glabrous, greyish-black when dry; bud scales c.2×2 mm, silky pubescent without, glabrous within. Petiole 18–28×1 mm, slender, sulcate above, glabrous, blackish when dry; lamina 8–10.2×3.5–4.3 cm, elliptic, elliptic-ovate, cuneate to slightly oblique at base, margins entire, acuminate at apex, coriaceous, glossy, glabrous above, areolate, glaucous beneath, dark green turning black when dry; midrib prominent on both surface, slightly pubescent beneath; lateral nerves 3 nerved, arise from 3–4 mm long from the base, impressed above, highly raised beneath; 2 basal lateral nerve prominent, slightly arcute, reaching 3/4$^{th}$ of the lamina, other lateral veins 3–4, very faint, glabrous; intercostae prominently scrobiculate, reticulate, impressed adaxially and prominent abaxially. Umbel 5–9 in each cluster, c.3×3 mm; flower 4–5 in each umbel; bracts c.4×3 mm, yellowish-green, orbicular, concave, coriaceous, brown hirsute on without, within glabrous, caducous. Male flowers: c.3×2 mm, pale creamy, whitish-yellow, densely tomentose; pedicel sub sessile, < 1mm long, white silky hairy; peduncle short, c.0.3 mm long; tepal c.3×2.5 mm, light green to yellow, ovate, acute, densely pubescent on outer surface, hirsute at base; stamens on outer whorl 1.8–2 mm long; anther 0.5–0.6 mm long, oblong or ovate, apex acute or obtuse; filament 1.2–1.5 mm long, sparsely pubescent; inner whorl of stamen c.2 mm long; filament sparsely pubescent, glandular, gland c.0.7 mm long, stacked, orbicular; pistillode linear. Female flower: c.3.5×3 mm; tepal c.3 × 2 mm, lanceolate, acute; carpel c.2.8 mm long; ovary c.1 mm long, globose, glabrous; style short, c.1.5 mm long, slender, glabrous; stigma discoid, hairy; staminodes linear or linear clavate; inner whorl with 2 glands at base of the filament. Berry 1.2−1.3×0.7−0.8 cm, globose, seated on enlarged perianth tube, light green with white spot when young, brownish red when mature. Seed 1, 1.8–0.9×0.4–0.5 cm, elliptic ovate–oblong, pale brown.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from March to May.

**Distribution**: *Neolitsea scrobiculata* is distributed in South India (Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Kottayam, Idukki, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad and Kannur districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of high elevations ranging from 800-1200 m in the of Southern Western Ghats. It is found in the wet evergreen forest slopes with streams draining to the river. It is a medium sized tree seen associated with *Palaquium ellipticum* (Dalzell) Baill, *Litsea floribunda* (Blume) Gamble., *Myristica beddomei* King., *Phoebe lanceolata* Nees, *Actinodaphne bourdillonii* Gamble.

**IUCN status**: Not evaluated.

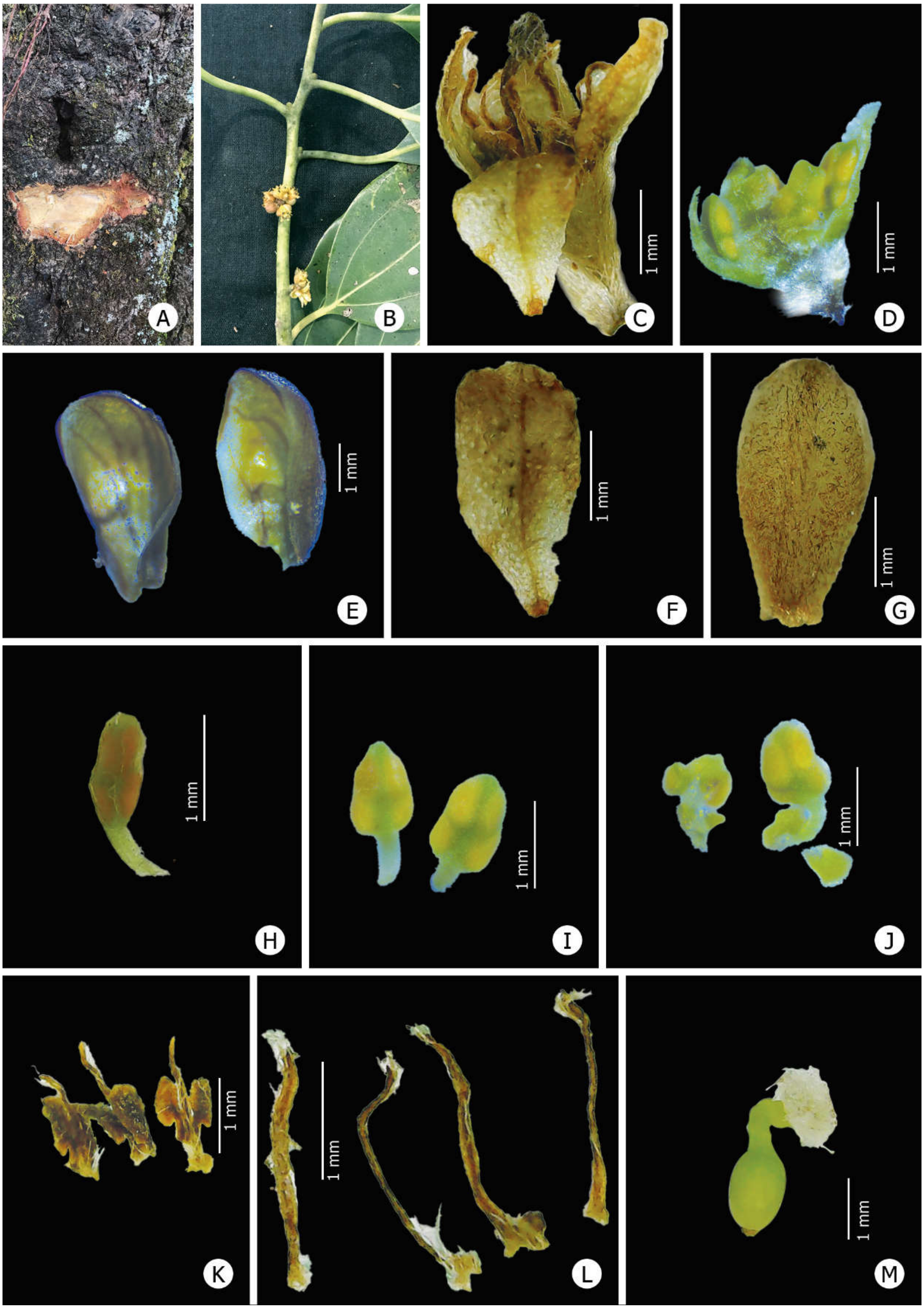


**Figure 4.16.** ***Neolitsea scrobiculata*** (Meisner) Gamble**: A.** Blaze; **B.** Flowering twig; **C.** Female flower; **D.** Male flower; **E.** Bract; **F.** Outer tepal male flower; **G.** Outer tepal female flower; **H.** 1st whorl of stamen; **I.** 2nd whorl of stamens; **J.** 3rd whorl of stamens; **K & L.** Staminodes; **M.** Pistil.

**Phenology**.

Flowering only once in year. Flower buds appeared in the fourth week of January and remained almost unchanged in appearance till the first week of February. Buds began to open by the first week of March. By the third week of March, the tree was in full bloom. Flowering continued till the last week of March. Green Juvenile fruits began to develop in last week of March. Fruits matured and became dark green by the last week of April. Fruits ripened to black and were fallen off by the second week of May.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Agasthyamala, Athirumala, 24.10.2003, *P.S. Udayan et al.* 1969 (CMPR); Athirumala to Pongalapara, 16.03.2008, *P.S. Udayan et al.* 4846 (CMPR); Nadukanipara, 16.03.2008, *P.S. Udayan et al.* 4814 (CMPR); Pongalapara, 16.03.2008, *P.S. Udayan et al.* 4851(CMPR); *ibid*., 13.02.2009, *P.S. Udayan et al.* 5643 (CMPR); *ibid*., 13.02.2009, *P.S. Udayan et al.* 5628 (CMPR); Merchiston Estate, 21.05.2009, *P.S. Udayan & A.J. Robi* 6063 (CMPR); *ibid*., 12.03.2010, *P.S. Udayan et al.* 6637 (CMPR); Kollam district, 25.01.1995, *S. Binu & E.S Santhosh Kumar* 22249 (TBGT); Kottayam district, Wagamon, 11.04.2009, *A.J. Robi* 5881 (CMPR); Idukki district, Devikulam, ±1800 m, 31.03.1978, *Nambiar* 315 (KFRI); Kathumala, 30.08.1998, *S.D Biju* 38318 (TBGT); Vayuvari, 02.05.1998, *S.D Biju* 38050 (TBGT); Thrissur district, Mudiyampara, Sholayar, 22.03.1989 *N. Sasidharan* 5379 (KFRI); Malakkappara Kasarapara, 20.02.2018, *P.K. Fasila et al*. 137472 (MESAH); Palakkad district, Palakkad: Aruvampara, ±1200 m, 30.04.1982, *T. Sabu* S V 10473 (CALI); Valliyaparathode, ±1350m, 28.08.1982, *K. S Prasannakumar* SV10387 (CALI); Poochappara, 02.05.2007, Rama *Sabu & Kulloli* 61597 (TBGT); Thodukki, 24.04.2008, *K.A. Anilkumar* 3304 (CMPR); *ibid.,* 26.10.2011, *K.A. Anilkumar* 4252 (CMPR); Thaishola, 14.05.2008, *K.A. Anilkumar* 3425 (CMPR); Attapady, Mathampotty, 19.05.2008, *K.A. Anilkumar* 3372 (CMPR); Parambikulam, Karimala, 04.12. 2008, *P.S. Udayan et al.* 5301 (CMPR); *ibid*., 07.05.2017, *P.K. Fasila et al.* 137451 (MESAH); Pandaravarai, 06.12. 2008, *P.S. Udayan et al.* 5303 (CMPR); Karimala, 26.03.2010, *P.S. Udayan et al.* 6694 (CMPR); Nelliyampathy, 29.06.1994, *AES Khan & E S Santhosh* 20094 (TBGT); *ibid*., 04.06.2010, *P.S. Udayan & A.J.*

*Robi*6871 (CMPR); *ibid*., 04.06.2010, *P.S. Udayan & A.J. Robi* 6878 (CMPR); *ibid*., 13.05.2019, *P.K. Fasila et al*. 150562, 150564 (MESAH); *ibid*., 18.02.2020, *P.K. Fasila* 150579 (MESAH); Meenvani, 10.10.2012, *K.A. Anilkumar* 4636 (CMPR); Silent valley, Sirendri-Pathrakadavu, 10.05.2019, *P.K. Fasila et al*. 150551 (MESAH); Malappuram district, Erumala, New Arambalam, 3.01.2000, *R. Jayakumar* RJ 21412 (KFRI); Kozhikkode district, Vellarimala, Kanjipara, 31.01.2008, *P.S. Udayan et al.* 4390 (CMPR); Kakkayam, 25.03.2008, *P.S. Udayan et al.* 4881 (CMPR); *ibid*., 20.01.2009, *P.S. Udayan & A.J. Robi* 5436 (CMPR); Wayanad district, 01.09.2014, *Deepthy & Usha* 82213 (TBGT); Periya, 01.09. 1994, *Deepthy & Usha* 82219 (TBGT).

**Neolitsea** sp.1 **(Figure 4.17.)**

A small tree, up to 4 m heigh; bark grey outside, pale yellow inside; blaze pale cream; branchlets terete, glabrous, black on dry; terminal bud scale c.2 mm long, obovate, obtuse at apex, densely silvery except the base row. Petiole 2–4 cm long, slender, sulcate above, glabrous, blackish when dry; lamina 10–21×3–8.5 cm, elliptic-ovate, lanceolate, acute to slightly oblique at base, margins entire, acuminate rarely acute at apex, chartaceous to sub coriaceous, areolate, glaucous beneath, glossy dark green turning black on upper surface when dry; midrib prominent, glabrous on both surface, prominent below, slender above, glabrous, dark brown to black on dry; lateral nerves triple nerved from the base, the lower pair prominent, arcute, reaching ¾ of the lamina, the other nerves 3–4, impressed above, prominent beneath, intercostae reticulate, areolate. Umbel 5–6 mm long, arranged in clusters of 2, covered by involucre bract, 5–7 flowered; bracts c.5.3×5 mm, yellowish green, orbicular, concave, outer coriaceous, inner sub coriaceous, brown hairs on without, within glabrous, caducous. Male flower: 5–6×4 mm, pale creamy, whitish-yellow, thickly sericeous; pedicel c.2×1 mm, white, silky pubescent; tepal un equal, 2.8–4×1.5–2 mm, pale green to yellow, obovate, obtuse or acute, hirsute at base, free, densely villous without; stamens on outer whorl 2.8–3.5 mm long; anther 1.6–1.7 mm long, oblong, obovoid, two lower lobe lateral; filament 1.2–1.8 mm long,

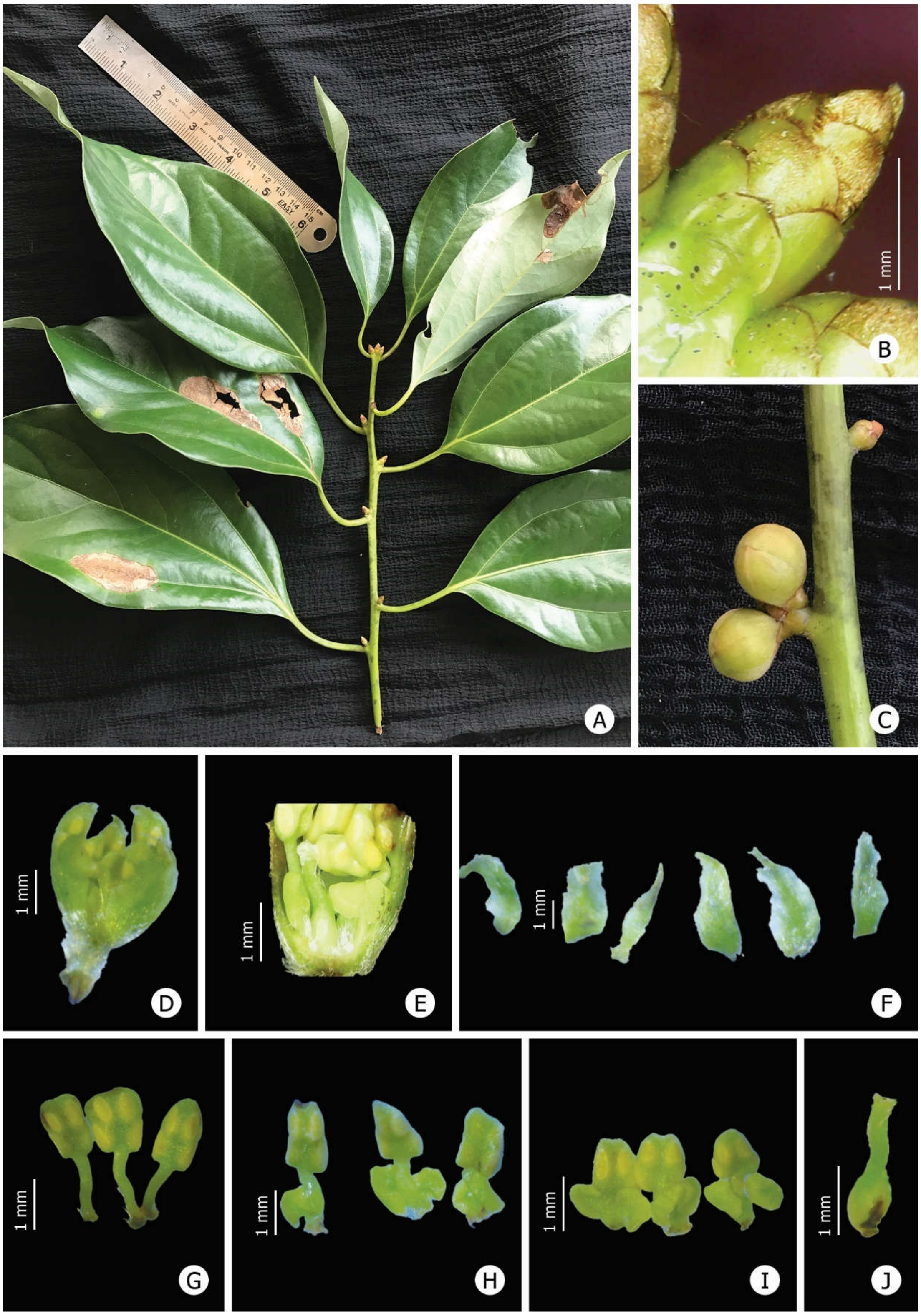


**Figure 4.17.** ***Neolitsea*** sp.1**:** **A.** Twig; **B.** Bud scale; **C.** Inflorescence; **D.** Single flower; **E.** Flower L.S; **F.** Tepals; **G.** 1st whorl of stamens; **H.** 2nd whorl of stamens; **I.** 3rd whorl of stamens; **J.** Pistil.

hirsute at base, densely villous; inner whorl c.2 mm long with 2 glands at base; glands c.1.2 mm long, stacked, orbicular; pistillode c.2 mm long, linear. Female flower: ovary c.1 mm long, ovoid, glabrous; style short, c.1mm long, slender, glabrous; stigma large, peltate, white hairy; staminodes linear or linear clavate, inner with 2 glands at base. Fruit not seen.

**Habitat**: The taxon is found in evergreen and wet evergreen forests of medium elevations ranging from 500-800 m in the of Southern Western Ghats. It is found in the wet evergreen forest slopes with streams draining to the river. It is a medium sized tree seen associated with *Schleichera oleosa* (Lour.) Oken., *Meliosma simplicifolia* (Roxb.) Walp., *Knema attenuata* (Hook. f. & Thoms.) Warb., *Cinnamomum malabatrum* (Burm.f.) Blume., *Litsea bourdillonii* Gamble.

**Specimen examined**: - INDIA, **Kerala**, Thrissur district, Vazhachal Karanthodu 25.02. 2018, *P.K. Fasila & K.H. Amitha Bachan* 150526 (MESAH).

**Phenology**

Flowering only once in year. Flower buds began to appear by the last week of January. Buds began to open by the second week of March. Flowering was sparse. Fruiting was not observed.

**Notes**

Neolitsea sp 1 resembles *Neolitsea scrobiculata* in lamina shape, number of lateral nerves, inter costae texture, fruiting perianth shape, but differ from *Neolitsea scrobiculata* in petiole length, number of inflorescences cluster, number of flowers in each umbel, pubescence in flower.

**PERSEA** Mill.

Gard. Dict. Abr., ed. 4. 1030. 1754 (*nom.cons*.).

**Persea macrantha** (Nees) Kosterm., Reinwardtia 6: 193. 1962; Mohanan, Fl. Quilon Dist. 348. 1984; C. J Saldanha & S.R. Ramesh, in Saldanha Fl. Karnataka 1: 71. 1984; V. Chandras., in A. N. Henry *et al*., Fl. Tamil Nadu, 2: 212. 1987; V. S. Ramach. &

V. J. Nair, Fl. Cannanore Dist. 397.1988; Vajr., Fl. Palghat Dist. 407. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 397, 1994; Sasidh. & Sivar. Fl. Pl. Thrissur For. 383.1996; Sivar. & Mathew, Fl. Nilambur 588. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 279. 2000; Mohanan & Sivas., Fl. Agasthyamala 573. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 426. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 611. 2009.

Machilus macrantha Nees in Wall., Pl. Asiat. Rar. 2: 70. 1831, 3: 31. 1832; Nees, Syst. Laurin. 174. 1836; Wight, Icon. Pl. Ind. Orient., 5: 14, t. 1824, text 12. 1852; Thwaites, Enum. Pl. Zeyl. 254. 1861; Meissn., in DC., Prod. 15(1): 40. 1864, p.p.; Hook.f., Fl. Brit. India 5: 140. 1886; Gamble, Fl. Pres. Madras 1227. 1925; Worthington, Ceylon Trees 357. 1959. **(Figure 4.18.)**

**Local name**: Kulamavu

An evergreen tree, 10-30 m high; outer bark greyish-black, thinly scaly rough, brittle; inner bark pale yellow; blaze pink; branchlets terete or angular, glabrous, dark brown to black on dry, lenticellate. Leaves simple, alternate, exstipulate, glabrous, smooth; petiole 1–3.5 cm long, slender, grooved above, glabrous, light green to dark green, black when dry; lamina 7–20×3.2–10 cm, oblong, elliptic-oblong to oblong-lanceolate, base acute, obtuse sometime oblique, margins entire, incurved, apex acute to acuminate, coriaceous, glaucous beneath, glabrous on both surface, greyish-brown above, greyish-brown below when dry; mid rib conspicuously elevated abaxially, slightly channelled on adaxially; lateral nerves 7–12 pairs at one side, slender, emergent on lower surface, glabrous on both surface, pale green to yellow; intercostae reticulate, obscure above. Inflorescence in branched cymose panicle, 5–17 cm long, slender, in terminal or sub terminal. Flowers hermaphrodite, c.6×4 mm, yellowish-green, finely appressed pubescent; peduncle 1.5–4 cm long, slender, angled towards the apices, glabrous, pale green to yellow; pedicel 2–4 mm long, pubescent; tepals in two whorls of three, outer three small, alternate with inner whorl, 2.8–3 mm long, obovate, lanceolate, apex acute, white tomentose, pale yellow, persistent in fruit; stamens 9, in 3+3+3 arrangement, unequal, first and 2$^{nd}$ whorls of stamen opposite to outer and inner whorls of perianth with introrse anther and eglandular; filament c.1.6

mm long, anther c.0.6 mm long, ovate, four lobed, upper 2 lobe small, and lower two large yellow; 3rd whorl with extrorse or latrorse anther, glandular, anther c.0.6 mm long, filament c.1.9 mm long, flat, silky villous; gland c.1mm long, ovate, stipitate; stipe c.0.6 mm long, fulvous tomentose; ovary c.0.9 mm long, narrow ovoid, half inferior, glabrous; style c.1.1 mm long, terete, sparsely pubescent; stigma simple, white; ovule single; staminodes 3, c.1.8 mm long, arrow shaped, fulvous pubescent. Berry 11–12×1.4–1.5 mm, depressed globose, brown to black when ripe. Seed 1, 0.9−1×1−1.1 cm, depressed globose, whitish grey.

**Flowering & Fruiting**: Flowering from October to December. Fruiting from March to April.

**Distribution**: *Persea macrantha* is distributed in South India (Karnataka, Kerala, and Tamil Nadu) and Sri Lanka. In Kerala it is distributed in all districts.

**Habitat**: The taxon is frequently found in evergreen and wet evergreen forests on hill slopes at elevations ranging from 600-1100 m Southern Western Ghats. It is a buttressed, top canopy tree seen associated with *Palaquium ellipticum* (Dalz.) Baill., *Myristica beddomei* King., *Vateria indica* L. *Canarium strictum* Roxb., *Litsea floribunda* Gamble, *Cryptocarya lowsonii* Gamble.

**Phenology**.

Flowering only once in year. Flower buds began to appear by the second week of October and remained almost unchanged in appearance till the last week of October. The buds began to open by the first week of November. By the first week of December, the tree was in full bloom. Massive flowering was occurred. Dried flowers remained in the tree till the last week of December. Green juvenile fruits developed by the first week of January. They matured slowly, by the second week of February became dark green. They ripened to black and were fallen off by the last week of April.

**IUCN Status**: Not evaluated.

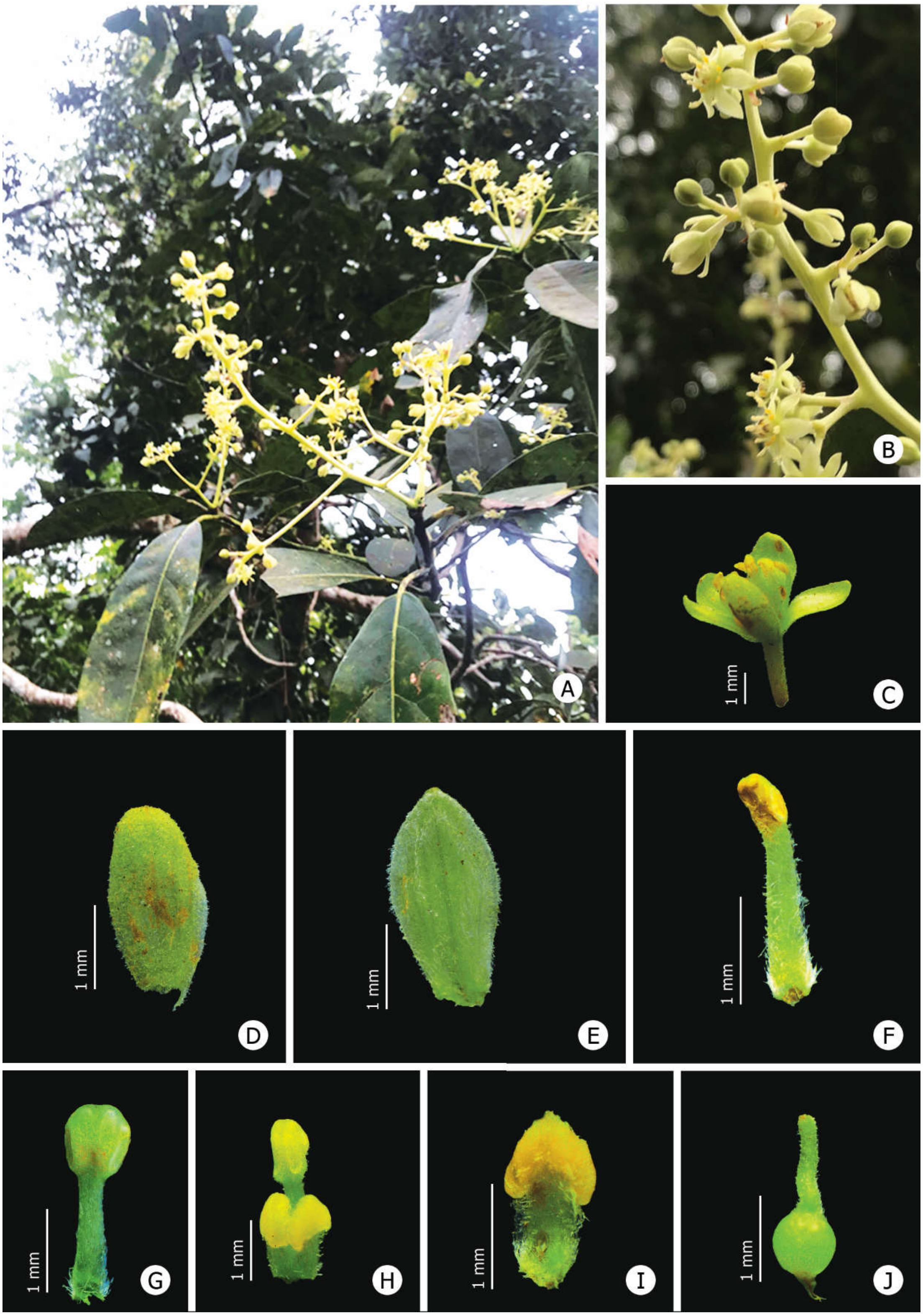


**Figure 4.18.** ***Persea macrantha*** (Nees) Kosterm**.: A.** Habit; **B.** inflorescence; **C.** Flower; **D.** 1st row tepal outer view; **E.** 2nd row tepal inner view; **F.** 1st whorl of stamen inner view; **G.** 2nd whorl of stamen inner view; **H.** 3rd whorl of stamen inner view; **I.** Staminode inner view; **J.** Pistil.

**Specimens Examined:** INDIA, **Kerala**, Thiruvananthapuram district, Bomccord, ±700 m, 22.12.1988, *N. Mohanan* 7924 (CALI); *ibid.*, 12.03.1993, *K.C. Koshy* 12542 (TBGT); Madathil Kavu 3.03.1993, *V. Sarojini Menon* 12725 (TBGT); Garden site, 27.12.1984, *N. Mohanan* 1265 (TBGT); Adiparamp, 21.01.1992, *Nazarudeen* 13666 (TBGT); Athirumala, 12.03.2010, *P.S. Udayan & A.J. Robi* 6668 (CMPR); Kollam district, Kaduvamada, 25.02. 1997, *S.D. Biju* 32401 (TBGT); Turners Valley, 25.06.1997, *S.D. Biju & Santhosh Kumar* 38045 (TBGT); Sasthanada, 5.01.2007, *Geetha Kumary* 56265 (TBGT); Alappuzha, Karthikapalli, 29.12.1996, *N. Rau* 33094 (TBGT); Pathanamthitta district, Nilakkal, 20.11. 2003, *P.S. Udayan et al.* 2092 (CMPR); Idukki district, Adimali, 29.12.1993, *A. Nazarudheen* 19623 (TBGT); Mannavan shola, Kanthalloor, ±1800 m, 08.10.1995, *K. Kishor kumar* 16660 (KFRI); *ibid.*, ±2000 m, 25.11.1995, *K. Kishor kumar* 16714 (KFRI); *ibid.*, 1450 m, 8.01.2004, *K. Sereen* 96826 (TBGT); Karimanal, 23.01.2001, *T. Shaju* 44692 (TBGT); Adimaly, Karadippara, 06.03.2008, *P.S. Udayan et al.* 4778 (CMPR); Periyar Tiger Reserve, Thannikudy, 17.03.2009, *P.S. Udayan & A.J. Robi* 5759 (CMPR); Eranakulam district, Kulathupuzha range, Shanngili, ±200 m, 19.02.1980, *N. Sasidharan* 1433 (KFRI); Thrissur district, Peechi, 5.01.980, *N. Sasidharan* 1130 (KFRI); Poringalkuthu, ±600 m, 12.12.1988, *N. Sasidharan* 5227 (KFRI); Sholayar, 03.01.2018, *P.K. Fasila* 137460 (MESAH); Anakkayam, 19.01.2020, *P.K. Fasila* 150573 (MESAH); Palakkad district, Nelliyampathy, ±200 m, 5.01.1980, *N. Sasidharan* 2697 (KFRI); *ibid.*, 5.01.1983, *Renuka & Mukesh* 2697 (KFRI); Varadimala, 20.02.2008, *K.A. Anilkumar* 2860 (CMPR); Attappady, Thodukki, 26.04.2008, *K.A. Anilkumar* 3305 (CMPR); Edavani, Yellakandi, 26.04.2008, *P.S. Udayan et al.* 5052 (CMPR); Parambikulam Tiger Reserve, Karimala, 04.12.2008, *A.J. Robi* 5189 (CMPR); Silent Valley, Vongal ala, 22.04.2018, *P.K. Fasila* 137474 (MESAH); Malappuram district, Nadukani, Way to Gudallore, 18.01.1979, *N. Sasidharan,* 455 (KFRI); Kanjirakkadavu, New amarambalam R.F, 21.01.1999, *R. Jayakumar* RJ 20551 (KFRI); Kozhikode district, Kakkayam, way to Ambalapara, 20.01.2009, *P.S. Udayan & A.J. Robi* 5448 (CMPR); Wayanad district, Thirunelveli, 17.01.1995, *K. Radha Krishnan* 23734 (TBGT).

## **PHOEBE** Nees

Syst. Laur.: 98 1836.

Medium sized evergreen trees. Leaves simple, alternate, estipulate, clustered at the end of branchlets, penninerved; lamina lanceolate or elliptic-lanceolate, obovate, or elliptic-obovate, base cuneate, acute to attenuate, margins entire or slightly dentate, apex acute to acuminate or long acuminate. Inflorescence in cymose panicle, arise in the axile of leaves or along the branches. Flowers hermaphrodite; perianth tube short; lobes 6, in 2 whorls of 3, subequal, accrescent in fruits. Stamen 9, in 3+3+3 arrangement, unequal, outer whorl of stamen opposite to outer and inner row of perianth; anthers introrse and eglandular; 3$^{rd}$ whorl opposite to the first whorl with extrorse anther, glandular, anthers 4 lobed, yellow, upper 2 lobe small and 2 lower large; staminodes 3 in the 4$^{th}$ whorl, opposite to the 2$^{nd}$ whorl. Fruit berry.

**Key to the species**

1a. Branchlets, leaves, inflorescence glabrous; lamina lanceolate, long acuminate at apex, long cuneate at base, margins entire; berry narrowly ellipsoid… ............... ........................................................................................................ **.P. lanceolata**

1b. Branchlets, leaves, inflorescence rusty tomentose; lamina obovate, shortly acuminate at apex, shortly cuneate at base, margins slightly crenate; berry ovoid….........................................................................................**P. wightii**

**Phoebe lanceolata** (Nees) Nees, Syst. Laurin. 109. 1836; Hook. F. Fl. Brit. Ind. 5: 141. 1886; Collett, Fl. Siml.432. 1902; Gamble, Fl. Pres. Madras 1228. 1925; C. J Saldanha & S.R. Ramesh in Saldanha, Fl. Karnataka 1: 72. 1984; V. Chandras in A. N. Henry *et al*., Fl. Tamil Nadu 2: 212. 1987; Vajr., Fl. Palghat Dist. 407. 1990; Sasidh. & Sivar. Fl. Pl. Thrissur For. 384. 1996; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 398. 1998; Sasidh., Fl. Parambikulam WLS 272. 2002. **(Figure 4.19.)**

*Ocotea lanceolata* Nees, Pl. Asiat. Rar. (Wallich). Ii. 71.1831.

*Ocotea lancifolia* Mez. Jahrb. Konigl. Bot. Gart. Berlin 5: 289. 1889.

Small evergreen tree, 10–15 m high; outer bark brownish-grey, deeply fissured; inner bark creamy white; blaze pale brown, branchlets terete, brown, lenticellate. Leaves showy green, purplish-red on both surface when young; leaf buds foliaceous, 2–3.5

mm long, lanceolate, pubescent on outer surface. Petiole c.1.5×0.5 cm, slender, sulcate above, pubescent, pale green to dark green, black when dry; lamina 8–17×5–2.5 cm, lanceolate or elliptic-lanceolate, base cuneate, margins entire, apex acute to acuminate or long acuminate, chartaceous, pubescent adaxially when young, glabrous on both surface on age, brownish black above, dark brown below when dry; mid rib prominent, light yellow to green, emergent, pubescent on lower surface, obscure or slightly channelled on upper surface; lateral nerves 6–12 pairs at one side, slender, pale green to yellow, emergent, arching, looped towards the apex, pubescent on lower surface, glabrous on upper surface; intercostae scalariform, obscure, slightly conspicuous adaxially. Inflorescence 5–14 cm long, slender, glabrous, arise from the axile of leaves or at the branches, branched near the top of the peduncle. Flowers 2.5–4 mm long, yellowish green, glabrous; peduncle 1–1.5 cm long, pale green to brownish, slender, glabrous; pedicel 0.5–1 mm long, smooth, glabrous; bracts 2, c.1 mm long, pubescent; perianth 2.8–3×1.8–2 mm equal, ovate, fleshy, apex acute, without glabrous, within white tomentose, light yellow; stamen 1.5–1.8 mm long; anther 0.7–0.9 mm long; filament 0.8–0.9 mm long, thick, grey-white, pubescent at base; gland shortly stacked, stipitate; ovary c.1 mm long, globose, half inferior, pubescent; style c.1.2 mm long, terete; stigma discoid with numerous hairs; ovule single; staminodes 0.5–1 mm long, cordate, stipitate, strigose at base. Berry 1.3−1.5×0.8−1 cm, ovoid to ellipsoid, pale green when young, black on mature. Seed 1, 1.1–1.3×0.7 cm, ovoid, brown.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from April to July.

**Distribution**: *Phoebe lanceolata* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). In Kerala it is distributed in Idukki, Thrissur, Palakkad, Malappuram, Wayanad and Kannur districts.

**Habitat**: This taxon found in evergreen and wet evergreen forests on at elevations ranging from 600-800 m. It is a medium canopy tree seen associated with *Palaquium ellipticum* (Dalz.) Baill., *Vateria indica* L., *Mesua ferrea*., *Litsea bourdillonii* Gamble, *Cinnamomum malabatrum* (Burm.f.) Blume.

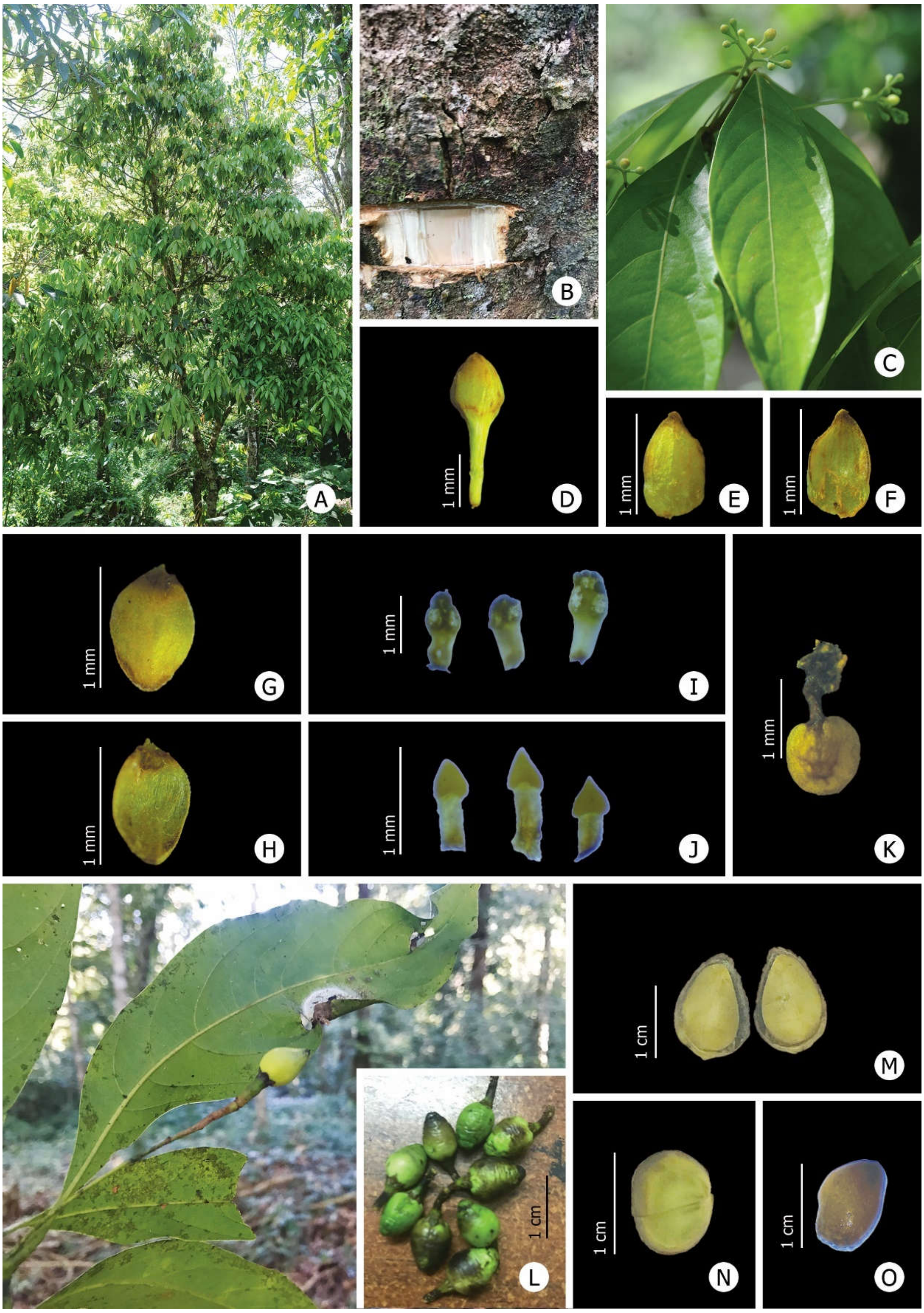


**Figure 4.19.** ***Phoebe lanceolata*** (Nees) Nees**:** **A.** Habit; **B.** Blaze; **C.** Flowering twig; **D.** Flower bud; **E.** Outer tepal outer view; **F.** Outer tepal inner view; **G.** Inner tepal outer view; **H.** Inner tepal inner view; **I.** Stamens; **J.** Staminodes; **K.** Pistil; **L.** Fruiting twig & fruits; **M.** Fruit L.S; **N.** Fruit C.S; **O.** Seed.

**IUCN Status**: Lower Risk/least concern

**Phenology**.

Flowering only once in year. Flower buds began to appear by the second week of January and remained almost unchanged in appearance till the first week of February. Buds began to open by the second week of January. Tree was in full bloom; massive flowering occurred by the second week of February. Dried flowers remained in the tree till the last week of April. Pale yellow juvenile fruits appeared by the first week of April. They were matured by the first week of May and colour changed to dark yellow. Fruits ripened to black and were fallen off by the last week of May.

**Specimens examined**: INDIA, **Kerala**, Idukki district, Mannavan shola, 28.05.2003, *P.S. Udayan* 1462 (CMPR); Munnar to Chinnar, 06.03.2008, *P.S. Udayan* 4780 (CMPR); PTR, Way to Mullakudi, Karadikkavala, 14.03.2009, *P.S. Udayan & A.J. Robi* 5720 (CMPR); Thrissur district, Sholayar, 20.02.1987, ±700 m, *N. Sasidharan* 3929 (KFRI); *ibid.*, 18.08. 1989, ±725 m, *N. Sasidharan* 5477 (KFRI); *ibid.*, 21.09.2005, *K.H. Amitha Bachan* 99178 (CALI); *ibid.*, 20.04.2010, *P.S. Udayan et al.* 6728 (CMPR); Ambalapara, 495 m, 3.04.2015, *P.K. Fasila* 137416 (MESAH); Palakkad district, Silent valley, 21.03.1979, ±1000 m, *Pascal* 1434 (KFRI); Pandaravarai, Parambikulam, 09.03.2007, *P.S. Udayan* 4979 (CMPR!); *ibid.*, 6.12.2008, *A.J. Robi* 5304 (CMPR); Parambikulam, Karimala, 26.03.2010, *P.S. Udayan & A.J. Robi* 6693 (CMPR); *ibid.*, 07.05.2017, *P.K. Fasila* 137450 (MESAH); Nelliyampathy, Pulayanpara, 05.06.2010, *P.S. Udayan & A.J. Robi* 6893 (CMPR); Nelliyampathy, Karimala, 13.05.2019, *P.K. Fasila* 150567 (MESAH); Malappuram district, New Amarambalam, Kedakkamala, 13.02.2000, *R. Jayakumar* 21356 (KFRI).

**Phoebe wightii** Meisn. in DC., Prodr. 15: 38. 1864; Gamble, Fl. Pres. Madras 1228. 1925.

*Phoebe paniculate* Hook.f., Fl. Brit. India 5: 142. 1886, non Nees 1836.

**(Figure 4.20.)**

**Local name**: Chudala, Mulakunari.

Small evergreen tree, 9–12 m height; bark thin brown; blaze creamy white; young branchlets terete, lenticellate, brown; young parts rusty tomentose. Leaves reddish-yellow when young. Petiole 1–15×1.2–2 mm, slender, terete, rusty tomentose, brownish-black when dry; lamina 7–13×3.5–5.5 cm, obovate or elliptic obovate, base acute to attenuate, margins slightly dentate, apex acuminate or apiculate, chartaceous, rusty tomentose on young leaves, glabrous on upper surface in older leaves, black on upper surface, greyish-glaucous below in younger leaves when dry; mid rib prominent, emergent, rusty tomentose on lower surface, obscure or slightly channelled, glabrous on upper surface, pale green to yellow; lateral veins 7–9 at one side, pinnate, close at base, slender, emergent, rusty tomentose on lower surface, slightly immersed, glabrous on upper surface, light yellow to brown; intercostae prominent, scalariform and reticulate. Inflorescence 2.5–5 cm long, rusty tomentose. Flowers 6–7×5 mm, yellow, rusty tomentose; peduncle 2.5–5 cm long, pale green, slender, pubescent; pedicel 5–9 mm long, smooth, rusty tomentose; perianth outer lobe, 2–3×1–1.5 mm, inner lobe, 2–3×1.5–2 mm, ovate, apex acute, fleshy, densely white pubescent on both surfaces; stamens unequal, first and second whorls of stamens c.1.3–1.5 mm long; filament 0.9–0.4 mm long, pubescent at base, grey-white; anther 0.6–0.9 mm long, yellow; third whorl of stamen opposite to first whorl of stamen with extrorse anther, glandular; gland shortly stipitate, c.0.3×0.3 mm, cordate; ovary c.0.3 mm long, globose, half inferior, slightly pubescent; style c.0.9 mm long, terete, glabrous; stigma capitate; staminodes cordate, stipitate. Berry c.10×5 mm, ovoid or ellipsoid, pale green to yellow when young, glossy black when mature. Seed 1.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from January to April.

**Distribution**: *Phoebe wightii* is distributed in South India (Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.). It is endemic to peninsular India. In Kerala it is distributed in Idukki, Palakkad districts.


**Figure 4.20.** ***Phoebe wightii*** **Meisn.: A.** Flowering twig; **B.** Single flower; **C.** Outer tepal outer view; **D.** Inner tepal inner view; **E.** 1st whorl of stamen; **F.** 2nd whorl of stamens; **G.** 3rd whorl of stamen; H. Pistil.

**Habitat**: This taxon found in evergreen and wet evergreen forests on at elevations ranging from 600-800 m. It is a medium canopy tree associated with *Palaquium ellipticum* (Dalz.) Baill., *Holigarna arnottiana* Wall.ex.Hook.f., *Vateria indica* L., *Elaeocarpus tuberculatus* Roxb*., Litsea bourdillonii* Gamble, *Cinnamomum malabatrum* (Burm.f.) Blume.

**IUCN Status**: Lower Risk/least concern

**Phenology**.

Flowering only once in year. Flower buds began to appear by the second week of November and remained almost unchanged in appearance till the first week of December. The buds were opened by the second week of December and tree was in full bloom by the last week of December. Dried flowers remained in the tree till the last week of January. Juvenile fruits began to appear by the first week of January. Fruits were matured by the last week of February. Fruits ripened to black and were fallen off by the last week of April.

**IUCN Status**: Not evaluated.

**Specimens examined**: INDIA, **Kerala**, Idukki district, Mannavanshola, 28.05.2003, *P.S. Udayan & A.J. Robi* 1462 (CMPR); Vattavada, 21.10.2004, *Geetha Kumary* 33620 (TBGT); *ibid*., 11.09. 2009, *Geetha Kumary* 29295 (TBGT); Munnar, 19.11.2005, *R. Rama Sabhu* 21731 (TBGT), Munnar to Chinnar, 06,03.2008, *P.S. Udayan & A.J. Robi* 4780 (CMPR); Munnar, 22.01.2009, *P.S. Udayan & A.J. Robi* 5466 (CMPR); Pampadumshola N.P, 28.11.2018, *P.K. Fasila et al.* 150512 (MESAH); Palakkad district, Parambikulam, Pandaravarai, 08.03.2007, *P.S. Udayan et al.* 4990 (CMPR); *ibid*., 09.03.2007, *P.S. Udayan et al.* 4979 (CMPR); *ibid*., 06.12.2008, *A.J. Robi* 5304 (CMPR); Karimala, 02.12.2008, *A.J. Robi* 5302 (CMPR); *ibid*., 25.03.2010, *P.S. Udayan & A.J. Robi* 6689 (CMPR); Nelliyampathy, Karimala, 13.05.2019, *P. K. Fasila et al*. 150561 (MESAH).

## MYRISTICACEAE R. Br.

Prodr. 399. 1810.

**Key to the genera**

1a. Filament and connective connate in peltate disc; fruit aril lacinate at the apex only ........................................................................................................... **Knema**

1b. Filament and connective connate in column; fruit completely encircle by the aril… ........................................................................................................... **Myristica**

## KNEMA Loureiro

Fl. Cochinch. 604. 1790.

**Knema attenuata** (Hook. f. & Thoms.) Warb., Monogr. Myris. 590. 1897; Gamble, Fl. Pres. Madras 1215. 1925; Mohanan, Fl. Quilon Dist. 340. 1984; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 390. 1988; Vajr., Fl. Palghat Dist. 400. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 386. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 377. 1996; Sivar. & Mathew, Fl. Nilambur 579. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 219. 2000; N. Mohanan & Sivad., Fl. Agasthyamala 558. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 420. 2005.

*Myristica attenuata* Wall. ex Hook. f. & Thoms., Fl. Ind. 157. 1855; Hook. f., Fl. Brit. India 5: 110. 1886.

*Myristica corticosa* Bedd., Fl. Sylv. t. 278. 1872.

**Local name**: Chorappathiri, Chorappayin

An evergreen medium sized tree, 15–30 meter high; outer bark greenish black; inner bark pale brown; blaze reddish; young branchlets stout, terete, rusty pubescent, grey to golden-grey when young. Leaves simple, alternate, distichous, estipulate. Petiole 0.5–1 cm long, stout, grooved above, young puberulous, glabrous on age, light brown to golden-brownish, brownish-black when dry; lamina 6–22.5×2.5–5.5 cm, elliptic, oblong-lanceolate, oblong or ovate, base acute or rounded, margins entire, slightly incurved, apex acuminate, coriaceous, glaucous beneath, glabrous on both surface, greyish above, brownish below when dry; mid rib prominent, emergent on both surface, slightly pubescent on lower surface; lateral nerves 13–15 pairs, parallel, opposite towards base, slender, looped towards the margin, emergent, on lower surface, slightly obscure on upper surface, glabrous on both surface, light brown; intercostae scalariform, prominent. Flowers dioecious, in rusty pubescent, fascicles on thick peduncle from the axile of leaves or at the scar of the fallen leaves. Male inflorescence 7–9 flowered, peduncle 1–1.5 cm, reddish pubescent when young, then warty, glabrous; pedicel 5–11 mm long, linear, reddish, tomentose. Male flowers 4.5–5×4–5.5 mm; tepals 2.5–3 mm long, triangular, acute, striate, puberulous to tomentose; anthers 13–14, connate at their base, attached stellately to the margin of the disc, dehiscing downward, sessile to obscurely stalked, stalk c.1 mm long, filaments and connective connate in a peltate disc. Female inflorescence 1-3 flowered; pedicel 7–8 mm long, perianth larger in female, lobes 3-4, triangular, acuminate rusty tomentose; ovary superior, c.4 mm long, ovoid, one celled, hairy, ovule 1; style short 0.5–0.6 mm long, thick, hairy; stigmas 2, laciniate on the margins. Fruit a capsule, 3.7–5×2–2.4 cm, ellipsoid, tip obtuse, 2 valved, rusty tomentose, dehiscent longitudinally, light green to light yellow on young, light yellow to dark yellow when ripe. Seed 1, 2.1–2.5×1.8–1.9 cm, ellipsoid, light yellow when young, brown when mature; aril surrounded the seed.

**Flowering & Fruiting**: Flowering from October to March. Fruiting from January to June.

**Distribution**: *Knema attenuata* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Kollam, Thiruvananthapuram, Pathanamthitta, Kottayam, Thrissur, Idukki, Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasaragod districts.

**Habitat**: The taxon is found in semi evergreen and evergreen forests on low and medium elevations ranging from 350-1100 m in the of Southern Western Ghats. It is a medium sized tree associated *Reinwardtiodendron anamalaiense* (Bedd.) D.J. Mabberley., *Aphanamixis polystachya* (Wall.) Parker, *Neolitsea cassia* (L.) Kosterm., *Cullenia exarillata* Robyns. etc.

**IUCN status**: - Lower Risk/least concern

**Phenology**

Flowering only once in year. Flower buds began to appear in the second week of October. The buds remained intact, and development was slow. Buds began to open by the third week of November. Pale green juvenile fruits were seen by the first week of January. The colour of the fruit changed to brown and ripened to bright yellow by the first week of April. Ripened fruits were split opened into two exposing the red aril by the late May, the fruits were fallen off the tree by the last week of June.

**Specimens examined**: INDIA, **Kerala,** Thiruvanathapuram district, Bomccord, ±700m, 22.12.1988 *N. Mohanan* 7917 CALI); Kollam district, Rosemala, Shendurny Wild life Sanctuary, ± 2000 m, 20.12.1993, *N. Sasidharan* 167 (KFRI); Idukki district, Periyar Tiger reserve, ±800 m, 9.01.1994, *Jomy Agustine* 13044 (KFRI); Chenthamara, PTR, ±800m, 15.03.1994, *Jomy Agustine* 13445 (KFRI); Karimala, PTR, ±320 m, 30.04.1994, *Jomy Agustine & K. P. Rajesh* 13695 (KFRI); Koruthode Periyar Tiger reserve, ±150m, 27.01. 1995, *N. Sasidharan & Jomy Agustine* 147116 (KFRI); *ibid*., ±320 m 13.08.1993, *Jomy Agustine* 12262 (KFRI); Thrissur district, Pullamkondam, 23.01.1978, *N. Sasidharan* 167 (KFRI); Arippa, Kulathupuzha range, ±150 m, 19.12.1980, *N. Sasidharan* 1404 (KFRI); *ibid*., 19.12.1980, ±160m, *N. Sasidharan* 1418 (KFRI); Mallayattoor Forest, 17.12.1991, *K.K.N. Nair* 6890 (KFRI); Sholayar, Ambalapara, 3.04.2015, *P.K. Fasila & K.H. Amitha Bachan* 137414 (MESAH); Palakkad district, Silent Valley, Thuthanpara, *P.K. Fasila & K.H. Amitha bachan* 150559 (MESAH); Malappuram district, Nilambur, Thalichola, *Philip Mathew* CU 33907, CU 28431 (CALI); Thalichola - Paduta, *Philip Mathew* CU 500 m 33125 (CALI); Wayanad district, Nadukani way to Gudallore from Nilambur, ±525 m, 28.11.1984, *N. Sasidharan* 3343 (KFRI); Vythiri ghat ±500 m, 30.05.2002, *M.K. Ratheesh Narayanan* 2623 (CALI); *ibid.,* 15.06.2002, *M.K. Ratheesh Narayanan* 3003 (CALI); Kurichiarmala, ±1400 m, 18.07.2002, *M.K. Ratheesh Narayanan* 3847 (CALI).

**MYRISTICA** Gronovius

P. E. Boissier, Fl. Orient.: 141.1755 (*nom. cons*.).

Trees. Leaves simple, alternate, distichous, chartaceous, evergreen; flowers dioecious, in cymes umbel or fascicles axillary or below the leaves; the peduncles usually thick; bracts deciduous; bracteoles persistent; perianth 3-4 lobed; androecium stalked, the filaments and connectives connate in a column; ovary ovoid; stigma connate. Fruit capsule; arillate.

**Key to species**

1a. Fruit ovoid or ellipsoid, aril orange-red........................................... **M. beddomei**

1b. Fruit oblong, aril yellow ..............................................................**M. malabarica**

**Myristica beddomei** King, Ann. Roy. Bot. Gard. (Calcutta) 3: 291, t. 118. f.1-8,1891, ssp *beddomei*: de Wilde, Blumea 42: 151. 1997; Gamble, Fl. Pres. Madras 1214. 1915. Banik *et al.*, Rheedea 27 (1): 5. 2017.

*Myristica dactyloides* auct. non Gaertn. 1788; Sinclair, Gard. Bull. Singapore 23: 445. 1968; Mohanan, Fl. Quilon Dist. 341. 1984; Mani., Fl. Silent Valley 233. 1988; V.S. Ramach & V.J. Nair, Fl. Cannanore Dist. 390. 1988; Vajr., Fl. Palghat Dist. 400. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 387. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 378. 1996; Sivar. & Mathew, Fl. Nilambur 580. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 246. 2000; N. Mohanan & Sivad., Fl. Agasthyamala 559. 2002; Sasidh., Fl. Parambikulam WLS 265. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 421. 2005.

*Myristica laurifolia* auct. non Hook. f. & Thoms. 1855; Hook. f., Fl. Brit. India 5: 103. 1886.

*Myristica laurifolia var. lanceolata* Hook.f., Fl. Brit. India 5: 103. 1886.

*Myristica contorta* Warb., Monogr. Myris. 5-7. 1897; Gamble, Fl. Pres. Madras 1214. 1925. **(Figure 4.21.)**

**Local name**: Pathripoo, Kattu-Jhadikka.

A Large evergreen tree, to 25 m high; bark 10–14 mm thick, brownish black, warty with linear pustular lenticels; blaze red; exfoliations small; exudation watery red; branchlets glabrous, except for terminal bud and inflorescence. Petiole 1.5–3×0.1–0.2 cm, grooved above, glabrous; lamina 12–22×2.5–8 cm, oblong or elliptic-ovate, base acute, round or rarely cuneate, margin entire, apex acute, glabrous on both surface, shining above and glaucous beneath, coriaceous, brownish-black above, glaucous beneath when dry; mid rib prominent, emergent on lower surface, glabrous; lateral nerves 14-20 pairs, pinnate, prominent, arcute, joined at the margin on lower surface, glabrous, slightly channelled on upper surface; intercostae reticulate, faint. Flowers white to creamy-yellow; male flowers 6-20 together in short axillary dense clusters; peduncle c.1×0.3 cm, prominently marked with cicatrices of the bracts; pedicels c.3 mm long, slender, ferrugineous tomentose; perianth connate into an urceolate tube, constricted above, suddenly expanded, breaking into 3 ovate, spreading acute lobes, fleshy, rusty tomentose, greenish-yellow; staminal column c.5 mm long, narrow to oblong, ferrugineous, included, produced beyond the anther; anthers 7–15, linear-oblong. Female flowers as in male, generally 3–4 in the heads; ovary superior, ovoid-globose, sessile, appressed pubescent, 1-celled, ovule 1; stigma oblique, 2-lobed. Fruit a capsule, 7–8×4.2–4.5 cm, ovoid or ellipsoid, apiculate, grooved on one side along the suture. Seed 1, ovoid; aril orange red, encircling the seed, deeply cut down into many lobes, each lanceolate at the apex into filiform segments.

**Flowering & Fruiting**: Flowering from December to March. Fruiting from February to June.

**Distribution**: *Myristica beddomei* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed Palakkad, Kollam, Idukki, Pathanamthitta, Malappuram, Kannur, Thiruvananthapuram, Thrissur and Wayanad districts.

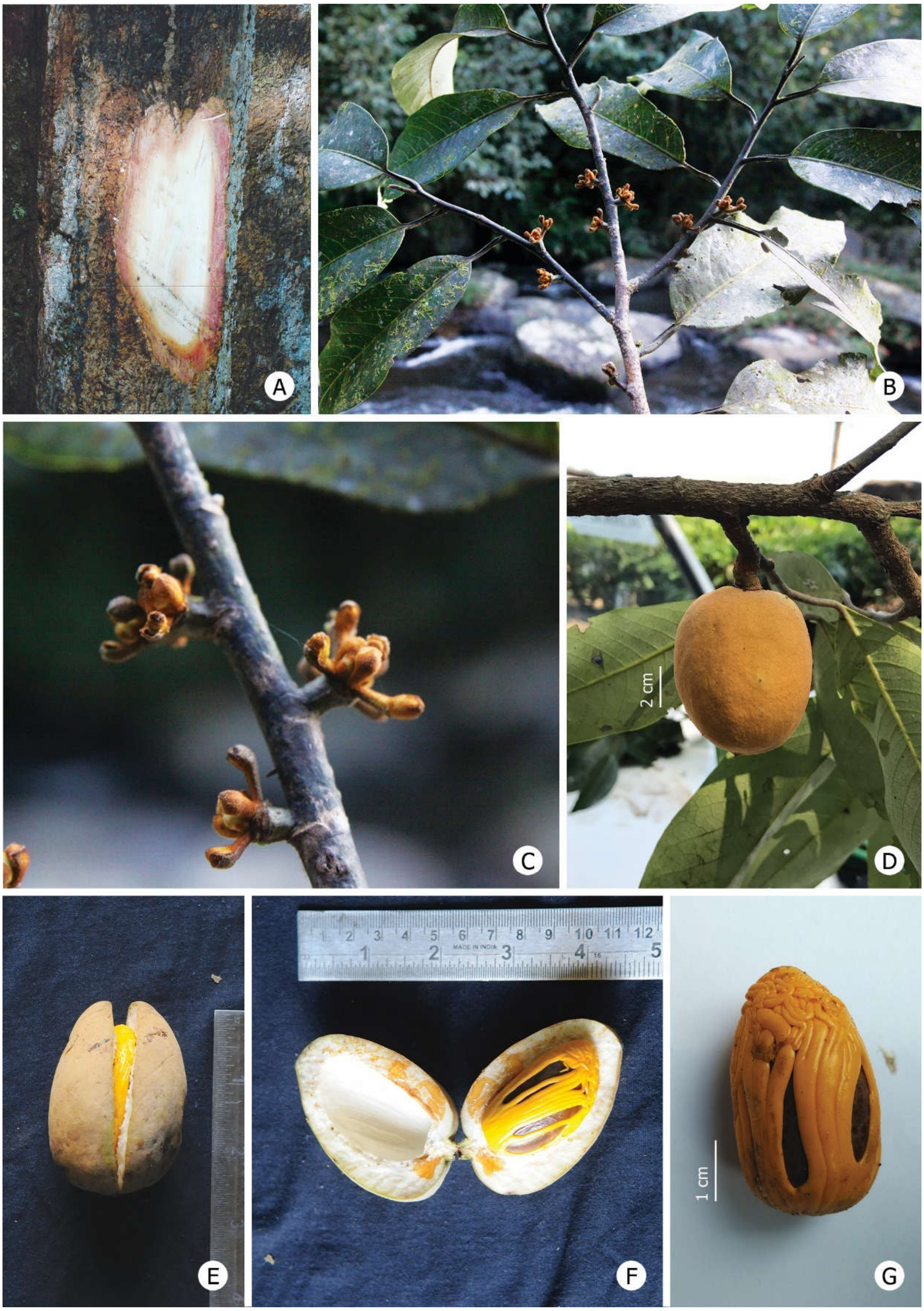


**Figure 4.21.** ***Myristica beddomei*** King**: A.** Blaze; **B & C.** Flowering twig; **D.** Fruiting twig; **E.** Single fruit; **F.** Fruit opened; **G.** Seed with aril.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on an elevation ranging from 600-1300 m in the of Southern Western Ghats. It is found in the wet evergreen forest slopes with streams draining to the river or reservoir. It is a buttressed, top canopy tree seen associated with *Palaquium ellipticum* (Dalz.) Baill, *Cullenia exarillata* Robyns., *Vateria indica* L., *Chukrasia tabularis* A. Juss., *Litsea oleoides* (Meisn.). Hook.f.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to by the first week of December. By the last week of January, all the buds were opened. Single flowers bloomed randomly all over the tree. By the second week of February, most of the flowers were shed. Young fruits began to appear by the first week of February. By the last week of April, fruits were matured, and colour changed to yellow. By the last week of May, the fruits were split open into two exposing the yellow arillate seed.

**Specimens examined**: INDIA, **Kerala**, Kollam district, Rosemala, Shendurny Wildlife Sanctuary, ±600 m, 16.02. *N. Sasidharan* 10849 (KFRI); Iddukki district, Koruthode, PTR, Idukki, ±250 m, 13.08.1993, *Jomy Agustine* 12263 (KFRI); Vellimala, PTR, ±1550 m, 11.12.1993, *Jomy Agustine* 12927 (KFRI); Kavalappara, Periyar Tiger Reserve 1.01.1995, *K. P. Rajesh* 14538 (KFRI); Thrissur district, Peechi, ±160 m, 10.03.1986, *N. Sasidharan* 3785 (KFRI); Sholayar, ±400 m, 12.12.1988, *N. Sasidharan* 5233 (KFRI); *ibid.,* 18.04.2019, *P.K. Fasila & K.H. Amitha Bachan* 150535 (MESAH); Malakkappara, Myladumpara, 19.04.2019, *P.K. Fasila & K.H. Amitha Bachan* 150539 (MESAH); Pazhavellachal Peechi, ±400 m, 15.03.1989, N. Sasidharan 5353 (KFRI); Palakkad district, Silent Valley Mannarghat range, ±800 m, 10.12.1980, *N. G. Nair & N Sasidharan* 1343 (KFRI); Wayanad district, Nadukani way to Gudallore, 18.01.1979, *N. Sasidharan* 474 (KFRI); Chandanthodu ghat side, 4.12.1986, *R. T. Balakrishnan* 42717 (CALI).

**Myristica malabarica** Lam., Acad. Roy. Sci. Mem. Math. Phys. (Paris) 162. 1791; Hook. f., Fl. Brit. India 5: 103. 1886; Gamble, Fl. Pres. Madras 1213. 1925; Mani., &

Sivar., Fl. Calicut 249. 1982; Mohanan, Fl. Quilon Dist. 342. 1984; Mani., Fl. Silent Valley 233. 1988; Vajr., Fl. Palghat Dist. 401. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 387. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 378. 1996; Sivar. & Mathew, Fl. Nilambur 581. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 250. 2000; N. Mohanan & Sivad., Fl. Agasthyamala 559. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 421. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 608. 2009; Banik *et al*., Rheedea 27 (1): 9. 2017.

**Local name**: Pathri, Pathripoo.

A medium sized evergreen tree, up to 20–25 m heigh; branchlets sub terete, glabrous; outer bark greenish-black, tuberculate-lenticellate; exudation deep red, inner bark reddish; blaze creamy yellow. Petiole 1.5–2 cm long, slender, grooved above, glabrous; lamina 4–20×3–10 cm, elliptic or elliptic-oblong, base rounded, subacute or slightly oblique, margin entire, apex acute, coriaceous, glabrous and glossy above, and glaucous beneath; mid rib prominent on both surface, glabrous; lateral nerves 12-16 pairs, pinnate, slender, emergent on lower surface, slightly obscure on upper surface, glabrous; intercostae reticulate and looped towards the margin on lower surface, obscure on upper surface. Flowers creamy white; male in cymose panicle 3–5 cm long; peduncle 2–3 cm long, very slender; pedicel 0.5–1 cm long, slender, glabrous. Male flowers: more numerous than in female and smaller, umbel at the apex of branchlets; perianth 3-4 lobed, minutely puberulous without, glabrous within, creamy-white; staminal column stalked, slightly produces above the anthers, pubescent; anthers 10–20, linear. Female flowers: slightly larger than male peduncle, generally simple with 3 umbelled pedicels at the apex, rarely once branched and bearing 5–6 flowers; bracteole forming a narrow linear cup round the base of the perianth; ovary superior, sessile, globose, hairy; stigma 2, clefted, glabrous. Fruit a capsule, oblong, 5–7.5×1.8–3.5 cm, brown tomentose. Seed 1, oblong, obtuse, slightly flattened on one side; aril yellow, irregularly lobed, laciniate, completely covering the seed.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from April to August.

**Distribution**: *Myristica malabarica* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Alappuzha, Kollam, Idukki, Pathanamthitta, Malappuram, Palakkad, Thiruvananthapuram, Kozhikode, Thrissur and Wayanad districts.

**Habitat**: The taxon is found in evergreen forests on low medium hill slopes at elevations ranging from 200-1000 m in the of Southern Western Ghats. It is a medium sized tree found in forest slopes. It is associated with *Alseodaphne semecarpifolia* Nees, *Vateria indica* L, *Beilschmiedia wightii* (Nees) Benth., *Phoebe lanceolata* (Nees) Nees.

**IUCN Status**: Vulnerable B1+ 2c

**Phenology**

During the study period, the flowering stages of *Myristica malabarica* could not be observed. Even though individual trees were spotted in Odankayam (Sholayar region), none of them flowered during the study period. The herbarium records of the species were examined from the Herbarium of the Kerala Forest Research Institute, Peechi. The specimen contained mature fruit and it was noted that the specimen was collected during the second week of May. In the preserved specimen, the fruits were split opened into two.

**Specimens examined**: INDIA, **Kerala**, Thiruvananthapuram district, Bomccord ±700 m, 29.05.1989, *N. Mohanan* 8445 (CALI); Athirumala, ±1000 m, 12.10.1985, *N. Mohanan* 4247 (CALI); Kollam district, Choodal, Shendurney Wild life sanctuary, 14.01.1993, *N. Sasidharan* 10140 (KFRI); Umiyar, Shendurney Wild life Sanctuary, ±500 m, 17.02.1994, *N. Sasidharan* 10860 (KFRI); Alappuzha district, Chengannore, Vallikkavu, *C. N. Sunil* 2411 (CALI); Idukki district, Chittammada, PTR, ±150 m, 27.02.1994, *Jomy Agustine* 13397 (KFRI); Thrissur district, Arippa, Kulathupuzha range, ±150 m, 21.12.1980, *N. Sasidharan* 1476 (KFRI); Kulathupuzha, 17.01.1985, *N. Sasidharan* 3436 (KFRI); Chimmini Dam, ±250 m, 14.03.1986, *N. Sasidharan* 3813 (KFRI); Malappuram district, Vaniampuzha 5.01.1983, *Phip Mathew* 33739 (CALI).

**ELAEOCARPACEAE** Juss. ex DC.

Prodr. 1: 519. 1824.

**ELAEOCARPUS** Linnaeus

Sp. Pl. 515. 1753.

Evergreen trees, buttressed. Leaves simple, alternate, stipulate, margin distantly serrate or crenate or subentire. Flowers hermaphrodite, white or cream; sepals 5, free, valvate; petals, free; stamens numerous, free, inserted between the glands on the disc; ovary superior, ovules 2 in each locule. Fruit drupe.

**Key to the species**

1a. Lamina broadly ovate, 10–22×5–13 cm, base cuneate or rounded, apex obtuse or retuse; sepals 1–2 cm long; flowers > 1 cm long;……………….**E. tuberculatus**

1b. Lamina elliptic, elliptic-ovate, 4–8.5×2.7–4 cm, base obtuse, sub-acute or oblique, apex acute; sepal < 1 cm long; flowers < 1cm long ………**E. variabilis**

**Elaeocarpus tuberculatus** Roxb., Fl. Ind. 2: 594.1832; Hook. f., Fl. Brit. India 1:404.1874; Gamble, Fl. Pres. Madras 124. 1915; Mohanan, Fl. Quilon Dist. 99. 1984; Mani., Fl. Silent Valley 37. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 74. 1988; Vajr., Fl. Palghat Dist. 97. 1990; S.K. Murti in B.D. Sharma & Sanjappa, Fl. India 3: 559. 1993; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 93. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 74. 1996; Sivar. & Mathew, Fl. Nilambur 112. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 121. 2002; Sasidh., Fl. Parambikulam WLS 39. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 102. 2005; Henry & V. Chithra in P. Daniel, Fl. Kerala 1: 503. 2005.

*Monocera tuberculata* (Roxb.) Wight &Arn., Prodr. 83. 1834.

**Local name**: Puzhathanni, Poumbu.

A large tree, 25–40 m high; bark greyish or brownish molted with grey-white outside; blaze yellowish; branchlets terete, with scars of fallen leaves, densely brown villous, when young, golden-reddish, golden-brown when dry, tawny velutinous to fulvous tomentose; lenticels few, elliptic-narrow, pale brown. Leaves simple, opposite, clustered at the tip of branchlets, stipulate; stipules free, lateral, brown-villous, caducous; domatia present. Petiole 1.5–2.5 cm long, base and tip swollen, stout, pubescent, blackish when dry; lamina 10–22×6–13 cm, broadly obovate, cuneate or round at base, acute, obtuse or retuse at apex, sub coriaceous, glabrous above, ferruginous pubescent beneath, dark green, glossy, turning brown when dry above, pale green turning greyish when dry below; mid rib prominent, glabrous on both surface, lateral nerves 10–11 pairs, closely arranged towards the base, slightly arcute, highly emergent below, glabrous; intercostae scalariform, slender, prominent below, inconspicuous above. Inflorescence a raceme in the axile of leaves or at the leaf scar usually more in the upper leaf axil, up to 12 cm long. Flowers 1–2.5 cm long; pedicel c.2 cm long, tomentose, deflexed; sepals c.1.8 cm long, lanceolate, tomentose without; petals obovate, fimbriate, fulvous tomentose, inserted round the base of glandular disc, disc 5 lobed and cushion like; anthers thinly tomentose, terminating in long bristle; filament short, basifixed, dehiscence through an apical slit; ovary subglobose, densely tomentose, placed on raised torus, 2-celled; ovules pendulous; style subulate, tomentose, entire. Fruit 3–5×2.5 cm, oblong or ellipsoid, green, ferrugenous tomentose; stones single, laterally compressed, coarsely tuberculate. Seed 1–2-celled.

**Flowering & Fruiting**: Flowering from September to October. Fruiting from February to July.

**Distribution**: *Elaeocarpus tuberculatus* is distributed in South India (Karnataka, Kerala and Tamil Nadu). In Kerala, it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad and Kannur districts.

**Habitat**: The taxon is found in semi evergreen and evergreen forests in elevations ranging from 240-900 m in the Southern Western Ghats. It is a large sized tree associated *Hopea parviflora* Bedd., *Vateria indica* L., *Otonephelium stipulaceum* (Bedd.) Radlk., etc are in the upper strata. *Ziziphus rugosa* Lam., etc. *Litsea floribunda* (Blume) Gamble, *Polyalthia coffeoides* (Thw.) J. Hk & Thoms, *Pterocarpus marsupium* Roxb. etc.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to appear by the last week of September. Flowers were opened by the second week of October and the tree was in full bloom till the first week of January. Green juvenile fruits were developed by the first week of February. By the third week of March, fruits matured, and colour changed to brownish green. By the first week of May, fruits were ripened, and colour changed to pale blue. By the first week of July, the fruits were fallen off the tree.

**Specimens examined**: INDIA**, Kerala**, Idukki district, Sabharigiri, TC tunnel area, ±1050 m, 30.03.1981, *B.K. Nayar & K. Rajappan* K10507 (CALI); Periyar, Pachakkanam, ±700 m, *Jomy Augustine* 12704 (CALI); Munnar, 07.01.1989, *Sulley George* 6513 (CALI); Munnar, 8.01.1989, *N.K. Mini* 2550 (CALI); Cheriyan Munnar, 08.01.1989, *T. Beena* 2605 (CALI); Vittal, 8.12.1989, *V.N. Usha Kumari* 8789 (CALI); Thrissur district, Vazhachal, ±350 m, *N. Sasidharan* 725 (CALI); Orukumbankutty ±500 m, 13.9.2005, *K.H. Amitha Bachan* 99019 (CALI); Sholayar, 04.04.2015, *P.K. Fasila* 137450 (MESAH); Palakkad district, Silent valley ±1100 m, 24.01.1982, *K.S. Prasanna Kumar* SV10254 (CALI); Wayanad district, Pookode lake, ±740 m, *A.K. Pradeep* 70542 (CALI); Vaithiri, 14.11.1987, *A.K. Prasitha,* 12860 (CALI); Vaithiri, 14.11.1987, *P.S. Ajitha,* 13322 (CALI), , ±710 m, 27.11. 1972, *N.A. Erasy & B.K. Nayar* 2272 (CALI).

**Elaeocarpus variabilis** Zmarzty, Kew Bull. 56: 429. 2001.

*Craspedumtectorium* Lour., Fl. Cochinch. 336. 1790.

*Elaeocarpus tectorius* (Lour.) Poir. in Lam., Encycl. Suppl. 2: 704. 1812; S.K. Murti in B.D. Sharma & Sanjappa, Fl. India 3: 559. 1993.

*Elaeocarpus oblongus* sensu Mast. in Hook.f., Fl. Brit. India 1: 403. 1874, non Gaertn. 1788; Gamble, Fl. Pres. Madras 124. 1915.

*Elaeocarpus glandulosus* Wall. ex Merr., Arnold Arbor, 32: 184.1951; Mani., Fl. Silent Valley 36. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 73. 1988; S.K. Murti in B.D. Sharma & Sanjappa, Fl. India 3: 539. 1993; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 92. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 74. 1996; N. Mohanan & Sivad., Fl. Agasthyamala 119. 2002; M. Reema *et al*. in P. Daniel, Fl. Kerala 1: 499. 2005.

**Local name**: Kara, Kattukara

Small to medium sized tree, 7–16 m high; bark greyish-brown outside, orange-brown inside; blaze red; branchlets terete, golden-reddish, golden brown when dry, fulvous tomentose; lenticels few, narrow elliptic, pale brown. Petiole 1.5–3 cm long, slender, terete, swollen at base and tip, rusty tomentose, greyish to blackish when dry; stipules lateral, caducous; lamina 4–8.5×2.7–4 cm, elliptic, elliptic-ovate, ovate, obtuse to sub-acute and oblique at base, acute at apex, coriaceous, dark green, glossy, turning greyish-brown when dry above, pale green turning greyish when dry below; mid rib prominent, fulvous to brown-tomentose or villous beneath; secondary veins 4–6 at one side, pinnate at base, slender, slightly sunken above and raised beneath; intercostae reticulate, inconspicuous above, highly raised beneath, percurrent. Inflorescence racemes in the axial of leaves or at the ends of branches; peduncle puberulous when young. Flowers bisexual, white; pedicel c.3 mm long; sepals 4–5 mm long, ovate-lanceolate, puberulous without, glandular within; petals 6–8 mm long, laciniate, glandular, inserted round the base of glandular disc; anthers tipped with hairs; ovary subglobose, placed on a raised torus, densely hairy without, 3-celled; style subulate, entire. Fruit 3.3–3.6×1.8–2.1 cm, oblong or ellipsoid; stone one, compressed. Seed 1–2.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from February to May.

**Distribution**: *Elaeocarpus variabilis* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala, it is distributed in Thiruvananthapuram, Kollam, Idukki, Thrissur, Palakkad, Kozhikode, Wayanad and Kannur districts.

**IUCN Status**: Not evaluated.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at high elevations ranging from 900-1800 m in the of Southern Western Ghats. It is a medium sized tree seen associated with *Cryptocarya stocksii* sensu Gamble., *Cullenia exarillata* Robyns., *Vateria indica* L., *Litsea oleoides* (Meisn.) Hook.f, *Actinodaphne wightiana* (Kuntze) Noltie, *Neolitsea cassia* (L.) Kosterm. etc.

**Phenology**

Flowering only once in year. Flower buds began to appear by the second week of November. Flowering period lasted for 4 weeks from the bud initiation. This species showed a peculiar type of flowering pattern with short period of mass flowering. By the last week of January, flower became matured. By the first week of February, young fruits started to develop. Fruits were matured by the last week of April by which time they were dark yellow in colour. Fruits were ripened to pale blue by the last week of May or first week of June. The ripened fruits were fallen off within two weeks.

**Specimens examined**: INDIA, **Kerala**, Thrissur district, Orukumbankutty ±450 m, 13.9.2005, *K.H. Amitha Bachan* 99104 (CALI); Palakkad district, Nelliyampathy, 11.05.2019, *P.K. Fasila* 150553 (MESAH).

**RHAMNACEAE** Juss.

Gen. Pl. 376. 1789.

**Maesopsis eminii** Engl., Pflanzenw. Ost-Afrikas, C. 255. 1895; Anil Kumar *et al*., Fl. Pathanamthitta 130. 2005; P.V. Sreekumar & A.N. Henry in P. Daniel (ed.), Fl. Kerala 1: 736. 2005.

**Local name**: Umbrella tree

A medium sized, semi deciduous tree, up to 25–42 m high; bole straight, cylindrical; outer bark pale greyish to white, deeply fissured; blaze red; branchlets terete, pubescent. Leaves opposite or sub opposite, decussate; stipules small, 2–6 mm long, subulate, puberulent, caducous. Petiole 10–20 mm long, grooved above, slender, tomentose, red; lamina 8.5–12×2.5–4.2 cm, ovate-lanceolate, oblong-ovate or lanceolate, base rounded or sub cordate, margin dentate, having gland at each tooth, apex acuminate, acumen 0.7–0.8 cm long, chartaceous, glabrous; midrib prominent, glabrous; lateral nerves 7–9 pairs, parallel, slender, prominent; intercostae reticulate, prominent. Inflorescence: many flowered axillary cymose panicle, 1–5 cm long; peduncle 0.4–2.5 cm long, densely rusty tomentose. Flowers bisexual, 5×6 mm, greenish-yellow, shortly stalked, slightly fragrant; pedicels short, c.0.5 cm long; calyx tube obconic, lobes 5, 2–6 mm long, deltoid; petals 5, c.3 mm long, valvate, orbicular, concave, green; stamens 5 in one whorl, enclosed by the petals; anthers subsessile, oblong; ovary superior, ovoid, c.1 mm long, glabrous, 1-celled; ovule 1, erect; style stout; stigma capitate, 5 furrowed. Fruit a drupe, 2.5–3×1–1.5 cm, oblong-obovoid, orange, muricate. Seeds 1-2, oblong.

**Flowering & Fruiting**: Flowering from September to March. Fruiting from January to April.

**Distribution**: *Maesopsis eminii* is distributed in South India (Kerala and Tamil Nadu). In Kerala it is distributed in Pathanamthitta, Kollam, Idukki, Palakkad, Kozhikode, Kannur and Wayanad distrits.

**Habitat**: It is a large indigenous tree in East, Central and West Africa, mostly grows in wet tropical and wet montane climate, and grows best below 2700 m. In southern India it is introduced as shade tree in tea and coffee plantations.

**IUCN status**: Least Concern.

**Phenology**

It is a fast-growing tree, starts flowering and fruiting at 4 to 6 years old. These trees flowered two times in a year. First flowering started in March. Flower buds began to appear by the first week of March. Buds were opened by the second week of March. All the buds were opened, and the tree was in full bloom by the last week of March. Juvenile fruits, light green in colour, were developed by the first week of April. Within one month, the colour changed to yellow. Upon maturation, by the last week of April, the colour changed to pink. Upon ripening, by the third week of May, the colour again changed to purplish black. By the first week of June, the fruits were fallen off the tree.

Second flowering started by the last week of September or first week of October. Buds were opened by the third week of October. All the buds were opened, and the tree was in full bloom by the first week of November. Juvenile fruits were developed by the first week of January. The fruits were ripened by the first week of February.

**Specimens examined**: INDIA, **Kerala,** Thrissur district, Malakkappara ±1450 m, 13.9.2005, *K.H. Amitha Bachan* 99179 (CALI); Palakkad district, Nelliyampathy, Victoria estate, 11.05.2019, *P.K. Fasila* 150589 (MESAH).

**MYRTACEAE** Juss.

Gen. Pl. 322. 1789.

**Syzygium** P. Browne ex Gaertn.,

Fruct.Sem.Pl.1:166.1788 (*nom. cons*.).

**Syzygium cumini** (L.) Skeels, U. S. DA. Bur. Pl. Industr. Bull. 248: 2. 1912, var. cumini; Mani., & Sivar., Fl. Calicut 107. 1982; Mohanan, Fl. Quilon Dist. 180. 1984; Mani., Fl. Silent Valley 104. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 181. 1988; Vajr., Fl. Palghat Dist. 199. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 188. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 181. 1996; Sivar. & Mathew, Fl. Nilambur 262. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 261. 2002; Sasidh., Fl. Parambikulam WLS 120. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 216. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 287. 2009.

**Local name**: Njaval, Njara.

*Myrtus cumini* L., Sp. Pl. 471. 1753.

*Eugenia jambolana* Lam., Encycl. 3: 198. 1789; Hook. f., Fl. Brit. India 2: 499. 1879.

*Syzygium jambolanum* (Lam.) DC., Prodr. 3: 259. 1828; Gamble, Fl. Pres. Madras 481. 1919.

A medium sized tree, 10–20 m high; young branches angular with white or grey shade, glabrous; bark pale yellow brown; blaze pale pink. Leaves simple, opposite, estipulate; petiole 1.5–2 cm long, rounded beneath, sulcate above, glabrous, light green, black when dry; lamina 14–12 x 5.5–4 cm, ovate-lanceolate, or elliptic, base acute, margins entire, apex long acuminate or obtusely acuminate, coriaceous, glabrous, glossy green, pellucid-dotted, abaxially slightly pale when dry, adaxially brownish green to blackish-brown and slightly glossy when dry; mid rib prominent on both surface, glabrous; lateral veins many, shining above, very closely arranged, astonishing, extending into margin; inter marginal veins not prominent. Inflorescence panicle, up to c.11 cm long, arise on leaf less branchlets. Flowers bisexual, white or creamy white, c.0.8 x 0.5 mm; pedicel c.1 cm long; bracteole 2, c.0.1 x 0.5 mm, fan shaped, free, placed opposite position at the rim of disc, membranous; calyx tube c.3 mm long, turbinate, lobe 4; petal 4, c.3 x 2 mm, concave, ovate and slightly rounded, one calyptra completely encloses the other, membranous, free, alternate to sepals; stamens many arranged in 3 whorls of different sizes 1.5–0.5 mm long, filaments filiform, anther c.1 mm long, versatile, 2 celled, dehisced longitudinally; ovary inferior, 2- celled, numerous ovules on axial placentation; style slender, filiform c.4.8 mm long, glabrous; stigma simple, small. Fruit c.15 x 0.6 mm, obovoid, light pink when young, turns to reddish violet when mature. Seed 1, c.10 x 5.5 mm, obovoid, green.

**Flowering** & **Fruiting**: Flowering from December to February. Fruiting from March to May.

**Distribution**: *Syzygium cumini var. cumini* is distributed in South India (Andra Pradesh, Kerala, and Tamil Nadu). In Kerala it is distributed in all districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes low and medium elevations ranging from 600-800 m in the of Southern Western Ghats. It is a medium sized tree associated *Persea macrantha* (Nees) Kosterm., *Palaquium ellipticum* (Dalz.) Baill., *Chukrasia tabularis* A. Juss, *Mesua ferrea* L., *Grewia tiliifolia* Vahl.

**IUCN Status**: Lower Risk/least concern.

**Phenology**

Flowering only once in year. Flower buds began to appear by the last week of December. Buds begin to open by the second week of January. By the last week of January, the tree was in full bloom. Juvenile green fruits began to appear by the first week of February. 80 % of the flower become fruits. Maturation of fruit was very slow, became fully matured by the first week of April. At this time, the colour of the fruit changed to pink. By the last week of April, the fruits were ripened to dark purple colour. By the first week of May, fruits were fallen off the tree.

**Specimens examined***:* INDIA, **Kerala**, Trivananthapuram district, Attayar, ±650 m, *N. Mohanan* 7988 (CALI); Idukki district, Vallakkadavu, ±800 m, 25.04.1994, *Jomy Augustine* 13472 (CALI); way to Munnar, 15.01.2019, *P.K. Fasila* 150503 (MESAH); Thrissur district, Sholayar, ±800 m, 21.04.1982, *N.G. Nair* 1769 (KFRI); *ibid*., 4.04.2015, *P.K. Fasila* 137419 (MESAH); Vazhachal, ±200 m, 2.04.2007, *K.H. Amitha Bachan* 123462 (CALI); Palakkad district, Silent valley Dam site, ±1100 m, 10.03.1982, *T. S. Sabu* 10401 ( CALI); Wayanad district, Kartikulam, 26.04.1986, *R.T. Balakrishnan,* 41994 (CALI); Wayanad Chembra peak, ±1000 m, 13.03.2001, *M. K. Ratheesh Narayan* 2601 (CALI).

**BURSERACEAE** Kunth

Ann. Sci. Nat. (Paris) 2: 346. 1824.

**CANARIUM** Linnaeus

Amoen. Acad. 4: 121. 1759.

**Canarium strictum** Roxb., Fl. Ind. 3: 138. 1832; Hook. f., Fl. Brit. India 1: 534. 1875; Gamble, Fl. Pres. Madras 172. 1915; Mohanan, Fl. Quilon Dist. 108. 1984; Mani., Fl. Silent Valley 47. 1988; Vajr., Fl. Palghat Dist. 107. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 108. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 86. 1996; Sivar. & Mathew, Fl. Nilambur 129. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 74. 2000; Sasidh., Fl. Parambikulam WLS 52. 2002; N. Mohanan & Sivad., Fl. Agasthyamala 147. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 115. 2005; Henry & V. Chithra in P. Daniel, Fl. Kerala 1: 629. 2005.

**Local name**: Mullanpali, Vediplavu.

A large tree, 30-35 m high; bole straight, buttressed; outer bark grey-brown, smooth; exfoliation small, irregular; blaze yellowish, aromatic; exudation brownish-black, resinous; branchlets terete, velvety tomentose. Leaves pinnately compound, alternate, spiral, clustered at the twig ends, imparipinnate; stipules obscure; rachis 22–42 cm long, stout, swollen at base, ferruginous pubescent; leaflets 7–11, opposite; lamina 5–16×2.5–7 cm, ovate, ovate-lanceolate, oblong-ovate or elliptic-ovate, base acute or oblique, margin entire or serrulate or crenulate, apex acuminate, the acumen 0.7–0.8 cm long, coriaceous, adaxially glabrous, abaxially nearly glabrous to densely rusty tomentose; midrib prominent and rusty tomentose on upper surface; lateral nerves 7–20 pairs, base pair alternate, distal pairs parallel, prominent on abaxially, very slender, slightly channelled on adaxially, intercostae scalariform, prominent; petiolule 3–8 mm long, stout, tomentose. Inflorescence axillary cymose panicle in male, many flowered, 7.5–40 cm long, racemose panicle in female, 7–20 cm long, few flowered, glabrescent, densely rusty or yellow tomentose. Flowers polygamous, 5–6 mm across, bright yellow, shortly stalked, slightly fragrant; bracts caducous; pedicels short; calyx tube c.5 mm long, campanulate, lobes 3, basally connate and valvate, pubescent; petals 3, c.1 cm long, oblong, concave, apiculate, valvate, white; disc obscurely 6-lobed, densely pubescent. Stamens 6, free from the disc; staminal tube c.3 mm long; filaments 1–2 mm long, glabrous, free from the disc and connate for 1/4–3/4 of length; anthers oblong, sub equal, acuminate, basifixed, introrse; pistillode short; ovary c.3.5 mm long, glabrous 3-celled; ovule 1 in each cell; style 1, stout; stigma capitate, 2–3 lobed. Fruit a drupe, 2.5–5.0×1.5 cm, ellipsoid, dark blue, 1–3-celled. Seeds 1–3.

**Flowering & Fruiting**: Flowering from November to January. Fruiting from January to April

**Distribution**: *Canarium strictum* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). In Kerala, it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad and Kannur districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests at medium elevations ranging from 400-1200 m in the of Southern Western Ghats. It is a large sized tree seen associated with *Cullenia exarillata* Robyns., *Otonephelium stipulaceum* (Bedd.) Radlk., *Schleichera oleosa* (Lour.) Oken., *Baccaurea* *courtallensis* (Wight) Mull.Arg., *Chukrasia tabularis* A. Juss., *Cinnamomum malabatrum* (Burm. f.) persl. etc.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to appear by the second week of November. Buds began to open by the first week of December. Juvenile fruits, pale green in colour, began to develop by the last week of January. Dried flowers will remain in the tree till the end of February. Fruits were matured by the last week of January. Upon maturation, the colour changed to dark green. Fruits were ripened by the second week of February and colour turned to black. Fruiting continued till the second week of May. By the first week of June, the fruits were fallen off the tree.

**Specimens examined**: INDIA, **Kerala**, Thrissur district, Chandanthodu, Sholayar, 28.05.2020, *P.K. Fasila* 1500586 (MESAH). Palakkad district, Valiaparathode ±1350 m, 8.3.1982, *K.S. Prasanna Kumar* SV 10291 (CALI).

## **MELIACEAE** Juss.

Gen. Pl. 263. 1789.

### Key to the genera.

1a. Anthers included in the staminal tube or only at the tip exerted .......................... 2

1b. Anthers exerted ........................................................................... **Trichilia**

2a. Flowers and staminal tube oblong ..................................................... **Dysoxylum**

2b. Flowers and staminal tube globose ....................................................... 3

3a. Stamen 9–10 in 2 rows; ovary 5 celled; fruit a berry ........ **Reinwardtiodendron**

3b. Stamen 5–6 in one row; ovary 3 celled; fruit capsule ......................................... 4

4a. Inflorescence 34–60 cm long; stamens 6; capsule spherical- pyriform or ovoid without an apical depression; seed with orange aril ....................... **Aphanamixis**

4b. Inflorescence up to 20 cm long; stamens 5; capsule sub-globose with an apical depression; seed with pale pink translucent aril ........................................ **Aglaia**

**AGLAIA** Loureiro

Fl. Cochinch.173. 1790, (*nom. cons*.).

**Aglaia malabarica** Sasidh., Kew Bull. Addl. ser. 16, 369. 1992; Sasidh. & Sivar., Fl. Pl. Thrissur For. 91. 1996; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 644. 2005.

**Local name**: Chuvannacheeralum, Chuvannakil.

Trees up to 25 m high; young shoots golden brown, densely peltate scaly; bark 4–5 mm thick, smooth, brown; blaze reddish. Leaves imparipinnate, alternately, estipulate; young leaves reddish brown; rachis 18–35 cm long, stout, covered with peltate scales, swollen at base, grooved above; leaflets 8–11, alternate, estipulate. Lamina 5.5–21×3–8 cm, oblong, oblong-lanceolate or elliptic-lanceolate, base obliquely round or acute, margin entire, apex acuminate, upper surface minutely pitted with peltate scales, lower surface with numerous peltate scales on the midrib and lateral nerves, coriaceous; mid rib prominent on lower surface, prominent, but slightly immersed on upper surface, reddish pubescent on young leaves; lateral nerves 10–19 pairs, sub opposite, prominent; intercostae reticulate, obscure; petiolule 7–20 mm long, slender, grooved above, covered with peltate scales, reddish brown when dry. Flowers yellow, polygamo dioecious. Male inflorescence: c.20 cm long, densely covered with peltate scales; pedicels 1–1.5 mm long. Male flowers: 2.5–3 mm long; sepals c.0.5 mm long, lobes 5, round, densely scaly; petals 5, yellow; stamens 5; staminal tube c.2 mm long, aperture 0.4–0.5 mm wide, entire; anthers 5, included. Female inflorescence: c.5.5 cm long, covered with reddish-brown peltate scales. Female flowers c.4.5 mm long; pedicels 3–4.5 mm long; sepals c.3.5 mm long, thick, fleshy at base; lobes 5, rounded, densely scaly; petals 5, 2 mm long; staminodes 5, included; ovary superior, depressed globose, with reddish-brown scales, 3-celled, ovules one in each cell; stigma subglobose with an apical depression. Fruit a capsule 3.5–4.5×2.7–4 cm, obovoid or subglobose with an apical depression. Seeds 1–3, 1.7–2.5×1–1.5 cm, surround by a thin, pale pink translucent aril.

**Flowering** & **Fruiting**: Flowering from December to March. Fruiting from January to April.

**Distribution**: *Aglaia malabarica* is distributed in South India (Kerala). It is endemic to Southern Western Ghats of Kerala. In Kerala it is distributed in Kollam, Thrissur, and Wayanad districts.

**Habitat**: This taxon found in evergreen and wet evergreen forests on at an elevation ranging from 500-1100 m. It is a medium canopy tree seen in wet evergreen forest associated with *Palaquium ellipticum* (Dalzell) Baill., *Chukrasia tabularis* A. Juss., *Mesua ferrea* L., *Diospyros crumenata* Thw., *Dysoxylum malabaricum* Bedd., *Garcinia indica* (Thouars) Choisy., *Phoebe lanceolata* (Nees) Nees etc.

**Phenology**

During the study period, the flowering and fruiting stages of *Aglaia malabarica* could not be observed. Even though a couple of trees were spotted in Sheikalmudi, none of them flowered during the study period. The herbarium records of the species were examined from the Herbarium of the Kerala Forest Research Institute (KFRI), Peechi. The specimen contained mature fruit and it was noted that the specimen was collected during the second week of April.

**IUCN Status**: Critically Endangered under criteria D.

**Specimens examined**: INDIA, **Kerala**, Kollam district, Rosemala, Shendurny Wildlife Statuary, ±550 m, 11.05.1994, *N. Sasidharan* 10957 (KFRI); Thrissur district, Velakkattupara, Peechi, ±500 m, *N. Sasidharan* 3122 (KFRI).

**APHANAMIXIS** Blume

Bijdr. 165. 1825.

**Aphanamixis polystachya** (Wall.) Parker, Indian For. 57: 486. 1931; Mani., & Sivar., Fl. Calicut 63. 1982; Mohanan, Fl. Quilon Dist. 109. 1984; Mani., Fl. Silent Valley 48. 1988; Vajr., Fl. Palghat Dist. 110. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 109. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 94. 1996; Sivar.

& Mathew, Fl. Nilambur 131. 1997; S.S. Jain & S.S.R. Bennet in Hajra *et al*., Fl. India 4: 477. 1997; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 57. 2000; N. Mohanan & Sivad., Fl. Agasthyamala 150. 2002; Sasidh., Fl. Parambikulam WLS 56. 2002; Anil Kumar *et a*l., Fl. Pathanamthitta 116. 2005; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 646. 2005; Sunil & Sivad., Fl. Alappuzha Dist. 166. 2009.

*Aglaia polystachya* Wall. in Roxb., Fl. Ind. 2: 429. 1824.

*Andersonia rohituka* Roxb., Fl. Ind. 2: 213. 1832.

*Amoora rohituka* (Roxb.) Wight & Arn. in Wight, Cat 24. 1833 & Prodr. 119. 1834; Hook. f., Fl. Brit. India 1: 559. 1875; Gamble, Fl. Pres. Madras 181. 1915.

**(Figure 4.22.)**

**Local name**: Chemmaram.

A medium sized tree, 10–20 m high, often flowering when very small; outer bark dark-brown, flaking, molted with green patches; inner bark reddish-brown often with white latex; blaze creamy white; branchlets terete, sericeous. Leaves imparipinnate, alternate, estipulate; rachis 25–45×2–4 cm, woody, glabrous, rounded with swollen hard base, green; leaf lets 5–6 pairs, opposite. Lamina 7.5–19×4–7.5 cm, elliptic, elliptic-oblong, base acute to obtusely oblique, margins entire, apex acute to abruptly acuminate to caudate, lowest pair smaller, pinnately netted, coriaceous, glabrous, dark brown above, reddish brown below when dry; mid rib prominent on both surface, glabrous; lateral nerves 6–12 pairs, slender, prominent on both surface, glabrous, arcute on lower surface; intercostae reticulate, prominent on lower surface, obscure on upper surface. Petiolule 1–2×0.5–1 cm; distal petiole up to c.4.5 cm long, slender, round below, sulcate above, glabrous. Inflorescence in the axial or terminal; male flower in panicle. Female flower or bisexual flower forming drooping spike, 34–60 cm long, glabrous, branches 12–25, consists of 20–26 flowers arranged alternatively. Flowers globose, light yellow, c.7×5 mm, glabrous; pedicel very small, c.8×2 mm, bright pale green, slightly pubescent; sepals 5, c.2×3 mm, white to dark brown, ovate or orbicular, obovate, fused at base, free, imbricate, unequal, coriaceous, ciliate on margin; petals 5, c.7×5 mm, free, globose, unequal, imbricate, pale yellow to pink colour on outer surface, inner orange-yellow, fleshy, coriaceous, slightly pubescent on outer surface, glabrous inner surface; stamens 6, filaments of anther jointed into a globose fleshy staminal tube, c.3×3 mm, glabrous, thick, white; anthers c.1.5×1 mm, included, linear, apex acute, 2 locular with longitudinal dehiscence, pale yellow to brown; carpel 2.5×1–1.2 mm, pink colour; ovary superior, c.1.5×1 mm, covered with minute protuberance; style very much reduced; stigma 3–5 lobed, truncate. Fruit a capsule, 2.9–4×2–2.3 cm, oblong, 3-lobed, glabrous, rough, pale green to yellow when young and turned to pale red with longitudinal dehiscence. Seed 3, 1.8–2×1.1–1.4 cm, oblong, with orange red scarlet oily aril.

**Flowering** & **Fruiting**: Flowering from October to January. Fruiting from February to April.

**Distribution**: *Aphanamixis polystachya* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed in Kollam, Thrissur, Palakkad, Malappuram, Wayanad and Kannur districts.

**Habitat**: The taxon is moderately found in evergreen and wet evergreen forests at an elevation ranging from 500-900 m Southern Western Ghats. It is found along the forest slopes, streams draining to the river or reservoir. It is medium canopy tree seen associated with *Chukrasia tabularis* A. Juss., *Syzygium hemisphericum* (Wight) Alston in Trimen., *Litsea floribunda* (Blume) Gamble., *Melicope lunu-ankenda* (Gaertn.) Hartley etc

**IUCN Status**: Lower Risk/least concern

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of October and remain almost unchanged in appearance for the whole month. Buds began to open by the first week of November. Flowering continued for two months, and the tree was in full bloom till the last week of December. Dried flowers remained in the tree till the end of February. Juvenile green fruits were begun to appear during the first week of January. Mature fruits were seen during the last week of February and first week of March. Fruits ripened to yellowish brown by the first week of April. By the last week of April or first week of May, the ripened fruits burst opened along the three longitudinal septa exposing the shiny brown seeds inside.

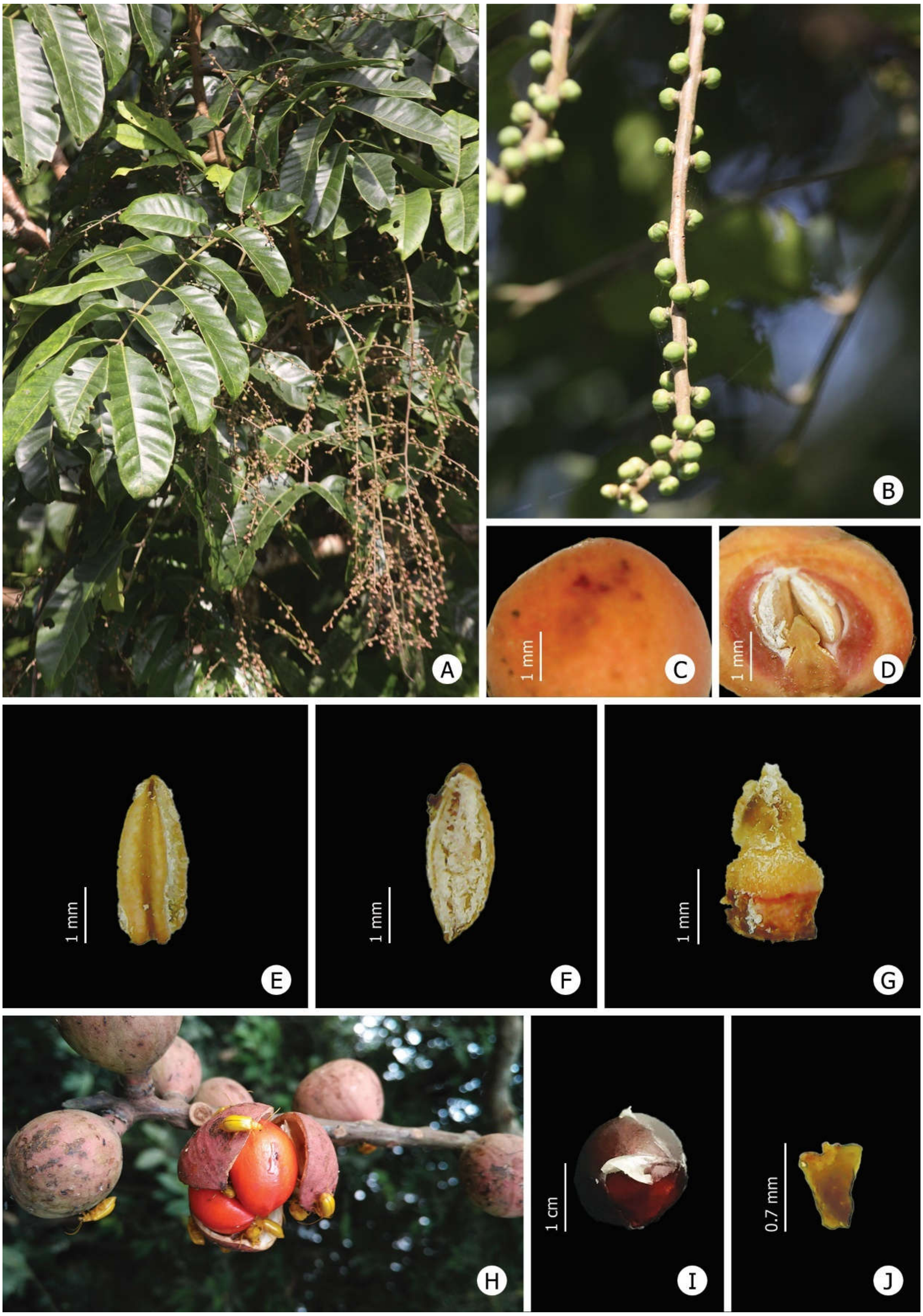


**Figure 4.22.** ***Aphanamixis polystachya*** (Wall.) Parker**: A.** Habit; **B.** Inflorescence; **C.** Single flower; **D.** Flower L.S; **E & F.** Stamens; **G.** Pistil; **H.** Fruiting twig; **I.** Seed; **J.** Embryo.

**Specimens examined**: INDIA, **Kerala**, Idukki district, Thekkady, Periyar Tiger reserve, ±1023 m, 15.10.1993, *Jomy Augustine & N. Sasidharan* 12501 (KFRI); *ibid*., 13.04.1994, *N. Sasidharan & Jomy Augustine* 13814 (KFRI); *ibid*., ±1023 m, 12.07.1993, *Jomy Augustine & N. Sasidharan* 12025 (KFRI); *ibid*., ±900 m, 13.06.1994, *Jomy Augustine* 13815 (KFRI); *ibid*., ±1000 m, 19.02.2018, *P.K. Fasila* 137465 (MESAH); Lakshmippara, PTR, ±1100 m, 9.02.1994, *Jomy Augustine* 13306 (KFRI); Olikkudi, Chinnar Wild life Sanctuary, ±1350 m, 19.04.1996, *K.K. Sajeev* 17337 (KFRI); Ernakulam district, Above Manikantan Chola, Pooyamkutty, 15.05.1986, *K.K.N. Nair* 4425 (KFRI); Near Pindimedu dam, 11.03.1986, *K.K.N. Nair* 4316 (KFRI); Thrissur district, Ambalapara, Sholayar, ±700 m, 19.06.1983, *N. Sasidharan* 2958 (KFRI); *ibid*., 3.04.2015, *P.K. Fasila* 137413 (MESAH); *ibid*., 23.09.2018, *P.K. Fasila* 137500 (MESAH); Vellayanipatcha, Pattikkad, ±200 m, 30.04.1984, *N. Sasidharan & Swarupan* 3120 (KFRI); Vazhachal, 23.09.2018, *P.K. Fasila* 150508 (MESAH); Palakkad district, Pothundi, kaikatti road, 25.04.1984, *N. Sasidharan & Swarupan* 3106 (KFRI); Campshed area, ±1200 m, *K. S. Prasannakumar* SV11112 (CALI).

## **DYSOXYLUM** Blume

Bijdr. 172. 1825.

Large trees. Leaves compound alternate, or opposite, imparipinnate or paripinnate; leaflet opposite or alternate, pinnately compound; stipules 0. Flowers small, hermaphrodite in axillary peduncled panicle; calyx and corolla 4 lobed; staminal tube cylindrical, dentate or crenulate mouth; disc tubular or cup-shaped; ovary free, 4 celled, attenuate to the style; ovule 1-2 in each cell. Fruit a capsule.

**Key to the species**

1a. Branchlets sub terete; rachis glabrous; leaflet 3–4 pairs; lateral nerves 5–9 pairs; staminal tube crenulate; disc tubular; fruit obovoid ........................... **D. ficiforme**

2b. Branchlets angular; rachis pubescent; leaflets 7–11 pairs; lateral nerves 12–20 pairs; staminal tube urceolate; disc cup-shaped; fruit pyriform .. **D. malabaricum**

**Dysoxylum ficiforme** (Wight) Gamble, Fl. Pres. Madras 178. 1915; Mohanan, Fl. Quilon Dist. 110. 1984; N.C. Nair & Bhargavan, Journ. Econ. Tax. Bot. 6: 709.

1985; S.S. Jain & S.S.R. Bennet in Hajra *et al*., Fl. India 4: 487. 1997; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 653. 2005.

*Amoora ficiforme* Wight, Illustr. 1: 47. 1840.

*Dysoxylum purpureum* Bourd., Journ. Bombay Nat. Hist. Soc. 12: 349, t. 2. 1899.

**(Figure 4.23.)**

**Local name**: Akil, Karakil.

A large tree, 25–30 meter high; branchlets sub terete, sericeous; outer bark dull-yellowish, greyish; blaze yellowish. Leaf rachis 7–19 cm long, rounded, with woody swollen base, glabrous; leaf lets 3-4 pairs, pinnately netted, proximal leaf let smaller than the distal leaf let. Lamina 5–20×2.5–7.5 cm, oblong, elliptic oblong, elliptic-lanceolate, base obtusely oblique, margins entire, apex acute to abruptly acuminate to caudate, acumen c.1 cm long, thinly coriaceous, glabrous, dark green to yellowish green above, light pale green below when dry; mid rib prominent on both surface, glabrous; lateral nerves 5–9 pairs at one side, emergent on lower surface, very slender slightly channelled on upper surface, glabrous; secondary nervules parallel, intercostae reticulate and prominent. Petiolule 0.5–1 cm long, glabrous, lower surface rounded and upper surface truncate. Panicle puberulous, 7–10 cm long; peduncle c.1.5 cm long; pedicel very small, c.2 mm long, slightly pubescent, bright light green. Flowers small, c.3 mm long, globose, pale yellow; sepals free, c.6 mm long, unequal, ovate or orbicular, obovate, green, fused at bases, fleshy, puberulous without, dark-brown with imbricate aestivation; petals free, unequal, globose, fleshy, coriaceous, minutely pubescent without, glabrous within, pale yellow to pink colour; disc tubular, margins slightly toothed; staminal tube c.8 mm long; anthers included; ovary superior, densely hairy, ovule 1–2 in each cells; style stout almost as long as staminal tube; stigma capitate with ring at base, slightly exerted. Fruit a capsule, 4.5–5.5×5–6.5 cm, obovoid or subglobose, 3-lobed, glabrous, rough, pale green to yellow when young and turned to light red with longitudinal dehiscence when mature. Seed 3, 1.8–2×1.1–1.4 cm, obovoid, with white or yellowish aril.

**Flowering & Fruiting**: Flowering from November to December. Fruiting from January to March.

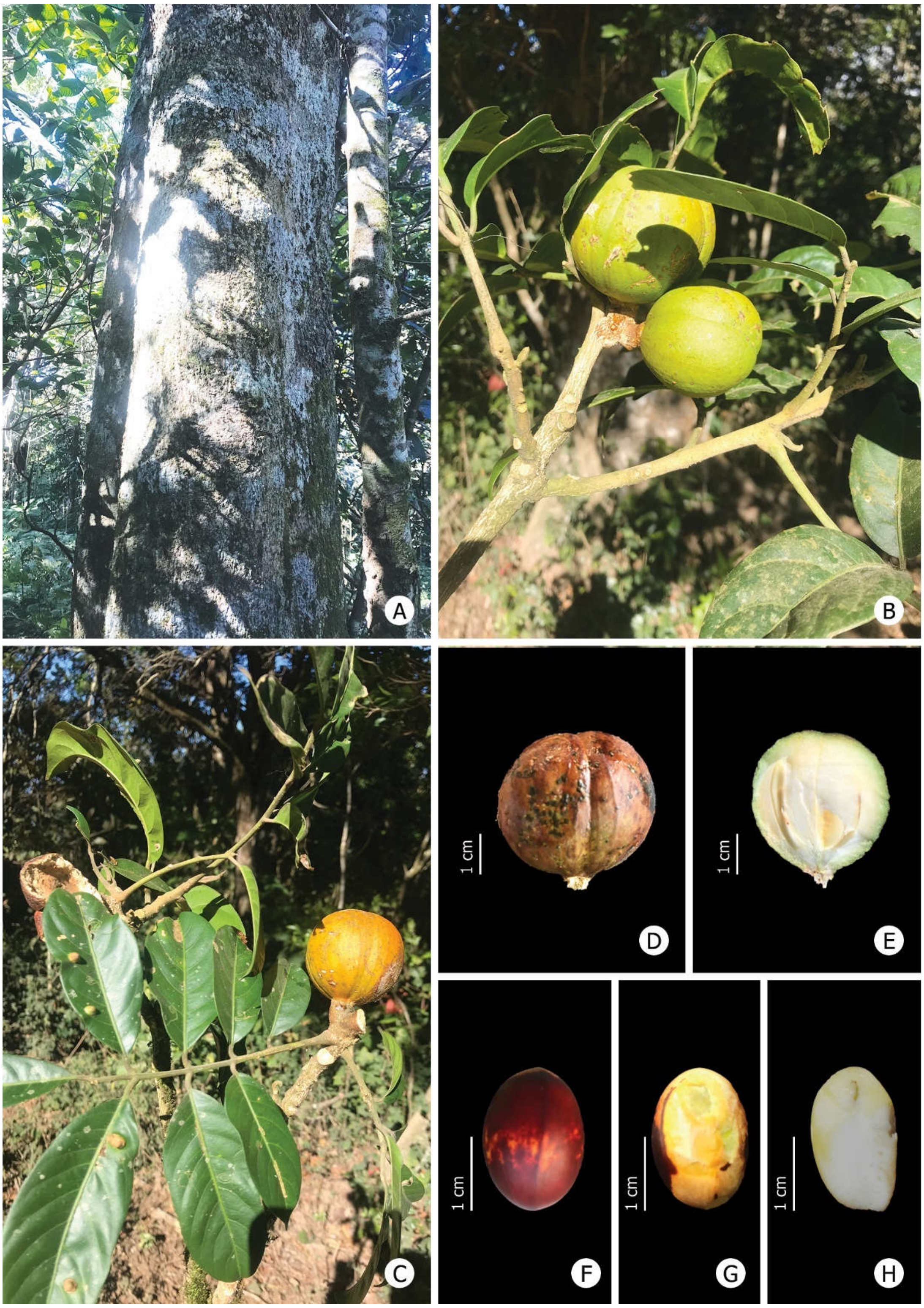


**Figure 4.23.** ***Dysoxylum ficiforme*** (Wight) Gamble**: A.** Habit; **B.** Fruiting twig; **C.** Twig with Young fruit; **D.** Mature fruit; **E.** Fruit L.S; **F & G.** Seed; **H.** Seed L.S.

**Distribution**: *Dysoxylum ficiforme* is distributed in South India (Karnataka, Kerala, and Tamil Nadu) and Sri Lanka. In Kerala it is distributed in Kollam, Pathanamthitta, Idukki and Palakkad districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at high elevations ranging from 900-1800 m in the of Southern Western Ghats. It is a large sized tree seen associated with *Litsea stocksii* (Meisn.) Hook.f.*, Litsea wightiana* (Nees) Wall. ex Hook. f.*, Elaeocarpus tuberculatus* Roxb.*, Actinodaphne tadulingamii* Gamble.

**IUCN status**: Vulnerable B1+2c.

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of November and remained almost unchanged in appearance for the whole month. Buds began to open by the first week of December. Flowering continued for three months, and the tree was in full bloom till the last week of February. Juvenile fruits began to appear in the first week of January. Colour of the fruits turned into yellow by the last week of January. Mature fruits were seen during the first week of March. The fruits retained this yellow colour in its mature stage also. Fruits ripened to red/pink in colour by the last week of May. The ripened fruits were seen attached to the tree till June or July by which time the fruits burst opened along the three longitudinal septa exposing the shiny brown seeds inside and fallen off by the last week of July.

**Specimens examined**: INDIA, **Kerala**, Pathanamthitta district, Mozhiyar, Ranni, 23.05.1984*, N. Sasidharan* 3138 (KFRI); Idukki district, Korunthode, Periayar Tiger Reserve, 25.03.1994, ±300 m, *Jomy Augustine* 13486 (KFRI); Palakkad district, Karimala, 18.02.2020, *P.K. Fasila* 150580 (MESAH).

**Dysoxylum malabaricum** Bedd. ex Hiern in Hook. f., Fl. Brit. India 1: 548. 1875; Gamble, Fl. Pres. Madras 178. 1915; Mohanan, Fl. Quilon Dist. 110. 1984; Sasidh. & Sivar., Fl. Pl. Thrissur For. 95. 1996; Sivar. & Mathew, Fl. Nilambur 133. 1997; S.S. Jain & S.S.R. Bennet in Hajra *et al*., Fl. India 4: 489. 1997; Ravikumar &Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 132. 2000; Sasidh., Fl. Parambikulam WLS 57.

2002; Anil Kumar *et al*., Fl. Pathanamthitta 118. 2005; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 653. 2005.

**Local name**: Vellakil.

A large tree, up to 35 meter high; branchlets angular, minutely pubescent; outer bark yellowish-grey with white warts, rough, exfoliating with large rectangular scales; blaze 4–5 cm thick, yellow, and white; lenticels dense, large, warty, fissured. Leaf rachis 11–26 cm long, glabrous, rounded at base, flattened at above swollen at base; leaf lets 7–11 pairs, pinnately netted, proximal leaf let smaller than the distal leaf let. Lamina 6–20× 4–8 cm, elliptic oblong, elliptic-lanceolate, base obtusely oblique or acute, margins entire, apex acuminate, acumen 1–2 cm long, coriaceous, puberulous when young, glabrous at maturity, dark green to yellowish green above, light pale green below when dry; mid rib prominent on lower surface, slender and channelled on upper surface, glabrous; lateral nerves 12–20 pairs, parallel, ascending, prominent on lower surface, glabrous, very slender, slightly channelled on upper surface; intercostae reticulate, prominent on lower surface, obscure on upper surface; petiolule 0.5–0.8 cm long, glabrous, lower surface rounded and flat on upper surface. Panicle c.10 cm long; pedicel c.0.5 cm long; peduncle c.0.5 cm long. Flowers small, globose, creamy yellow, fragrant, 5–6 mm long; sepals more or less obtuse, green; petals linear-oblong, subacute, imbricate fleshy, coriaceous, minutely pubescent on outer surface, glabrous inner surface, white; staminal tube cylindric, more or less 4 angled with 8 deep emarginate crenatures; anthers 8, included; disc cup-shaped, entire, nearly enclosing the ovary; ovary superior, densely hairy, ovule 2 in each cells; style tapering; stigma capitate, 4 lobed. Fruit a capsule, 5–7×4.4–5.5 cm, pyriform or globose verrucose, bright yellow, with 4 longitudinal furrows. Seeds 3–4, 1.5–1.8 x 1 cm, bluntly trigonous, reddish-brown.

**Flowering & Fruiting**: Flowering from September to December. Fruiting from January to May.

**Distribution**: *Dysoxylum malabaricum* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed to Palakkad, Kollam, Idukki, Pathanamthitta, Malappuram, Thrissur, Kannur and Wayanad districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests on hill slopes at high elevations ranging from 800-1200 m in the of Southern Western Ghats. It is a large sized tree seen associated *Schleichera oleosa* (Lour.) Oken., *Cullenia exarillata* Robyns., *Palaquium ellipticum* (Dalz.) Baill., *Vateria indica* L., *Tarenna monosperma* Wight & Arn.

**IUCN status**: Endangered A+2c.

**Phenology**

Flowering only once in year. Flower buds began to appear in the second week of September and remained almost unchanged in appearance for the whole month. Buds began to open by the first week of October. Flowering continued for three months, and the tree was in full bloom till the last week of December. Juvenile fruits appeared in the first week of January. Fruits matured very slowly. Mature fruits were seen during the last week of March. By the first week of April, the fruits were ripened to bright yellow. By the last week of April, the fruits were burst opened along the four longitudinal septa, exposing the shiny brown seeds inside and fallen off by the first week of June.

**Specimens examined**: INDIA, **Kerala**, Kottayam district, Koruthodu, ±300 m, 16.01.1995, *Jomy Augustine* 14719 (CALI); Thrissur district, Chandanthodu, Sholayar, 22.02.1979, *Bhat* 5005 (KFRI); Vellayanipacha, Pattikad, 18.04.1984, 300m, *N. Sasidharan & Swarupanandan* 3073 (KFRI); Malappuram district, Thalichola, 5.02.1982, *Philip Mathew* 33933 (CALI).

**Reinwardtiodendron anamalaiense** (Bedd.) Mabb., Malaysian For. 45: 452. 1982; Mohanan, Fl. Quilon Dist. 110. 1984; S.S. Jain & S.S.R. Bennet in Hajra *et al*., Fl. India 4: 498.1997; Sasidh., Fl. Parambikulam WLS 58. 2002; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 658. 2005.
*Lansium anamalaiense* Bedd., Madras J. Lit. Sci. ser.3, 1: 40. 1864.

*Lansium anamallayanum* Bedd., Fl. Sylv. t. 131. 1871 & Ic. t. 104. 1868-1874; Hook. f., Fl. Brit. India 1: 558. 1875; Gamble, Fl. Pres. Madras 182. 1915.

*Aglaia anamallayana* (Bedd.) Kosterm., Reinwardtia 7: 257, t.10. 1966; Vajr., Fl. Palghat Dist. 109. 1990.

*Reinwardtiodendron anamallayanum* (Bedd.) Saldanha in Saldanha & Nicolson, Fl. Hassan Dist. 392. 1976; Mani., Fl. Silent Valley 50. 1988; Sasidh. & Sivar., Fl. Pl. Thrissur For. 98. 1996; Sivar. & Mathew, Fl. Nilambur 135. 1997.

**(Figure 4.24.)**

**Local name**: Cheeralam.

A medium sized tree, 15–20 m high; outer bark greyish; inner bark brown; blaze dull yellow; branchlets terete, smooth glossy; lenticels greyish or whitish. Leaves compound, alternate; rachis 3–7.5 cm long, slender, glabrous, abaxially rounded, adaxially with a shallow groove, green; leaf lets 4–5, alternate, pinnately compound, imparipinnate. Petiole 4–8 cm long, slender, glabrous; lamina 9–13×2.5–5 cm, elliptic, lanceolate, elliptic-lanceolate to sub ovate or sub ovate-elliptical, tip lamina obovate, base oblique, margins entire, apex attenuate, acute, coriaceous, chartaceous to thinly, smooth, glabrous, very broadly and bluntly acuminate to caudate, with hairy domatia on the lower leaf surface, dark green above light green below when dry; mid rib more prominent on lower surface slightly puberulous, slightly obscure on upper surface, glabrous; lateral veins 7–12 pairs, puberulous slender, pinnate, closely arranged toward the base, prominent; intercostae reticulate prominent on lower surface, obscure on upper surface; petiolule 0.5–0.8 mm long, slender, adaxially sulcate, attenuate to the leaf slightly puberulous. Inflorescence male, in axillary panicle; female flowers in racemes, 2.6–6 cm long, stellately lepidote, unbranched or 2–3 branches, thick, green often pendulous consists of up to c.12 flowers arranged alternatively. Flowers small c.7×5 mm, light yellow, globose, glabrous; pedicel very small c.0.5 mm long, glabrous; sepals 5, c.2×1.8 mm, broadly obovate or broadly triangular, fused at the base, stellately lepidote at apex, imbricate aestivation, coriaceous, glabrous, white to green; petals 5, 3–3.5×2.3–3 mm, ovate–elliptical obtuse, free, light green to yellow on outer surface, inner light yellow to white, fleshy, glabrous; staminal tube c.3×3 mm, globose, fleshy, apical margin 10 lobed, glabrous; stamens 10, attached in two whorls of 5 each; filaments of anther jointed in to a globose fleshy staminal tube; anthers c.1.2×1 mm, white, included, with longitudinal dehiscence, upper whorl anther c.1×1 mm, oblong, lower whorl of cordate; ovary superior, c.1.2×1 mm, compressed, densely covered with white hairs, ovules 2, on axial placentation; style very much reduced; stigma white, 3 lobed, truncate; disc is very reduced. Berry 2.5–3.6×2.4–2.5 cm, ovoid-obovate. Seed 1, oblong, 1.8–2.2×1.4–1.6 cm, smooth, embedded in a pulpy aril.

**Flowering & Fruiting**: Flowering from January to March. Fruiting from February to June.

**Distribution**: *Reinwardtiodendron anamalaiense* is distributed in South India (Kerala and Tamil Nadu). It is endemic to Southern Western Ghats. In Kerala it is distributed in Palakkad, Kollam, Malappuram, Kannur, Thrissur and Wayanad districts.

**Habitat**: The taxon is distributed in medium elevation and wet evergreen forest of Western Ghats at an elevation of 700-1000 m. This is tall evergreen medium sized tree found abundantly in its habitat, usually seen associated with *Palaquium ellipticum* (Dalz.) Baill., *Cullenia exarillata* Robyns., *Mesua ferrea* L., *Dysoxylum malabaricum* Bedd. ex Hiernas., *Litsea floribunda* (Blume) Gamble., *Paracroton pendulus* (Hassk.) Miq., *Aporosa acuminata* Thw.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of January and remained almost unchanged in appearance for the two weeks. Buds began to open by the last week of January. Flowering continued for two months, and the tree was in full bloom till the last week of January. Juvenile fruits began to appear during the first week of February. Mature fruits were seen till the last week

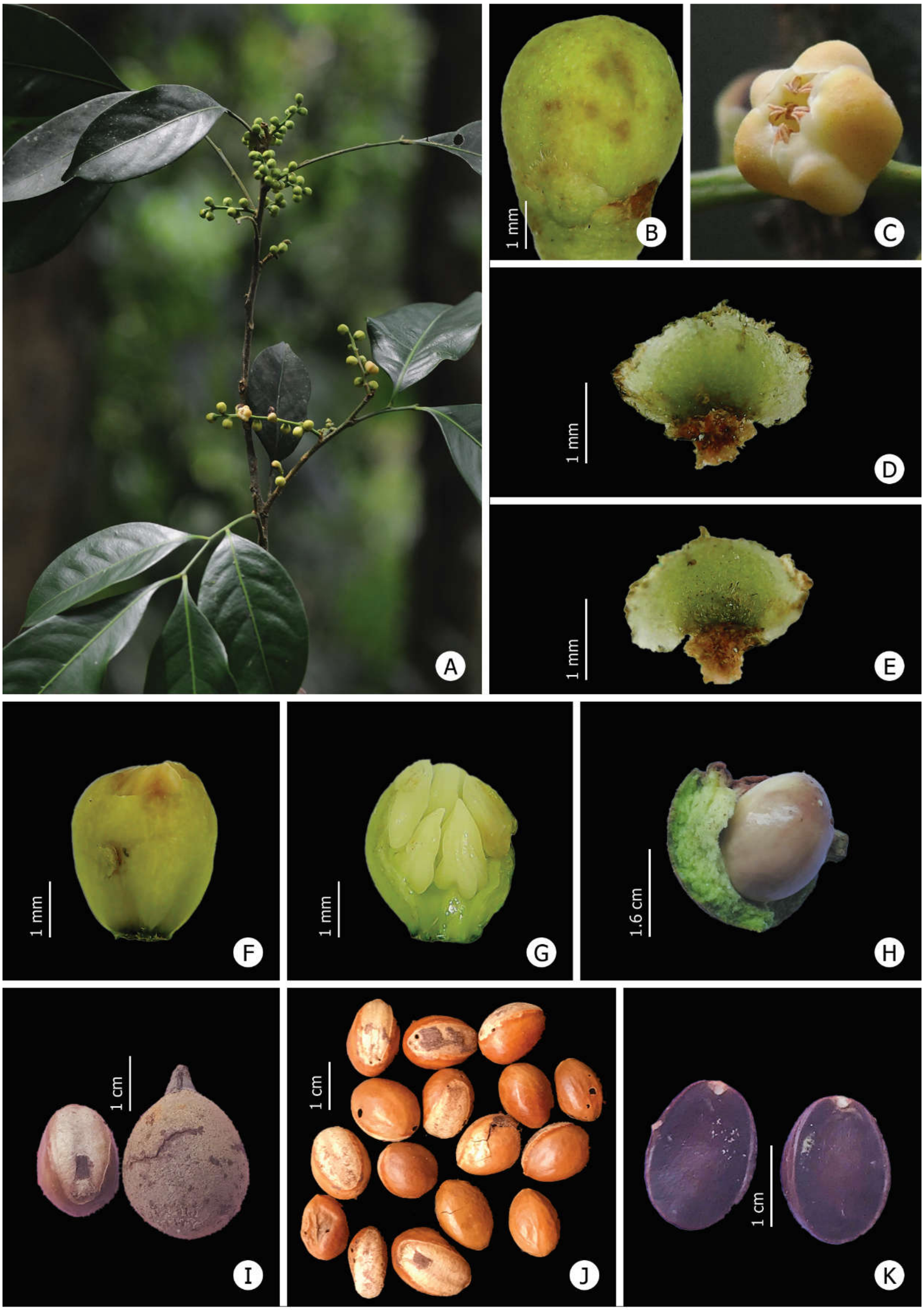


**Figure 4.24.** ***Reinwardtiodendron anamalaiense*** (Bedd.) Mabb.**:** **A.** Flowering twig; **B.** Flower bud; **C.** Single flower; **D.** Sepal outer view; **E.** Sepal inner view; **F.** Staminal tube; **G.** Staminal tube L.S; **H & I.** Fruit & Seed; **J.** Seeds; **K.** Seed L.S.

of March. Fruits ripened to brown during the first week of April. By the last week of May or first week of June, the ripened fruits burst open along the three longitudinal septa exposing the shiny brown seeds inside and fallen off by the first week of July.

**Specimens examined**: INDIA, **Kerala**, Thrissur district, Peechi, 17.07.1990, *N. Sasidharan* 5659 (KFRI); Vellayanimala, 4.02.1985, *N. Sasidharan* 3375 (KFRI); *ibid*., 24.02.1986, ±300 m, *N. Sasidharan* 3759 (KFRI); Chimmony dam, 19.03.1981, *Naimbiar* 1290 (KFRI); Ambalapara, 03.04.2015, *P.K. Fasila* 137418 (MESAH); Chandanthodu, 3.03.2020, *P.K. Fasila & K.H. Amitha Bachan* 150582 (MESAH); Palakkad district, Kummattanthodu, ±1100 m 1.07.1983, *T. Sabu* 11395 (CALI); Panthanthode, Silent Valley, 13.03.1985, ±650 m, *N. Sasidharan* 3622 (KFRI); Parambikulam, Thuthanpara, 07.04.2015, *P.K. Fasila* 137457 (MESAH); Wayanad district, Vithiri Churam, ±800 m, 4.03.1999, *M.K. Ratheesh Narayan* 1475 (CALI); Narimala, 10.03.2003, *M.K. Ratheesh Narayan* 3222 (CALI).

**Trichilia** P. Browne

Civ.Nat. Hist. Jamica 278. 1756.

**Trichilia connaroides** (Wight & Arn.) Bentv., Acta Bot. Neerl. 11: 13. 1962; Mani., Fl. Silent Valley 51. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 91. 1988; Vajr., Fl. Palghat Dist. 112. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 111. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 99. 1996; Sivar. & Mathew, Fl. Nilambur 137. 1997; S.S. Jain & S.S.R. Bennet in Hajra *et al*., Fl. India 4: 515. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 152. 2002; Sasidh., Fl. Parambikulam WLS 58. 2002; Anil Kumar *et al*., Fl. Pathanamthitta 121. 2005; N.C. Nair & N.P. Balakr. in P. Daniel, Fl. Kerala 1: 664. 2005.

*Zanthoxylum connaroides* Wight & Arn., Prodr. 148. 1834, "Zanthoxylon".

*Heynea trijuga* Roxb. ex. Sims, Bot. Mag. 41 t. 1738. 1815; Hook. f., Fl. Brit. India 1: 565. 1872; Gamble, Fl. Pres. Madras 183. 1915, non *Trichilia trijuga* Vell. 1825.

**Local name**: Karuvilangam, Korakkadi, Thirivembu.

A medium sized tree, 10–15 m high; outer bark greyish, warty; inner bark yellow; blaze reddish brown; branchlets reddish, terete with small greyish or whitish lenticels. Leaves compound, alternate or spiral toward the tip; rachis 18–30 cm long, rounded, slender, glabrous, red; leaf lets 4-5, opposite, pinnately compound, imparipinnate; petiole 1–1.5 cm long, slender, adaxially sulcate, glabrous; lamina 6–15×2.5–6 cm, ovate, to narrow ovate or lanceolate, base oblique, margins entire, apex acuminate or shortly caudate-acuminate, acumen c.1 cm long, smooth, glabrous, coriaceous, glaucous beneath; mid rib more prominent on lower surface, glabrous on both surface, slightly obscure on upper surface; lateral veins 9–12 pairs, slender, pinnate, closely arranged toward the base, prominent; intercostae reticulate, prominent on lower surface, obscure on upper surface. Inflorescence in elongated axillary panicle, 12–21 cm long, glabrous. Flowers small polygamodioecious, c.6×8 mm, white, glabrous; pedicel articulated, pubescent; sepals 5, c.2×1.8 mm, white to green, broadly obovate, acute at apex, imbricate, coriaceous, pubescent; petals 5, 3–4×1 mm, oblong, margins ciliate, free, fleshy, light yellow to white; staminal tube oblong, c.4×4 mm, deeply 10 lobed, lobes 2 fid fleshy, pubescent; stamens 10, anthers attached between the 2-fid lobes; carpel c.2×1 mm; ovary superior, compressed, 2 celled, glabrous; ovules 2, on axial placentation, disc annular, fleshy; style short, slightly obconic; stigma capitate, 2 dentate. Fruit a capsule, 1.5–1.7×1–1.2 cm, globose, bright red, pointed, 2 valved. Seed 1, yellowish-brown, surrounded by a white fleshy aril.

**Flowering & Fruiting**: Flowering from December to January. Fruiting from March to July.

**Distribution**: *Trichilia connaroides* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is distributed in Indo-Malesia. In Kerala it is distributed in Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad and Kannur districts.

**Habitat**: It is distributed in evergreen forest of Western Ghats at a medium elevation of 350-800 m. This is a medium sized tree found moderately in its habitat, usually seen associated with *Chukrasia tabularis* A. Juss., *Melicopelunu-Melicope lunu-ankenda* (Gaertn.) Hartley., *Xanthophyllum arnottianum* Wight., *Agrostistachys borneensis* Becc.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to appear in the first week of December and remained almost unchanged in appearance for the whole month. Buds began to open by the last week of December. Flowering continued for two months, and the tree was in full bloom till the last week of February. Juvenile fruits, pink in colour, began to appear during the first week of March. Upon maturation, the colour changed to dark pink. By the second week of June, fruits ripened to yellowish red in colour. By the last week of June or first week of July, the ripened fruits burst opened along the two longitudinal septa exposing the shiny brown seeds inside and fallen off by the last week of August.

**Specimens examined**: INDIA, **Kerala**, Idukki district, Unikupppan, PTR, 25.10.1993, ±950 m, *N. Sasidharan & Jomy Augustine* 12646 (KFRI); Upper manalar, PTR, 13.12.1993, ±1750 m, *Jomy Augustine* 12977 (KFRI); Thekkady, PTR, 13.05.1995, ±1800 m *Jomy Augustine & N. Sasidharan* 15246 (KFRI); Olikkudy, Chinnar, 1.03.996, ±1000 m, *K.K. Sajeev* 17227 (KFRI); *ibid*., 17.04.1996 , *K.K. Sajeev* 17280 (KFRI); Palakkad district, Silent Valley Mannarghat range, 11.12.1980, ±600 m, N. G. Nair *& N. Sasidharan* 1381 (KFRI); Panthanthode, Silent Valley, 13.03.1985, ±650 m, *N. Sasidharan* 3625 (KFRI); Thrissur district, Linetha dam, Peechi, 6.04.1988, ±350 m *N. Sasidharan* 5006 (KFRI); Sholayar, 20.01.1989, ±750 m *N. Sasidharan* 5312 (KFRI); *ibid*., 7.07.2018, *P.K. Fasila* 137494 (MESAH).

**EBENACEAE** Gurke

in Engler & Prantl Nat. Pflanzenfam. 4 (1): 153. 1891.

**DIOSPYROS** Linnaeus

Sp. Pl. 1057. 1753.

**Diospyros crumenata** Thw., Enum. Pl. Zeyl. 179. 1860; Hook. f., Fl. Brit. India 3: 567. 1882; Sasidh. & Sivar., Fl. Pl. Thrissur For. 270. 1996; V. Singh, Monogr. Indian Diospyros 83. 2005.

**Local name**: Karimbudan, Karimaram.

Evergreen trees, up to 25 m high; bark c.4 mm thick, black, thin scaly with small depression; blaze creamy yellow turning to brown on exposure; branchlets terete glabrous. Leaves simple, alternate, exstipulate; petiole 7–13 mm long, stout, grooved above, glabrous; lamina 7.5–15×3.5–6.8 cm, oblong, elliptic, ovate-oblong or elliptic-oblong, obtuse or acute at base, margin entire, bluntly acute or acuminate at apex, glossy, coriaceous, glabrous; mid rib prominent on abaxially, channelled on adaxially; lateral nerves 6–10 pairs, pinnate, prominent on abaxially, obscure adaxially; intercostae reticulate, prominent. Flowers unisexual, yellow. Male flowers: in shortly stalked 3-7 flowered cymes; peduncle 3–10 mm long, pilose; pedicels nodding, short, ultimate ones 1–4 mm long; calyx large, cupular, lobes 4, obtuse, tomentose without; corolla tubular, c.14 mm long, yellow, lobes 4, short, broad, rounded, recurved; stamens c.12, 4–6 mm long, sub equal; pistillode small or absent. Female flowers: solitary, axillary; pedicel short, stout; calyx large, cupular, tomentose on both surfaces; corolla tubular, c.15 mm long, lobes 4, broad, acute, patent or reflexed, densely tomentose, yellowish-white; staminodes 8–12, epipetalous, unequal; ovary superior, pilose, 8-celled, ovule 1-in each cell; stigmas 4, fleshy, short. Fruit a berry, 6–9×5–7 cm, sub-globose, smooth; calyx much enlarged in fruit, nearly flat, woody. Seeds 1–8, 2.2×1.2 cm, oblong, compressed, glossy black.

**Flowering** & **Fruiting**: Flowering from November to February. Fruiting from February to June.

**Distribution**: *Diospyros crumenata* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). In Kerala it is distributed in Thrissur district only.

**Habitat**: The taxon is found in evergreen and wet evergreen forests in medium and high elevations ranging from 800-1200 m in the of Southern Western Ghats. It is a large sized tree associated *Vateria indica* L., *Palaquium ellipticum* (Dalz.) Baill., *Myristica beddomei* King., *Canarium strictum* Roxb., *Garcinia indica* (Thouars) Choisy in DC., *Knema attenuata* (Hook. fil. & Thoms.) Warb.

**IUCN Status**: Critically Endangered.

**Phenology**

Flowering irregular in these trees. This is a dioecious plant. In the study area, female plants were less in number compared to male plants. Flower buds began to appear in first week of November. The buds are remaining intact and develop slowly, by third week of December, all the buds were opened. Green juvenile fruits were developed by the last week of February. Fruits were matured by the last week of April by which time the colour changed to yellow. By the last week of June, fruits were ripened to reddish brown and fallen off last week of July.

**Specimens examined**: INDIA, **Kerala**, Thrissur district, Vellarimala, 4.2.1985, ±3000 m, *N. Sasidharan* 3377 (KFRI); Peechi, 4.4.1987, *N. Sasidharan* 3954 (KFRI); *ibid*., 30.4.1984, *N. Sasidharan* 3122 (KFRI). Vazhachal, 28.5.2020, ±450 m, *P.K. Fasila* 150587 (MESAH).

**SAPOTACEAE** Juss.

Gen. Pl. 151. 1789.

**Palaquium** Blanco.

Fl. Filip.403.1837.

**Palaquium ellipticum** (Dalz.) Baill., Traite, Bot. Med. Phan. 1500. 1884; Gamble, Fl. Pres. Madras 764. 1921; Mohanan, Fl. Quilon Dist. 242. 1984; Mani., Fl. Silent Valley 168. 1988; V.S. Ramach. & V.J. Nair, Fl. Cannanore Dist. 264. 1988; Vajr., Fl. Palghat Dist. 267. 1990; M. Mohanan & A.N. Henry, Fl. Thiruvananthapuram 278. 1994; Sasidh. & Sivar., Fl. Pl. Thrissur For. 267. 1996; Sivar. & Mathew, Fl. Nilambur 397. 1997; N. Mohanan & Sivad., Fl. Agasthyamala 414. 2002; Sasidh., Fl. Parambikulam WLS 180. 2002; Anil Kumar et al., Fl. Pathanamthitta 296. 2005.

*Bassia elliptica* Dalz. in Hook.'s J. Bot. Kew Gard. Misc. 3: 36. 1851.

*Dichopsis elliptica* (Dalz.) Benth. in Benth. & Hook. f., Gen. Pl. 2: 658. 1876; Hook. f., Fl. Brit. India 3: 542. 1882.

**Local name**: Pali, Choppala.

An evergreen tree, up to 30–35 m high, without branches for a considerable height; outer bark greyish, mottled with white-reddish inside; young branchlets terete, minutely pubescent, later glabrous; branches glabrous, sympodial; exudation milky latex. Leaves simple, closely alternate, stipulate, clustered towards the apex, tip leaves opposite, stipules small, caduceus, and leaving leaf scar. Petiole 1.5–2.5 cm long, slender, slightly pubescent when young, flat above, round beneath; lamina 7–13×3–7 cm, obovate, elliptic-obovate, cuneate at base, margin entire, obtusely acuminate at apex, coriaceous, glabrous above, glabrescent below, dark green above, pale green below; mid rib slender above, emergent on lower surface, glabrous; secondary nerves 8–12 pairs, pinnate, slender, prominent below, slender, channelled obscure above; tertiary nerve reticulate, slender. Flowers bisexual, white, fragrant, in axillary and lateral fascicles; pedicels 2–2.5 cm long, glabrous; calyx lobes 6, in 2 series, outer 3 ovate, valvate aestivation, inner 3 c.1 cm long, lanceolate, densely villous; corolla lobes 6, c.0.5 cm long, campanulate, ovate-oblong, white; stamens 12–20, anthers extrorse, lanceolate, connective produced above anthers; filaments short, hairy; ovary superior; ovoid, villous, 6-celled; style exserted, glabrous, subulate. Fruit a berry, 3–5×1–1.9 cm, ellipsoid, fleshy, smooth, green. Seeds 1 or 2, 2.9–4.5×1.5–2.2 cm, ellipsoid to strongly laterally flattened, with a distinct detachment scar, light yellow when young, brown when mature.

**Flowering** & **Fruiting**: Flowering from January to February. Fruiting from March to July.

**Distribution**: *Palaquium ellipticum* is distributed in South India (Karnataka, Kerala, and Tamil Nadu). It is endemic to Western Ghats. In Kerala it is distributed Palakkad, Kollam, Idukki, Pathanamthitta, Malappuram, Kannur, Thiruvananthapuram, Thrissur, and Wayanad districts.

**Habitat**: The taxon is found in evergreen and wet evergreen forests in medium and high elevations ranging from 700- 1800 m in the Western Ghats. It is a large sized tree associated *Hopea parviflora* Bedd., *Vateria indica* L., *Myristica beddomei* King., *Cullenia exarillata* Robyns., *Litsea floribunda* Gamble.

**IUCN Status**: Not evaluated.

**Phenology**

Flowering only once in year. Flower buds began to appear by the last week of January. Buds begin to open by the second week of February. By the last week of March, the tree was in full bloom. Juvenile green fruits began to appear by the first week of March. Maturation of fruit was very slow, became fully matured by the first week of May. At this time, the colour of the fruit changed to dark green. By the last week of May, the fruits were ripened to black colour. By the first June of May, fruits were fallen off the tree.

**Specimens examined**: INDIA, **Kerala**, Kollam district, Rosemala, Shendurney Wild life Sanctuary, ±300 m, 17.09.1992, *N. Sasidharan* 10002 (KFRI); *ibid*., ±400 m 20.01.1994, *N. Sasidharan* 10808 (KFRI); Choodal, Shendurney Wild life Sanctuary, ±400 m, 24.02.1993, *N. Sasidharan* 10194 (KFRI); Kulathupuzha, Shendurney Wild life Sanctuary, ±160 m, 16.03.1993, *N. Sasidharan* 10217 (KFRI); Idukki district, Vellimala, Periyar Tiger Reserve, ±1550 m, 11.02.1993, *Jomy Augustine* 12926 (CALI); Thrissur district, Sholayar, ±700 m, 4.05.1989, *N. Sasidharan* 5450 (KFRI); *ibid*., ±700 m, 18.04.1990, *N. Sasidharan* 5594 (KFRI); 2.3.2006, *K.H. Amithabachan* 11773 (CALI); 29.01.2015, *P.K. Fasila* 137410 (MESAH) Malappuram district, Thalichola, 9.04.1981, *Philip Mathew* 28405 (CALI); Silent valley camp shed, ±1200 m, 26.02.1982, *T. Sabu* 11087 (CALI); Calicut district, Kakkayam, 26.03.2008, P. S. *Udayan et al.* 04909 (CMPR); Kannur district, Ambayathode, Kottiyur, 09.04. 2003, *P. S. Udayan et al.* 01402 (CMPR).

# CHAPTER 5
# FRUIT AND SEED MORPHOLOGY

**Taxonomic Key based on fruit and seed morphology.**

**LAURACEAE** Juss.

**Key based on fruit and seed morphology of the family Lauraceae.**

1a. Fruit berry .......................................................................................... 2

1b. Fruit a drupe .......................................................................... ***Cryptocarya***

2a. Fruiting perianth not persistent in fruit ......................................... ***Beilschmiedia***

2b. Fruiting perianth persistent in fruit ..................................................................... 3

3a. Berry subglobose to globose ................................................................. 4

3b. Berry ellipsoid, oblong, ovate-oblong, cylindrical-oblong ................................ 5

4a. Perianth joined at base, straight in young fruit, persistent. ................................ 6

4b. Perianth form a basal rim, lobes reflexed in young fruit, deciduous later ........... ....................................................................................................... ***Persea***

5a. Fruit with a short rostrum at apex, fruit straw yellow when ripe. ............. ***Phoebe***

5b. Fruit apex obtuse, without rostrum at apex, fruit red or black when ripe ........... 7

6a. Perianth disc shaped, sparsely pubescent; fruit black when ripe...… ................ .. ................................................................................................. ***Actinodaphne***

6b. Perianth thick, triangular shaped, glabrous; fruit red when ripe ............ ***Neolitsea***

7a. Fruit green with white spots, perianth cup without persistent tepals at rim.......... …............................................................................................................ ***Litsea***

7b. Fruit green without white spots; perianth cup with tepals at rim......................... …........................................................................ ***Cinnamomum malabatrum***

**ACTINODAPHNE** C.G.D. Nees

1a. 1-5 fruits developed from infructescence; peduncle < 2 mm long ............ **A.** ***tadulingamii***.

1b. 6-10 fruits developed from infructescence; peduncle > 2 mm long.................................... 2

2a. Fruit depressed globose, fruiting perianth disc shaped; seed hemispherical ............................................................................................................................................***A. wightiana***

2b. Fruit subglobose, fruiting perianth cup- shaped; seed obovate....................***A. bourdillonii***

***Actinodaphne bourdillonii*** Gamble

Fruits a berry, usually 8 fruits developed from infructescence, 1.3–1.5×0.5–8 cm, subtended by perianth tube, sub globose, acute at base, apex obovate, smooth, glabrous, glossy, light to bright green when young, black when ripe. Perianth 0.4–0.5×c. 0.5 cm, cup- shaped, margin of the cup entire or slightly undulate, glabrous within, pubescent without; perianth fruit proportion is 1:4 mm; fruiting pedicel 1–1.2×c.0.1cm, terete, pubescent; fruiting peduncle 0.5–0.7 cm long, thick, pubescent; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.1 mm thick, fleshy, endocarp membranous. Fruit fresh mass in weight c.0.34 g; dry mass in weight c.0.19 g; fruit pulp in fresh mass in weight c.0.11 g; moisture content in percentage 44. Seed 1, 0.8–0.9×c.0.7 cm, obovate, base acute, apex apiculate, glabrous, smooth, brown not conform to the fruit. Seed fresh mass in weight c.0.23 g; dry mass is in weight c.0.13 g; testa brown, membranous, firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 1–1.5 mm long, straight, basal capitate; radicle minute.

***Actinodaphne tadulingamii*** Gamble

Fruits a berry, usually 1–5 fruits developed from infructescence, 1.2–1.3×0.7–0.8 cm, subtended by perianth tube, sub globose to globose, acute at base, apex obovate, smooth, glabrous, glossy, light to bright green with white spots when young, black when ripe. Perianth 0.6–0.7×c. 0.6 cm, cup- shaped, dark green with white to brown spots, margin of the cup entire, glabrous inside, rufous villous outside; perianth fruit proportion is 1:4 mm; fruiting pedicel 1–1.2×c.0.1cm, terete, sparsely pubescent; shortly peduncle c.2 mm long, thick, pubescent; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.0.5 mm thick, fleshy, endocarp membranous. Fruit fresh mass in weight c.0.22 g; dry mass in weight c.0.1 g; fruit pulp in fresh mass in weight c.0.164 g; moisture content in percentage 55. Seed 1, 0.8–0.9 x c.0.7 cm, obovate, obtuse at base, with short acumen at apex, glabrous, smooth, dark brown, not conform to the fruit. Seed fresh mass in weight c.0.23 g; dry mass in weight c.0.13 g;

testa brown, membranous firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo straight, c.1mm long, apical capitate; radicle minute. **(Figure 5.1.)**

***Actinodaphne wightiana*** (Kuntze) Noltie

Fruits a berry, usually 6–10 fruits developed from infructescence 0.8–1×0.8–1 cm, subtended by perianth tube, depressed globose to globose, base rounded, apex truncate, smooth, glabrous, glossy, light to bright green with white spots when young, purplish black when ripe. Perianth 0.3–0.4×c.0.6 cm, disc shaped, dark green to yellow, margin of the disc is entire, sparsely pubescent within, rufous tomentose without; perianth fruit proportion is 1:6; fruiting pedicel 0.8–1.2×c.0.2 cm, terete, sparsely pubescent; fruiting peduncle 0.5–0.6 cm long, thick, rufous tomentose; pericarp coriaceous and succulent; epicarp 0.1–0.2 mm thick, smooth, leathery, mesocarp c.1.5–2 mm thick, fleshy, endocarp c.0.2 mm thick, membranous. Fruit fresh mass in weight c.0.4372 g; dry mass in weight c.0.17 g; fruit pulp in fresh mass in weight c.0.1872 g; moisture content in percentage 61. Seed 1, 0.5–0.6×0.6–0.7 cm, hemispherical; base truncate, apex obtuse, light brown, glabrous, smooth, not conform to the fruit. Seed fresh mass in weight c.0.25 g; dry mass in weight c.0.11 g; testa brown, membranous firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo < c.1mm long, straight, basal capitate; radicle minute.

**BEILSCHMIEDIA** Nees

1a. Fruit 2–2.7 cm long, cylindrical-oblong, black when ripe; fruiting pedicel >2cm long, red, sparsely pubescent .......................................................***B. bourdillonii***

1b. Fruit 1.7– 1.8 cm long, ovoid, or ellipsoid, purple when ripe; fruiting pedicel < 2cm long, green, glabrous.....................................................................***B. wightii***

***Beilschmiedia bourdillonii*** Brandis

Fruits a berry, usually 1 fruit developed from infructescence, 2–2.7×c.1–0.5 cm, cylindrical- oblong, base acute, apex obtuse, smooth, glabrous, glossy, bright green

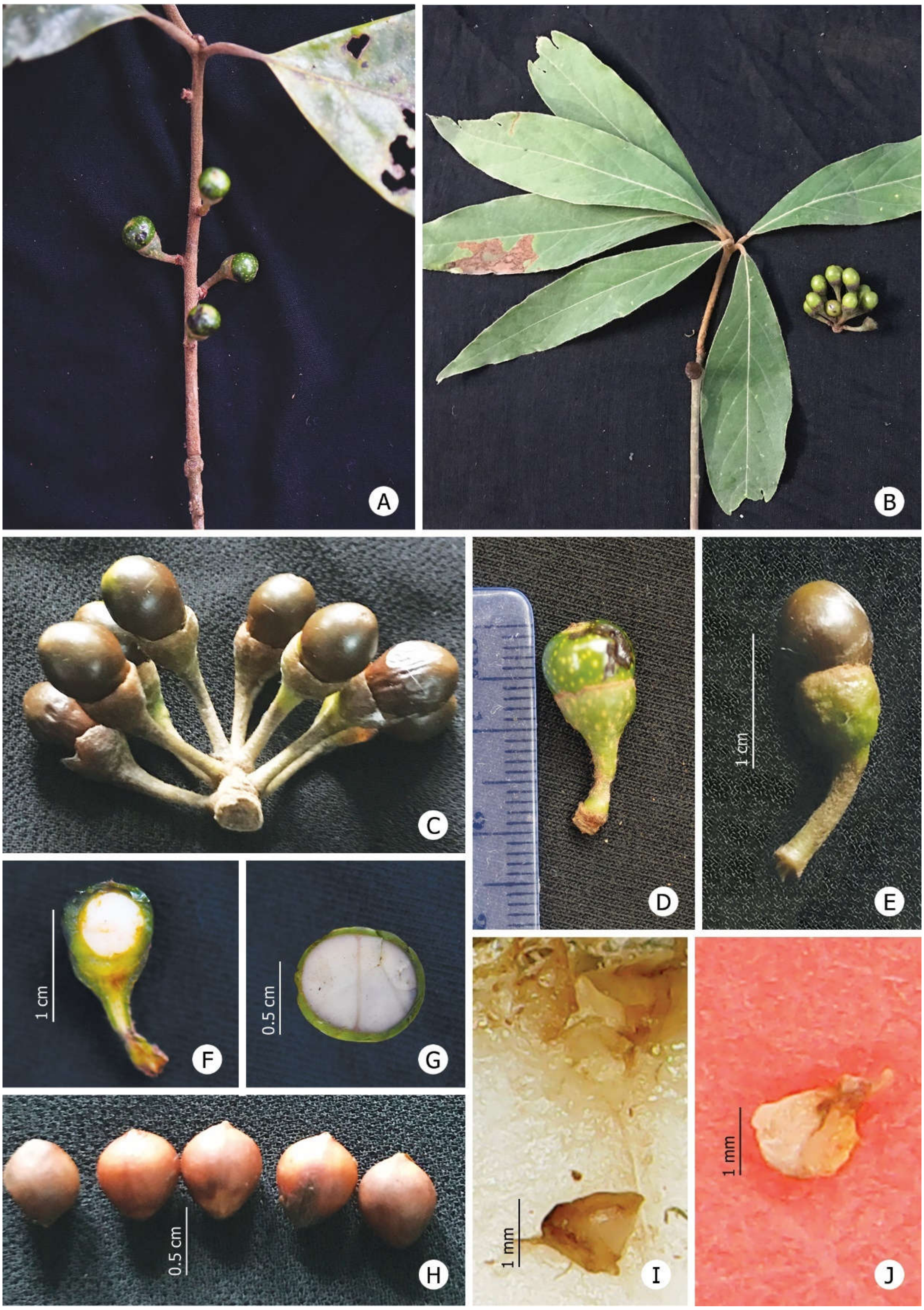


**Figure 5.1. Fruit and seed morphology of** ***Actinodaphne tadulingamii*** Gamble **and** ***Actinodaphne bourdillonii*** Gamble**:** ***Actinodaphne tadulingamii*** Gamble**:** **A.** Fruiting twig; **D.** Fruit; F. Fruit L.S; **G**. Fruit C.S; **I.** Embryo; ***Actinodaphne bourdillonii*** Gamble: **B & C.** Fruiting twig; **E.** Fruit; **H.** Seed; **J.** Embryo.

when young, brown to black when ripe. Fruiting pedicel 2-2.3×c.0.2 cm, terete, not smooth, splited or cracked, red sparsely pubescent; fruiting peduncle 1-2 cm long, thick, red, pubescent; pericarp coriaceous and succulent, epicarp smooth, leathery, mesocarp c.1 mm thick, fleshy, endocarp membranous. Fruit fresh mass in weight c.4.33 g; dry mass in weight c.1.93 g; fruit pulp in fresh mass in weight c.3.796 g; moisture content in percentage 55. Seed 1, 1.5–2×0.7–1 cm, ellipsoid or oblanceolate to oblong; base obtuse, apex acute, surface punctate, glabrous, light brown when mature, not conform to the fruit. Seed fresh mass in weight c.0.23 g; dry mass in weight c.0.13 g; testa membranous, brown, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, whitish to pink; hilum proximal; micropyle near to hilum; embryo c.1 mm long, straight, basal capitate; radicle minute.

***Beilschmiedia wightii*** Benth. & Hook

Fruits a berry, usually 1 fruit developed from infructescence, 2–3×1.2–1.5 cm, ovoid or ellipsoid, base acute, apex obtuse, smooth, glabrous, glossy, bright green when young, purple when ripe. Fruiting pedicel 1.2–1×c.0.3 cm, terete, smooth, greenish, glabrous. fruiting peduncle 2–4 cm long, thick, brown, glabrous; pericarp coriaceous and succulent, epicarp smooth, leathery, mesocarp c.1 mm thick, fleshy; endocarp membranous. Fruit fresh mass in weight c.3.292 g; dry mass in weight c.1.98 g; fruit pulp in fresh mass in weight c.3.052 g; moisture content in percentage 40. Seed 1, 1.5–2×0.6–1 cm, ellipsoid, base obtuse, apex acute, glabrous, surface punctate, light brown, not conform to the fruit. Seed fresh mass in weight c.0.24 g; dry mass is in weight c.0.132 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, whitish to pink; hilum proximal; micropyle near to hilum; embryo c.1 mm long, straight, basal capitate; radicle minute.

### **CINNAMOMUM** Schaeffer

***Cinnamomum malabatrum*** (Burm. f.) Blume

Fruits a berry, usually 2–3 fruits developed from infructescence 1.8–2×0.9–1 cm, subtended by perianth tube, ellipsoid, base truncate, apex rounded, smooth, glabrous, glossy, bright green when young, violet to black when ripe. Perianth 0.8–0.9×0.5–0.6

cm, cup- shaped, fusing on lower surface, obtuse at the base, truncate at the middle, glabrous on both surface, sericeous or glabrous, tepals at rim, light to dark green; perianth fruit proportion is fruit 1:3; fruiting pedicel 0.4–0.5×c.0.2 cm, terete, glabrous; fruiting peduncle 0.7–1.2 cm long, slender, glabrous; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.2 mm thick, fleshy, aromatic, endocarp membranous. Fruit fresh mass in weight c.0.84 g; dry mass in weight c.0.3298 g; fruit pulp in fresh mass in weight c.0.32 g; moisture content in percentage 61. Seed 1, 1.2–1.3×0.5–0.6 cm, ellipsoid, acute at base and apex, glabrous, smooth light brown, conform to the fruit. Seed fresh mass in weight c.0.52 g; dry mass in weight c.0.197 g; testa brown, membranous, firmly attached to cotyledons; cotyledons oblong, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo < 2 mm long, straight, apical capitate; radicle minute.

## **CRYPTOCARYA** R. Br.

1a. Fruit ovoid or cylindrical oblong, apex acute or truncate without stigmatic crown; fruiting pedicel glabrous ........................................................................ 2.

1b. Fruit ellipsoid or obovate-oblong, apex obtuse with sigmatic crown; fruiting pedicel velutinous tomentose. ................................................***C. anamalayana***

2a. Fruit lenticellate, without longitudinal ridges; seed ovoid, apex rounded... ......... ................................................................................................. ***C. lawsonii***

2b. Fruits non lenticillate, with longitudinal ridges; seed oblong, apex apiculate ...... ...................................................................................***C. sheikelmudiyana***

***Cryptocarya anamalayana*** Gamble

Fruits drupe, usually 2-6 fruits developed per infructescence, 2.4−5×0.8−1.3 cm, enclosed with accrescent perianth tube with only a minute orifice at the apex: ellipsoid or obovate-oblong, base acute or obtuse, apex obtuse, truncate, with small stigmatic crown, deeply longitudinally striated, 10-12 ribbed, non lenticellate, sparsely pubescent, bright green when young, glossy black when ripe; fruiting pedicel 2−4×1−2 mm, terete, velutinous tomentose; pericarp crustaceous on fruit, endocarp membranous. Fruit fresh mass in weight c.2.1 g; dry mass in weight c.1.26 g; fruit pulp in fresh mass in weight c.1.2 g; moisture content in percentage 40. Seed 1, 2−3.5×0.5−1 cm, oblong or obovate, ellipsoid with an epical projection c.1 mm long, base obtuse, apex obtusely acute, slightly constricted below the middle, glabrous, smooth, white to light yellow when young, brown when mature. Seed fresh mass in weight c.0.9 g; dry mass in weight c.0.40 g; testa membranous, firmly attached to endocarp, tegmen brown, membranous, firmly attached to cotyledons; cotyledons milky white, ovate–discoid, thick; hilum proximal; micropyle near to hilum; embryo 1−1.5 mm long, straight, basal capitate; radicle minute.

***Cryptocarya lawsonii*** Gamble

Fruit drupe, usually 3-5 fruits developed per infructescence, 2.5−3.5×1.5−1.8 cm, enclosed with accrescent perianth tube with only a minute orifice at the apex, ovoid to oblong, base rounded, apex acute, sometime abruptly constricted slightly above the base, lenticellate, glabrous, bright green when young, reddish brown when ripe; fruiting pedicel 3−3.5×c.3 mm, terete, glabrous; pericarp crustaceous on fruit; endocarp membranous. Fruit fresh mass in weight c.1.9 g; dry mass in weight c.0.9 g; fruit pulp in fresh mass in weight c.1 g; moisture content in percentage 53. Seed 1, 1.8−2×c.0.6 cm, ovoid, rounded at base and apex, glabrous, smooth, white to bright brown when young, reddish brown when mature. Seed fresh mass in weight c.0.98 g; dry mass in weight c.0.6 g; testa brown, membranous, firmly attached to cotyledon; cotyledon oblong, thick, milky white; hilum proximal; micropyle near to hilum; embryo c.1.3 mm long, straight, basal capitate; radicle minute.

***Cryptocarya sheikelmudiyana.*** Fasila *et al.*,

Fruit drupe, usually 12-21 fruits developed per infructescence, 2−2.4×0.8−1 cm, enclosed with accrescent perianth tube with only a minute orifice at the apex, cylindrical-oblong, base broad, apex slightly narrowed and truncate, constricted just below the middle, with 6−11 shallow longitudinal ridges, non-lenticellate, glabrous, bright green when young, glossy black when ripe; fruiting pedicel 0.5−0.6×c.2 mm, terete, glabrous; pericarp crustaceous on fruit; endocarp membranous. Fruit fresh mass in weight c.1.38 g, dry mass in weight c.0.9 g, fruit pulp in fresh mas in weight c.0.66 g, moisture content in percentage 35. Seed 1, 1.7−1.8×c.0.6 cm, oblong, rounded at base, apex narrowly apiculate with the apicula c.1 mm long, glabrous, smooth, white to bright brown when young, reddish brown when mature. Seed fresh mass in weight c.0.72 g, dry mass in weight c.0.58 gm; testa brown, membranous, firmly attached to cotyledon; cotyledon oblong, thick milky white; hilum proximal; micropyle near to hilum; embryo c.1.5 mm long, straight, basal capitate; radicle minute.

### **LITSEA** Lamarck

1a. Fruit > 3 cm long, subglobose, or hemispherical .............................. ***L. oleoides***

1b. Fruit < 3 cm long, oblong, ellipsoid, broadly ellipsoid, obovate ...................... 2

2a. Fruiting perianth cup- shaped ............................................................................ 4

2b. Fruiting perianth urn or obconic shaped. ........................................................... 3

3a. Fruit < 2 mm long, oblong obovoid; perianth margin dissected ........................... .............................................................................................. ***L. bourdillonii***.

3b. Fruit > 2 mm long, broadly ellipsoid, obovate; perianth margin entire ............... ............................................................................................................ ***L. stocksii***

4a. Fruit apex apiculate; perianth pubescent .................................................. ***L.*** sp.1

4b. Fruit apex obtuse; perianth silky pubescent on outside glabrous inside ............ 5

5a. Fruit ellipsoid-ovate; fruiting pedicel terate ....................................................... 6

5b. Fruit ellipsoid – oblong; fruiting pedicel angular............................ ***L.wightiana***

6a. Fruiting pedicel < 5mm long, glabrous ............................................ ***L. coriacea***

6b. Fruiting pedicel >5mm long, densely pubescent ........................... ***L. floribunda***

***Litsea bourdillonii*** Gamble

Fruits a berry, usually 2−8 fruits developed from one umbellule, 1.5−1.8×0.8−1 cm, subtended by perianth tube, oblong, obovoid, base slightly truncate, apex acute and apiculate with the apiculi 1−1.5 mm long, smooth, glabrous, glossy, pale to bright green with small white spots when young, dark red when ripe. Perianth 0.8−0.9×0.8−0.9 m, urn or obconic, entire, glabrous within, pubescent without, margins dissected; perianth fruit proportion is 1:2 covering 50% of fruit; fruiting pedicel 2−3×c.2 mm, angular, pubescent; fruiting peduncle c.0.3×0.3 cm, glabrous; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp fleshy c.1 mm thick, endocarp membranous. Fruit fresh mass in weight c.0.43 g; dry mass in weight c.0.22 g; fruit pulp in fresh mass in weight c.0.21 g; moisture content in percentage 49. Seed 1, 1.2−1.3×c. 0.9 cm, ellipsoid-oblong, base truncate, apex acute, with a c.1mm long sharp pointed tip, glabrous, pale yellow-brown, not conform to the fruit. Seed fresh mass in weight c.0.22 g; dry mass in weight c.0.11 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 1−1.2 mm long, basal capitate, straight.

***Litsea coriacea*** ( B. Heyne ex Nees) Hook.f.

Fruits a berry, usually 3−8 fruits developed from one umbellule,1.4−1.8×0.8−1 cm, subtended by perianth tube, ellipsoid, ovate, base acute, apex obtuse, with small depression, smooth, glabrous, glossy, pale to bright green with small white spots when young, dark red when ripe. Perianth 0.5−0.6×0.6−0.7 cm, cup- shaped, oblique, glabrous on within slightly puberulous without, margins entire; perianth fruit proportion is 1:4 mm covering 26% of fruit; fruiting pedicel 4−5×2−3 mm, terete, glabrous; fruiting peduncle c.0.2 cm long, glabrous; pericarp coriaceous and succulent; epicarp smooth leathery, mesocarp fleshy c.1 mm thick, endocarp membranous. Fruit fresh mass in weight c.0.34 g; dry mass in weight c.0.156 g; fruit pulp in fresh mass in weight c.0.156 g; moisture content in percentage 54. Seed 1, 1.2−1.3×0.6 cm, ellipsoid, ovate-oblong, base obtuse, apex acute, glabrous, smooth, pale yellow-brown, not conform to the fruit. Seed fresh mass in weight c.0.19 g; dry mass in weight c.0.09 g; testa brown, membranous firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, milky white; hilum proximal, micropyle near to hilum; embryo 1−1.5 mm long, basal capitate, straight; radicle minute.

**(Figure 5.2.)**

***Litsea floribunda*** (Blume) Gamble

Fruits a berry, usually 2-4 fruits developed from one umbellule, 1.8−2 ×0.9−1.2 cm subtended by perianth tube, ellipsoid, obovate; base obtuse or slightly flat, apex obtuse, smooth, glabrous, glossy, pale to bright green with small white spots when young, red to black when ripe. Perianth 5−6×7 mm, deeply cup- shaped, or unaltered silky pubescent without; perianth fruit propotion 1:3; fruiting pedicel 0.9−1.2×2−3 mm, terete, pubescent; fruiting peduncle 1−2 cm long, pubescent; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.1 mm thick, fleshy, succulent, aromatic; endocarp membranous. Fruit fresh mass in weight c.0.64 g; dry mass in weight c.0.27 g; fruit pulp in fresh mass in weight c.0.28 g; moisture content in percentage 58. Seed 1, 1.2−1.4×0.8 cm, ellipsoid-oblong; base obtuse, apex acute, glabrous, smooth, pale yellow-brown not conform to the fruit. Seed fresh mass in weight c.0.36 g; dry mass in weight c.0.12 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 1.2−1.5 mm long, apical capitate straight. **(Figure 5.3.)**

***Litsea*** sp 1

Fruits a berry, usually 1-2 fruit developed from one umbellule, 2.3−2.9×1.1−1.2 cm, subtended by perianth tube, ellipsoid, base and apex rounded, smooth, glabrous, glossy, pale bright green with small white spots when young, dark red when ripe. Perianth 0.8−1×0.8−0.9 cm, cup- shaped, oblique at rim, pubescent without, puberulous within, pale green to yellowish green; perianth fruit proportion 1:5; fruiting pedicel 0.4−0.7×0.2−0.4 cm, terete, pubescent; fruiting peduncle 1−2 cm long, brown, pubescent; pericarp coriaceous, succulent, epicarp smooth leathery, mesocarp c.2 mm thick, fleshy; endocarp membranous. Fruit fresh mass in weight c.1.7 g; dry mass in weight c.0.51g; fruit pulp in fresh mass in weight c.0.9 g; moisture content in percentage 70. Seed 1, 1.5−1.6×0.6−1 cm, broadly ellipsoid, base obtuse, apex apiculate, glabrous, smooth, pale yellow-brown, not conform to the fruit. Seed fresh mass in weight c.0.8 g; dry mass in weight c.0.3 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, flat, fleshy, milky white, hilum proximal, micropyle near to hilum; embryo 1.5−1.8 mm long, basal capitate.

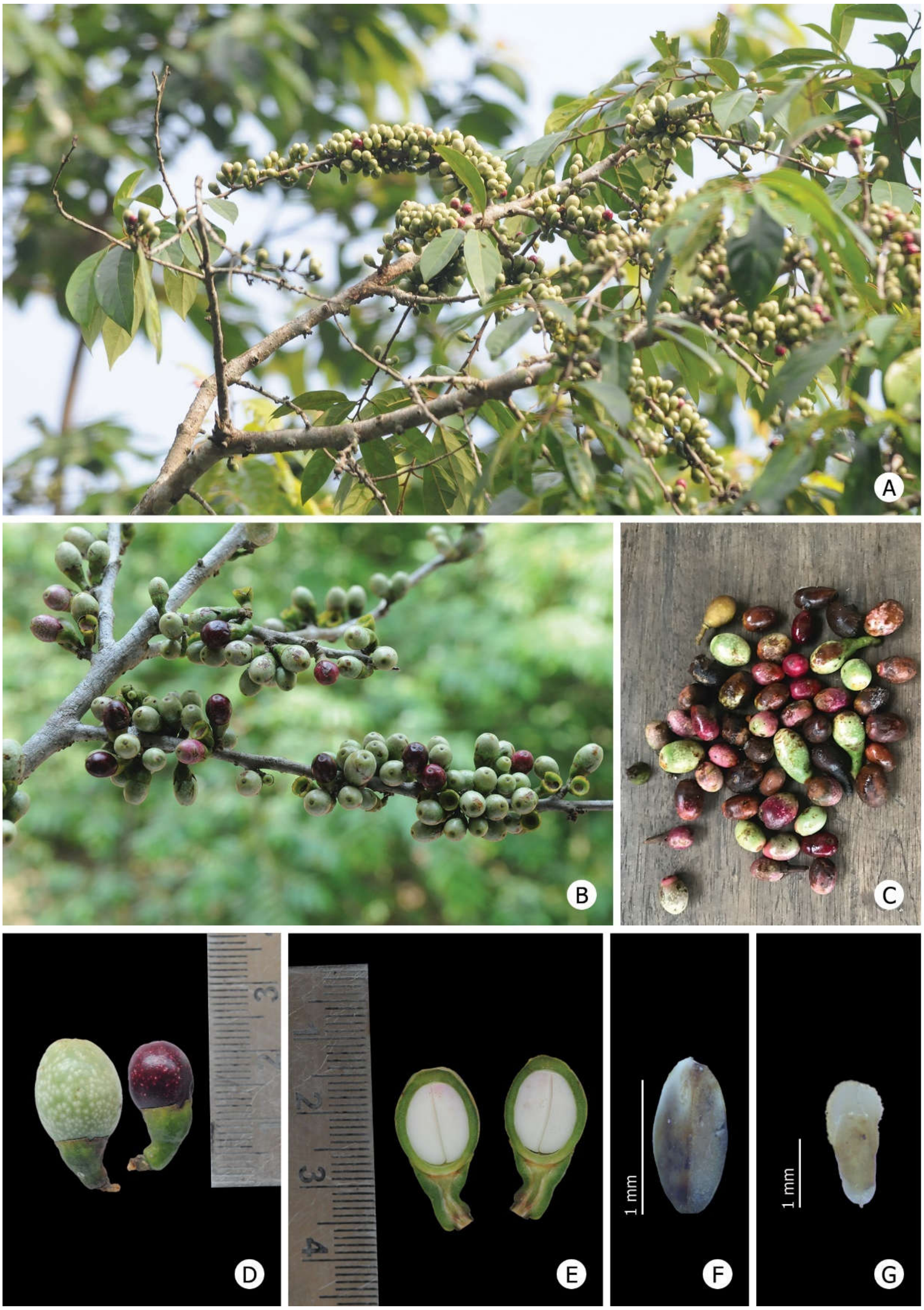


**Figure 5.2. Fruit and seed morphology of *Litsea coriacea*** B. (Heyne ex Nees) Hook.f.**: A & B.** Fruiting twig; **C & D.** Mature fruits; **E.** Fruit L.S; **F.** Seed; **G.** Embryo.

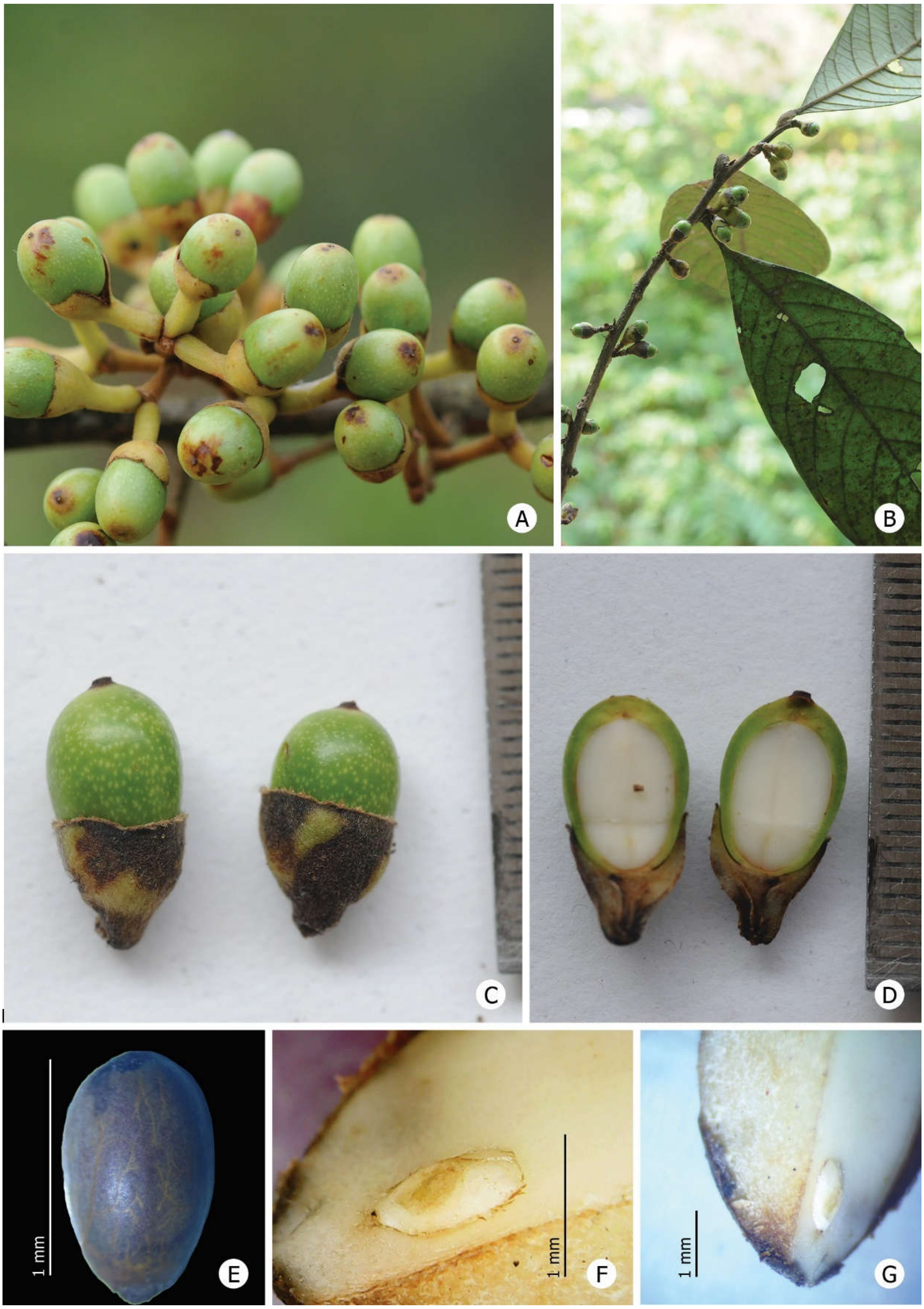


**Figure 5.3. Fruit and seed morphology of *Litsea floribunda* (Blume)** Gamble **and *Litsea bourdillonii*** Gamble**: *Litsea floribunda* (Blume)** Gamble: **A.** Fruiting twig; **E.** Seed; **F.** Embryo; ***Litsea bourdillonii*** Gamble**: B.** Fruiting twig; **C.** Young fruits; **D.** Fruit L.S; **G.** Embryo.

***Litsea oleoides*** (Meisn.) Hook.f.

Fruits a berry, usually 1-3 fruit is developed from one umbellule, 3.8−4×2.4−3 cm subtended by perianth tube, sub globose or hemispherical, obtuse at base, apex truncate, smooth, glabrous, glossy, indehiscent, light to bright green with small white spots when young, dark pink red when ripe. Perianth 1−1.4×1.5 cm. obconical, c.0.4 cm in depth, glabrous on both surface; perianth fruit proportion is 1:4 mm covering 50% of fruit. fruiting pedicel 10−20×2.8−3 mm, angular, glabrous; fruiting peduncle 0.7×0.6 cm, glabrous; pericarp coriaceous and succulent, epicarp smooth thin, mesocarp 1−2 mm thick, fleshy; endocarp membranous. Fruit fresh mass c.7.74 g; dry mass c.2.0445 g; fruit pulp in fresh mass is c.3.79 g; moisture content in percentage 61. Seed 1, 1.4−1.5×2.1−2.4 cm, sub globose or hemispherical; obtuse at base, acute at apex, pale yellow-brown glabrous, not conform to the fruit. Seed fresh mass c.3.959 g; dry mass is c.1.8025 g; testa brown membranous firmly attached to cotyledons; cotyledons thick, fleshy, sub globose, milky white, hilum proximal, micropyle near to hilum; embryo 2−3 mm long, straight, basal capitate; radicle minute.

***Litsea stocksii*** (Meisner.) Hook.f.

Fruits a berry, usually 1-2 fruits developed from one umbellule, 2.1−2.5×0.8−1.5 cm, subtended by perianth tube, broadly ellipsoid, obovate, base slightly truncate, apex obtuse- emarginate or obtuse, smooth, glabrous, glossy, pale to bright green with small white spots when young, dark pink, red to black when ripe. Perianth tube 0.8−1.3×0.9−1.4 cm, obconic, margins slightly undulate, glabrous on both surface; perianth fruit proportion is 1:2 covering half the of the fruit; fruiting pedicel 4−5 cm x1−2 mm, slender, terete, glabrous; fruiting peduncle 1.5−2 cm long, glabrous; pericarp coriaceous and succulent, epicarp smooth, leathery, mesocarp 1−2 mm thick, fleshy. endocarp membranous. Fruit fresh mass in weight c.2.295 g; dry mass in weight c.1.585 g; fruit pulp in fresh mass in weight c.1.33 g; moisture content in percentage 31. Seed 1, 1.5−1.8×0.8−1 cm, ellipsoid-oblong, base obtuse, apex acute, glabrous, smooth, pale yellow brown, not conform to the fruit. Seed fresh mass in weight c.1.02 g; dry mass in weight c.0.72 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 1.5−1.8 mm long, straight, basal capitate.

***Litsea wightiana*** (Nees) Hook. f.

Fruits a berry, usually 2-5 fruits developed from one umbellule, 1.8−2×0.7−0.8 cm, subtended by perianth tube, oblong, base acute, apex obtusely short acuminate, smooth, glabrous, glossy, pale to bright green with small white spots when young, purple when ripe. Perianth tube 1−1.2×0.9−1 cm, cup- shaped, sparely pubescent, margins oblique, sparsely pubescent without, glabrous within, greenish to orange-yellow; perianth fruit proportion 1:1; fruiting pedicel 3−4×2−3 mm, angular, stout, densely pubescent; fruiting peduncle 3−4 cm long, sparsely pubescent; pericarp coriaceous, succulent; epicarp smooth, leathery, mesocarp c.1 mm, thick, endocarp membranous. Fruit fresh mass in weight c.0.5 g; dry mass in weight c.0.2 g; fruit pulp in fresh mass in weight c.0.41 g; moisture content in percentage 60. Seed 1, 1−1.3×0.6 cm, ellipsoid-oblong; base obtuse, apex acute, white glabrous, smooth, not conform to the fruit. Seed fresh mass in weight c.0.09 g; dry mass in weight c.0.04 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 0.5−0.8 mm long, basal capitate, straight; radicle minute.

**NEOLITSEA** (Benth. & J.D. Hook.) Merr.

1a. Perianth tube long above 0.5 cm long.................................................................. 2

1b. Perianth tube short below 0.5 cm long .................................................***N. fischeri***

2a. Fruit subglobose to globose; fruiting perianth cup-shaped, entire .......................
.........................................................................................***N. scrobiculata***

2b. Fruit globose; fruiting perianth disc shaped, crenate..............................***N. cassia***

***Neolitsea cassia*** (L.) Kosterm.

Fruit a drupe, usually 5-6 fruits developed from infructescence, 1−1.2×0.6−0.7 cm, subtended by perianth tube, globose, base and apex rounded, smooth, glabrous, glossy, indehiscent, bright green with white spots when young, red when ripe;

wrinkled or alveolate when dry. Perianth 0.3−0.4×0.3−0.4 cm, disc-shaped, crenate, thick, triangular, glabrous on both surface, bright to dark green; perianth fruit proportion is 1:4 mm covering 1/4 of fruit; fruiting pedicel 0.5−0.6×c.0.2 cm, terete, slender, glabrous; fruiting peduncle 0.1−0.2 cm long, thick, glabrous; pericarp coriaceous and succulent; epicarp smooth, leathery; mesocarp fleshy, c.1 mm thick, endocarp membranous. Fruit fresh mass in weight c.0.89 g; dry mass in weight c.0.34 g; fruit pulp in fresh mass in weight c.0.59 g; moisture content in percentage 62. Seed 1, 1−1.1×0.6−0.7 cm, ellipsoid, ovate-oblong; pale brown, base rounded, apex acute, glabrous, smooth, conform to the fruit. Seed fresh mass in weight c.0.3 g; dry mass in weight c.0.17 g; testa brown, membranous firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo < 1 mm long, basal capitate, straight.

***Neolitsea fischeri*** Gamble

Fruit a drupe, usually 2-6 fruits is developed from infructescence, 10−15×10−12 mm, subtended by perianth tube, globose or obovoid, base and apex rounded glabrous, bright green when young, red when mature, black when ripe. Perianth tube c.10 mm long, triangular, green, glabrous on both surface; fruiting pedicel c.8 mm long, terete, short, and thick glabrous. Fruit not seen during the study period.

***Neolitsea scrobiculata*** (Meisner) Gamble

Fruits a drupe, usually 2-6 fruits developed from infructescence, 1.2−1.3×0.7−0.8 cm, subtended by perianth tube, sub globose to globose, base rounded, apex rounded with small narrow apical projection, smooth, glabrous, glossy, bright green with white spots when young, red when ripe. Perianth 0.5−0.6×0.6−0.7 cm, cup-shaped, triangular, thick, glabrous on both surface, dark green, margin of the cup entire; perianth fruit proportion is 1:4 mm, covering 1/4 of fruit; fruiting pedicel 0.6−0.7×c.0.2 cm, terete, glabrous; fruiting peduncle 0.2−0.3 cm long, thick, glabrous; pericarp coriaceous and succulent, epicarp smooth leathery, mesocarp c.1 mm thick, fleshy, endocarp membranous. Fruit fresh mass in weight c.0.9 g; dry mass in weight c.0.35 g; fruit pulp in weight c.0.58 g; moisture content in percentage

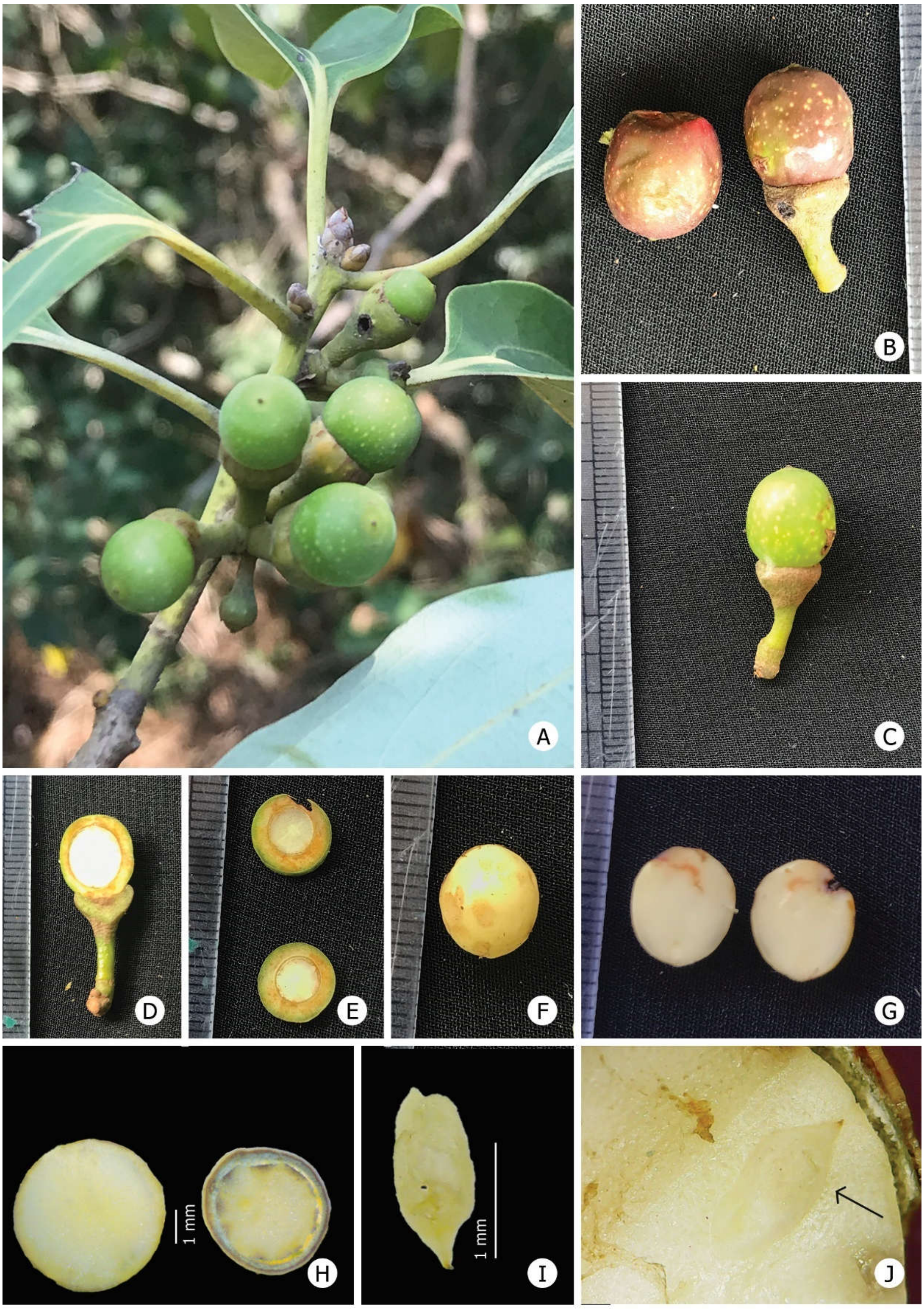


**Figure 5.4. Fruit and seed morphology of *Neolitsea scrobiculata*** (Meisner) Gamble**: A.** Fruiting twig; **B.** Matured Fruits; **C.** Single fruit; **D.** Fruit L.S; **E.** Fruit C.S; **F.** Seed; **G.** Seed L.S; **H.** Seed C.S microscopic view; **I & J.** Embryo.

61. Seed 1, 1−1.2×0.6−0.7 cm, ellipsoid, ovate-oblong; base rounded, apex acute, glabrous, smooth, light brown, conform to the fruit. Seed fresh mass in weight c.0.32 g; dry mass in weight c.0.19 g; testa brown, membranous firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal, micropyle near to hilum; embryo < 1mm long, straight, basal capitate; radicle minute.

**(Figure 5.4.)**

**PERSEA** Mill.

***Persea macrantha*** (Nees) Kosterm.

Fruits a berry, usually 2−4 fruits developed from infructescence 1.1−1.2×1.4−1.5 cm, globose, base rounded, apex obtuse, smooth, glabrous, glossy, indehiscent, bright green with white spots when young, black when ripe, aromatic. Perianth form a basal rim, 4−5 mm long, lobes reflexed in young fruit, deciduous later; fruiting pedicel 1.1−1.2×c.0.1 cm, terete, glabrous green; fruiting peduncle 5−16 cm long, greenish to pale yellow, thin glabrous; pericarp coriaceous, and succulent; epicarp smooth, leathery; mesocarp c.2 mm thick fleshy, milky exudes; endocarp brown, membranous. Fruit fresh mass in weight c.1.01 g; dry mass in weight c.0.350 g; fruit pulp in fresh mass in weight c.0.164 g; moisture content in percentage 65. Seed 1, 0.9−1×1−1.1 cm in diameter, globose; glabrous, smooth, light brown. rounded at apex and base, conform to the fruit. Seed fresh mass in weight c.0.509 g; dry mass in weight c.0.302 g; testa brown, membranous, firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white; hilum proximal; micropyle near to hilum; embryo 1.5−1.8 mm long, basal capitate, straight.

**PHOEBE** Nees.

1a. Fruit above 1cm across, ellipsoid; fruiting pedicel slender .............. ***P. lanceolata***

1b. Fruit up to 1 cm across, globose; fruiting pedicel thickened................. ***.P. wightii***

***Phoebe lanceolata*** *(*Nees) Nees

Fruits a berry, usually 1-2 fruits developed from infructescence, 1.3−1.5×0.8−1 cm, ovoid to ellipsoid, base rounded, apex with a short rostrum, smooth, glabrous, glossy, pale to bright yellow when young, glossy black when ripe. Perianth lobe at base hardening and clasping the fruit, 3−4 mm long, straw yellow, dark green glabrous; fruiting pedicel 8−9×0.1-0.3 cm, terete, glabrous; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.1 mm thick, fleshy, endocarp membranous. Fruit fresh mass in weight c.0.71 g; dry mass in weight c.0.205 g; fruit pulp in fresh mass in weight c.0.11 g; moisture content in percentage 71. Seed 1, 1.1−1.3×0.8−0.9 cm; ovoid to ellipsoid; base widely obtuse or rounded, apex, acute, glabrous, smooth, black conform to the fruit. Seed fresh mass in weight c.0.60 g; dry mass in weight c.0.283 g; testa brown, membranous, firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, creamy white; hilum proximal; micropyle near to hilum; embryo < 1mm long, basal capitate, straight.

***Phoebe wightii*** Meisner

Fruit a berry, c.1×0.5 cm, globose, usually with short rostrum at apex; perianth lobes persistent, greenish yellow, cupular, erect; fruiting pedicel slightly thickened; epicarp fleshy; seed confirm to the fruit. Seed 1. Fruit not seen during the study period.

**MYRISTICACEAE** R. Br.

**Key based on fruit and seed morphology of the family Myristicaceae.**

1a. Fruit < 5cm long; pedicel rusty tomentose; peduncle 0.3–0.5 cm long, pubescent; aril laciante at the apex, brilliant crimson; cotyledons suberect ............................................................................................................ ***Knema attenuata***

1b. Fruit > 5 cm long; pedicel glabrous; peduncle above 3 cm long, glabrous; aril completely surround the seed, yellow to orange; cotyledon connate.................. 2

2a. Fruit ovoid, apex rounded, broadly acute; aril orange ......... ***Myristica beddomei***

2b. Fruit oblong, apex obtuse, slightly flattened on one side: aril yellow. .................. ........................................................................................ ***Myristica malabarica***

**KNEMA** Loureiro

***Knema attenuata*** (Hook. f. & Thoms.) Warb.

Fruits a capsule, usually 1–2 fruits developed from infructescence, 3.7–5×2–2.4 cm, ellipsoid to oblong, base annular, apex apiculate with apiculi 2–3 mm long, rusty tomentose, dehisce longitudinally in two 2, greenish when young, yellowish when ripe; fruiting pedicel 0.5–0.9×0.2–0.3 cm, woody, rusty tomentose; fruiting peduncle 0.3–0.5 cm long, pubescent; pericarp coriaceous and succulent; epicarp thin, green, rusty tomentose, firmly attached to mesocarp; mesocarp 2–2.5 mm thick, succulent, aromatic, white to pale yellow, endocarp brown, membranous. Fruit fresh mass in weight c.7.364 g; dry mass in weight c. 5.140 g; fruit pulp in fresh mass in weight c.2.8 g; moisture content in percentage 30. Seed 1, 2.1–2.5×1.8–1.9 cm, ellipsoid, base acute, apex acute, glabrous, having impressions of aril toward apex pale yellow when young, brown when mature, conform to the fruit; aril surrounded the seed, 0.5–0.8 mm thick, brilliant crimson, fleshy, aromatic, lacinate at the apex only. Seed fresh mass in weight c.4.564 g; dry mass in weight c.3.335 g; testa c.0.5 mm thick, hard, pale yellow-brown, not smooth, having the impressions of aril; tegmen thin, membranous, firmly attached to cotyledons; cotyledons sub erect, connate at base, thick, white to light yellow, endosperm ruminate; hilum ventral, embryo small, 0.3–0.5 mm long, basal sub erect; radicle basal, cylindric.

**MYRISTICA** Gronovius

***Myristica beddomei*** King

Fruits a capsule, usually 1-2 fruits developed from infructescence, 7–8×4.2–4.5 cm, ovoid, base broadly acute, apex narrowly rounded, grooved on one side along the suture, glabrous, dehisce longitudinally in to 2, yellowish-green when young, yellowish-brown when ripe; fruiting pedicel 1–1.2×0.5–0.7 cm, woody, glabrous; fruiting peduncle c.3.3 cm long, glabrous; pericarp rufous, pubescent when young, coriaceous, thick, succulent; epicarp thin, yellow; glabrous, firmly attached to mesocarp; mesocarp 10–12 mm thick, succulent, aromatic, white or pale yellow, endocarp yellow, thick. Fruit fresh mass in weight c.60.64 g; dry mass in weight c.37.44 g; fruit pulp in fresh mass in weight c.45.64 g; moisture content in percentage 38. Seed 1, 3.5–4.7×2–2.2 cm, obovoid, base broadly acute, apex rounded, glabrous, having impressions of aril, pale yellow when young, brown when mature, conform to the fruit; aril surrounded the seed, c.1 mm thick, deeply cut down into many lobes, fleshy, lacinate at the entire seed, yellow orange, aromatic. Seed fresh mass in weight c.15 g; dry mass in weight c.11.5 g; testa hard, dark-brown, 3 layered, outer thin, middle layer c.2 mm, thick; tegmen thin, membranous, firmly attached to cotyledons;

cotyledons thick, connate, white to pale yellow; endosperm ruminate; hilum distal; embryo small, basal capitate, flat; radicle basal, cylindric.

***Myristica malabarica*** Lam.

Fruits a capsule, usually 1-3 fruits developed from infructescence, 5–7.5×1.8–3.5 cm oblong, pubescent, base broadly rounded, apex acutely rounded, grooved on one side along the suture, glabrous, dehisce longitudinally in to 2, reddish tomentose when young, reddish yellow when mature; fruiting pedicel 0.5–1×0.3–0.5 cm, woody, glabrous; fruiting peduncle c.2.5 cm long, glabrous; pericarp coriaceous and succulent, epicarp thin, yellow glabrous, firmly attached to mesocarp; mesocarp 0.6–1 mm thick, fleshy, coriaceous, aromatic, pale yellow. Seed 1, 5–4×2–2.2 cm, oblong, slightly flattened on one side, base broadly rounded, apex obtuse, glabrous, having impressions of aril, pale yellow when young, brown when mature, conform to the fruit; aril surrounded the seed, c.1 mm thick, fleshy, irregularly lobed, lacinate at the entire seed, yellow, aromatic. Fruit not seen during the study period.

**ELAEOCARPACEAE** Juss. ex DC.

**Key based on fruit and seed morphology of the family Elaeocarpaceae**

**ELAEOCARPUS** Linnaeus

1a. Fruit apex rounded; fruiting pedicel 2.5–3 cm long; seed 1, 2–2.6 cm long ........ ........................................................................................... ***E. tuberculatus***

1b. Fruiting apex obtuse; fruiting pedicel 1–1.2 cm long; seeds 2-3, 1.8–2.2 cm long. ...............................................................................................***E. variabilis***

***Elaeocarpus tuberculatus*** Roxb.

Fruits a drupe, usually 3-4 fruits developed from infructescence, 3–5×2.5 cm, oblong or ellipsoid, nearly ovoid, base acute, apex obtuse, ferruginous tomentose, indehiscent, greenish when young, yellow when ripe. Fruiting pedicel 2.5–3×1 cm, slender, ferrugineous tomentose; fruiting peduncle c.1 cm long, ferrugineous tomentose; pericarp coriaceous and succulent, epicarp glabrous, green, firmly attached to the mesocarp; mesocarp fleshy, coriaceous, fibrous, endocarp hard, bony surface, lacunose, surrounding the seed. Fruit fresh mass in weight c.6.37 g; dry

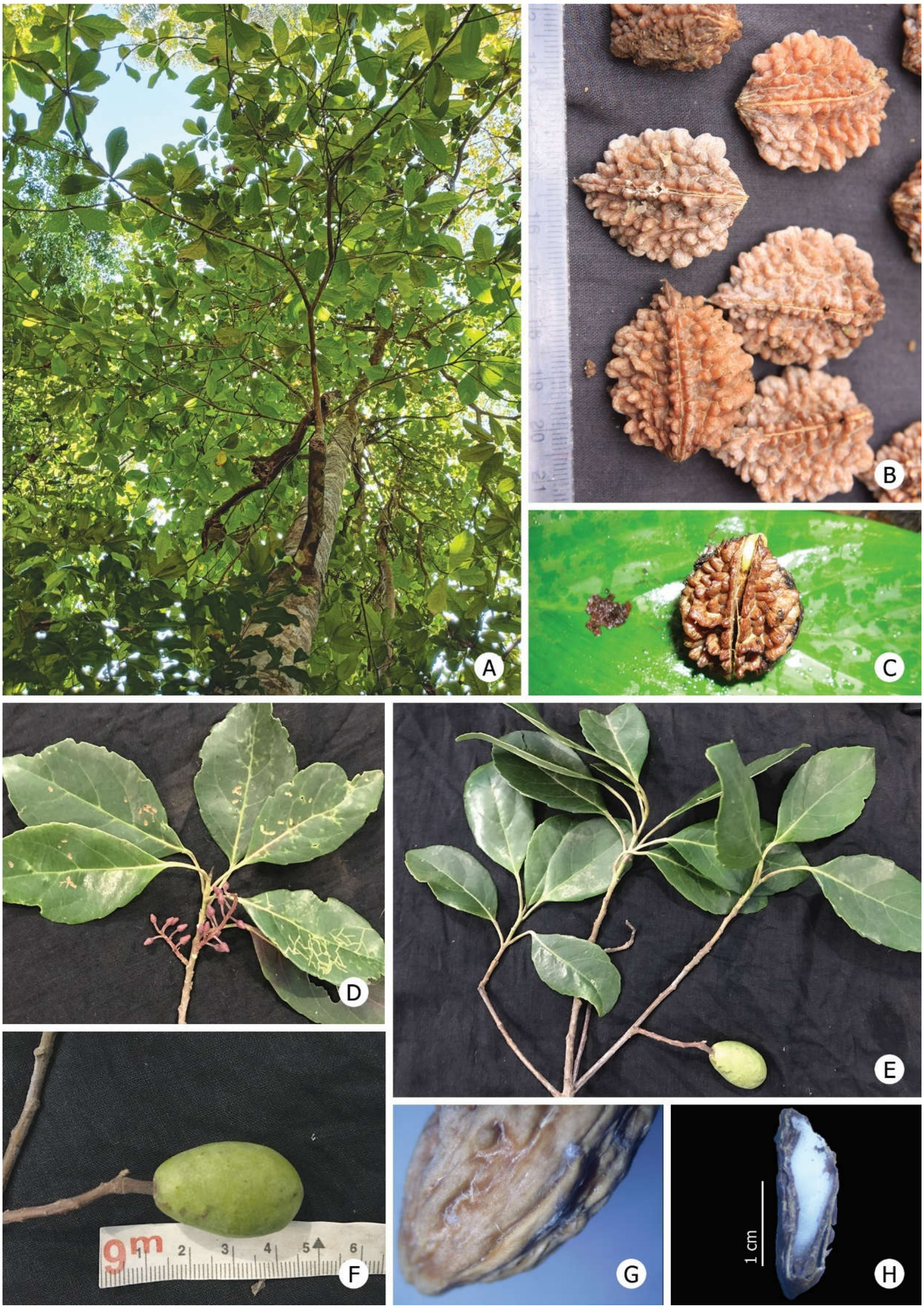


**Figure 5.5. Fruit and seed morphology of *Elaeocarpus tuberculatus*** Roxb. **and *Elaeocarpus variabilis*** Zmarzty**: *Elaeocarpus tuberculatus*** Roxb**.: A.** Habit; **B.** Seeds from nest midden; **C.** Seed germinating in nest midden; ***Elaeocarpus variabilis*** Zmarzt**y: D.** Flowering twig; **E.** Fruiting twig; **F.** Single fruit; **G.** Seed; **H.** Seed with cotyledon.

mass in weight c.3.1 g; fruit pulp in fresh mass in weight c.5.31g; moisture content in percentage 51. Seed 1-2, 1.8–2.2 ×1–1.2 cm, ellipsoid, base obtusely acute, apex obtusely acuminate, coarsely tuberculated glabrous, pale white when young, brown when mature, not conform to the fruit. Seed fresh mass in weight c. 2.28 g; dry mass in weight c.1.2 g; testa thick c.1.5 mm thick, testa membranous; endosperm dense; tegmen thin, brown, membranous firmly attached to cotyledons; cotyledons thin, elongate, foliaceous milky white; embryo straight. **Figure 5.5.)**

***Elaeocarpus variabilis*** Zmarzty

Fruits a drupe, usually 1-2 fruits developed from infructescence, 3.3–3.6×1.8–2.1 cm, obovoid or ellipsoid, base acute or cuneate, apex nearly ovoid or rounded, ferruginous tomentose, indehiscent greenish with white glaucous when young, slightly glossy dark brown when ripe; fruiting pedicel 1–1.2×c.0.2 cm, slender, ferrugineous tomentose; fruiting peduncle c.1 cm long, thick, ferrugineous tomentose; pericarp coriaceous and succulent, epicarp woody, glabrous, green; mesocarp 0.5-4 mm thick, fleshy, coriaceous, endocarp hard, bony surface, lacunose; Fruit fresh mass is in weight c.6.98 g; dry mass in weight c.3.4 g; fruit pulp in fresh mass in weight c.5.5 g; moisture content in percentage 51. Seed 1, 2–2.6×1–1.3 cm, stone ellipsoid, obovoid, surface rugose or deeply concave, sculptured, oblate or planoconvex hemispherical in cross section, base rounded or obtusely acute, apex obtusely acuminate, coarsely tuberculated glabrous, pale yellow when young, dark brown when mature, not conform to the fruit. Seed fresh mass in weight c.2.8 g; dry mass in weight c.1.35 g; testa c.2 mm thick; tegmen thin, brown, membranous firmly attached to cotyledons; cotyledons elongate, thin, foliaceous milky white; embryo straight.

**RHAMNACEAE** Juss.

***Maesopsis eminii*** Engl.

Fruits a drupe, usually 2–5 fruits developed from infructescence, 2–3.5×1–1.8 cm, obovoid, acute at base, apex obovate, smooth, glabrous, glossy, green when young, yellow when mature, purplish-black when ripe; fruiting pedicel 1.5–2×c.0.3 cm, terete, glabrous, brown; fruiting peduncle 3–4 cm long, slender, glabrous; pericarp coriaceous and succulent; epicarp smooth, leathery, mesocarp c.1 mm thick, floury, creamy coloured, endocarp creamy brown, stony. Fruit fresh mass in weight c.2.1 g;

dry mass in weight c.0.93 g; fruit pulp in fresh mass in weight c.1.1 g; moisture content in percentage 56. Seed 1, 1.5–2.3×0.8–1 cm, oblong, in transection triangular, base obtuse, apex acute, surface punctate, glabrous, light brown when mature, not conform to the fruit, albuminous. Seed fresh mass in weight c.0.52 g; dry mass in weight c.0.32 g; testa brown, membranous, firmly attached to cotyledons; cotyledons elliptic, thick, fleshy, whitish to pink; hilum proximal; micropyle near to hilum; embryo c.1 mm long, foliate, straight; radicle minute, straight.

### **MYRTACEAE** Juss.

### **Syzygium** P. Browne ex Gaertn.

***Syzygium cumini*** (L.) Skeels

Fruits a berry usually 10-40 fruits developed from infructescence 1.5–3.5×1–1.3 cm, ellipsoid to oblong, base and apex truncate, glabrous, indehiscent; light pink a when young turns to reddish violet when ripe; fruiting pedicel small, c.0.2 mm long, glabrous; fruiting peduncle 3–5 cm long; pericarp coriaceous and succulent; epicarp thin, smooth, glossy, green, firmly attached to mesocarp; mesocarp 2–3 mm thick, fleshy, coriaceous, very juicy, pulp greyish-yellow, white or pale violet; endocarp brown, membranous. Fruit fresh mass in weight c.1.21 g; dry mass in weight c.0.98 g; fruit pulp in fresh mass in weight c.0.91 g; moisture content in percentage 32. Seeds 2–5, 1–1.2×c.1 cm, ovate or oblong, compressed together into a mass resembling a single seed, base truncate, apex shortly acuminate, glabrous, pale yellow when young, brownish black when mature, not conform to the fruit. Seed fresh mass in weight c.1.25 g; dry mass in weight c.0.98 g; testa 0.3 mm thick, thin, smooth, shiny light yellow to brown; tegmen thin, membranous, firmly attached to cotyledons; cotyledons large, flat, angular, thick, pale green; hilum conspicuous, narrow, elongating, extending near to micropyle; embryo vertical.

## **BURSERACEAE** Kunth

### **CANARIUM** Linnaeus

***Canarium strictum*** Roxb.

Fruits a drupe, usually 1–2 fruits developed from infructescence, 1-3 celled, subtended by fused calyx c. 3 cm long, brown glabrous, 2.8–3.5×1.2–1.5 cm, ellipsoid, acute at base, apex trigonite, smooth, glabrous, glossy, pale to bright green when young, black when ripe; calyx fruit proportion is 1:4 mm covering 1/4 of fruit; fruiting pedicel 1–1.3×c.0.1 cm, terete, peduncle c.2 mm long, thick, pubescent; epicarp smooth, leathery; mesocarp c.0.3 mm thick, fleshy, white-yellow; endocarp c.0.4 mm, stony, surface scabrous white. Fruit fresh mass in weight c.4.59 g; dry mass in weight c.3.5 g; fruit pulp in fresh mass in weight c.2.5 g; moisture content in percentage 24. Seed 1-3, 2–3×1 cm, ellipsoid, trigonous, acuminate at base and apex, glabrous, woody dark brown. Seed fresh mass in weight c.1.38 g; dry mass in weight c.0.8 g; testa c.1mm, hard, green; tegmen thin, membranous, firmly attached to cotyledons; cotyledons hemispheric, thick, fleshy, milky white become green, tri foliate during germination; hilum proximal; embryo c.1 mm, long straight, apical capitate.

## **MELIACEAE** Juss.

**Key based on fruit and seed morphology of the family Meliaceae**

1a. Fruit capsule, dehiscent........................................................................... 2

1b. Fruit berry, indehiscent.............................***Reinwardtiodendron anamalaiense***

2a. Fruit obovoid or subglobose .................................................................... 3

2b. Fruit globose or globose-pyriform.......................................................... 4

3a. Seeds 2-3 per fruit, fruit dehisce longitudinally in to 3 valves; fruiting peduncle 34−60 cm long, woody, warty................................. ***Aphanamixis polystachya***

3b. Seed 1 per fruit, fruit dehisce longitudinally in to 2 valves; fruiting peduncle 2.5−4 cm long, slender, not warty.................................. ***Trichilia connaroides***

4a. Pericarp with numerous irregular longitudinal ridges and dense peltate scale ........................................................................................ ***Aglaia malabarica***

4b. Pericarp without numerous peltate scale ........................................ ***Dysoxylum***

**AGLAIA** Loureiro

***Aglaia malabarica*** Sasidh.

Fruit a capsule, usually 1-2 fruits developed from infructescence, 3.5−4.5×2.7−4 cm, obovoid or sub globose with an apical depression, base truncate, apex obtuse; fruiting pedicel c.4×0.5 cm, woody, glabrous; pericarp with numerous irregular longitudinal ridges and dense peltate scales, c.0.5 cm thick, granular. Seed 1−3, 1.7−2.5×1−1.5 cm, surround by a thin pale pink translucent aril. Fruit not seen during the study period.

**APHANAMIXIS** Blume

***Aphanamixis polystachya*** (Wall.) Parker

Fruits a capsule, usually 15–25 fruits developed from infructescence, 2.9–4×2–2.3 cm, globose–pyriform nearly ovoid, base acute, apex obtuse, woody, glabrous, dehisce longitudinally in to 3 valves, yellowish when young, light red to pink when ripe; fruiting pedicel 0.7–1×0.5–0.8 cm, woody, glabrous; fruiting peduncle 34–60 cm long, woody, warty; pericarp coriaceous, fibrous and succulent, some time with white latex; epicarp woody, brown, glabrous; mesocarp 3-celled, 2–3 mm thick, fleshy, coriaceous; endocarp thin, white membranous. Fruit fresh mass in weight c.15.59 g; dry mass in weight c.7.0445 g; fruit pulp in fresh mass in weight c.12.83 g; moisture content in percentage 55. Seeds 2–3, 1.8–2.2×1–1.2 cm, hanging by strips of endocarp from capsule, oblate or planoconvex, hemispherical in cross section, base obtusely acute, apex obtusely acuminate, glabrous, smooth, orange-yellow when young, blackish-brown when mature not conform to the fruit; aril surrounded the seed, c.2 mm thick, yellow to orange, fleshy not aromatic. Seed fresh mass in weight c.2.76 g; dry mass in weight c.0.97 g; testa c.1 mm thick, coriaceous, dark brown, tegmen thin, white, firmly attached to cotyledons; cotyledons thick, fleshy, superposed or conferruminate, milky white; hilum ventral; embryo 0.7–0.8 mm long, flat, axile and centric; radicle horizontal, minute.

## **DYSOXYLUM** Blume

1a). Fruit obovoid or sub globose; seeds ovate or ovate-oblong ............***D. ficiforme***

1b). Fruit pyriform; seeds blunty trigonous ......................................***D. malabaricum***

***Dysoxylum ficiforme*** (Wight) Gamble

Fruits a capsule, usually 1–2 fruits developed from infructescence, 5–6.5×4.5–5.5 cm, obovoid or subglobose with 4 shallow horizontal ridges, base acute, apex retuse, rough, dehisce longitudinally in to 3 valves, green when young, yellowish-brown when ripe; fruiting pedicel 1.5–2×0.5–1 cm, woody, warty appearance, greenish-yellow, glabrous; fruiting peduncle c.1 cm long, glabrous; pericarp coriaceous and succulent; epicarp c.0.5 mm thick, warty appearance, brownish-yellow, glabrous, firmly attached to mesocarp; mesocarp c.1 mm thick, with 4 longitudinal striations, fleshy, coriaceous, yellowish, endocarp brown-membranous. Fruit fresh mass in weight c.89.43 g; dry mass in weight c.38.54 g; fruit pulp fresh mass in weight c.79.62 g; moisture content in percentage 57. Seeds 3–4, 3×2.5–2.7 cm, hanging by strips of endocarp from capsule, ovate-oblong, hemispherical in cross section, base rounded, apex broadly acute, glabrous, smooth, orange-yellow, when young, dark-brown or reddish-brown when mature not conform to the fruit; aril c.1 mm completely surrounded the seed, white to yellow, smooth not aromatic. Seed fresh mass in weight c.9.810 g; dry mass in weight c.6.753 g; testa c.2 mm long, coriaceous, brown; tegmen thin, membranous, firmly attached to cotyledons; cotyledons ovate, thick, fleshy, superposed, creamy white to yellow white; hilum distal, large; micropyle near to hilum; embryo 3–4 mm long, flat, axile and centric.

***Dysoxylum malabaricum*** Bedd.

Fruits a capsule, usually 1-2 fruits developed from infructescence 5–7×4.4–5.5 cm, pear shaped, base obtusely acuminate, apex acute, verrucose, woody, nearly glabrous, dehisce longitudinally in to 4 valves, green when young, bright yellow when ripe; fruiting pedicel 0.5×0.5–0.8 cm, woody, greenish-yellow, glabrous; pericarp glabrous, succulent; epicarp c.1 mm thick, glabrous, verrucose, yellow, firmly attached to mesocarp; mesocarp 1–1.5 cm thick, fleshy, coriaceous, yellowish have

4 longitudinal furrows, c.1 cm thick, endocarp brown leathery. Fruit fresh mass in weight c.84.2 g; dry mass in weight c.36.54 g; fruit pulp fresh mass in weight c.75.29 g; moisture content in percentage 57. Seeds 3-4, 1.5–1.8×1 cm, seed attached by their whole inner surface to the central placenta, bluntly 3-sided, base obtusely acute, apex round, glabrous, smooth, orange-yellow when young, reddish-brown when mature, does not conform to the fruit; aril cover the dorsal side of the seed 1 mm thick, yellow, leathery, smooth not aromatic. Seed fresh mass in weight c.8.910 g; dry mass in weight c.4.650 g; testa 1 mm thick, brown, leathery; tegmen thin, orange in colour membranous firmly attached to cotyledons: cotyledons thick, fleshy green oblong creamy white to yellow white; hilum distal.

***Reinwardtiodendron anamalaiense*** (Bedd.) Mabb.

Fruits a berry, usually 1-2 fruits developed from infructescence 2.5–3.6×2.4–2.5 cm, obovoid, base acute, apex rounded, woody, glabrous, indehiscent, green, when young, brownish when ripe, with persistent calyx lobe, lobes 6, 2 rows, outer 3 large, c.0.5 cm long, alternate with 3 small inner row; fruiting pedicel 1–1.2×0.2–0.3 cm, slender, glabrous; fruiting peduncle 7–12 cm long, slender, glabrous; pericarp coriaceous and succulent, epicarp woody, brown, glabrous; mesocarp, c.5 mm thick, succulent, with 3 longitudinal striations; endocarp brown, membranous. Fruit fresh mass in weight c.7.74 g; dry mass in weight c.3.49 g; fruit pulp in fresh mass in weight c.6.03 g; moisture content in percentage 55. Seed 1-2, 1.8–2.2×1–1.6 cm, oblong, base acute, apex rounded, glabrous, smooth, white when young, brown with white patch on the dorsal side about ¼ the of the seed, when mature, not conform to the fruit; aril completely surrounded the seed, c.2 mm thick, orange-yellow to white, fleshy not aromatic. Seed fresh mass in weight c.1.71 g; dry mass in weight c.1.06 g; testa c.1mm thick, hard, scleraceous, tegmen thin, membranous firmly attached to cotyledons; cotyledons oblong, thick, fleshy not superposed, conferruminate, brown; hilum ventral; micropyle near to hilum; embryo small c.1 mm long, flat, axile and centric; radicle minute, horizontal.

**Trichilia** P.Browne

***Trichilia connaroides*** (Wight & Arn.) Bentv

Fruits a capsule, usually 2-9 fruits developed from infructescence, 1.5–1.7×1–1.2 cm, globose, base acute, apex acuminate glabrous, dehisce longitudinally in to 2, greenish when young, pale pink when ripe; fruiting pedicel 0.3–0.4×c.0.2 cm, woody, glabrous; fruiting peduncle 2.5–4 cm long, slender, glabrous; pericarp coriaceous and succulent; epicarp thin, yellowish-red, glabrous; mesocarp succulent; endocarp membranous. Fruit fresh mass in weight c.1.36 g; dry mass in weight c.0.187 g; fruit pulp in fresh mass in weight c.0.59 g; moisture content in percentage 86. Seed 1, 1.2–1×0.9–1.1 cm, hemispherical, base acuminate, apex obtusely acuminate, glabrous, smooth, whitish-yellow when young, black when mature, not conform to the fruit; aril completely surrounded the seed, white, fleshy; not aromatic. Seed fresh mass in weight c.0.77 g; dry mass in weight c.0.0935 g; testa hard, scleraceous, tegmen thin, membranous firmly attached to cotyledons; cotyledons thick, whitish green colour; embryo small flat, axile and centric.

**EBENACEAE** Gurke

**DIOSPYROS** Linnaeus

***Diospyros crumenata*** Thw.

Fruits a berry, usually 1 fruits developed from infructescence, 5.4–9×4.9–7 cm, sub globose, round at base, apex obtuse or round with a small notch, smooth, glabrous, glossy, light to bright green when young, orange yellow when ripe; calyx much enlarged in fruits 1.5–3.5×1.5–1.8 cm, flat, reflexed, glabrous woody, lobes broadly rounded and abruptly tapering in to the acute apex, green when young become black when mature; fruiting pedicel short, 1–1.2×c.5 cm, terete, woody, pilose; pericarp coriaceous, succulent; epicarp thin, green glabrous firmly attached to mesocarp; mesocarp 4–5 mm thick, fleshy coriaceous, white to pale green. Fruit fresh mass is c.19.300 g; dry mass in wight 13.5 g; pulp in fresh mass is c.8.5 g; moisture content in percentage 30. Seeds 8-19, 3–3.2×1.2–1.5 cm, oblong to strongly laterally flattened, base obtusely acuminate tip, glabrous, brownish red colour when young, glossy black when mature, not conform to the fruit. Seed fresh mass in weight c.10.800 g; dry mass is in weight c.6.87 g; testa brown, thin, membranous, wrinkled firmly attached to cotyledons; cotyledons ovate, large thin, white to light pink; endosperm ruminate; hilum distal; embryo < 1 mm long, straight, axile; radicle superior.

**SAPOTACEAE** Juss.

**Palaquium** Blanco.

***Palaquium ellipticum*** (Dalz.) Baill.

Fruits a berry, usually 1 fruits developed from infructescence, 3–5×1–1.9 cm, ellipsoid to oblong, base and apex acute, glabrous, indehiscent; greenish when young, yellowish to brownish when ripe; fruiting pedicel 2–3×0.3–0.4 cm, woody, glabrous; persistent calyx 5, ovate to lanceolate, free, glabrous; pericarp coriaceous and succulent; epicarp thin, glabrous, green, firmly attached to mesocarp; mesocarp 2–3 mm thick, fleshy, coriaceous, lactiferous, white to pale yellow; endocarp brown, membranous. Fruit fresh mass in weight c.11.11 g; dry mass in weight c.6.62 g; fruit pulp in fresh mass in weight c.7.87 g; moisture content in percentage 40. Seed 1 or 2, 2.9–4.5×1.5–2.2 cm, ellipsoid to strongly laterally flattened, with a distinct detachment scar, base and apex obtusely acuminate, glabrous, light yellow when young, brown when mature. Seed fresh mass in weight c.3.24 g; dry mass in weight c.1.64 g; testa c.1 mm thick; crustaceous, smooth, shiny pale yellow to brown, tegmen thin, membranous, firmly attached to cotyledons; cotyledons large, flat, planoconvex, thick, white to light pink; endosperm oily; hilum conspicuous, narrow, elongating, extending near to micropyle; embryo vertical, large flat, radicle exerted.

# CHAPTER 6

# SEED GERMINATION

## Introduction

The germination experiments of seeds collected from parent tree and Great hornbill regurgitated seeds were commenced from 2018 and continued for the subsequent years up to 2022 (Table 6.1., 6.2. & Figure 6.1.). The seeds were planted after the heavy rain in June 2018. From the total of 9 species of seeds collected from parent trees (seeds collected from hornbill dependent trees), all seeds were germinated. However, the seeds of *Actinodaphne wightiana*, *Canarium strictum, Litsea oleoides* showed poor germination. The germination of seeds collected from Great hornbill nest midden, all the seeds were germinated and showed high germination percentage.

**Table 6.1. Seeds from parent trees (controlled seed)**

| Sl No. | Name of species | Family | Collected area | Altitude (MSL) |
|---|---|---|---|---|
| 1 | *Actinodaphne wightiana* (Kuntze) Noltie | Lauraceae | Sholayar | 868 |
| 2 | *Litsea oleoides* (Meisn.) Hook. f. | Lauraceae | Sholayar<br>Nelliyampathy<br>Karapara | 848<br><br>1687 |
| 3 | *Persea macrantha* (Nees) Kosterm. | Lauraceae | Sholayar Swapnamudi<br><br>Nelliyampathy<br>Karapara | 947<br><br>1570 |
| 4 | *Palaquium ellipticum* (Dalz.) Baill. | Sapotaceae | Oodankayam | 874 |
| 5 | *Myristica beddomei* King | Myristicaceae | Myladumpara<br>Malakkappara | <br>1041 |
| 6 | *Knema attenuata* (Hook. f. & Thoms.) Warb, | Myristicaceae | Ambalapara | 876 |
| 7 | *Maesosis eminii* Engl. | Rhamnaceae | Nelliyampathy<br>Victoria estate | 1489 |
| 8 | *Dysoxylum malabaricum* Bedd. ex Hiern. | Meliaceae | Chandanthodu<br>Sholayar | 746 |
| 9 | *Canarium strictum* Roxb. | Burseraceae | Parakuthali | 1118 |


**Figure 6.1. Seeds collected form Great hornbill nest midden: A.** Sholayar Puliveenathodu; **B.** Nelliyampathiy Lilly Estate; **C.** Ambalapara Thandu; **D.** Sholayar Power house; **E.** Ambalapara IB; **F.** Pottenmopu.

**Table 6.2. Seeds from hornbill nest midden (regurgitated)**

| Sl No. | Name of species collected | Nesting tree | Nesting Location | Altitude (MSL) |
|---|---|---|---|---|
| 1 | *Knema attenuata* (Hook. f. & Thoms.) Warb. | *Bombax ceiba* L. | Sholayar Puliveenathodu | 732 |
| 2 | *Litsea oleoides* (Meisn.) Hook. f. | *Bombax ceiba* L.<br><br>*Toona ciliata* M.Roem | Sholayar Puliveenathodu<br><br>Nelliyampathy (Lilly estate) | 732<br><br>1585 |
| 3 | *Actinodaphne wightiana* (Kuntze) Noltie | *Vateria indica* L. | Pottenmopu | 882 |
| 4 | *Myristica beddomei* King | *Tetrameles nudiflora* R.Br. | Sheikalmudi | 1100 |
| 5 | *Persea macrantha* (Nees) Kosterm. | *Mesua ferrea* L.<br><br>*Toona ciliata* M.Roem | Ambalapara thandu<br><br>Nelliyampathy (Lilly estate) | 987<br>1590 |
| 6 | *Palaquium ellipticum* (Dalz.) Baill. | *Bombax ceiba* L.<br><br>*Vateria indica* L | Sholayar Puliveenathodu<br><br>Pottenmopu | 732<br><br>480 |
| 7 | *Dysoxylum malabaricum* Bedd. ex Hiern. | *Calophyllum polyanthum* Wall. ex. Choisy | Pathadipalam | 954 |
| 8 | *Canarium strictum* Roxb. | *Tetrameles nudiflora* R.Br. | Sheikalmudi | 1100 |
| 9 | *Maesosis eminii* Engl. | *Tetrameles nudiflora* R.Br.<br>*Albizia odoratissima* (L.f.) Benth. | Sheikalmudi<br><br>Nelliyampathy (Victoria estate) | 1100<br><br>1585 |

**Comparison of germination rate of seeds collected from parent tree and Nest midden.**

The rate of germination of seeds collected from parent trees are as follows: *Palaquium ellipticum* (57%), *Myristica beddomei* (56%) and *Knema attenuata* (46%) showed high germination percentage whereas *Litsea oleoides* (6%), *Canarium strictum* (6%) and *Actinodaphne wightiana* (8%) showed very poor germination percentage. *Persea macrantha* (13%) *Dysoxylum malabaricum* (18%) and *Maesosis eminii* (32%) showed average germination percentage (Table 6.3.).

Seed from nest midden (regurgitated) showed high rate of germination. *Actinodaphne wightiana* (86%) had maximum germination percentage followed by *Knema attenuata* (84%), *Palaquium ellipticum* (80%), *Myristica beddomei* (76%), *Persea macrantha* (73%) *Maesosis eminii* (72%) *Litsea oleoides* (64%), *Canarium strictum* (65%) and *Dysoxylum malabaricum* (62%) (Table 6.3. & Figure 6.2.).

**Table 6.3. Germination Percentage of seeds.**

| Sl. No. | Name of Species | Germination % | |
|---|---|---|---|
| | | Seeds from Parent tree | Seeds from Nest midden |
| 1 | *Actinodaphne wightiana* (Kuntze) Noltie | 8 | 86 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 13 | 73 |
| 3 | *Litsea oleoides* (Meisn.) Hook. f. | 6 | 64 |
| 4 | *Myristica beddomei* King | 56 | 76 |
| 5 | *Knema attenuata* (Hook. f. & Thoms.) Warb. | 46 | 84 |
| 6 | *Palaquium ellipticum* (Dalz.) Baill. | 57 | 80 |
| 7 | *Maesosis eminii* Engl. | 32 | 72 |
| 8 | *Canarium strictum* Roxb. | 6 | 65 |
| 9 | *Dysoxylum malabaricum* Bedd. ex Hiern | 18 | 62 |

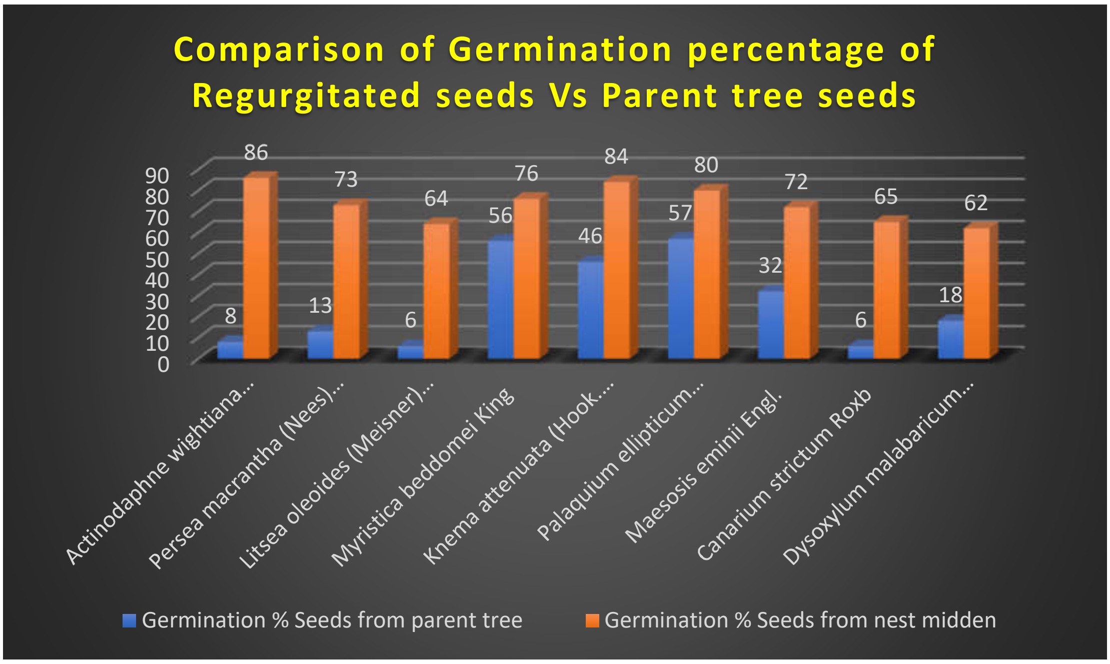


**Figure 6.2. Comparison of Germination percentage of Regurgitated seeds Vs Parent tree seeds**

**Germination of *Actinodaphne wightiana*** (Kuntze) Noltie

Shoot length, number of leaves, and seedling length of the seeds collected from parent tree and from under the nest were periodically monitored (in alternative weeks up to 9$^{th}$ week of germination). In *Actinodaphne wightiana* the shoot length showed a variation of 1.5 cm in the first week of germination. The seed from the parent tree showed a growth of 2 cm in the first week whereas the seed collected the nest midden showed a growth of 3.5 cm. For the remaining weeks, the shoot length showed little variation. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed minimal variation. In the 1$^{st}$ week of germination, the seeds collected from parent tree showed 3.63 cm and from the nest midden it was 4.3. In the 3$^{rd}$ week of germination, the seedling growth was 8.46 cm and 8.61 in seeds from parent tree and nest midden. In the 3$^{rd}$ week of germination, the seedling was 13.5 cm and 14.5 cm in seeds from parent tree and nest midden. In the 7$^{th}$ week of germination, it was 17.51 and 18.03 in seeds from parent tree and nest midden. In the 9$^{th}$ week of germination, the seedling length of seeds collected from parent tree and nest nidden was 23.8 and 24 cm respectively. (Table 6.4. & Figure 6.3.).

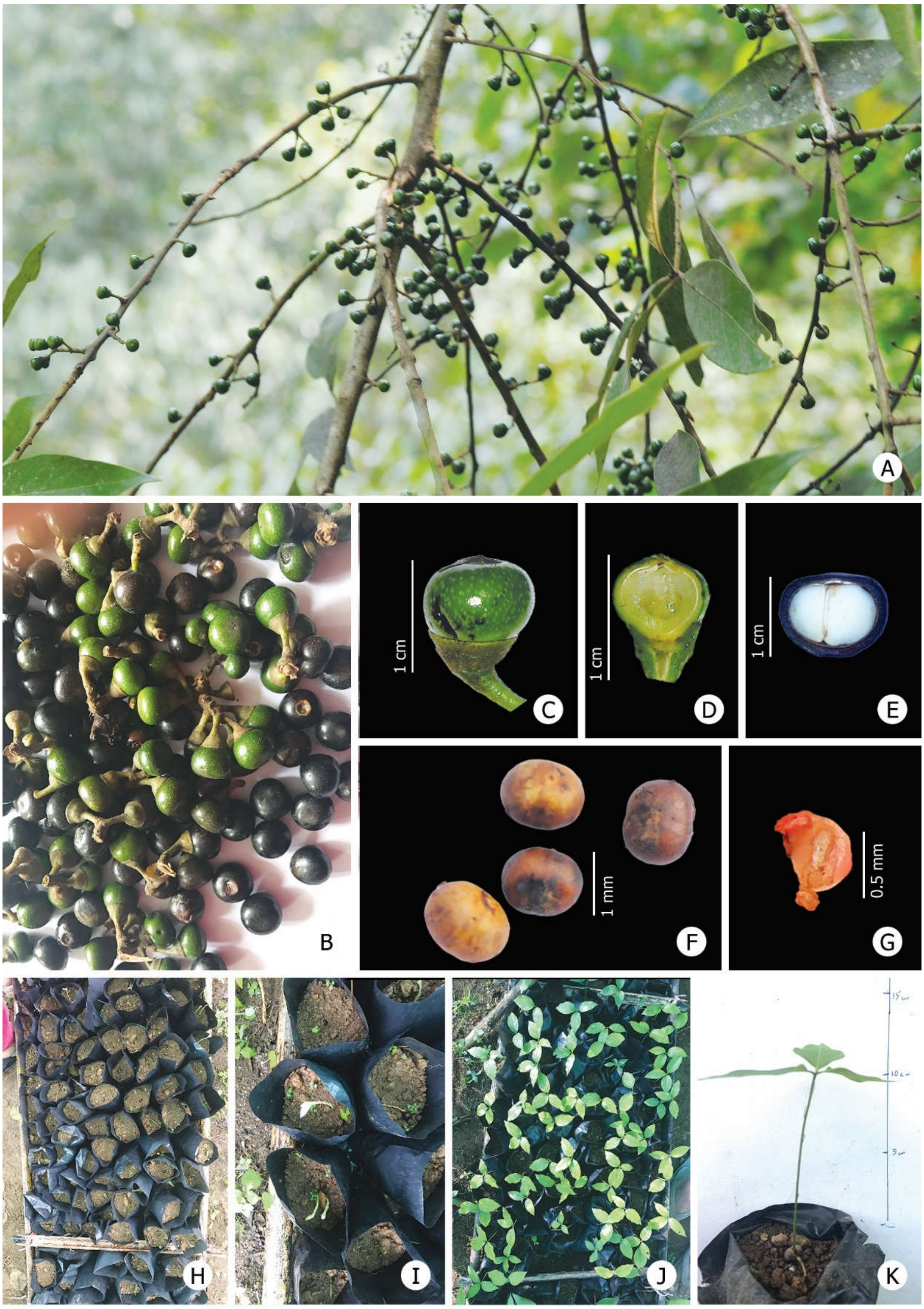


**Figure 6.3. Germination of *Actinodaphne wightiana*** (Kuntze) Noltie**: A.** Fruiting twig; **B.** Fruits; **C.** Single fruit; **D.** Fruit L.S; **E.** Fruit C.S; **F.** Seeds; G. Embryo; **H, I, J & K.** Seed germination in nursery.

**Table 6.4. Germination of *Actinodaphne wightiana* (Kuntze) Noltie**

| | Shoot length (cm) | | Number of leaves | | Seed ling length (cm) | |
|---|---|---|---|---|---|---|
| | Parent tree | Nest midden | Parent tree | Nest midden | Parent tree | Nest midden |
| 1st week of germination | 2.±0.8 | 3.5±0.94 | 2 | 2 | 3.63±0.10 | 4.3±0.10 |
| 3rd week | 5.24±0.06 | 5.47±0.07 | 3 | 3 | 8.46±0.45 | 8.61±0.46 |
| 5th week | 8.4±0.10 | 8.6±0.07 | 3 | 3 | 13.5±0.09 | 14.5±0.08 |
| 7th week | 11.8±0.07 | 12.2±0.03 | 3 | 3 | 17.51±0.09 | 18.03±0.07 |
| 9th week | 17.3±0.07 | 17.8±0.06 | 3 | 3 | 23.8±0.09 | 24.0±1.08 |

**Germination of *Persea macrantha*** (Nees) Kosterm.

In *Persea macrantha* the shoot length showed a variation of 1.3 cm in the first week of germination. The seed from the parent tree showed a growth of 3 cm in the 1st week whereas the seed collected the nest midden showed a growth of 4.3 cm. For the 3rd week, the shoot length showed little variation. In the 5th week of germination, the variation was 2 cm. The seed from the parent tree showed a growth of 12.5 cm, whereas the seed collected from nest midden showed a growth of 14.5 cm. In the 7th week of germination, a little variation was noted. In the 9th week of germination, the variation was 1.2 cm, the seed from parent tree showed a growth of 23.8 cm and seeds from nest midden showed a growth of 25 cm. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed minimal variation in the 1st and 2nd week of germination. In the 3rd week of germination, the variation was 1.06 cm. The seed from parent tree showed a growth of 8.95 cm and seed from the nest midden showed a growth of 10.61 cm. In the 5th of week of germination, the variation was 2.81 cm, the seed from parent tree showed a growth of 15.2 cm, seeds from nest midden showed a growth of 18.01 cm. In the 7th week of germination, the growth of seedling showed minimum variation. In the 9th week of germination, the variation was 3.07 cm, the seed from the parent tree showed a growth of 24.73 cm whereas the seeds from the nest midden showed a growth of 27.8 cm (Table 6.5. & Figure 6.4.).


**Figure 6.4. Germination of *Persea macrantha*** (Nees) Kosterm**.: A.** Fruits; **B.** Single fruit; **C.** Fruit L.S; **D & E.** Seeds; **F.** Seed L.S; **G.** Embryo; **H, I, J, K & L.** Seed germination in nursey; **M.** Seedling in the Great hornbill nest midden.

**Table 6.5. Germination of *Persea macrantha*** (Nees) Kosterm.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 3±0.8 | 4.3±0.107 | 2 | 2 | 4.351±0.10 | 4.81±0.10 |
| 3rd week | 7.6±0.1 | 8.47±0.07 | 2 | 2 | 8.95±0.11 | 10.61±0.46 |
| 5th week | 12.5±0.09 | 14.5±0.08 | 2 | 2 | 15.2±0.22 | 18.01±0.07 |
| 7th week | 17.51±0.09 | 18.03±0.07 | 4 | 4 | 19.8±0.12 | 20.2±0.03 |
| 9th week | 23.8±0.09 | 25.0±0.08 | 4 | 4 | 24.73±0.07 | 27.8±0.06 |

**Germination of *Litsea oleoides*** (Meisn.) Hook. f.

In *Litsea oleoides*, the shoot length showed a variation of 1 cm in the first week of germination. The seed from the parent tree showed a growth of 2.3 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 3.3 cm. In the 3rd week of germination, the variation was 3.25 cm. The seed from the parent tree showed a growth of 7.05 cm whereas the seed collected from the nest midden showed a growth of 10.3 cm. In the 5th week of germination, the variation was 4.1 cm. The seed from the parent tree showed a growth of 15.3 cm whereas the seed collected from the nest midden showed a growth of 19.4 cm. For the remaining weeks, the shoot length showed minimal variation. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed marked variation. In the 1st week of germination, the variation was 1.6 cm. The seed from the parent tree showed a growth of 3.4 cm in the 1st week, whereas the seed collected from the nest midden showed a growth of 5 cm. In the 3rd week of germination, the variation was 0.34 cm. The seed from the parent tree showed a growth of 12.7 cm whereas the seed collected from the nest midden showed a growth of 13.04 cm. In the 5th week of germination, the variation was 1.26 cm. The seed from the parent tree showed a growth of 17.2 cm whereas the seed collected from the nest midden showed a growth of 24.08 cm. In the 7th week of germination, it was 1.26 cm. The seed from the parent tree showed a growth of 30.2 cm whereas the seed collected from the nest midden showed a growth of 31.46 cm. In the 9th week of germination, the variation was 1.07

cm. The seed from the parent tree showed a growth of 41.57 cm whereas the seed collected from the nest midden showed a growth of 42.25 cm (Table 6.6. & Figure 6.5.).

**Table 6.6. Germination of *Litsea oleoides*** (Meisn.) Hook. f.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 2.3±0.07 | 3.3±0.08 | 2 | 2 | 3.4±0.1 | 5±0.09 |
| 3rd week | 7.05±0.3 | 10.3±0.24 | 3 | 3 | 12.7±0.12 | 13.04±0.17 |
| 5th week | 15.3±0.11 | 19.4±14 | 3 | 3 | 17.2±0.18 | 24.08±0.08 |
| 7th week | 26.5±0.3 | 27.0±0.41 | 5 | 5 | 30.2±0.4 | 31.46±0.30 |
| 9th week | 37.0±0.3 | 37.1±0.4 | 5 | 5 | 41.57±0.2 | 42.25±0.25 |

**Germination of *Palaquium ellipticum*** (Dalz.) Baill.

In *Palaquium ellipticum*, the shoot length showed a variation of 0.7 cm in the first week of germination. The seed from the parent tree showed a growth of 2.23 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 2.3 cm. For the remaining weeks, the shoot length showed little variation. In the 9th week of germination shoot length showed 0.2 cm variation. Number of leaves was the same for both seeds during the entire period of germination. The growth of seedlings showed minimal variation up to 3rd week. In the 5th week of germination, variation was 1.02. The seeds from the parent tree showed a growth of 21.04, where as the seed collected from nest midden showed a growth of 22.06. In the 7th week of germination, the variation was 1.6 cm, the seeds from parent tree showed a growth of 35.1 cm, whereas the seeds germinated from nest midden showed a growth of 36.7 cm. In the 9th week of germination, the variation was 1 cm. In parent tree, the seedling length was 52.7 cm and for the seed from nest midden the seedling length was 53.7 cm (Table 6.7. & Figure 6.6.).

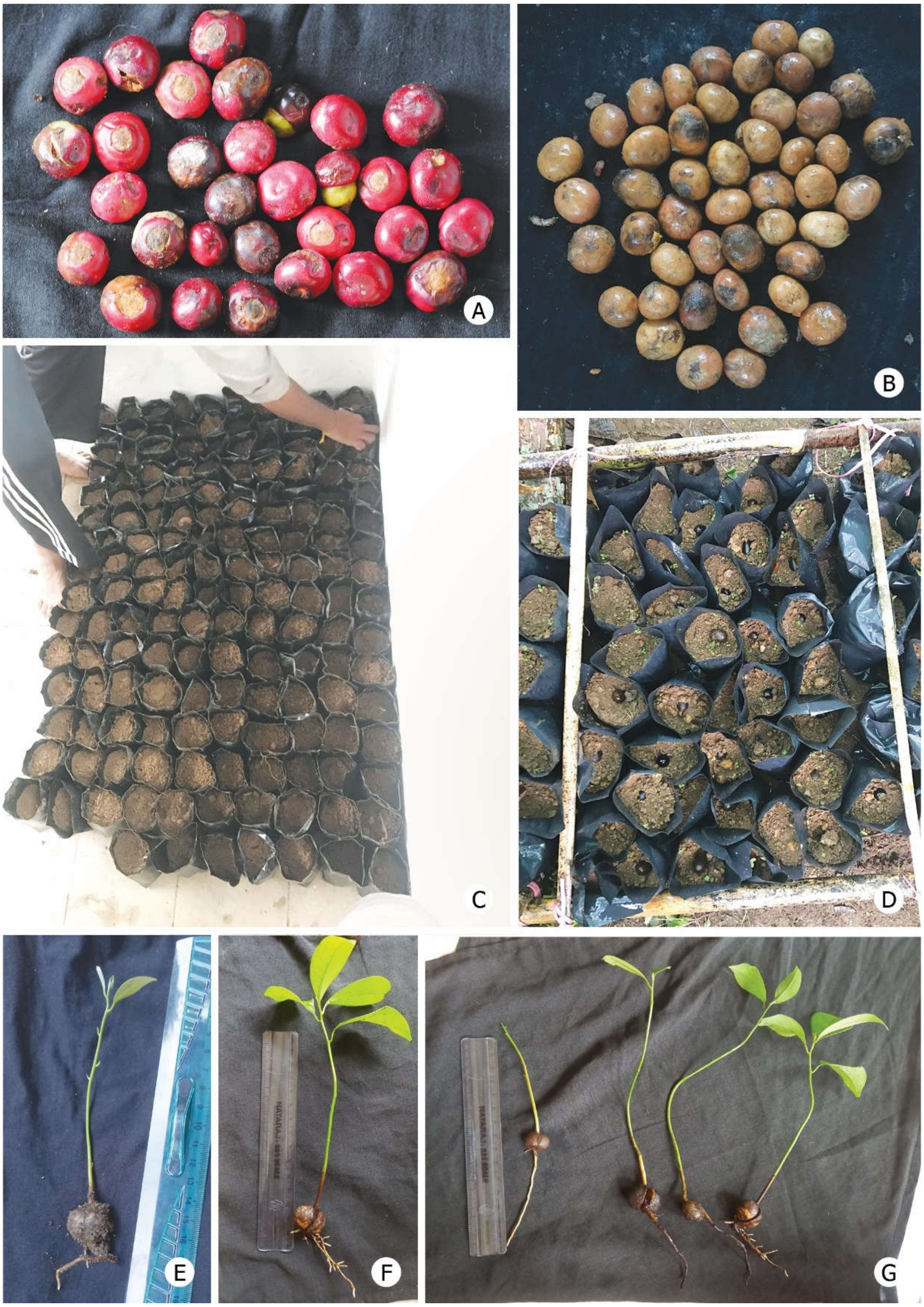

**Figure 6.5. Germination of *Litsea oleoides* (Meisn.) Hook. f.: A.** Fruits; **B.** Seeds; **C & D.** Seed germination in nursery; **E, F & G.** Seedlings.

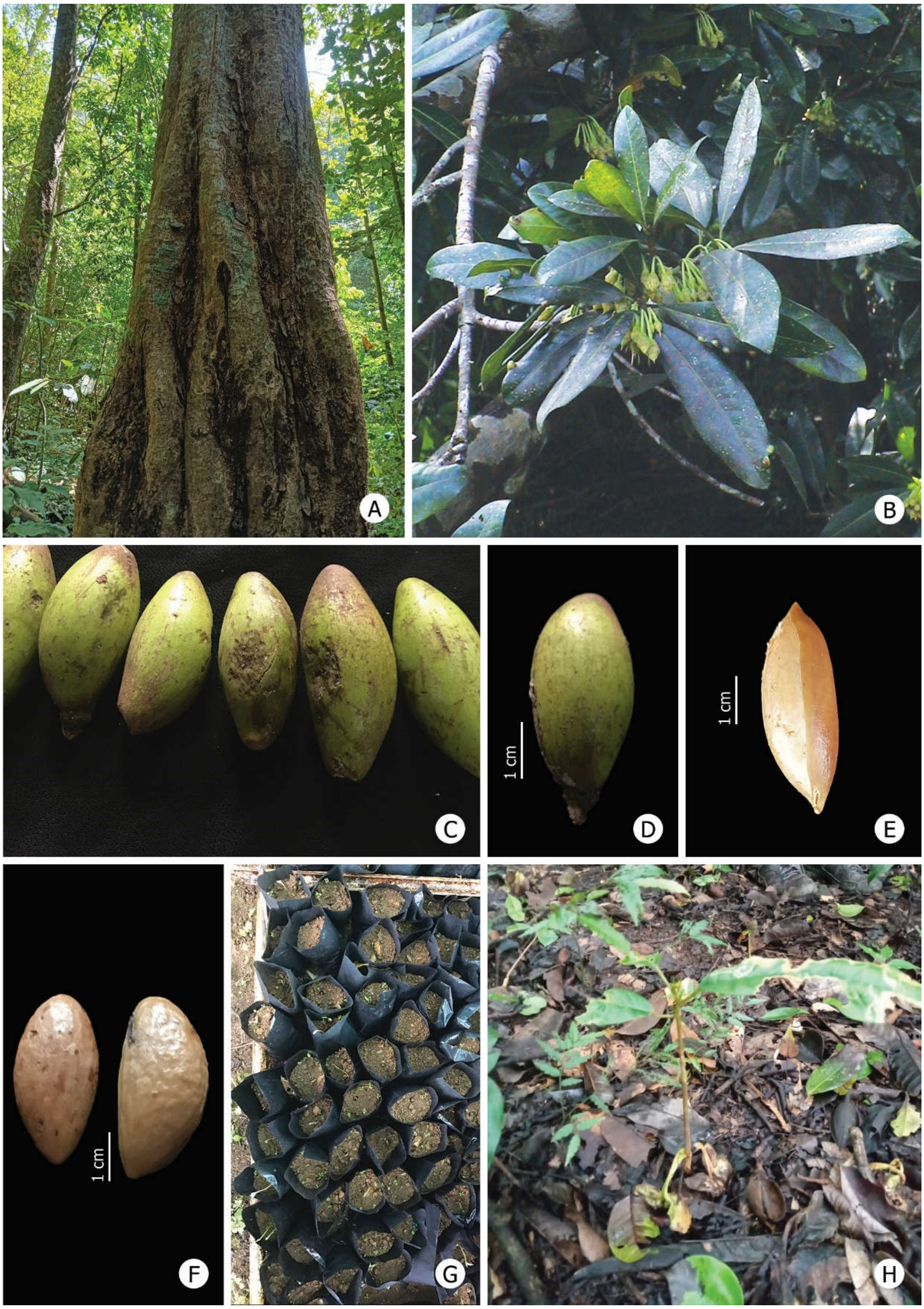


**Figure 6.6. Germination of *Palaquium ellipticum*** (Dalz.) Baill**.: A.** Habit; **B.** Flowering twig; **C.** Fruits; **D.** Single fruit; **E.** Seed; **F.** Cotyledons; **G.** Seed germination in nursery; **H.** Seedling in Great hornbill nest midden.

**Table 6.7. Germination of *Palaquium ellipticum*** (Dalz.) Baill.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 2.23±0.04 | 2.3±0.05 | 2 | 2 | 3.2±0.01 | 3.9±0.07 |
| 3rd week | 8.17±0.05 | 8.5±0.08 | 2 | 2 | 14.3±0.03 | 14.6±0.06 |
| 5th week | 17.2±0.05 | 17.4±0.08 | 4 | 4 | 21.04±0.08 | 22.06±0.11 |
| 7th week | 30.6±0.15 | 30.9±0.14 | 4 | 4 | 35.1±0.30 | 36.7±0.28 |
| 9th week | 48.9±0.09 | 49.1±0.01 | 5 | 5 | 52.7±0.12.20 | 53.7±0.15 |

**Germination of *Myristica beddomei*** King

In *Myristica beddomei*, the shoot length showed a minimum variation up to 9th week of germination. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed minimal variation up to 1st week of germination. In the 3rd week of germination, the variation was 1.3 cm. The seed from the parent tree showed a growth of 8.1 cm in the second week whereas the seed collected from the nest midden showed a growth of 9.4 cm. In the 5th week of germination, the variation was 0.5 cm. The seed from the parent tree showed a growth of 14.6 cm whereas the seed collected from the nest midden showed a growth of 15.1 cm. In the 7th week of germination, the variation was 1.6 cm. The seed from the parent tree showed a growth of 18.2 cm whereas the seed collected from the nest midden showed a growth of 19.8 cm. In the 9th week of germination, the difference was 0.8 cm. The seed from the parent tree showed a growth of 22.9 cm whereas the seed collected from the nest midden showed a growth of 23.7 cm (Table 6.8. & Figure 6.7.).


**Figure 6.7. Germination of *Myristica beddomei* King: A.** Seeds; **B & C.** Seed germination in nursery **D, E & F.** Seedlings.

**Table 6.8. Germination of *Myristica beddomei*** King

| | Shoot length (cm) | | Number of leaves | | Seed ling length (cm) | |
|---|---|---|---|---|---|---|
| | Parent tree | Nest midden | Parent tree | Nest midden | Parent tree | Nest midden |
| 1st week of germination | 0.34± 0.01 | 0.348±0.014 | 2 | 2 | 2.5±0.05 | 2.7±0.04 |
| 3rd week | 4.6± 0.04 | 4.77±0.03 | 3 | 3 | 8.1±0.20 | 9.4.7±0.07 |
| 5th week | 9.91±0.06 | 9.94±0.04 | 3 | 3 | 14.6±0.1 | 15.1±0.17 |
| 7th week | 12.5±0.05 | 12.7±0.02 | 4 | 4 | 18.2±0.05 | 19.8±1.01 |
| 9th week | 14.50±0.12 | 14.6±0.09 | 5 | 5 | 22.9±0.26 | 23.7±0.4 |

**Germination of *Knema attenuata*** (Hook. f. & Thoms.) Warb.

In *Knema attenuata*, the shoot length showed little variation in the first week of germination. The seed from the parent tree showed a growth of 1.3 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 1.4 cm. For the remaining weeks, the shoot length showed little variation. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed little variation in the 1st week of germination, 0.2 cm. The seed from the parent tree showed a growth of 2.2 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 2.4 cm. In the 3rd week of germination, the variation was 1.2 cm. The seed from the parent tree showed a growth of 7.5 cm whereas the seed collected from the nest midden showed a growth of 8.7 cm. In the 5th week of germination, the variation was 2.9 cm. The seed from the parent tree showed a growth of 12.9 cm whereas the seed collected from the nest midden showed a growth of 15.8 cm. In the 7th week of germination, the variation was only 0.7 cm. The seed from the parent tree showed a growth of 18.4 cm whereas the seed collected the nest midden showed a growth 19.1 cm. In the 9th week of germination, the seed from the parent tree showed a growth of 20.11 cm whereas the seed collected from the nest midden showed a growth 21.2 cm, showing variation of 1.09 (Table 6.9. & Figure 6.8.).


**Figure 6.8. Germination of *Knema attenuata*** (Hook. fil. & Thoms.) Warb**.: A.** Habit; **B.** Blaze; **C & D.** Fruiting twig; **E.** Fruits; **F.** Seed germination in nursery; **G & H.** Seedling

**Table 6.9. Germination of *Knema attenuata*** (Hook. f. & Thoms.) Warb.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 1.30±0.01 | 1.4± 0.03 | 2 | 2 | 2.2±0.08 | 2.4±0.08 |
| 3rd week | 4.28±0.09 | 4.9±0.2 | 3 | 3 | 7.5±0.14 | 8.7±0.07 |
| 5th week | 8.71±0.17 | 8.9±0.15 | 4 | 4 | 12.9±0.2 | 15.8±0.28 |
| 7th week | 11.30±0.42 | 12±0.17 | 4 | 4 | 18.4±0.12 | 19.1±0.17 |
| 9th week | 14.11±0.09 | 14.2±0.08 | 5 | 5 | 20.11±0.13 | 21.2±0.2.4 |

**Germination of *Maesosis eminii*** Engl.

In *Maesosis eminii*, the shoot length showed a variation of 0.6 cm in the first week of germination. The seed from the parent tree showed a growth of 2 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 2.65 cm. For the remaining weeks, the shoot length showed marked variation. In the 3rd week of germination, shoot length showed a variation of 1.6 cm. The seed from the parent tree showed a growth of 5.2 cm whereas the seed collected from the nest midden showed a growth of 6.8 cm. In the 5th week of germination, shoot length showed a variation of 1.4 cm. The seed from the parent tree showed a growth of 8.4 cm whereas the seed collected from the nest midden showed a growth of 10.1 cm. In the 7th week of germination, shoot length showed a variation of 3.3 cm. The seed from the parent tree showed a growth of 11.8 cm whereas the seed collected from the nest midden showed a growth of 15.2 cm. In the 9th week of germination, shoot length showed a variation of 4.3 cm. The seed from the parent tree showed a growth of 20.3 cm whereas the seed collected from the nest midden showed a growth of 24.6 cm. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling in the 1st week of germination showed a variation of 1.08 cm. The seed from the parent tree showed a growth of 4.3 cm whereas the seed collected from the nest midden showed a growth of 5.38 cm. In the 3rd week of germination, seedling length showed a variation of 1.8 cm. The seed from the parent tree showed a growth of 8.6 cm whereas the seed collected from the nest midden showed a growth of 10.4 cm. In the 5th week of germination, seedling length showed a variation of 3.6 cm. The seed from the parent tree showed a growth of 12.5 cm whereas the seed collected from the nest midden showed a growth of 16.1 cm. In the 7th week of germination, seedling length showed a variation of 3.2 cm. The seed from the parent tree showed a growth of 14.8 cm whereas the seed collected from the nest midden showed a growth of 18 cm. In the 9th week of germination, seedling length showed a variation of 4.3 cm. The seed from the parent tree showed a growth of 22.3 cm whereas the seed collected from the nest midden showed a growth of 26.6 cm (Table 6.10. & Figure 6.9.).

**Table 6.10. Germination of *Maesosis eminii*** Engl.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 2.08±0.82 | 2.65±0.01 | 2 | 2 | 4.3±0.1 | 5.38±0.02 |
| 3rd week | 5.2±0.06 | 6.8±0.07 | 3 | 3 | 8.6±0.06 | 10.4±0.04 |
| 5th week | 8.4±0.10 | 10.1±0.09 | 4 | 4 | 12.5±0.08 | 16.1±0.05 |
| 7th week | 11.8±0.07 | 15.2±0.04 | 4 | 4 | 14.8±0.07 | 18±0.07 |
| 9th week | 20.3±0.07 | 24.6±0.07 | 5 | 5 | 22.3±1.08 | 26.6±0.31 |

**Germination of *Dysoxylum malabaricum*** Bedd. ex Hiern.

In *Dysoxylum malabaricum*, the shoot length showed slight variation in the first week of germination to 7th week of germination. The seed from the parent tree showed a growth of 2.4 cm in the 1st week whereas the seed collected from the nest midden showed a growth of 2.5 cm. In the 3rd week of germination, the seed from the parent tree showed a growth of 4.5 cm whereas the seed collected from the nest midden showed a growth of 4.7 cm. In the 5th week of germination, the seed from

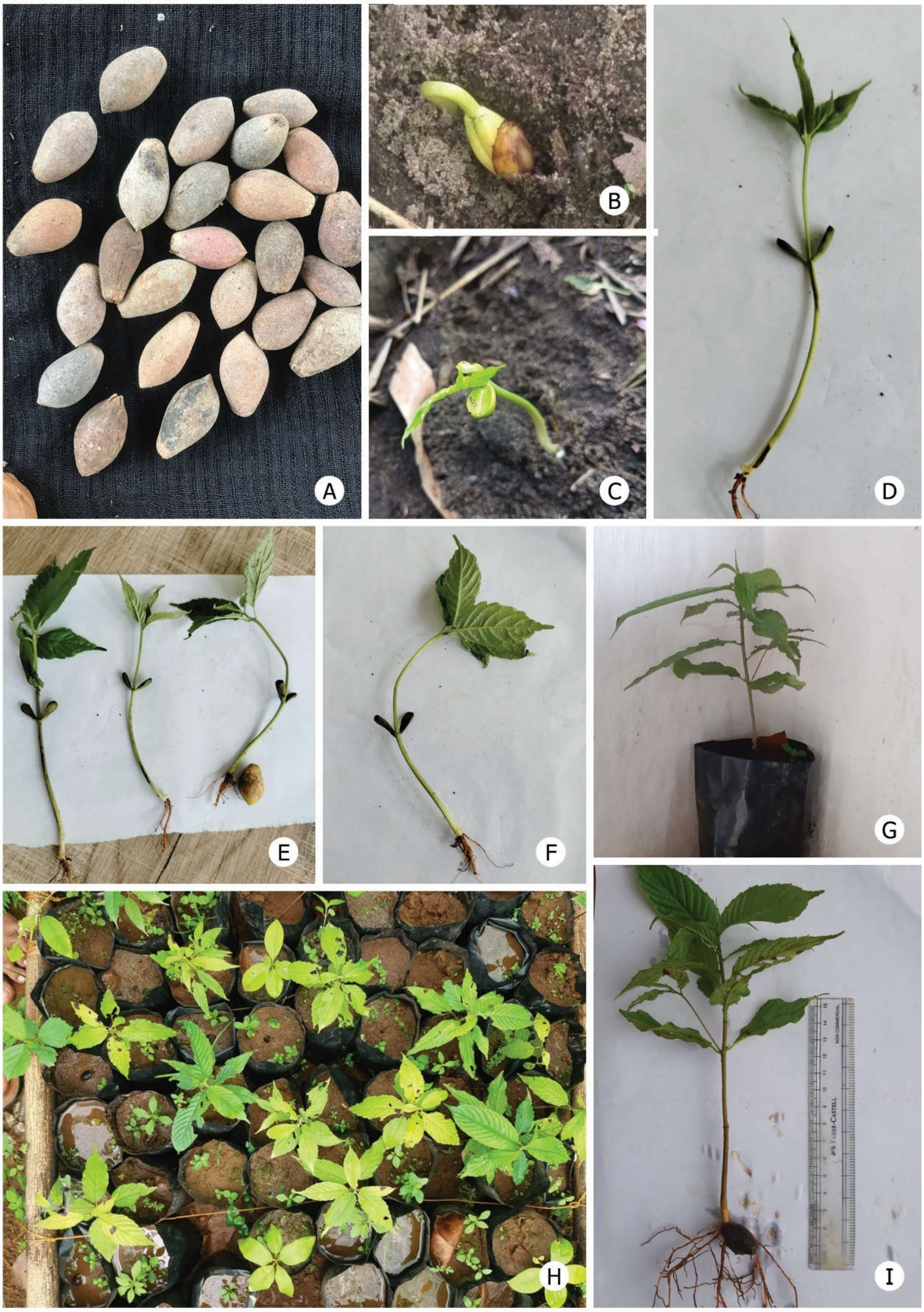


**Figure 6.9. Germination of *Maesopsis eminii* Engl.: A.** Seeds from Great hornbill nest midden; **B, C, G & H.** Seed germination in nursery; **D, E, F & I.** Seedlings.

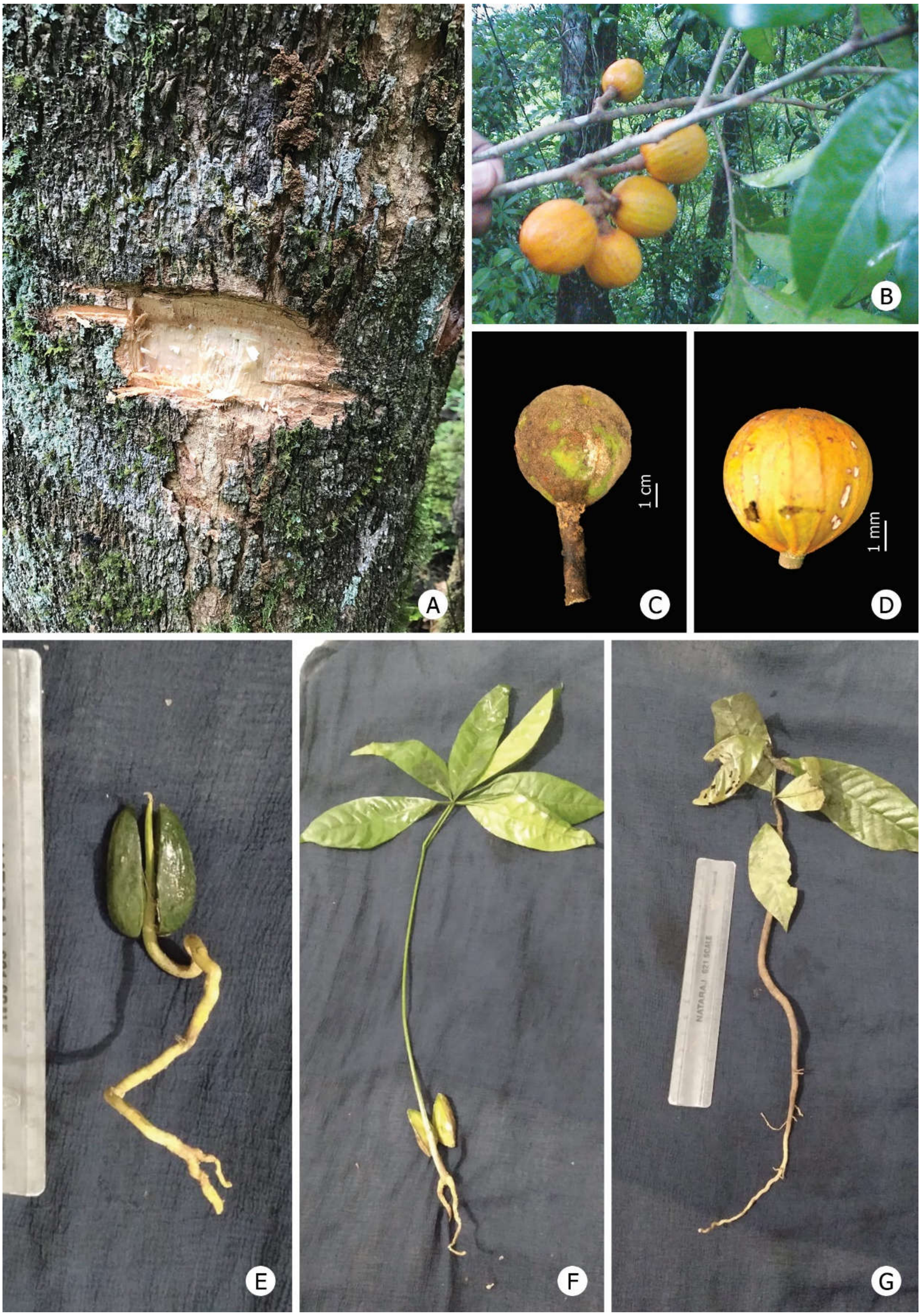


**Figure 6.10. Germination of *Dysoxylum malabaricum*** Bedd. ex Hiern**.: A.** Blaze; **B.** Fruiting twig; **C.** Young fruit; **D.** Mature fruit; **E, F & G.** Seed germination stages.

the parent tree showed a growth 10.3 cm whereas the seed collected from the nest midden showed a growth of 10.7 cm. In the 7th week of germination, the seed from the parent tree showed a growth of 18.7 cm whereas the seed collected from the nest midden showed a growth of 18.9 cm. In the 9th week of germination, the seed from the parent tree showed a growth 30.4 cm whereas the seed collected from the nest midden showed a growth of 31 cm. Number of leaves was the same for both seeds during the entire period of germination. Growth of seedling showed minimal variation during the germination period (Table 6.11. & Figure 6.10.).

**Table 6.11. Germination of *Dysoxylum malabaricum*** Bedd. ex Hiern.

| | **Shoot length (cm)** | | **Number of leaves** | | **Seed ling length (cm)** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Paren t tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germinatio n | 2.4±0.06 | 2.5±0.05 | 2 | 2 | 4.1±0.04 | 4.6±0.07 |
| 3rd week | 4.5±0.03 | 4.7±0.04 | 2 | 2 | 7.1±0.05 | 7.98±0.07 |
| 5th week | 10.3±0.0 3 | 10.7±0.1 | 3 | 3 | 15.1±0.0 7 | 15.5±0.08 |
| 7th week | 18.7±0.0 5 | 18.9±0.05 | 5 | 5 | 24.3±0.0 5 | 25.02±0.05 |
| 9th week | 30.4±0.1 3 | 31.0±0.16 | 6 | 6 | 36.8±0.0 3 | 37.2±0.01 |

**Germination of *Canarium strictum*** Roxb.

In *Canarium strictum*, the shoot length showed a minimum variation during the germination period. In Canarium seed germination was peculiar, no leaves were formed, instead the cotyledons developed just like leaves. Six leaf like cotyledons were found into the 3rd week of germination. Growth of seedling showed minimal variation. Growth of seedling in the 1st week of germination showed a variation of 0.63 cm. The seed from the parent tree showed a growth of 2 cm whereas the seed collected from the nest midden showed a growth of 2.63 cm. In the 3rd week of

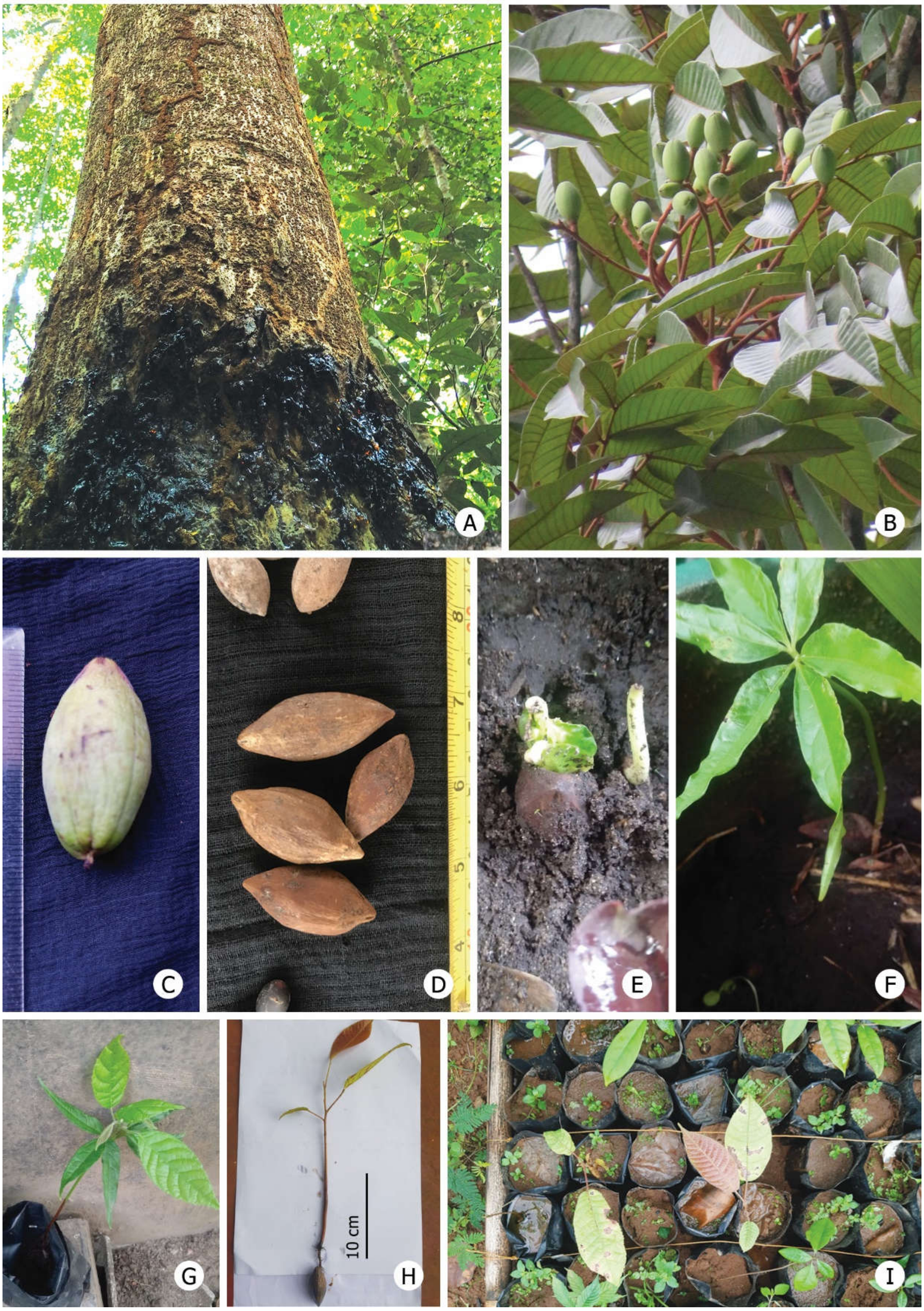


**Figure 6.11. Germination of *Canarium strictum*** Roxb.**: A.** Tree with resin; **B.** Fruiting twig; **C.** Single fruit; **D.** Seed; **E, F, G, H & I.** Seed germination in nursery.

germination, seedling length showed a variation of 0.75 cm. The seed from the parent tree showed a growth of 6.71 cm whereas the seed collected from the nest midden showed a growth of 7.46 cm. In the 5th week of germination, seedling length showed a variation of 1.12 cm. The seed from the parent tree showed a growth of 13.38 cm whereas the seed collected from the nest midden showed a growth of 14.5cm. In the 7th week of germination, seedling length showed minimam variation. The seed from the parent tree showed a growth of 18.04 cm whereas the seed collected from the nest midden showed a growth of 18.8 cm. In the 9th week of germination, seedling length showed a variation of 0.54 cm. The seed from the parent tree showed a growth of 20.96 cm whereas the seed collected from the nest midden showed a growth of 21.5 cm (Table 6.12. & Figure 6.11.).

**Table 6.12. Germination of *Canarium strictum*** Roxb.

| | **Shoot length** | | **Number of leaves cm** | | **Seed ling length** | |
|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| 1st week of germination | 0.31±0.009 | 0.39± 0.02 | 0 | 0 | 2± 0.15 | 2.63± 0.10 |
| 3rd week | 4.5±0.18 | 4.96± 0.11 | 0 | 0 | 6.71±0.18 | 7.46± 0.09 |
| 5th week | 9.41±0.15 | 10.62± 0.2 | 6 | 6 | 13.38±0.15 | 14.5± 0.13 |
| 7th week | 13.2±0.135 | 13.8± 0.14 | 6 | 6 | 18.04±0.06 | 18.8± 0.16 |
| 9th week | 17±0.21 | 17.4± 0.12 | 8 | 8 | 20.96±0.24 | 21.5± 0.32 |

**Comparison of developmental stages during seed germination in seed collected from parent tree and nest midden.**

Study showed marked variations in developmental stages between seeds from parent trees and seeds from nest midden. Seeds from nest midden of all the species showed fast developmental stages than parent seeds. From the 9 species selected for germination in parent seeds, *Maesosis eminii* took 19 days for sprouting (emergence of radicle) and *Canarium strictum* took about 95 days for sprouting. For both species, seeds collected from nest midden showed faster germination, 12 days for *Maesosis eminii* and 64 days for *Canarium strictum*. *Dysoxylum malabaricum* took 32 days, *Persea macrantha* took 22 days, *Palaquium ellipticum* took 30 days, *Litsea oleoides* took 37 days, *Actinodaphn*e *wightiana* took 30 days, *Myristica beddomei* took 30 days, *Knema attenuata* took 32 days for sprouting in seed germinated from parent tree. In seeds from nest midden *Dysoxylum malabaricum* took 25 days, *Persea macrantha* took 16 days, *Palaquium ellipticum* took 21 days, *Litsea oleoides* took 26 days, *Actinodaphne wightiana* took 21 days, *Myristica beddomei* took 23 days and *Knema attenuata* took 21 days for sprouting.

In parent seeds, *Maesosis eminii* took 22 days for appearance of buds. *Persea macrantha* took 26 days, *Canarium strictum* took 115 days and *Litsea oleoides* took 41 days for appearance of buds. In seeds collected from nest midden, appearance of buds was comparatively fast. It took 15 days for appearance of buds in *Maesosis eminii,* 18 days for *Persea macrantha*, 78 days in *Canarium strictum* and 29 days in *Litsea oleoides*. In parent seeds, *Dysoxylum malabaricum* took 34 days, *Palaquium ellipticum* took 32 days, *Actinodaphne wightiana* took 34 days, *Myristica beddomei* took 35 days and *Knema attenuata* took 41 days for appearance of buds. In seeds collected from nest midden, *Dysoxylum malabaricum* took 27 days, *Palaquium ellipticum* took 26 days, *Actinodaphne wightiana* took 25 days, *Myristica beddomei* took 27 days and *Knema attenuata* took 28 days for appearance of buds.

In parent seeds, the appearance of first leaf took 30 days in *Persea macrantha*, 41 days in *Palaquium ellipticum*, 130 days in *Canarium strictum,* 44 days in *Dysoxylum malabaricum,* 50 days in *Litsea oleoides*, 40 days in *Actinodaphne wightiana*, 38 days in *Myristica beddomei*, 45 days in *Knema attenuata* and 27 days in *Maesosis eminii.* In seeds collected from the nest midden, the appearance of first leaf took 20 days in *Persea macrantha*, 34 days in *Palaquium ellipticum*, 92 days in *Canarium strictum,* 30 days in *Dysoxylum malabaricum,* 35 days in *Litsea oleoides*, 29 days in

*Actinodaphne wightiana*, 31 days in *Myristica beddomei*, 30 days in *Knema attenuata* and 20 days in *Maesosis eminii.*

In parent seeds, main shoot development took 55 days in *Dysoxylum malabaricum*, 151 days in *Canarium strictum*, 38 days in *Persea macrantha,* 54 days in *Palaquium ellipticum*, 82 days in *Litsea oleoides*, 54 days in *Actinodaphne wightiana*, 58 days in *Myristica beddomei*, 53 days in *Knema attenuata* and 47 days in *Maesosis eminii.* In seeds collected from nest midden, main shoot development was faster. It took 39 days in *Dysoxylum malabaricum*, 110 days in *Canarium strictum*, 28 days in *Persea macrantha,* 47 days in *Palaquium ellipticum*, 74 days in *Litsea oleoides*, 40 days in *Actinodaphne wightiana*, 42 days in *Myristica beddomei*, 45 days in *Knema attenuata* and 37 days in *Maesosis eminii* (Table 6.13.).

**Table 6.13. Comparison of Germination features of seed from parent tree and Nest midden**

| **Germination Features** | ***Dysoxylum malabaricum*** Bedd. ex Hiern. | | ***Canarium strictum*** Roxb. | | ***Persea macrantha*** (Nees) Kosterm. | | ***Palaquium ellipticum*** (Dalz.) Baill | | ***Litsea oleoides*** (Meisner) Hook. f. | | ***Actinodaphne wightiana*** (Kuntze) Noltie | | ***Myristica beddomei*** King | | ***Knema attenuata*** (Hook. f. & Thoms.) Warb | | ***Maesosis Emini*** Engl. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** | **Parent tree** | **Nest midden** |
| Sprouting of seed | 32±0.9 | 25±1 | 95±0.41 | 64±0.81 | 22.5±0.76 | 16.3±0.13 | 30.63±0.02 | 21.3±0.07 | 37±0.70 | 26±0.9 | 30.5±0.6 | 21.4±0.8 | 29.9±0.09 | 20.1±0.86 | 32±0.86 | 21.2±0.76 | 19±0.7 | 12.1±0.76 |
| Appearance of bud | 34±0.5 | 27±0.8 | 115±0.21 | 78.4±0.5 | 26.04±0.15 | 18.3±0.06 | 37.1±0.1 | 26.1±0.05 | 41.3±0.09 | 29.07±0.13 | 34.2±0.17 | 25.1±0.12 | 34.94±0.06 | 27.07±0.09 | 41±0.37 | 28.1±0.21 | 22.22±0.17 | 15.3±0.18 |
| Appearance of first leaf | 44±0.84 | 30±1 | 130.1±0.8 | 92.3±0.22 | 30.1±0.13 | 20±0.08 | 44.0±0.12 | 32.08±0.09 | 50.1±0.07 | 35.15±0.11 | 40.8±0.13 | 29±0.29 | 38.1±0.12 | 31.1±0.22 | 45.73±0.15 | 30.4±0.12 | 27.1±0.13 | 20.4±0.13 |
| Main shoot deveopment | 55±1 | 39±0.2 | 151±1.1 | 110.2±0.37 | 38.1±0.13 | 28.4±0.10 | 54.07±0.12 | 47.1±0.1 | 82.2±1.0 | 74±1.02 | 54.4±0.15 | 40.6±0.16 | 58.32±0.12 | 42.9±0.17 | 53.03±0.12 | 45.09±0.12 | 47.4±0.15 | 37±1.2 |

The germination speed also showed variation in parent and regurgitated seeds. The germination speed was faster in hornbill regurgitated seeds. In seeds collected from parent tree, germination speed was 2.3 in *Litsea oleoides*, 2.4 in *Actinodaphne wightiana*, 3 in *Myristica beddomei*, 3.6 in *Persea macrantha*, 1 in *Canarium strictum*, 2.9 in *Dysoxylum malabaricum,* 5.2 in *Maesosis eminii* and 3 in *Myristica beddomei* and *Knema attenuata*. In regurgitated seeds, the germination speed was 3.7 in *Litsea oleoides*, 4.7 in *Actinodaphne wightiana*, 4.1 in *Myristica beddomei*, 4.5 in *Knema attenuata*, 4.3 in *Palaquium ellipticum*, 5.9 in *Persea macrantha*, 1.9 in *Canarium strictum*, 3.7 in *Dysoxylum malabaricum,* and 7.4 in *Maesosis eminii*. (Figure 6.12.).

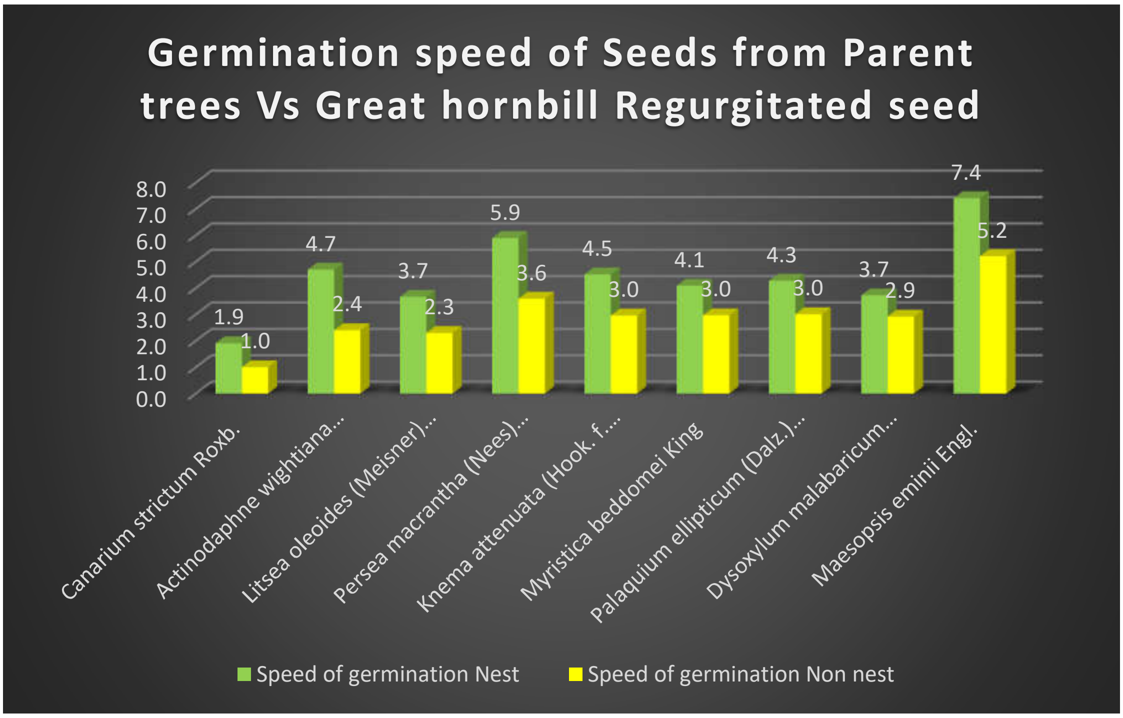


**Figure 6.12. Germination speed of seeds from Parent trees Vs Great hornbill Regurgitated seed**

**Discussion**

The seeds of *Myristica beddomei* were not naturally germinating in soil may be due to the absence of available sunlight, nature of soil and the presence of hard seed coat (Pillai *et al*., 2016). The germination study on *Myristica beddomei* was poor. In the present study, *Myristica beddomei* took 30 days for germination in parent seed and 20 days in Great hornbill regurgitated seeds. The present study showed that 56% of seeds collected from parent tree and 76% of seeds collected from hornbill regurgitated seeds were germinated.

*Knema attenuata* is endemic to Southern Western Ghats. (Hussain *et al.,* 2020) reported that *Knema attenuata* shows about 55% of germination in laboratory condition. The germination study based on the moisture content of seed showed that when moisture content in the seed increased percentage of seed germination also increased. In the present study, *Knema attenuata* took 32 days for germination in parent seed and 21 days in hornbill regurgitated seeds. 46% of seeds collected from parent tree germinated in natural condition. The germination percentage was 76 in Great hornbill regurgitated seeds.

In *Palaquium ellipticum,* germination study was very rare. A study conducted by Kerala Forest Research Institute (KFRI), Peechi in nursery condition showed that the seed commenced germination in 17 days and culminated in 50 days. In the present study, germination commenced in 30 days in seeds collected from parent tree and 21 days in Great hornbill regurgitated seeds in nursery condition.

*Dysoxylum malabaricum* which comes under Vulnerable B1+2c. is an important evergreen forest component. The seeds of this tree are recalcitrant. The germination studies were very rare in *Dysoxylum malabaricum*. One study conducted by KFRI Peechi ( Pillai *et al*., 2016) showed that under laboratory condition it took 14 days for germination and culminated in 34 days. In the present study, it took 32 days for seed collected from the parent tree to germinate and 25 days for the seed collected from the nest midden in nursery condition.

*Maesosis eminii* is an exotic tree species in natural forest. The seed germination in *Maesosis eminii* in response to various shade level showed that seed germination is higher in low shade condition (Mwendwa *et al*., 2020). Another study in soaking treatment, seed soaked for 48 hours showed 85 % of germination whereas unsoaked seed showed 48% (Odoi *et al*., 2019). The present study showed that *Maesosis eminii* started germination in 19 days for seed collected from parent tree i.e, 32% of germination under natural condition. It took 12 days for the commencement of germination for hornbill regurgitated seeds, showing 72 % of germination.

*Persea macrantha* is an important component of diet of Great hornbill. The germination study is very scarce in *Persea macrantha.* In the present study, germination started from 30 days for seeds from parent tree and 20 days for hornbill regurgitated seeds.

Germination, establishment and growth of seedlings of *Actinodaphne wightiana* were studied in humid tropical forest of Nelliyampathy showing germination days between 1.5 to 5 months (Chandrashekara & Ramakrishnan, 1993). In the present study, germination of seeds collected from parent tree started after 90 days and in hornbill regurgitated seeds, the germination started after 41 days. It was also noted that the germination rate is very poor in seeds collected from parent trees, only 8% of seeds were germinated.

*Litsea oleoides* is an endemic species in Southern Western Ghats which produces large seeded fruits, about 3 cm long, brightly colored which attract large birds and mammals. The germination percentage of *Litsea oleoides* in natural condition is very poor due to the presence of seed coat and fungal infection. The passage of seed through the guts of hornbill softens the seed coat and enhance the germination. Germination studies on *Litsea oleoides* were scarce. However, in a study of propagation technique of *Litsea glutinosa* seed germination commenced within 6 weeks and percentage of germination was 30% in nursery condition. Under controlled condition, after treatment with gibberellin, the germination percentage improved to 41% (Gopal, 2020). In the present study, germination commenced in 37 days for seeds collected from parent tree and 26 days for seeds collected from hornbill nest midden. Only 6% of seeds collected from parent tree germinated whereas 64% of seeds collected from hornbill regurgitated seeds germinated.

*Canarium strictum* is a critically endangered species of Western Ghats. Seeds of *Canarium strictum* have mechanical dormancy which inhibits germination. Under IBA treatment, *Canarium strictum* showed a germination percentage of 48.61 whereas germination percentage of untreated seed was 23.93 (Singh *et al.*, 2018). In another study, seeds soaked overnight in 4% $H_2O_2$ in nursery condition showed a germination percentage of 74.75 and 76.6% in lab condition (Puwein *et al.*, 2022). In the present study, seeds collected from parent tree took 95 days for germination while the seeds collected from the hornbill regurgitated seeds took 64 days, showing a germination percentage of 6 for seeds from parent tree and 65% for seeds from nest midden.

The Great hornbill are important seed disperses of many large fruited plants. Its diet mainly consists of fruits and defecate the seed intact. Besides hornbills, squirrels and monkeys also feed large seeded fruits but they crush and damage the seeds resulting in reduced germination. In the present study hornbill dispersed seeds showed high germination. Similar observations were also made in the studies conducted (Datta, 2001) on hornbill regurgitated seeds and control seeds showed that regurgitated seeds showed 33% of germination than controlled seeds which showed 30% of germination. The same result was obtained when (Santhoshkumar & Balasubramanian, 2011) in which out 16 species of regurgitated seeds 15 species showed enhanced germination. Another study by (Balasubramanian & Maheswaran, 2003) established the role plays the frugivory in seed germination. Similar results were obtained study of (Midya & Brahmachary, 1991) here 58% of bird dispersed seeds of *Ficus benghalensis* germinated against control seeds. A study of (Mishra *et al.*, 1987) showed that bird defeated seeds of *Azadirachta indica* showed 76 % of germination than controlled seeds. The study of (Diaz velez *et al.*, 2018) in seeds of *Cotoneaster franchetii* (Rosaceae) showed a high germination percentage from bird de fecated seeds and from manually depulped seeds. Studies conducted in Malabar Grey hornbill *Ocyceros griseus* and other birds (Ridley, 1956; Naranjo *et al.*, 2003; Nogales *et al.,* 2005) also showed the same result.

All these studies and our present study prove that the Great hornbill plays an important role in forest regeneration. During the present study, regeneration of hornbill food plants was noticed around the nesting tree even in the coffee and tea plantation in Nelliyampathy Lakshmi estate and Victoria estate. Hornbills always disperse the intact seeds by removing or softening the hard seed coat thereby enhancing the seed germination. During the breeding season, hornbills disperse the seeds along with faecal matter which will also help germination.

# CHAPTER 7

# PHYTOSOCIOLOGICAL COMPOSITION OF GREAT HORNBILL NESTING HABITAT

**Introduction**

Vegetational analysis of eight nesting plots of Great hornbill were done in Vazhachal and Parambikulam forest division from elevation ranges from 274 m to 1118 m. Plot 1 was in Vazhachal, near to Vazhachal waterfalls and it was named as VNS (Vazhachal Nesting Site). Plot 2 was in Pottenmopu, which was named as PNS1 (Pottenmopu Nesting Site). Plot 3 was in Ambalapara IB area which was named as ANS (Ambalapara Nesting Site). Plot 4 was in Sholayar Powerhouse area which was named as SPNS1 (Sholayar Powerhouse Nesting Site I). Plot 5 was at Sholayar Puliveenathodu which was named as SPNS 2 (Sholayar Puliveenathodu Nesting Site II). Plot 6 was at Pathadipalam which was named as PNS 2 (Pathadipalam Nesting Site II). Plot 7 was Ambalapara Thandu which was named as ATNS (Ambalapara Thandu Nesting Site). Plot 8 was at Sheikalmudi which was named as SNS (Sheikalmudi Nesting Site).

**Important Value Index of Tree species in Nesting Plot 1**

Plot 1- Vazhachal Nesting Site (VNS) was situated at low elevation riparian forest. Detailed phytosociological survey was conducted to find out the dominant and associated species around the nesting tree. The study documented 15 trees belonging to 11 species. The stand density of the species was also 15. The nesting tree was *Terminalia Billerica* which had a GBH of 4.2 m and had an IVI of 55. It was the dominant tree in this plot. The second dominant tree was *Palaquium ellipticum* (IVI 40) followed by *Litsea coriaceae* (IVI 32), *Hopea parviflora* (IVI 29), *Diospyros crumenata* (IVI 26), *Vateria indica* (IVI 23), *Calophyllum polyanthum* (IVI 23), *Terminalia paniculata* (IVI 21), *Olea dioica* (IVI 18), *Kingiodendron pinnatum* (IVI 18), *Polyalthia coffeoides* (IVI 16). In this plot, *Diospyros crumenata (*Endangered) and *Kingiodendron pinnatum* (Threatened) were found (Figure 7.1. & Table 7.1.).

**Table 7.1. Vegetation structure of Hornbill Nesting habitat Plot 1 VNS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Terminalia bellirica* (Gaertn.) Roxb. | 1 | 13.85 | 55 | 0.18 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 6.15 | 40 | 0.27 |
| 3 | *Vateria indica* L. | 1 | 2.54 | 23 | 0.18 |
| 4 | *Calophyllum polyanthum* Wall.ex Choisy | 1 | 2.54 | 23 | 0.18 |
| 5 | *Diospyros crumenata* Thw. | 1 | 3.46 | 26 | 0.18 |
| 6 | *Hopea parviflora* Bedd. | 2 | 2.27 | 29 | 0.27 |
| 7 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 3 | 1.00 | 32 | 0.32 |
| 8 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 1 | 0.85 | 18 | 0.18 |
| 9 | *Polyalthia coffeoides* (Thw.) J. Hk &Thoms | 1 | 0.23 | 16 | 0.18 |
| 10 | *Olea dioica* Roxb. | 1 | 0.80 | 18 | 0.18 |
| 11 | *Terminalia paniculata* Roth | 1 | 1.77 | 21 | 0.18 |
| | | **15** | **35.47** | **300** | **2.30** |

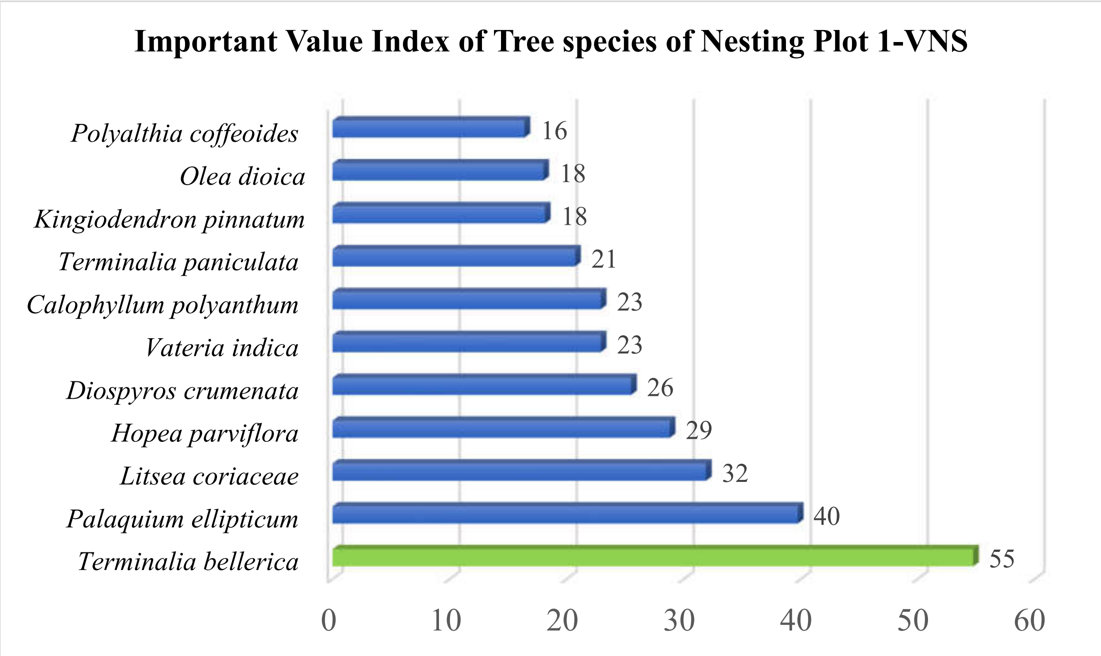


**Figure 7.1. Important Value Index of Tree species of Nesting Plot VNS**

**Important Value Index of Tree species of Nesting Plot 2**

In Plot 2- Pottenmopu Nesting Site (PNS 1), study recorded 15 trees belonging to 10 species. The stand density was 16. The nesting tree was *Vateria indica* which showed a GBH of 3.23 m with an IVI of 79. The other dominant trees were *Litsea floribunda* (IVI 37) followed by *Dysoxylum malabaricum* (IVI 36), *Myristica beddomei* (IVI 29), *Vateria indica* (IVI 23), *Alseodaphne semecarpifolia* (IVI 23), *Ficus exasperata (*IVI 20) and *Phoebe lanceolata*, *Persea macrantha and Garcinia gummi-gutta* (IVI 18). In this plot *Litsea floribunda, Alseodaphne semecarpifolia* are (Near Threatened), *Dysoxylum malabaricum* is (Endangered), and *Vateria indica* (Vulnerable) (Figure 7.2. & Table 7.2.).

**Table 7.2. Vegetation structure of Hornbill Nesting habitat Plot 2 PNS 1**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Litsea floribunda* Gamble | 4 | 0.95 | 37 | 0.35 |
| 2 | *Garcinia gummi-gutta* (L.) Robs. | 1 | 0.71 | 18 | 0.17 |
| 3 | *Ficus exasperata* Vahl | 1 | 1.77 | 20 | 0.17 |
| 4 | *Phoebe lanceolata* (Nees) Nees | 1 | 0.71 | 18 | 0.17 |
| 5 | *Myristica beddomei* King | 1 | 6.47 | 29 | 0.17 |
| 6 | *Alseodaphne semecarpifolia* Nees | 1 | 3.17 | 23 | 0.17 |
| 7 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 2 | 6.60 | 36 | 0.26 |
| 8 | *Persea macrantha* (Nees) Kosterm. | 1 | 0.95 | 18 | 0.17 |
| 9 | *Tetrameles nudiflora* (Dalzell) Baill. | 1 | 3.46 | 23 | 0.17 |
| 10 | *Vateria indica* L. | 3 | 25.5 | 79 | 0.31 |
| | | 16 | 50.3 | **300** | **2.1** |

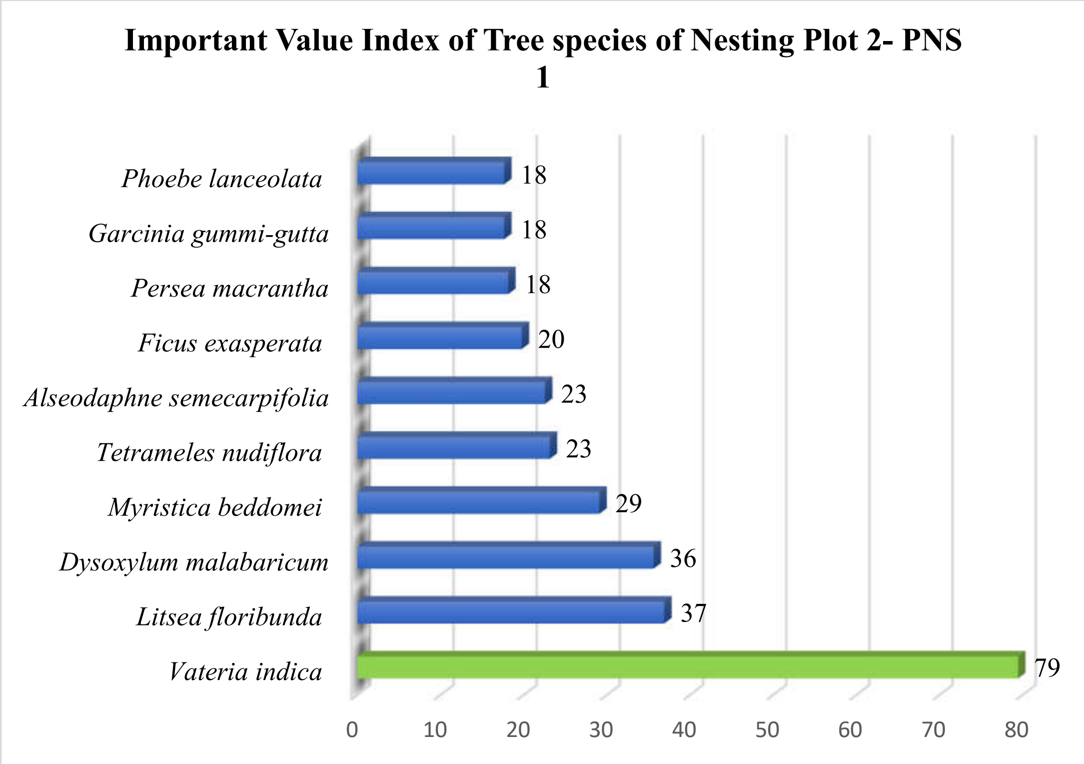


**Figure 7.2. Important Value Index of Tree species of Nesting plot PNS 1**

**Important Value Index of Tree species of Nesting Plot 3**

In Plot 3- Ambalapara IB Nesting Site (ANS), study revealed 11 trees belonging to 8 species. The stand density was also 11. The nesting tree was *Palaquium ellipticum* with a GBH of 3.83 m which had an IVI of 99. The other dominant species was *Litsea floribunda* (IVI 41). Other tree species observed in this plot were *Schleichera oleosa* (IVI 36), *Macaranga peltata* (IVI 28), *Elaeocarpus tuberculatus* (IVI 25), *Alstonia scholaris* and *Persea macrantha* (IVI 24) and *Terminalia paniculata* (IVI 23). The area had forest fire in 2004 and much of the forest cover was lost. The regeneration was very low in this area and the Great hornbill nesting was frequently found in this region. *Litsea floribunda* (Near Threatened) was found here (Figure 7.3., 7.4. & Table 7.3.).

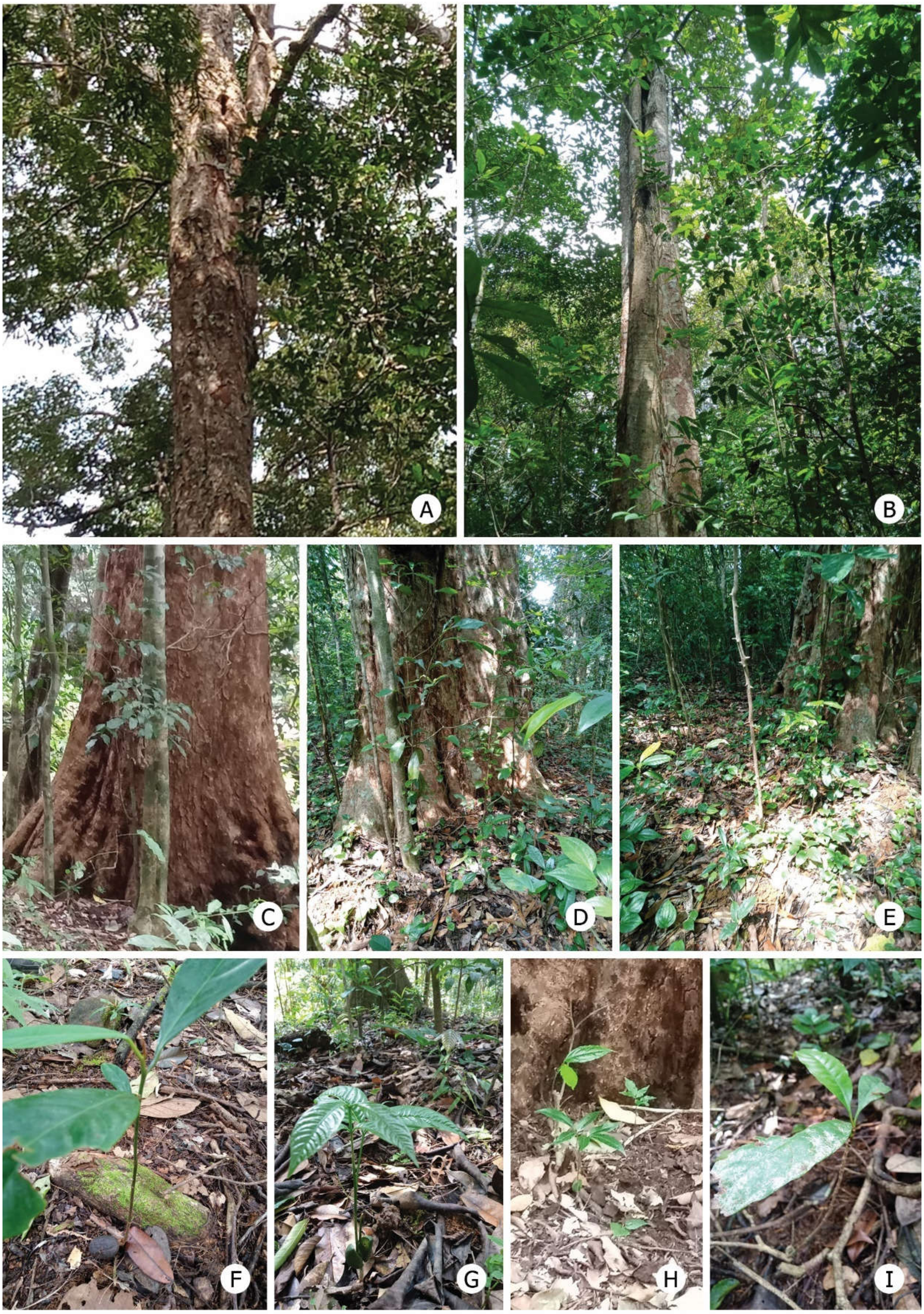


**Figure 7.3. Nesting site Ambalapara Thandu and Ambalapara IB: Nesting site (Ambalapara Thandu) (ATNS): A.** Nesting tree (*Mesua ferrea* L.); **C, F & H.** Seedlings under the nest; **Nesting site (Ambalapara IB) (ANS): B.** Nesting tree (*Palaquium ellipticum* (Dalz. Baill.); **D, E, G & I.** Seedlings under the nest.

**Table 7.3. Vegetation structure of Hornbill Nesting habitat Plot 3 ANS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Schleichera oleosa* (Lour.) Oken | 2 | 1.70 | 36 | 0.31 |
| 2 | *Litsea floribunda* Gamble | 2 | 3.46 | 41 | 0.30 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 22.89 | 99 | 0.30 |
| 4 | *Elaeocarpus tuberculatus* Roxb. | 1 | 1.02 | 25 | 0.21 |
| 5 | *Terminalia paniculata* Roth | 1 | 0.61 | 23 | 0.21 |
| 6 | *Macaranga peltata* (Roxb.) Mull. Arg. | 1 | 2.30 | 28 | 0.21 |
| 7 | *Persea macrantha* (Nees) Kosterm. | 1 | 0.71 | 24 | 0.21 |
| 8 | *Alstonia scholaris* (L.) R.Br. | 1 | 0.95 | 24 | 0.21 |
| | | **11** | **33.63** | **300** | **1.94** |

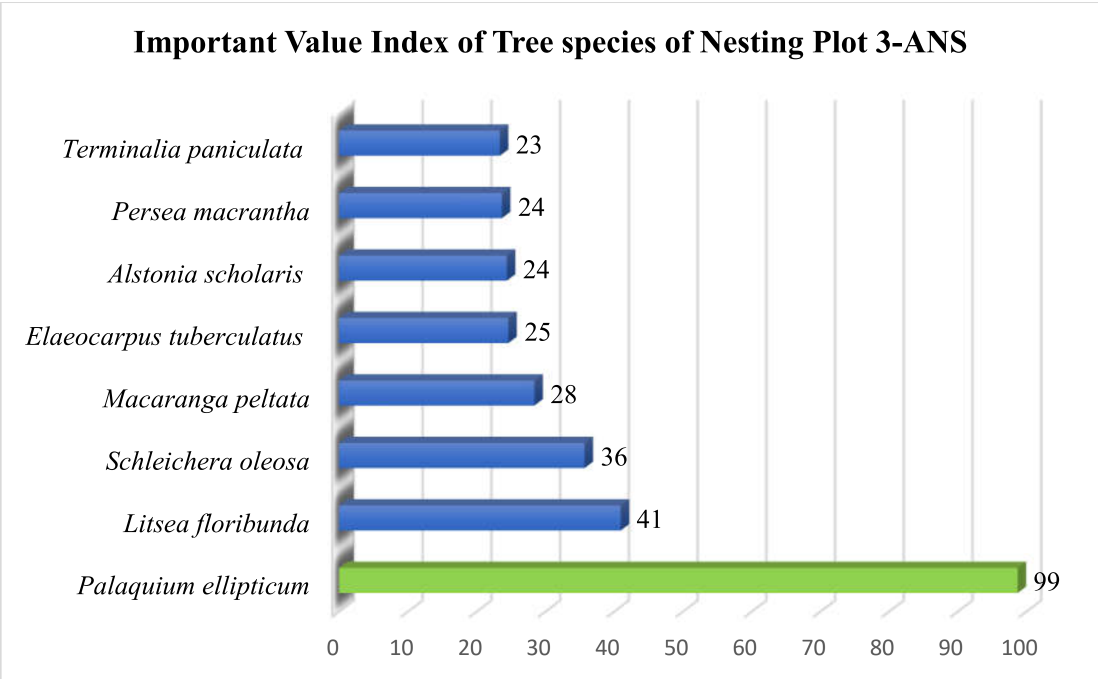


**Figure 7.4. Important Value Index of Tree species of Nesting Plot ANS**

**Important Value Index of Tree species of Nesting Plot 4**

In plot 4- The Sholayar Powerhouse Nesting Site (SPNS 1), the study revealed 23 trees belonging to 14 species. The stand density was 18. The nesting tree was *Vateria indica* which had a GBH of 4.52 m and IVI of 47. The other tree species observed in this site were *Bombax ceiba* (IVI 44), *Mesua ferrea* (IVI 23), *Cullenia exarillata* (IVI 19), *Myristica beddomei* (IVI 18), *Actinodaphne bourdillonii* and *Palaquium ellipticum* (IVI 16), *Alseodaphne semecarpifolia, Litsea stocksii and Mastixia arborea* (IVI 15), *Litsea floribunda* and *Chukrasia tabularis* (IVI 13), *Holigarna arnottiana* and *Diospyros montana* (IVI 12). *Actinodaphne bourdillonii*, *Alseodaphne semecarpifolia*, *Litsea stocksii* and *Litsea floribunda* found in this plot come under Near Threatened category (Figure 7.5. & Table 7.4.).

**Table 7.4. Vegetation structure of Hornbill Nesting habitat Plot 4 SPNS 1**

| Sl. No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Bombax ceiba* L. | 4 | 13.8 | 44 | 0.33 |
| 2 | *Chukrasia tabularis* A. Juss. | 1 | 0.9 | 13 | 0.16 |
| 3 | *Alseodaphne semecarpifolia* Nees | 1 | 2.9 | 15 | 0.16 |
| 4 | *Vateria indica* L. | 2 | 22.9 | 47 | 0.24 |
| 5 | *Holigarna arnottiana* Wall.ex Hook.f. | 1 | 0.7 | 12 | 0.16 |
| 6 | *Mesua ferrea* L. | 1 | 8.0 | 23 | 0.16 |
| 7 | *Diospyros montana* Roxb. | 1 | 0.4 | 12 | 0.16 |
| 8 | *Litsea floribunda* Gamble | 1 | 0.9 | 13 | 0.16 |
| 9 | *Myristica beddomei* King | 1 | 4.5 | 18 | 0.16 |
| 10 | *Palaquium ellipticum* (Dalzell) Baill. | 1 | 3.5 | 16 | 0.16 |
| 11 | *Cullenia exarillata* A. Robyns | 1 | 5.7 | 19 | 0.16 |
| 12 | *Actinodaphne bourdillonii* Gamble | 1 | 3.6 | 16 | 0.16 |
| 13 | *Litsea stocksi*i Hook. f. | 1 | 2.5 | 15 | 0.16 |
| 14 | *Mastixia arborea* (Wight) C.B.Clarke | 1 | 2.3 | 15 | 0.16 |
| | | 18 | **72.69** | **300** | **2.51** |

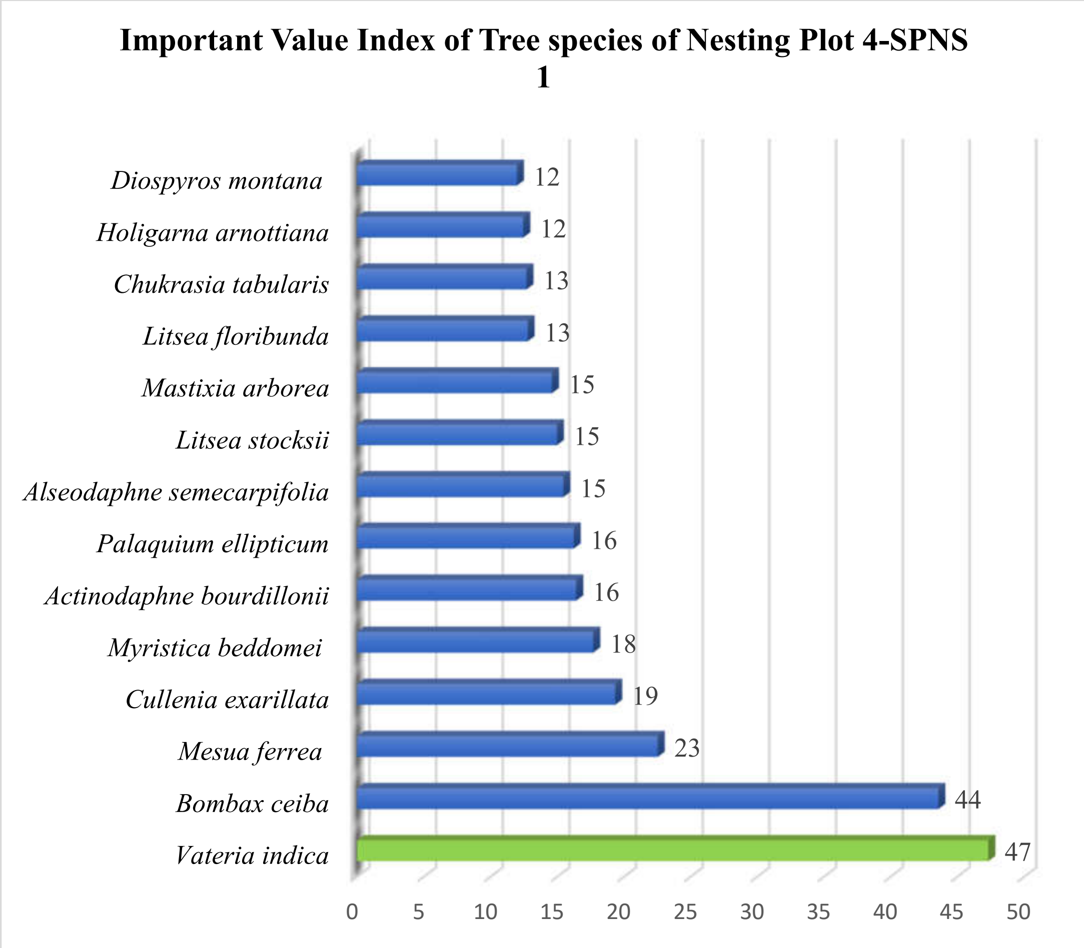


**Figure 7.5. Important Value Index of Tree species of Nesting Plot SPNS 1**

**Important Value Index of Tree species of Nesting Plot 5**

In plot 5- Sholayar Puliveenathodu Nesting Site (SPNS 2), the study revealed 28 trees belonging to 13 species. The stand density was also 28. The nesting tree was *Bombax ceiba* with a GBH of 4.97 m and IVI of 27. The dominant tree species was *Palaquium ellipticum* (IVI 57) followed by *Knema attenuata* and *Chukrasia tabularis* (IVI 30), *Myristica beddomei* (IVI 24), *Turpinia malabarica* (IVI 22), *Litsea oleoides* (IVI 20), *Cinnamomum malabatrum* (IVI 18), *Actinodaphne wightiana* (IVI 17), *Mesua ferrea* (IVI 15), *Dysoxylum malabaricum*, *Elaeocarpus tuberculatus* (IVI 13) and *Litsea floribunda* (IVI 12). *Litsea oleoides* (Vulnerable), *Dysoxylum malabaricum* (Endangered) and *Litsea floribunda* (Near Threatened) were found in this plot (Figure 7.6., 7.7. & Table 7.5.).

**Table 7.5. Vegetation structure of Hornbill Nesting habitat Plot 5 SPNS 2**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Turpinia malabarica* Gamble | 2 | 5.3 | 22 | 0.189 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill. | 5 | 25.2 | 57 | 0.308 |
| 3 | *Knema attenuata* (Hook, fil.&Thomas.)Warb. | 4 | 6.6 | 30 | 0.278 |
| 4 | *Actinodaphne wightiana* (Kuntze) Noltie | 2 | 1.9 | 17 | 0.189 |
| 5 | *Bombax ceiba* L. | 1 | 12.4 | 27 | 0.119 |
| 6 | *Mesua ferrea* L. | 1 | 3.2 | 15 | 0.119 |
| 7 | *Elaeocarpus tuberculatus* Roxb. | 1 | 1.2 | 13 | 0.119 |
| 8 | *Litsea floribunda* Gamble | 1 | 0.9 | 12 | 0.119 |
| 9 | *Litsea oleoides* (Meissn.) Hook.f. | 2 | 4.2 | 20 | 0.189 |
| 10 | *Chukrasia tabularis* A. Juss. | 4 | 6.5 | 30 | 0.278 |
| 11 | *Myristica beddomei* King | 2 | 7.5 | 24 | 0.189 |
| 12 | *Cinnamomum malabatrum* (Burm.f.) Persl | 2 | 2.5 | 18 | 0.189 |
| 13 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 1 | 1.65 | 13 | 0.119 |
| | | **28** | **79.1** | **300** | **2.401** |


**Figure 7.6. Nesting site Sholayar Puliveenathodu (SPNS2): A.** Nesting tree (*Bombax ceiba* L.); **B.** Seedlings under the nest; **C.** *Palaquium ellipticum* (Dalz.) Baill.; **D.** *Persea macrantha* (Nees) Kosterm.; **E.** *Reinwardtiodendron anamalaiense* (Bedd.) D.J. Mabb.; **F.** *Cryptocaria* sp.; **G.** *Dysoxylum malabaricum* Bedd. ex C. DC.; **H.** *Knema attenuata* (Hook. fil. & Thoms.) Warb.

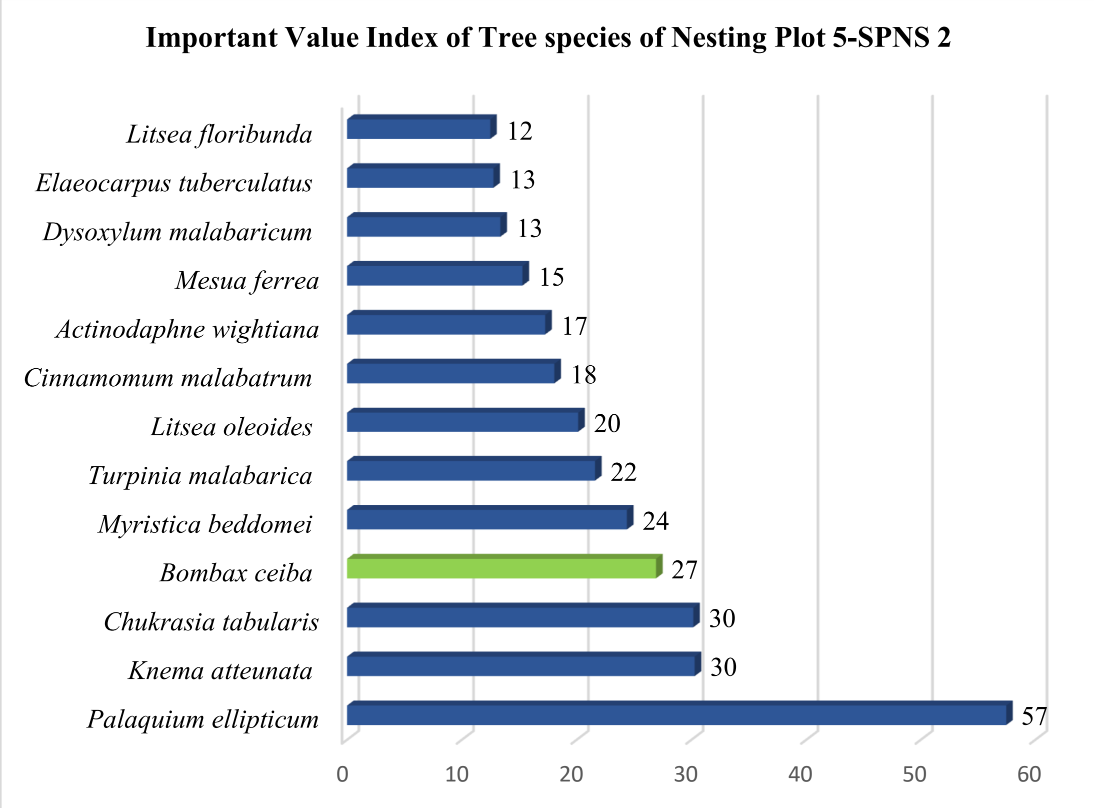


**Figure 7.7. Important Value Index of Tree species of Nesting Plot SPNS 2**

**Important Value Index of Tree species of Nesting Plot 6**

In Plot 6- the Pathadipalam Nesting Site (PNS 2), the study revealed 24 trees belonging to 11 species. The stand density of the species was 25. The nesting tree was *Calophyllum polyanthum* with a GBH of 4.74 m and an IVI of 38. The dominant trees were *Cullenia exarillata* (IVI 51) followed by *Litsea bourdillonii* (IVI 39), *Dysoxylum malabaricum* (IVI 31), *Canarium strictum* (IVI 31), *Phoebe lanceolata* (IVI 26), *Alseodaphne semecarpifolia* (IVI 24), *Palaquium ellipticum* (IVI 22), *Knema attenuata* (IVI 15), *Drypetes venusta* (IVI 15) and *Cinnamomum malabatrum* (IVI 14). *Litsea bourdillonii* and *Alseodaphne semecarpifolia* (Near Threatened), *Dysoxylum malabaricum* (Endangered) were found in this plot comes under IUCN Red list (Figure 7.8. & Table 7.6.).

**Table 7.6. Vegetation structure of Hornbill Nesting habitat Plot 6 PNS 2**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Alseodaphne semecarpifolia* Nees | 2 | 4.15 | 24 | 0.202 |
| 2 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 2 | 9.67 | 31 | 0.202 |
| 3 | *Drypetes venusta* (Wight) Pax & K.Hoffm. | 1 | 0.38 | 15 | 0.129 |
| 4 | *Cullenia exarillata* A. Robyns | 3 | 21.23 | 51 | 0.254 |
| 5 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 1 | 0.95 | 15 | 0.129 |
| 6 | *Calophyllum polyanthum* Wall.ex Choisy | 1 | 17.64 | 38 | 0.129 |
| 7 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 2.83 | 22 | 0.202 |
| 8 | *Litsea bourdillonii* Gamble | 6 | 3.46 | 39 | 0.343 |
| 9 | *Cinnamomum malabatrum* (Burm.f.) Persl | 1 | 0.20 | 14 | 0.129 |
| 10 | *Phoebe lanceolata* (Nees) Nees | 3 | 2.83 | 26 | 0.254 |
| 11 | *Canarium strictum* Roxb. | 2 | 9.62 | 31 | 0.202 |
| | | **25** | **72.96** | **300** | **2.175** |

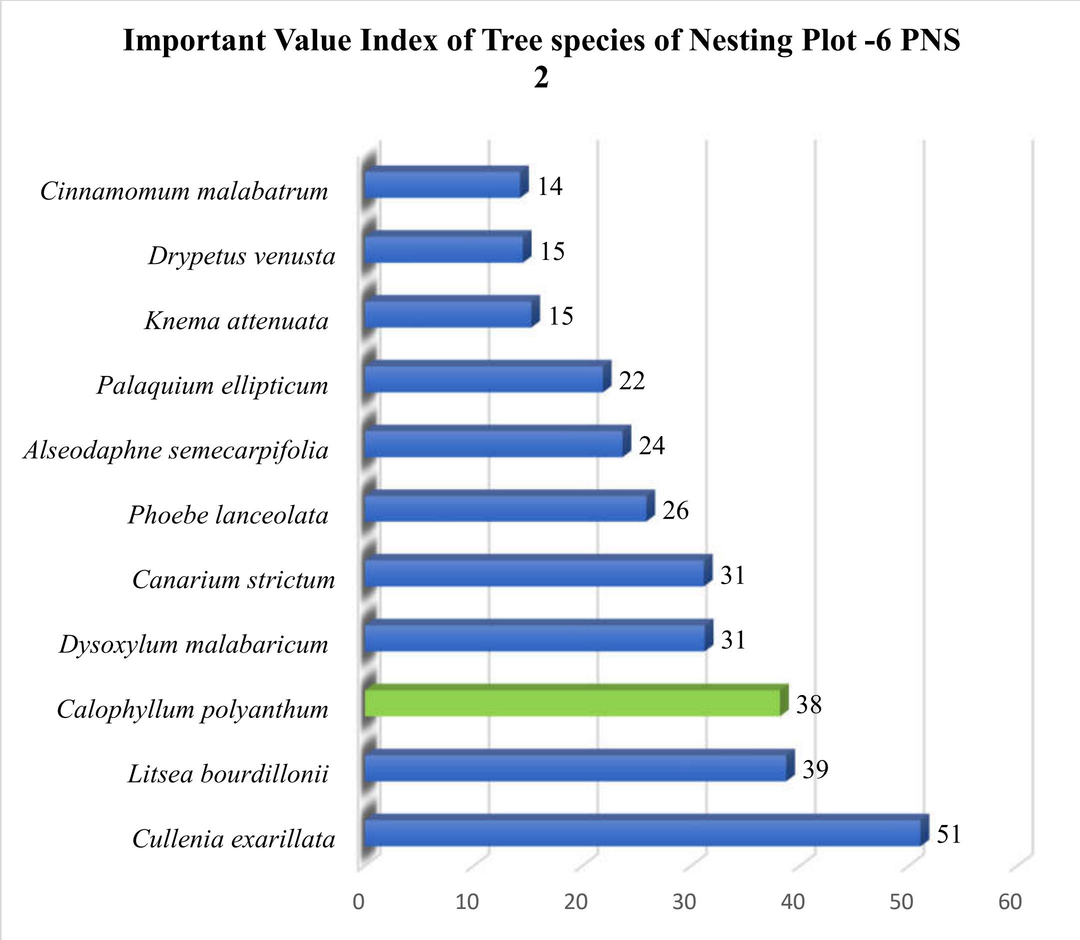


**Figure 7.8. Important Value Index of Tree species of Nesting Plot PNS 2**

**Important Value Index of Tree species of Nesting Plot 7**

In plot 7- Ambalapara Thandu Nesting Site (ATNS), the study revealed 25 trees belonging to 11 species. The stand density of the species was also 25. The nesting tree was *Mesua ferrea* having GBH of 4.10 m and IVI of 25. The dominant species was *Persea macrantha* (IVI 46) followed by *Myristica beddomei* (IVI 40), *Palaquium ellipticum* (IVI 33), *Knema attenuate* (IVI 32), *Litsea oleoides* (IVI 25), *Schleichera oleosa* (IVI 25), *Vateria indica* (IVI 22), *Litsea bourdillonii* (IVI 20), *Actinodaphne bourdillonii* (IVI 15) and *Chukrasia tabularis* (IVI 15). *Litsea oleoides* and *Vateria indica* (Vulnerable) and *Litsea bourdillonii* (Near Threatened) were found in this site (Figure 7.9., 7.11. & Table 7.7.).


**Figure 7.9. Nesting site Sholayar power house (SPNS1): A.** Nesting tree (*Vateria indica* L.); **B, C, D, E, F, G & H.** Seedlings under the nest.


**Figure 7.10. Nesting site Sheikalmudi (SNS): A.** Nesting tree (*Tetrameles nudiflora* R. Br.); **B, C, D & E.** Seedlings under the nest; **F & G.** Sheikalmudi field.

**Table 7.7. Vegetation structure of Hornbill Nesting habitat Plot 7 ATNS**

| **Sl.No** | **Name of the species** | **Stand Density** | **Basal Area** | **Important Value Index** | **Shannon Diversity Index** |
|---|---|---|---|---|---|
| 1 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 2 | 16.4 | 32 | 0.202 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 12.6 | 33 | 0.254 |
| 3 | *Vateria indic*a L. | 2 | 5.7 | 22 | 0.202 |
| 4 | *Schleichera oleosa* (Lour.) Oken | 3 | 4.5 | 25 | 0.254 |
| 5 | *Persea macrantha(*Nees) Kosterm. | 4 | 22.5 | 46 | 0.293 |
| 6 | *Mesua ferrea* L. | 1 | 13.2 | 25 | 0.129 |
| 7 | *Litsea oleoides* (Meissn.) Hook.f. | 3 | 4.6 | 25 | 0.254 |
| 8 | *Actinodaphne bourdillonii* Gamble | 1 | 2.5 | 15 | 0.129 |
| 9 | *Litsea bourdillonii* Gamble | 1 | 7.1 | 20 | 0.129 |
| 10 | *Chukrasia tabularis* A. Juss. | 1 | 2.3 | 15 | 0.129 |
| 11 | *Myristica beddomei* King | 4 | 15.9 | 40 | 0.293 |
| | | **25** | **107.2** | **300** | **2.269** |

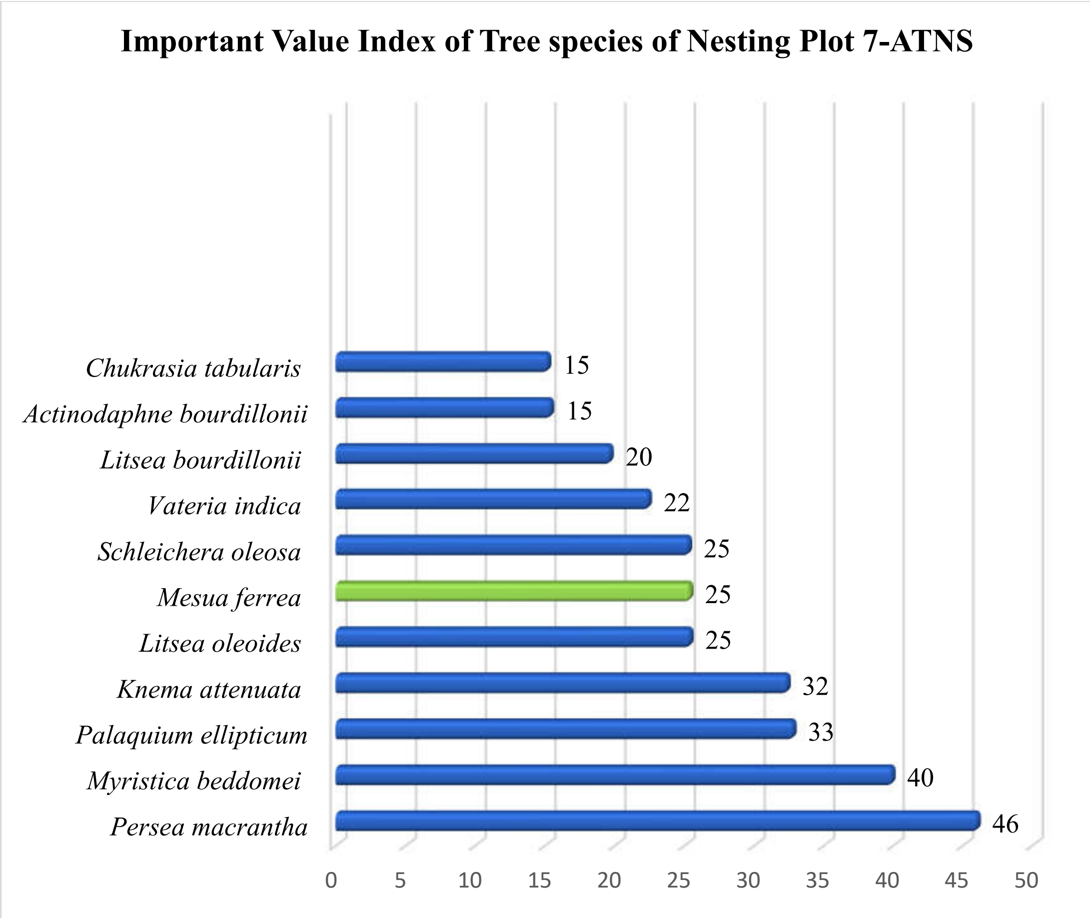


**Figure 7.11. Important Value Index of Tree species of Nesting Plot ATNS**

**Important Value Index of Tree species of Nesting Plot 8**

In plot 8- Sheikalmudi Nesting Site (SNS), the study documented a total of 21 trees belonging to 12 species. The stand density was also 21. The nesting tree was *Tetrameles nudiflora* having a high GBH of 4.98 m which was also the dominant tree with an IVI of 53. The other species observed were *Holigarna arnottiana* (IVI 49), *Palaquium ellipticum* (IVI 28), *Cryptocarya sheikelmudiyana* (27), *Mesua ferrea* and *Myristica beddomei* sub sp *sphaerocarpa* (IVI 25), *Mallotus atrovirens* and *Alseodaphne semecarpifolia* (IVI 18), *Litsea floribunda* (IVI 15) and *Chukrasia tabularis*, *Vateria indica*, and *Diospyros candolleana* (each with IVI of 14). *Mallotus atrovirens*, *Vateria indica*, and *Diospyros candolleana* (Vulnerable), *Alseodaphne semecarpifolia* and *Litsea floribunda* (Near Threatened) were recorded in this plot (Figure 7.10., 7.12. & Table 7.8.).

**Table 7.8. Vegetation structure of Hornbill Nesting habitat Plot 8 SNS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Holigarna arnottiana* Wall.ex Hook.f. | 4 | 13.85 | 49 | 0.316 |
| 2 | *Chukrasia tabularis* A. Juss. | 1 | 0.88 | 14 | 0.145 |
| 3 | *Alseodaphne semecarpifolia* Nees | 1 | 2.89 | 18 | 0.145 |
| 4 | *Tetrameles nudiflora* R. Br. | 2 | 22.89 | 53 | 0.224 |
| 5 | *Vateria indica* L. | 1 | 0.71 | 14 | 0.145 |
| 6 | *Mesua ferrea* L. | 1 | 8.04 | 25 | 0.145 |
| 7 | *Diospyros candolleana* Wight | 1 | 0.36 | 14 | 0.145 |
| 8 | *Litsea floribunda* Gamble | 1 | 0.95 | 15 | 0.145 |
| 9 | *Myristica beddomei* sub sp. *Sphaerocarpa* W. J. de Wilde | 2 | 4.52 | 25 | 0.224 |
| 10 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 3.49 | 28 | 0.278 |
| 11 | *Mallotus atrovirens* Wall.ex.Mull.Arg. | 1 | 3.46 | 18 | 0.145 |
| 12 | *Cryptocarya sheikelmudiyana* Fasila *et al.*, | 3 | 3.0 | 27 | 0.278 |
| | | **21** | **65.1** | **300** | **2.335** |

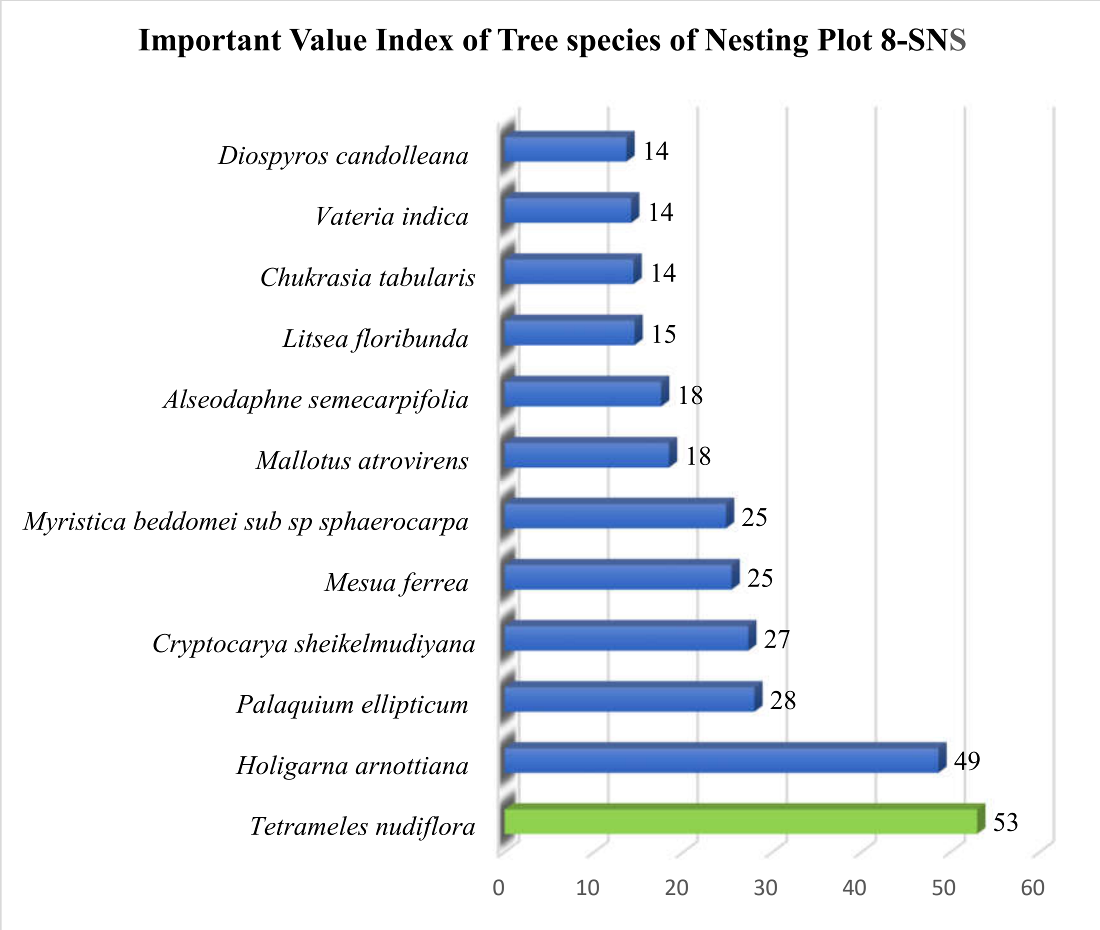


**Figure 7.12. Important Value Index of Tree species of Nesting Plot SNS**

**Regeneration of Sapling of important tree species in the Hornbill Nesting Habitat**

In Plot 1- VNS, 65 saplings of 16 species were found. The stand density was 8.13. It was found that *Persea macrantha* had high regeneration (IVI 29), *Elaeocarpus tuberculatus* (IVI 28), *Litsea coriaceae* and *Vateria indica* (IVI 24) and *Kingiodendron pinnatum*, *Litsea coriaceae*, *Schleichera oleosa* each with an IVI of 22. In this plot, *Litsea coriaceae*, *Persea macrantha, Elaeocarpus tuberculatus*, *Myristica beddomei, Dysoxylum malabaricum* (which is also Endangered) and *Cinnamomum malabatrum* were the important hornbill dispersed tree species (Figure 7.13. & Table 7.9.).

**Table 7.9. Regeneration study of Hornbill Nesting habitat Plot 1 VNS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 0.38 | 0.02 | 18 | 0.14 |
| 2 | *Hopea parviflora* Bedd. | 0.50 | 0.02 | 20 | 0.17 |
| 3 | *Hydnocarpus pentandrus* (Buch-Ham.) Oken | 0.38 | 0.01 | 14 | 0.14 |
| 4 | *Chukrasia tabularis* A. Juss. | 0.50 | 0.01 | 19 | 0.17 |
| 5 | *Schleichera oleosa* (Lour.) Oken | 0.50 | 0.02 | 22 | 0.17 |
| 6 | *Vateria indica* L. | 0.50 | 0.01 | 24 | 0.17 |
| 7 | *Persea macrantha*(Nees) Kosterm. | 1.00 | 0.02 | 29 | 0.26 |
| 8 | *Elaeocarpus tuberculatus* Roxb. | 0.75 | 0.02 | 28 | 0.22 |
| 9 | *Holigarna arnottiana* Wall.ex Hook.f. | 0.50 | 0.01 | 17 | 0.17 |
| 10 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 0.63 | 0.03 | 24 | 0.20 |
| 11 | *Calophyllum polyanthum* Wall.ex Choisy | 0.50 | 0.02 | 18 | 0.17 |
| 12 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 0.63 | 0.02 | 22 | 0.20 |
| 13 | *Terminalia bellirica* (Gaertn.) Roxb. | 0.63 | 0.02 | 22 | 0.20 |
| 14 | *Xylia xylocarpa* (Roxb.)Taub. | 0.25 | 0.00 | 7 | 0.11 |
| 15 | *Cinnamomum malabatrum* (Burm.f.) Persl | 0.13 | 0.00 | 3 | 0.06 |
| 16 | *Myristica beddomei* King | 0.38 | 0.01 | 12 | 0.14 |
| | | **8.13** | **0.22** | **300** | **2.70** |

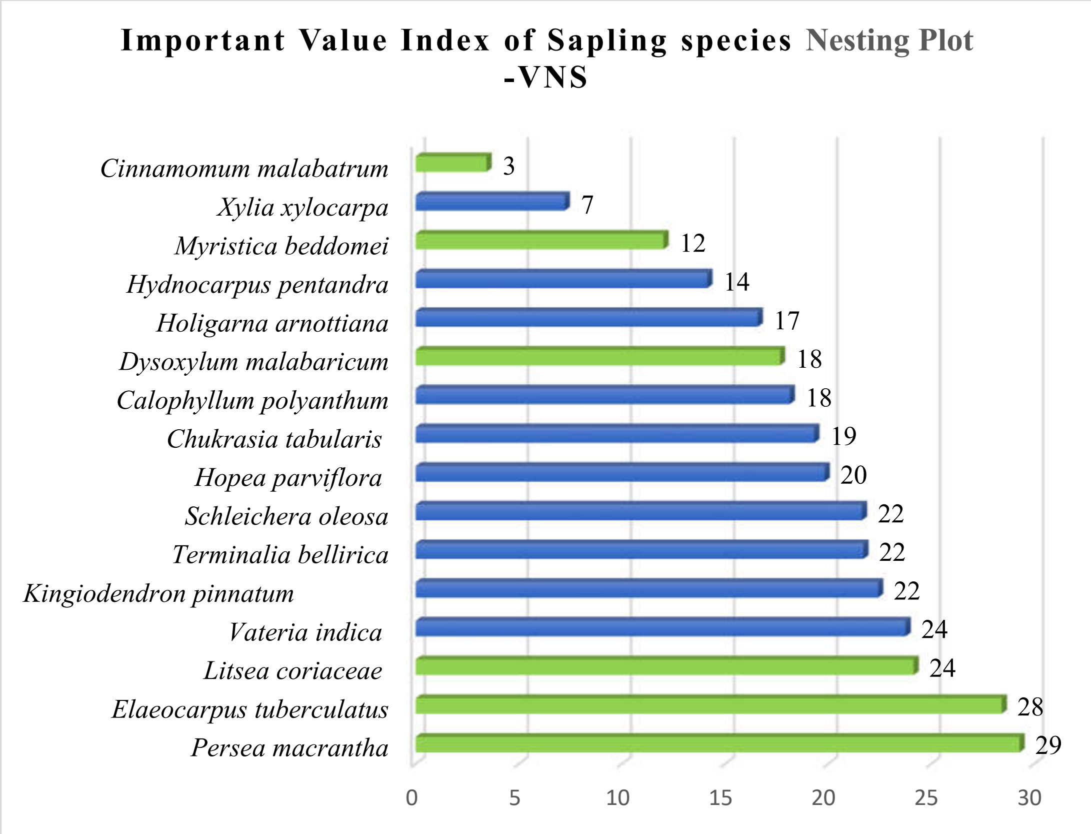


**Figure 7.13. Important Value Index of Sapling species of Nesting Plot VNS**

In Plot 2- PNS1, 83 saplings of 18 species were observed. The stand density was 10. *Palaquium ellipticum* showed high regeneration with an IVI of 36. Other species observed in this plot are *Schleichera oleosa* (IVI 31), *Vateria indica* (IVI 29), *Otonephelium stipulaceum* (IVI 28), *Litsea floribunda* (IVI 26), *Cullenia exarillata* and *Glycosmis mauritiana* (IVI 18). In this plot, the important hornbill diet species are *Palaquium ellipticum*, *Knema attenuata*, *Litsea floribunda* (Near Threatened), *Neolitsea cassia, Persea macrantha*. The endangered species *Kingiodendron pinnatum* and *Syzygium occidentale* were also found in this region. Besides this, the vulnerable species *Vateria indica* was also found in this plot. The presence of *Macaranga peltata* indicates high regeneration of forest in this region (Figure 7.14. & Table 7.10.).

**Table 7.10. Regeneration study of Hornbill Nesting habitat Plot 2 PNS 1**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0.5 | 2.7 | 28 | 0.15 |
| 2 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 1.1 | 0.9 | 24 | 0.24 |
| 3 | *Persea macrantha* (Nees) Kosterm. | 0.6 | 0.3 | 14 | 0.17 |
| 4 | *Cullenia exarillata* A. Robyns | 0.9 | 0.5 | 18 | 0.21 |
| 5 | *Palaquium ellipticum* (Dalzell) Baill. | 0.8 | 3.5 | 36 | 0.19 |
| 6 | *Polyalthia fragrans* (Dalzell) Hook.f &Thomson | 0.3 | 0.2 | 6 | 0.09 |
| 7 | *Syzygium occidentale* (Bourd.) Gandhi | 0.3 | 0.3 | 5 | 0.09 |
| 8 | *Vateria indica* L. | 0.9 | 2.0 | 29 | 0.21 |
| 9 | *Neolitsea cassia* (L.) Kosterm. | 0.4 | 0.4 | 9 | 0.12 |
| 10 | *Litsea floribunda* Gamble | 0.8 | 2.4 | 26 | 0.19 |
| 11 | *Schleichera oleosa* (Lour.) Oken | 0.6 | 2.8 | 31 | 0.17 |
| 12 | *Cinnamomum sulphuratum* Nees | 0.6 | 0.5 | 15 | 0.17 |
| 13 | *Terminalia paniculata* Roth | 0.6 | 0.4 | 12 | 0.17 |
| 14 | *Glycosmis mauritiana* (Lam.)Tanaka | 0.9 | 0.5 | 18 | 0.21 |
| 15 | *Macaranga peltata* (Roxb.)Mull.Arg. | 0.4 | 0.2 | 9 | 0.12 |
| 16 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 0.3 | 0.1 | 6 | 0.09 |
| 17 | *Ziziphus rugosa* Lam. | 0.1 | 0.0 | 3 | 0.05 |
| 18 | *Olea dioica* Roxb. | 0.5 | 0.3 | 12 | 0.15 |
| | | **10** | **18** | **300** | **3** |

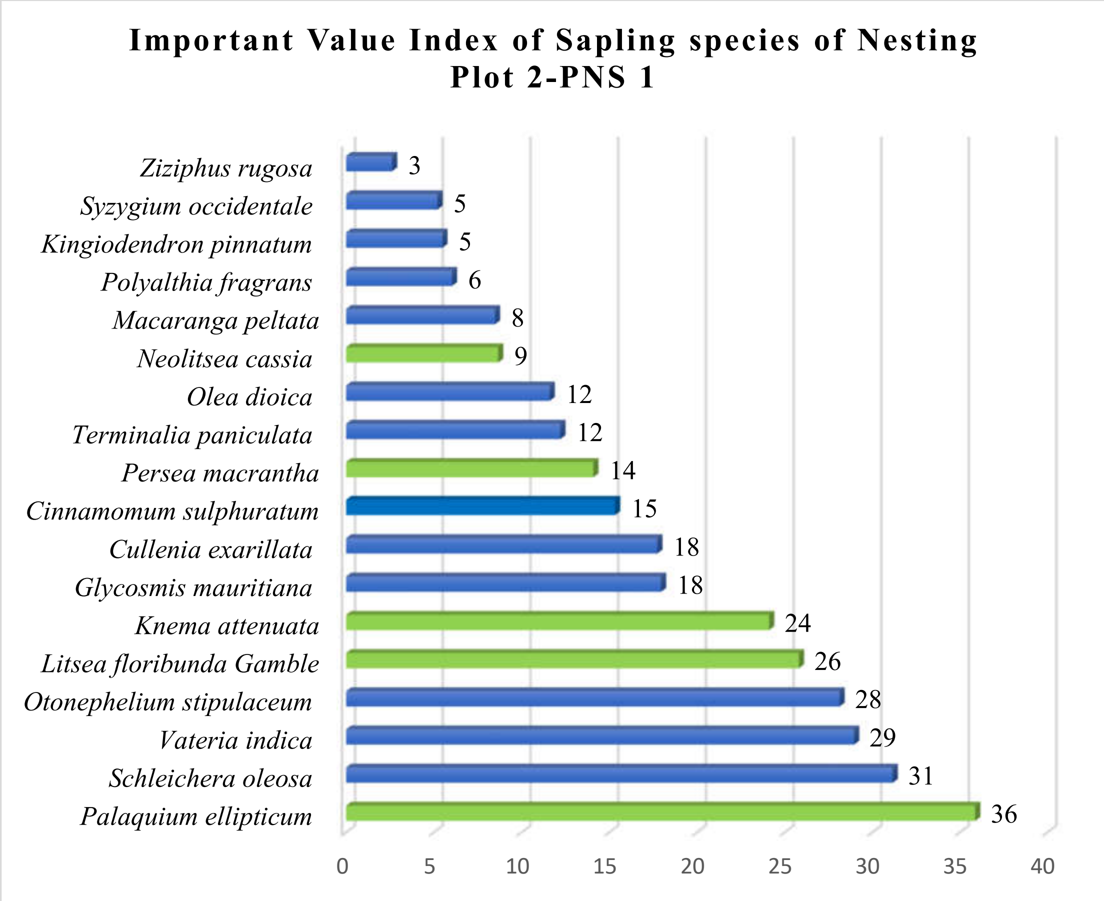


**Figure 7.14. Important Value Index of Sapling species of Nesting Plot PNS 1**

In Plot 3- ANS, 58 saplings of 16 species were reported. The stand density was 7.3. The regeneration was very low compared to other plots. Sapling density was also very poor. A forest fire happened in this region in 2004. However, hornbill nesting was noticed frequently. The important sapling species found in this region are *Palaquium ellipticum* (with an IVI of 40), *Myristica beddomei* (IVI 33), *Litsea coriaceae* (IVI 32), *Persea macranth*a (IVI 29), *Otonephelium stipulaceum* (IVI 29), *Aphanamixis polystachya* (IVI 23) and *Cinnamomum malabatrum* (IVI 20). *Hopea parviflora* (Endangered) was found in this plot. The hornbill diet species found in this plot were *Palaquium ellipticum*, *Myristica beddomei*, *Litsea coriaceae*, *Persea macrantha*, *Aphanamixis polystachya*, *Cinnamomum malabatrum, Litsea floribunda* (Near Threatened), *Elaeocarpus tuberculatus* and *Actinodaphne wightiana.* (Figure 7.15. & Table 7.11.).

**Table 7.11. Regeneration study of Hornbill Nesting habitat Plot 3 ANS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Actinodaphne wightiana* (Kuntze) Noltie | 0.3 | 0.035 | 9 | 0.1 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 0.9 | 0.622 | 29 | 0.3 |
| 3 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0.9 | 0.594 | 29 | 0.3 |
| 4 | *Hopea parviflora* Bedd. | 0.1 | 0.049 | 5 | 0.1 |
| 5 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 0.6 | 1.539 | 32 | 0.2 |
| 6 | *Alstonia scholaris* (L.) R.Br. | 0.1 | 0.062 | 5 | 0.1 |
| 7 | *Elaeocarpus tuberculatus* Roxb. | 0.3 | 0.255 | 11 | 0.1 |
| 8 | *Terminalia paniculata* Roth | 0.1 | 0.062 | 5 | 0.1 |
| 9 | *Holigarna arnottiana* Wall.ex Hook.f. | 0.1 | 0.057 | 5 | 0.1 |
| 10 | *Dipterocarpus indicus* Bedd. | 0.3 | 0.246 | 11 | 0.1 |
| 11 | *Litsea floribunda* Gamble | 0.4 | 0.594 | 17 | 0.2 |
| 12 | *Myristica beddomei* King | 0.6 | 1.227 | 33 | 0.2 |
| 13 | *Cinnamomum malabatrum* (Burm.f.) Persl | 0.5 | 0.515 | 20 | 0.2 |
| 14 | *Aphanamixis polystachya* (Wall). R.N.Parker | 0.5 | 0.739 | 23 | 0.2 |
| 15 | *Schleichera oleosa* (Lour.) Oken | 0.6 | 0.679 | 26 | 0.2 |
| 16 | *Palaquium ellipticum* (Dalzell) Baill. | 1 | 0.985 | 40 | 0.3 |
| | | **7.3** | **8.3** | **300** | **2.6** |

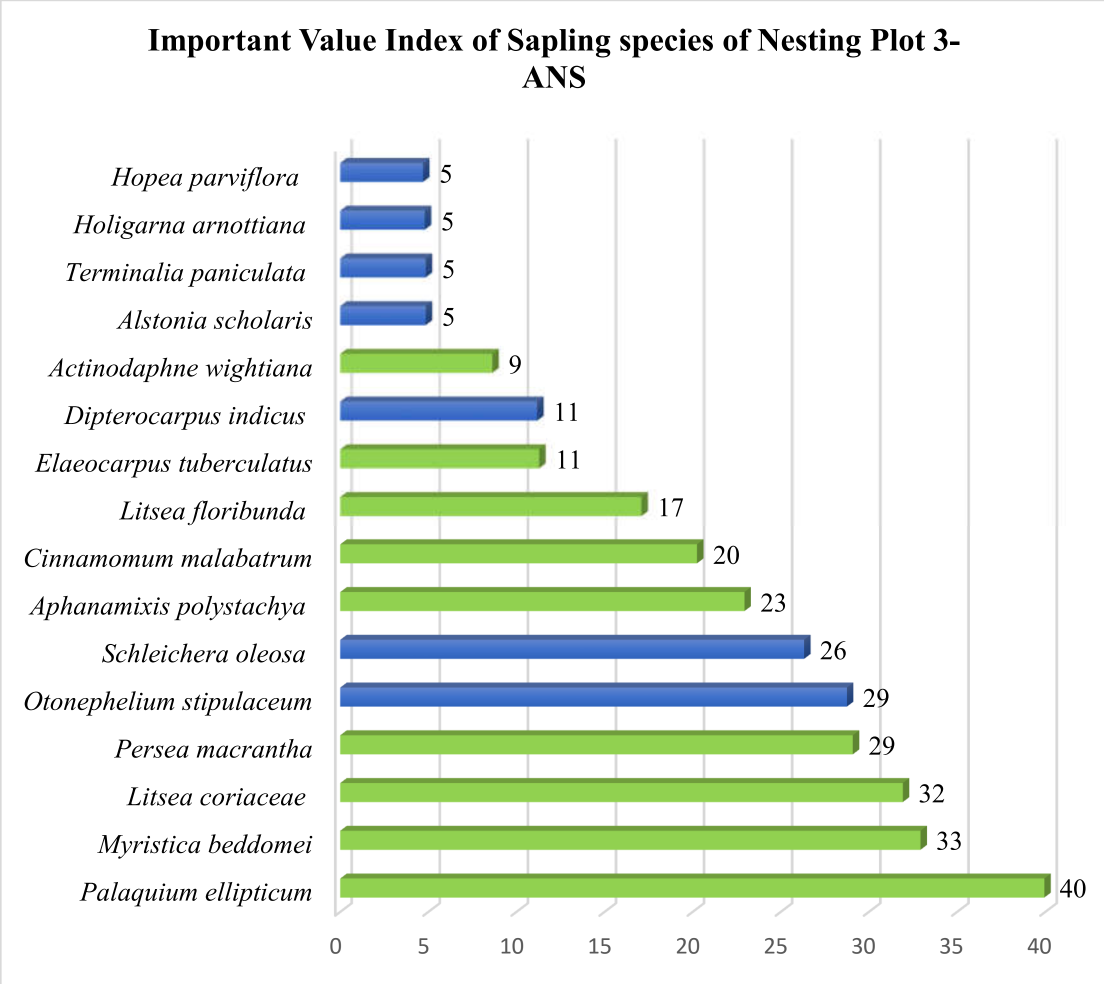


**Figure 7.15. Important Value Index of Sapling species of Nesting Plot ANS**

In Plot 4- SPNS1, 112 saplings of 21 species were reported. The stand density was 14. Among them, *Schleichera oleosa*, *Chukrasia tabularis* and *Cullenia exarillata* showed high regeneration with an IVI of 22. Other noted species were *Myristica beddomei* (IVI 21), *Mesua ferrea* (IVI 19), *Vateria indica* (IVI 18), *Otonephelium stipulaceum* (IVI 18), *Knema attenuata*, *Aphanamixis polystachya* and *Holigarna arnottiana* (IVI 16). *Syzygium occidentale* (Endangered), *Tarenna monosperma* and *Vateria indica* (Vulnerable) were also found in this plot. The important hornbill diet species found in this region were *Myristica beddomei, Knema attenuata*, *Aphanamixis polystachya* and *Diospyros crumenata* (Endangered) (Figure 7.16. & Table 7.12.).

**Table 7.12. Regeneration study of Hornbill Nesting habitat Plot 4 SPNS1**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Vateria indica* L. | 0.9 | 0.694 | 18 | 0.2 |
| 2 | *Chukrasia tabularis* A. Juss. | 1.0 | 0.754 | 22 | 0.16 |
| 3 | *Cullenia exarillata* A. Robyns | 0.9 | 1.149 | 22 | 0.15 |
| 4 | *Myristica beddomei* King | 0.8 | 1.368 | 21 | 0.1 |
| 5 | *Drypetes venusta* (Wight) Pax & K.Hoffm. | 0.5 | 0.430 | 12 | 0.12 |
| 6 | *Mastixia arborea* (Wight) C.B.Clarke | 0.5 | 0.173 | 7 | 0.12 |
| 7 | *Calophyllum polyanthum* Wall.ex Choisy | 0.5 | 0.352 | 10 | 0.18 |
| 8 | *Holigarna arnottiana* Wall.ex Hook.f. | 0.8 | 0.650 | 16 | 0.16 |
| 9 | *Schleichera oleosa* (Lour.) Oken | 0.8 | 1.207 | 22 | 0.05 |
| 10 | *Paracroton pendulus* (Hassk.) Miq. | 0.3 | 0.255 | 6 | 0.22 |
| 11 | *Artocarpus heterophyllus* Lam | 0.8 | 0.255 | 11 | 0.08 |
| 12 | *Diospyros crumenata* Thw. | 0.4 | 0.132 | 8 | 0.13 |
| 13 | *Syzygium occidentale* (Bourd.) Gandhi | 0.5 | 0.594 | 12 | 0.21 |
| 14 | *Mesua ferrea* L. | 0.9 | 0.950 | 19 | 0.17 |
| 15 | *Aphanamixis polystachya* (Wall). R.N.Parker | 0.9 | 0.739 | 16 | 0.1 |
| 16 | *Mitragyna parvifolia* (Roxb.) Korth. | 0.5 | 0.204 | 9 | 0.24 |
| 17 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 1.0 | 0.679 | 18 | 0.12 |
| 18 | *Saprosma glomeratum* (Gardner) Bedd. | 0.6 | 0.594 | 14 | 0.11 |
| 19 | *Tarenna monosperma* Wight &Arn. | 0.5 | 0.594 | 11 | 0.18 |
| 20 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 0.8 | 0.739 | 16 | 0.1 |
| 21 | *Mallotus philippensis* (Lam.)Mull.Arg. | 0.5 | 0.173 | 10 | 0.12 |
| | | **14.0** | **12.69** | **300** | **3** |

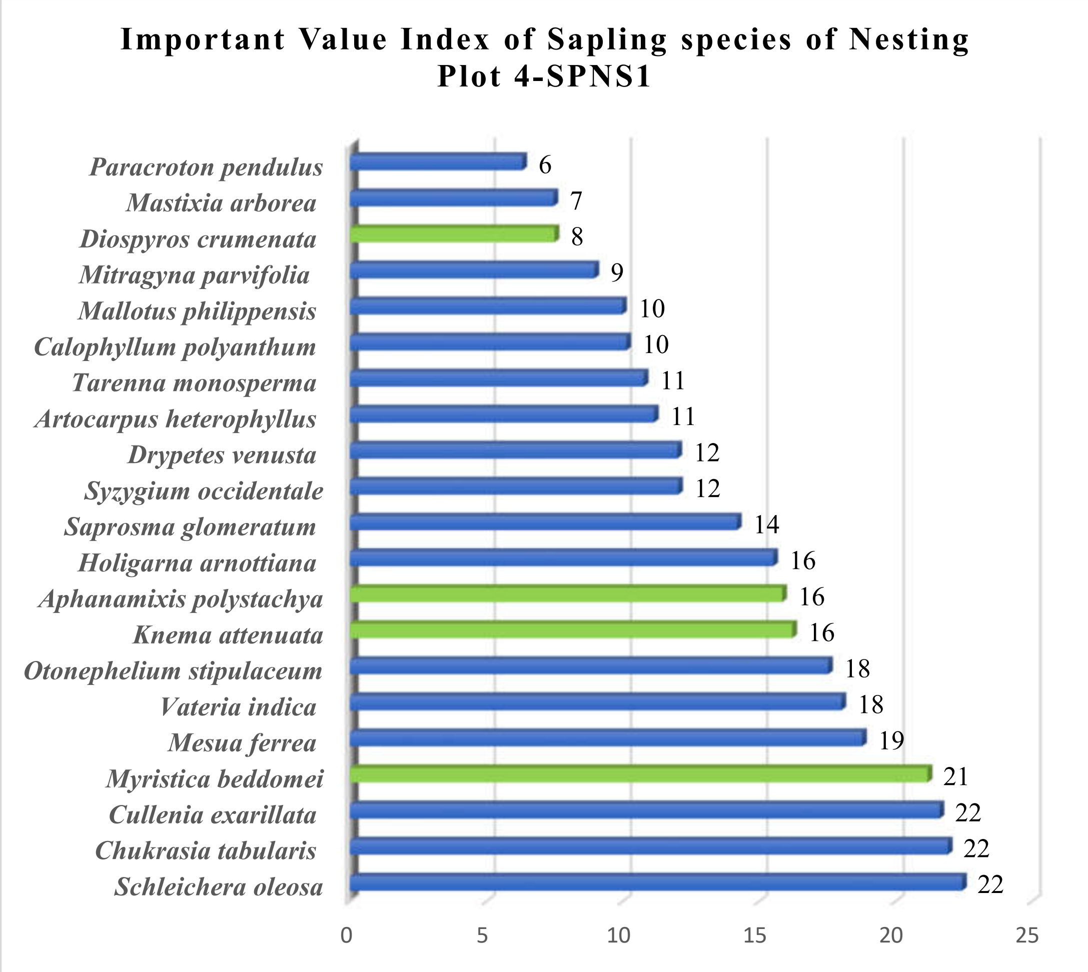


**Figure 7.16. Important Value Index of Sapling species of Nesting Plot SPNS 1**

In plot 5- SPNS 2, 156 saplings of 31 different species were recorded. The stand density in this plot was 25. *Knema attenuata* and *Cinnamomum malabatrum* showed highest regeneration with an IVI of 22 followed by *Palaquium ellipticum* (IVI 20), *Schleichera oleosa* (IVI 12) and *Dysoxylum malabaricum* (IVI 12). *Melicope lunu-ankenda, Mallotus philippensis* and *Mesua ferrea* each had an IVI of 10. *Mallotus atrovirens* (Vulnerable) was found in this plot. The important hornbill diet species were *Knema attenuata*, *Cinnamomum malabatrum*, *Palaquium ellipticum, Dysoxylum malabaricum* (Endangered), *Myristica beddomei*, *Actinodaphne wightiana*, *Litsea bourdillonii* (Near Threatened), *Trichilia connaroides*, *Persea macrantha*, *Cryptocarya* sps, *Reinwardtiodendron anamalaiense* and *Litsea oleoides* (Vulnerable). The regeneration of *Litsea oleoides* was observed to be very low. (Figure 7.17. & Table 7.13.).

**Table 7.13. Regeneration study of Hornbill Nesting habitat Plot 5 SPNS 2**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Litsea bourdillonii* Gamble | 0.5 | 0.33 | 5 | 0.08 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 0.4 | 0.20 | 4 | 0.06 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 1.4 | 2.89 | 20 | 0.16 |
| 4 | *Mallotus philippensis* (Lam.)Mull.Arg. | 1.0 | 0.69 | 10 | 0.13 |
| 5 | *Myristica beddomei* King | 0.9 | 0.52 | 9 | 0.12 |
| 6 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 1.1 | 1.02 | 12 | 0.14 |
| 7 | *Aglaia barberi* Gamble | 0.4 | 0.23 | 4 | 0.06 |
| 8 | *Chukrasia tabularis* A. Juss. | 0.9 | 0.98 | 9 | 0.12 |
| 9 | *Actinodaphne wightiana* (Kuntze) Noltie | 0.5 | 0.43 | 5 | 0.08 |
| 10 | *Schleichera oleosa* (Lour.) Oken | 1.0 | 1.70 | 12 | 0.13 |
| 11 | *Agrostistachys borneensis* Becc | 0.5 | 0.40 | 4 | 0.08 |
| 12 | *Dendrocnide sinuata* (Bi.) Chew | 0.6 | 0.65 | 7 | 0.09 |
| 13 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | 0.5 | 0.13 | 2 | 0.05 |
| 14 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0.8 | 0.59 | 6 | 0.1 |
| 15 | *Aporosa acuminata* Thw. | 0.6 | 0.36 | 7 | 0.09 |
| 16 | *Bombax ceiba* L. | 0.4 | 0.20 | 5 | 0.06 |
| 17 | *Garcinia gummi-gutta* (L.) Robs. | 0.5 | 0.26 | 5 | 0.08 |

| | | | | | |
|---|---|---|---|---|---|
| 18 | *Calophyllum polyanthum* Wall.ex Choisy | 0.6 | 0.35 | 7 | 0.09 |
| 19 | *Litsea oleoides* (Meisn.)J.Hk | 0.1 | 0.01 | 1 | 0.03 |
| 20 | *Ficus* sps. | 0.3 | 0.03 | 2 | 0.05 |
| 21 | *Polyalthia fragrans* (Dalzell) Hook.f &Thomson | 0.5 | 0.13 | 5 | 0.08 |
| 22 | *Trichilia connaroides* (Wight & Arn.) Bentvelzen | 0.6 | 0.29 | 7 | 0.09 |
| 23 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 1.0 | 0.65 | 10 | 0.13 |
| 24 | *Drypetes malabarica* (Bedd.) Airy Shaw | 0.1 | 0.03 | 1 | 0.03 |
| 25 | *Knema attenuata* (Hook. fil.& Thomas.) Warb. | 1.4 | 3.46 | 22 | 0.16 |
| 26 | *Holigarna grahamii* (Wight) Kurz. | 0.5 | 0.57 | 6 | 0.08 |
| 27 | *Mallotus atrovirens* Wall.ex.Mull.Arg. | 0.3 | 0.09 | 3 | 0.05 |
| 28 | *Mesua ferrea* L. | 0.9 | 0.65 | 10 | 0.12 |
| 29 | *Spondias pinnata* (L.f) Kurz | 0.8 | 0.55 | 8 | 0.1 |
| 30 | *Cryptocarya lowsonii* Gamble | 0.3 | 0.13 | 3 | 0.05 |
| 31 | *Cinnamomum malabatrum* (Burm.f.) Persl | 1.5 | 2.95 | 22 | 0.17 |
| | | **25** | **29.4** | **300** | **2.82** |

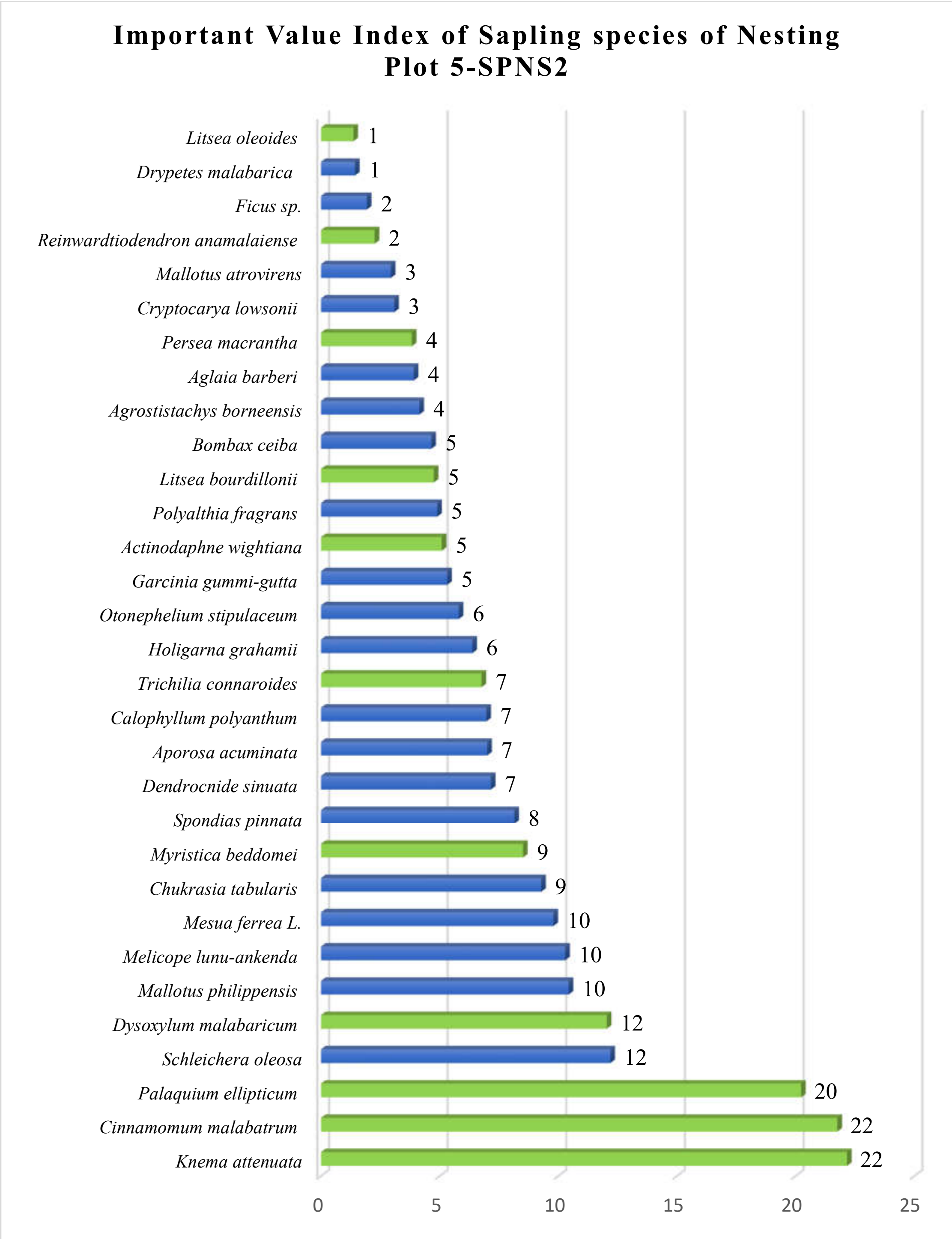


**Figure 7.17. Important Value Index of Sapling species of Nesting Plot SPNS 2**

In Plot 6- PNS 2, 165 saplings of 25 species were found. Stand density in this plot was 21. Among them *Vateria indica* (Vulnerable), showed highest regeneration (with an IVI of 26) followed by *Paracroton pendulus* (IVI 22), *Drypetes venusta* (IVI 18), *Melicope lunu-ankenda* (IVI 17), *Calophyllum polyanthum* (IVI 15), *Alseodaphne semecarpifolia* (Near Threatened, IVI 7) and *Polyalthia coffeoides* (IVI 13).

The important hornbill diet species found in this plot were *Myristica beddomei*, *Knema attenuata* (IVI 15), *Canarium strictum* (IVI 11), *Phoebe lanceolata* (IVI 10), *Litsea floribunda* (Near Threatened, IVI 12), *Dysoxylum malabaricum* (Endangered, IVI 11), *Cryptocarya anamalayana* (Endangered, IVI 10) *Cinnamomum malabatrum, Cryptocarya* sps, *Aglaia* sps, (IVI 8), *Litsea oleoides* (Vulnerable IVI 6) and *Litsea bourdillonii* (Near Threatened IVI 5) (Figure 7.18., 7.19. & Table 7.14.).

**Table 7.14. Regeneration study of Hornbill Nesting habitat Plot 6 PNS 2**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Cinnamomum malabatrum* (Burm.f.) Persl | 0.625 | 0.5 | 8 | 0.106 |
| 2 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 1.25 | 2.4 | 17 | 0.17 |
| 3 | *Eugenia mooniana* Wight | 0.5 | 0.3 | 6 | 0.09 |
| 4 | *Gymnacranthera canarica* (Bedd.ex King)Warb. | 1 | 1.0 | 13 | 0.147 |
| 5 | *Drypetes venusta* (Wight) Pax & K.Hoffm. | 1.125 | 3.0 | 18 | 0.159 |
| 6 | *Polyalthia coffeoides* (Thw.) J. Hk&Thoms | 0.875 | 1.2 | 13 | 0.134 |
| 7 | *Litsea floribunda* Gamble | 0.875 | 1.7 | 12 | 0.134 |
| 8 | *Canarium strictum* Roxb. | 0.75 | 1.4 | 11 | 0.121 |
| 9 | *Schleichera oleosa* (Lour.) Oken | 0.875 | 1.1 | 12 | 0.134 |
| 10 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 0.875 | 0.7 | 11 | 0.134 |
| 11 | *Aglaia* sps. | 0.5 | 0.5 | 8 | 0.09 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | *Syzygium laetum* (Buch.Ham). Gandhi | 0.75 | 0.4 | 10 | 0.121 |
| 13 | *Litsea bourdillonii* Gamble | 0.375 | 0.5 | 5 | 0.073 |
| 14 | *Solenocarpus indicus* Wight & Arn. | 0.875 | 1.6 | 12 | 0.134 |
| 15 | *Litsea oleoides* (Meisn) Hook.f. | 0.5 | 0.7 | 6 | 0.09 |
| 16 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 0.875 | 1.9 | 15 | 0.134 |
| 17 | *Myristica beddomei* King | 1 | 1.8 | 15 | 0.147 |
| 18 | *Alseodaphne semecarpifolia* Nees | 0.5 | 0.5 | 7 | 0.09 |
| 19 | *Actinodaphne tadulingamii* Gamble | 0.875 | 1.1 | 10 | 0.134 |
| 20 | *Cryptocarya lowsonii* Gamble | 0.5 | 0.7 | 8 | 0.09 |
| 21 | *Calophyllum polyanthum* Wall.ex Choisy | 1.125 | 2.2 | 15 | 0.159 |
| 22 | *Phoebe lanceolata* (Nees) Nees | 0.625 | 0.7 | 10 | 0.106 |
| 23 | *Cryptocarya anamalayana* Gamble | 0.625 | 0.9 | 10 | 0.106 |
| 24 | *Paracroton pendulus* (Hassk.) Miq. | 1.375 | 3.8 | 22 | 0.181 |
| 25 | *Vateria indic*a L. | 1.375 | 4.8 | 26 | 0.181 |
| | | **21** | **36** | **300** | **3.165** |

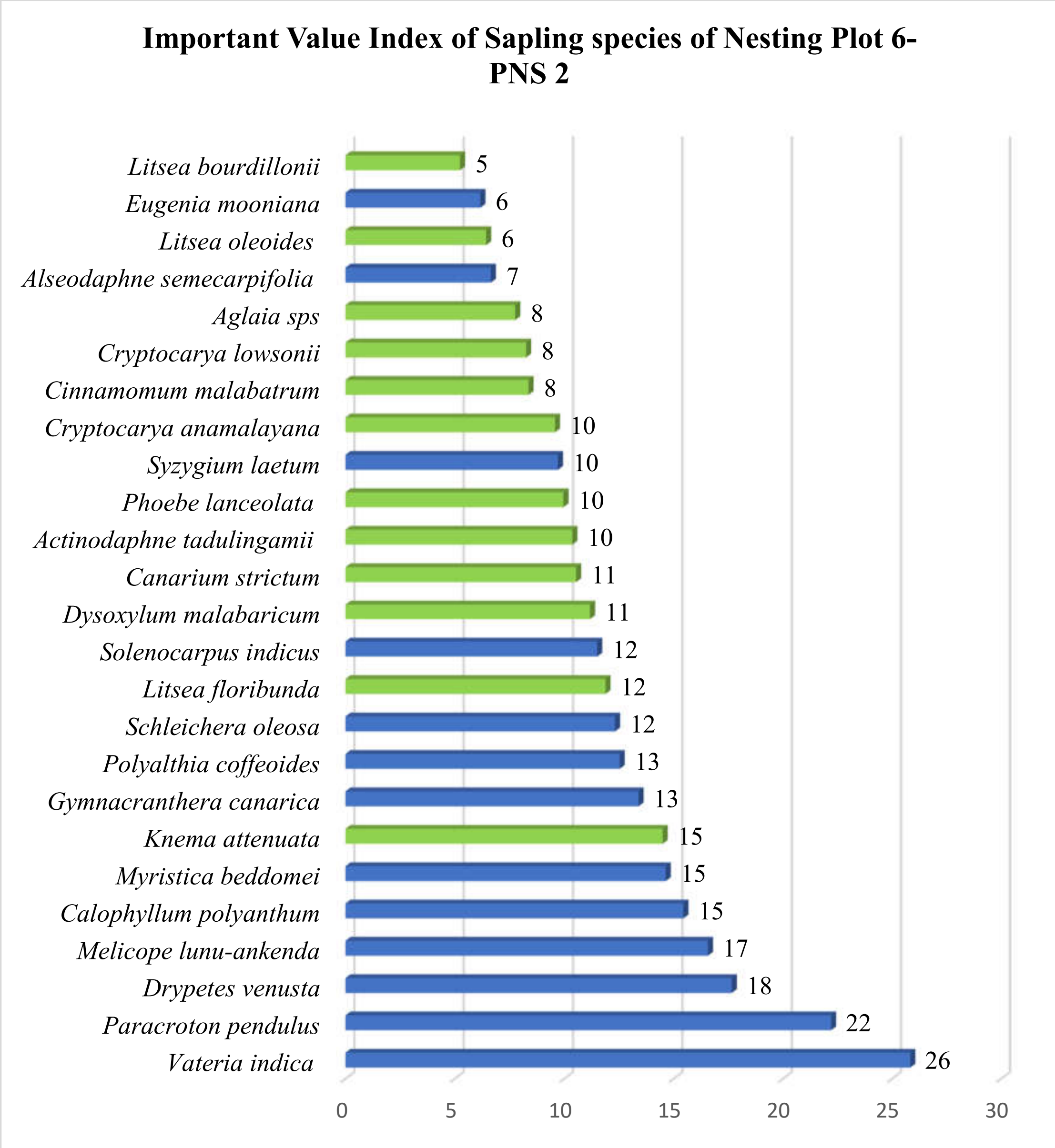


**Figure 7.18. Important Value Index of Sapling species of Nesting Plot PNS 2**

In plot 7- ATNS, 158 saplings of 27 species were recorded. The stand density was 20. Regeneration was high in *Vateria indica* with an IVI of 29 followed by *Litsea floribunda* (Near Threatened, IVI 17), *Antidesma montanum* (IVI 16), *Myristica beddomei, Meiogyne pannosa*, *Neolitsea scrobiculata*, *Elastostema acuminatum, Dysoxylum malabaricum* (IVI 14). *Vateria indica* (Vulnerable IVI 29), *Meiogyne pannosa* (Near Threatened IVI 14). The important hornbill diet species were *Litsea floribunda, Litsea wightiana* (Near Threatened), *Myristica beddomei*, *Neolitsea* *scrobiculata, Dysoxylum malabaricum* (Endangered), *Knema attenuata*, *Elaeocarpus tuberculatus*, *Syzygium cumini*, *Canarium strictum*, *Litsea oleoides* (Vulnerable), *Palaquium ellipticum* and *Litsea wightiana*, *Actinodaphne tadulingamii* (Near Threatened) (Figure 7.20. & Table 7.15.).

**Table 7.15. Regeneration study of Hornbill Nesting habitat Plot 7 ATNS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Vateria indica* L. | 1.8 | 3.46 | 29 | 0.21 |
| 2 | *Litsea oleoides* (Meissn.) Hook.f. | 0.6 | 0.43 | 9 | 0.11 |
| 3 | *Myristica beddomei* King | 1 | 1.54 | 16 | 0.15 |
| 4 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 0.9 | 0.74 | 14 | 0.14 |
| 5 | *Palaquium ellipticum* (Dalzell) Baill. | 0.5 | 0.19 | 6 | 0.09 |
| 6 | *Antidesma montanum* Blume | 1.5 | 0.75 | 16 | 0.19 |
| 7 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 0.9 | 1.11 | 13 | 0.14 |
| 8 | *Mangifera indica* L. | 0.3 | 0.17 | 4 | 0.05 |
| 9 | *Meliosma pinnata* Roxb. | 0.9 | 0.50 | 11 | 0.14 |
| 10 | *Poeciloneuron indicum* Bedd. | 1 | 0.07 | 9 | 0.15 |
| 11 | *Litsea floribunda* Gamble | 1.1 | 1.02 | 17 | 0.16 |
| 12 | *Lophopetalum wightianum* Arn. | 0.9 | 0.23 | 9 | 0.14 |
| 13 | *Neolitsea scrobiculata* (Meisn.) Gamble | 0.6 | 1.54 | 14 | 0.11 |
| 14 | *Canarium strictum* Roxb. | 0.5 | 0.95 | 10 | 0.09 |
| 15 | *Dimocarpus longan* Lour. | 0.5 | 0.75 | 8 | 0.09 |
| 16 | *Syzygium cumini* (L.) Skeels | 0.5 | 0.98 | 10 | 0.09 |

| | | | | | |
|---|---|---|---|---|---|
| 17 | *Litsea wightiana* (Nees) Benth. & Hook. | 0.3 | 0.17 | 3 | 0.05 |
| 18 | *Elaeocarpus tuberculatus* Roxb. | 0.8 | 0.43 | 10 | 0.12 |
| 19 | *Alstonia scholaris* (L.) R.Br. | 0.3 | 0.09 | 3 | 0.05 |
| 20 | *Antidesma montanum* Blume | 0.5 | 0.26 | 7 | 0.09 |
| 21 | *Aporosa acuminata* Thw. | 0.5 | 0.40 | 6 | 0.09 |
| 22 | *Actinodaphne tadulingamii* Gamble | 0.9 | 0.98 | 14 | 0.14 |
| 23 | *Eugenia mooniana* Wight | 0.5 | 0.65 | 8 | 0.09 |
| 24 | *Glochidion ellipticum* Wight | 0.6 | 0.54 | 8 | 0.11 |
| 25 | *Holigarna arnottiana* Wall.ex Hook.f. | 0.5 | 0.26 | 6 | 0.09 |
| 26 | *Meiogyne pannosa* (Dalzell)J. Sinclair | 1 | 1.00 | 14 | 0.15 |
| 27 | *Melicope lunu-ankenda* (Gaertn.) T.G. Hartley | 0.6 | 0.75 | 10 | 0.11 |
| | | **20** | **19.97** | **300** | **3.16** |


**Figure 7.19. Nesting site Pathadipalam, Vazhachal and Pottanmopu: A.** Pathadipalam nesting site (PNS2) (*Calophyllum polyanthum* Wall. ex Choisy); **B.** Vazhachal nesting site (VNS) (*Terminalia bellirica* (Gaertn.) Roxb.); **C.** Pottanmopu nesting site (PNS1) (*Vateria indica* L.); **D.** Fecal matter under nesting tree (Vazhachal); **E.** Seedlings under the nesting tree (Pathadipalam).

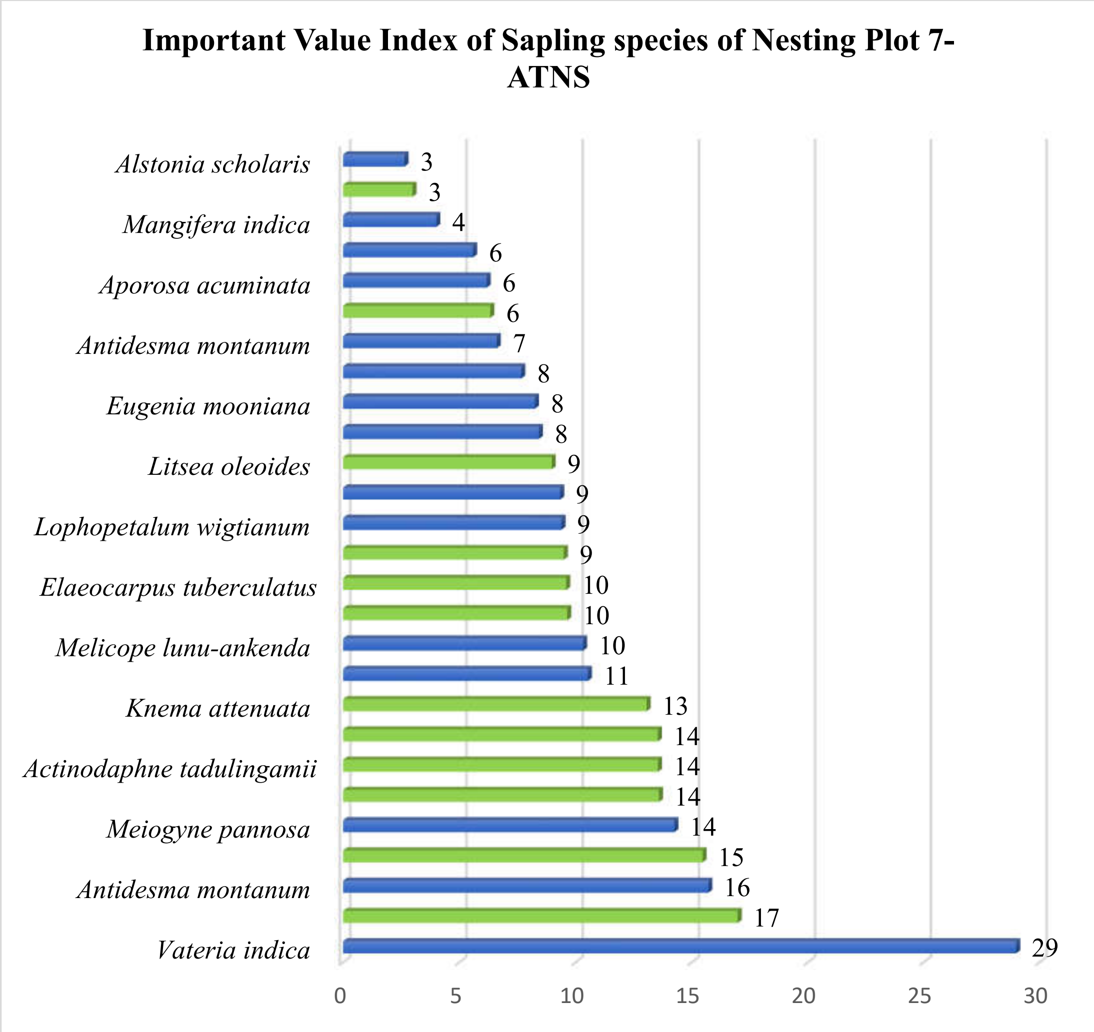


**Figure 7.20. Important Value Index of Sapling species of Nesting Plot ATNS**

In plot 8- SNS, 142 saplings of 21 species were recorded. The stand density was 16. The dominant species was *Palaquium ellipticum* with an IVI of 44 followed by *Chukrasia tabularis* (IVI 30), *Mesua ferrea* (IVI 29), *Mallotus philippensis* (IVI 28), *Vateria indica* (IVI 22), *Psychotria anamalayana* (IVI 20) and *Dendrocnide sinuata* (IVI 15). *Tarenna monosperma* (Endangered), *Alseodaphne semecarpifolia* Nees (Near Threatened) and *Vateria indica* (Vulnerable) were record here. The important hornbill diet species in this plot were *Palaquium ellipticum*, *Myristica beddomei*, *Knema attenuata*, *Beilschmiedia wightii* (Near Threatened), *Persea macrantha*, *Litsea floribunda* (Near Threatened), *Phoebe lanceolata*, *Cryptocarya sheikelmudiyana* and *Aglaia* sp. (Figure 7.21. & Table 7.16.).

**Table 7.16. Regeneration study of Hornbill Nesting habitat Plot 8 SNS**

| Sl.No | Name of the species | Stand Density | Basal Area | Important Value Index | Shannon Diversity Index |
|---|---|---|---|---|---|
| 1 | *Myristica beddomei* King | 0.88 | 0.6 | 13 | 0.16 |
| 2 | *Cryptocarya sheikelmudiyana Fasila et al*., | 0.50 | 0.2 | 9 | 0.11 |
| 3 | *Psychotria anamalayana* Bedd. | 1.00 | 1.9 | 20 | 0.17 |
| 4 | *Persea macrantha*(Nees) Kosterm. | 0.63 | 0.3 | 10 | 0.13 |
| 5 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 1.00 | 1.2 | 13 | 0.17 |
| 6 | *Polyalthia coffeoides* (Thw.) J. Hk.&Thoms. | 0.63 | 0.4 | 10 | 0.13 |
| 7 | *Vateria indic*a L. | 1.38 | 1.4 | 22 | 0.21 |
| 8 | *Litsea floribunda* Gamble | 0.88 | 0.2 | 10 | 0.16 |
| 9 | *Dendrocnide sinuata* (Bi.) Chew | 1.00 | 0.8 | 15 | 0.17 |
| 10 | *Phoebe lanceolata* (Nees) Nees | 0.88 | 0.5 | 10 | 0.16 |
| 11 | *Chukrasia tabularis* A. Juss. | 1.38 | 3.5 | 30 | 0.21 |
| 12 | *Alseodaphne semecarpifolia* Nees | 0.25 | 0.2 | 5 | 0.06 |
| 13 | *Bombax ceiba* L. | 0.63 | 0.1 | 7 | 0.13 |
| 14 | *Mesua ferrea* L. | 1.38 | 3.8 | 29 | 0.21 |
| 15 | *Palaquium ellipticum* (Dalzell) Baill. | 1.75 | 6.8 | 44 | 0.24 |
| 16 | *Tarenna monosperma* (Wight & Arn.) D.C.S .Raju | 0.63 | 1.1 | 13 | 0.13 |
| 17 | *Mallotus philippensis* (Lam.)Mull.Arg. | 1.38 | 3.0 | 28 | 0.21 |
| 18 | *Canarium strictum* Roxb. | 0.38 | 0.4 | 8 | 0.09 |
| 19 | *Hydnocarpus alpina* Wight | 0.38 | 0.5 | 8 | 0.09 |
| 20 | *Beilschmiedia* sps. | 0.63 | 0.3 | 11 | 0.13 |
| 21 | *Aglaia* sps. | 0.25 | 0.2 | 5 | 0.06 |
| | | **16** | **27** | **300** | **3.12** |

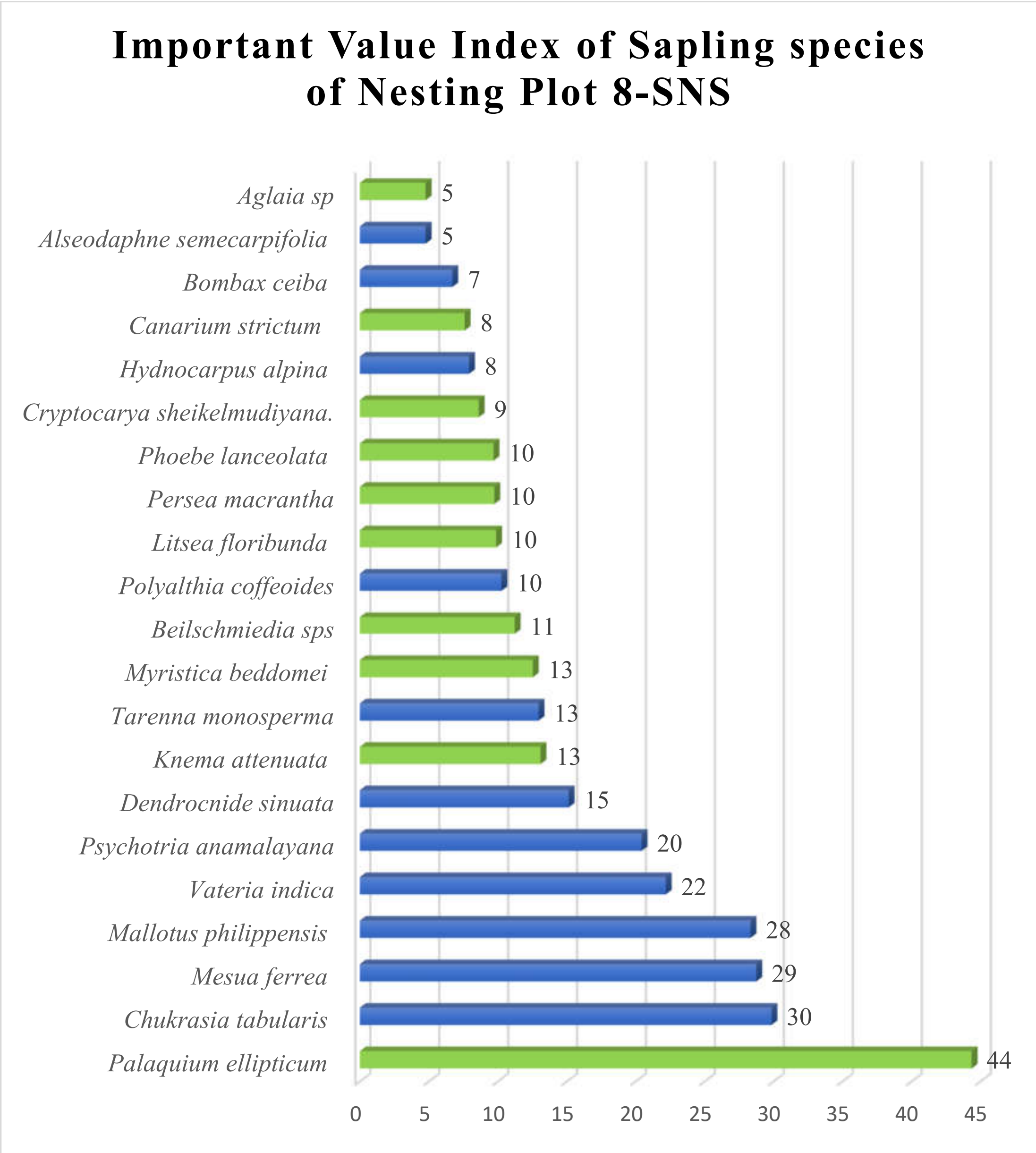


**Figure 7.21. Important Value Index of Sapling species of Nesting Plot SNS**

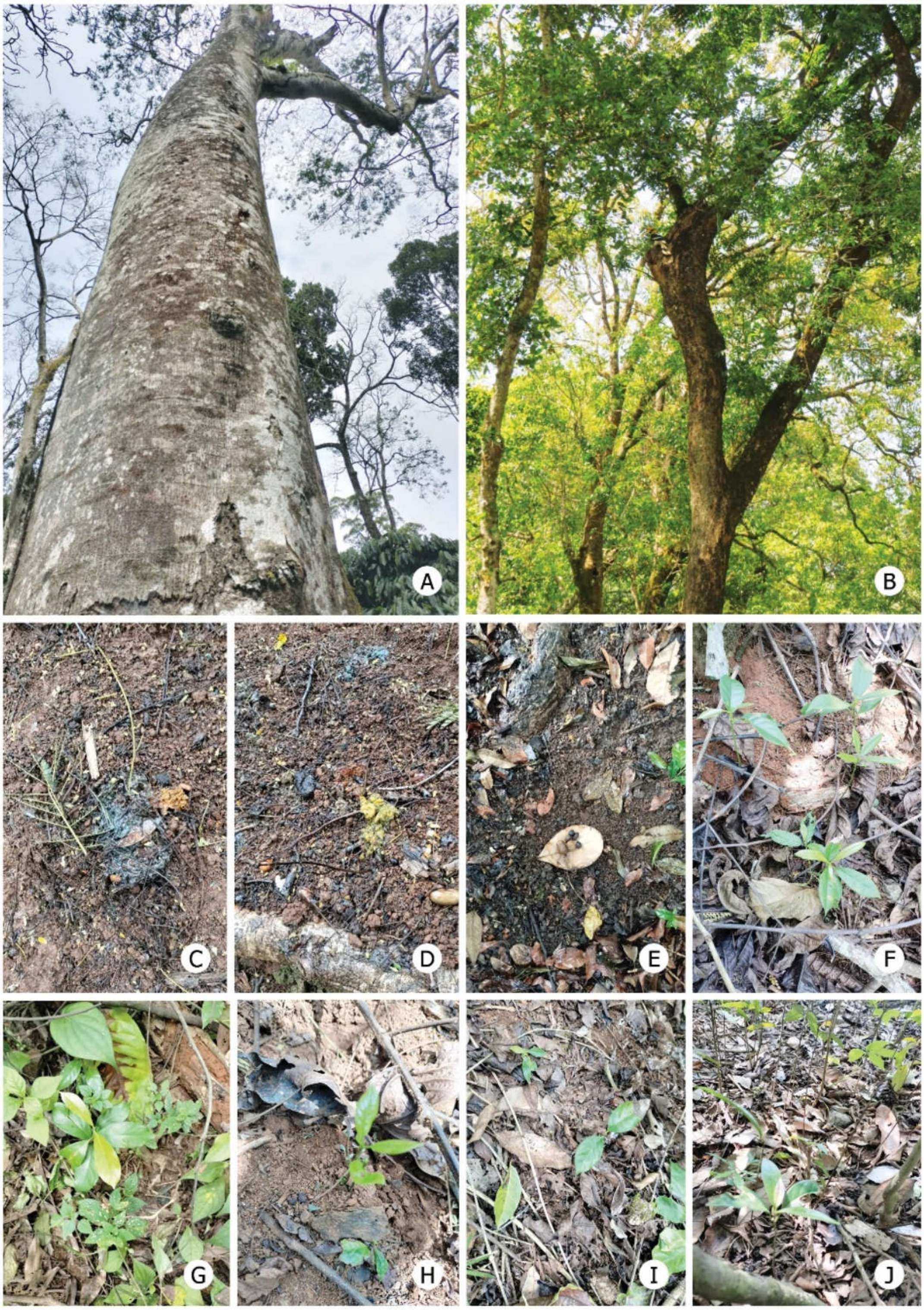


**Figure 7.22. Nesting site Nelliyampathy Victoria estate and Lilly estate: Nelliyampathy Victoria estate nesting site: A**. Nesting tree (*Albizia odoratissima* (L.f.) Benth); **C, D & E.** Fecal under the nesting tree; Lilly estate nesting site: **B.** Nesting tree (*Toona ciliata* M. Roem.); **F, G, H, I & J.** Seedlings under the nesting tree.

**Diversity Index of Nesting Plots.**

Comparing the diversity indices of tree species in all 8 nesting plots using Shannon index showed variation from 1.9 to 2.4. The high diversity index was observed in SPNS 2, and the least diversity was found in ANS (diversity index of 1.9).

Comparing the diversity indices of saplings species in all 8 nesting plots using Shannon index showed variation from 2.6 to 3. The high diversity index was observed in PNS 1 and SPNS 1 and the least diversity was found in ANS (diversity index of 2.6) (Figure 7.23.).

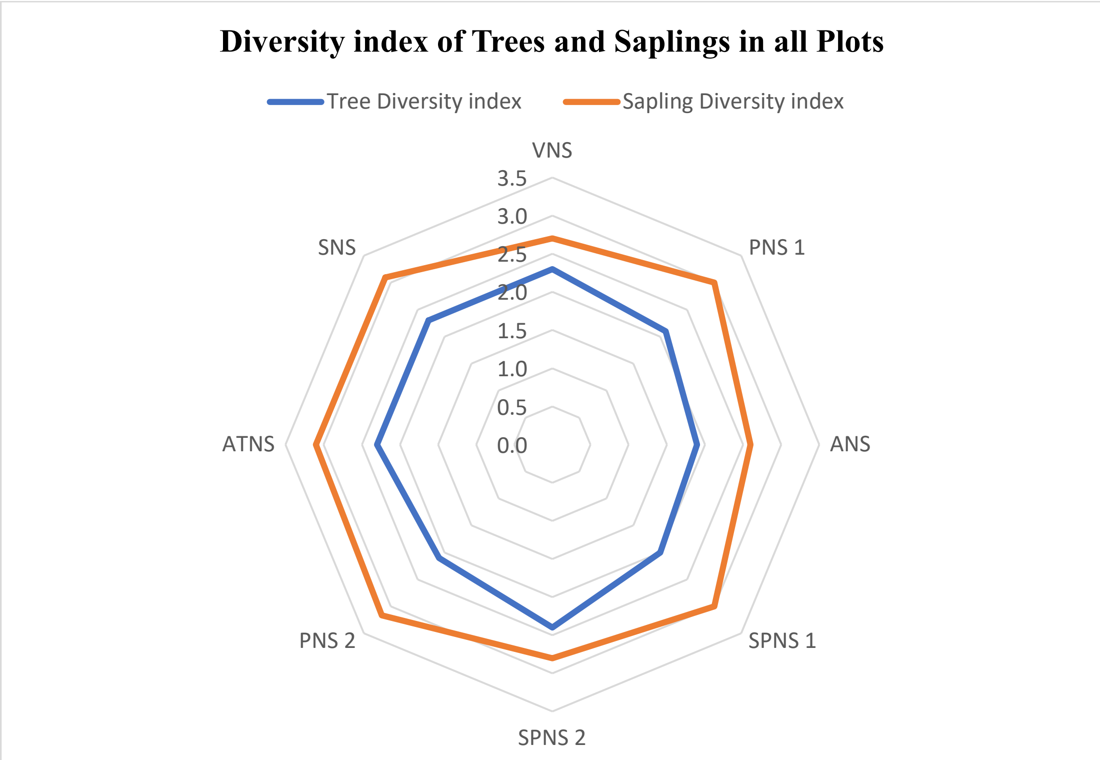


**Figure 7.23. Diversity index in all Plots**

**Population of trees, Saplings and seedlings in the selected Nesting plots**

The number of trees, sapling, and seedling was different in different plots. In each plot, tree species and saplings were enumerated around the nesting tree.

In Plot 1 (VNS), the number of trees was 15, sapling 65 and seedling 107. In Plot 2 (PNS 1), the number of trees was 15, sapling 83 and seedling 110. In Plot 3 (ANS), the number of trees was 11, sapling 58 and seedling 42. In Plot 4 (SPNS 1), the number of trees is 23, sapling 112 and seedling 128. In Plot 5 (SPNS 2), the number of trees is 28, sapling 156 and seedling 131. In Plot 6 (PNS 2), the number of trees is 24, sapling 165 and seedling 110. In Plot 7 (ATNS), the number of trees is 25, sapling 158 and seedling 107. In plot 8 (SNS), the number of trees is 21, sapling 142 and seedling 104 (Figure 7.24).

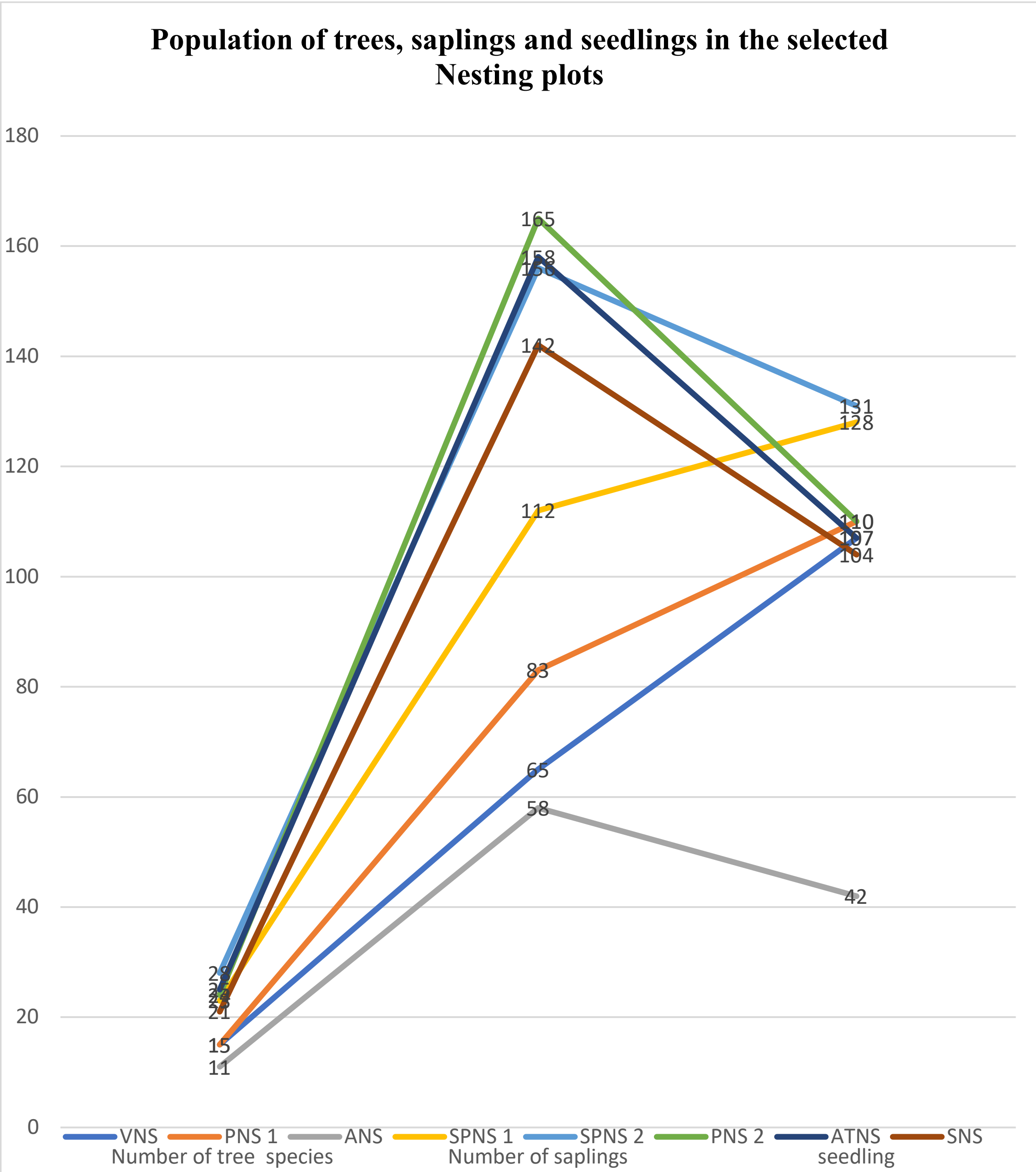


**Figure 7.24. Population of trees, saplings and seedlings in the selected Nesting plots**

The regeneration of a tree species was considered good in a forest area when the seedling diversity is greater than saplings and saplings is greater than tree. There are more common species present between trees and regenerating seedling. There was a total of 98 species of 73 genus belonging to 38 family. The dominant family was Lauraceae represented by 20 species, the other dominant families were Anacardiaceae, Euphorbiaceae, Meliaceae, Myristicaceae, Myrtaceae, Moraceae and Rubiaceae (Figure 7.25.).

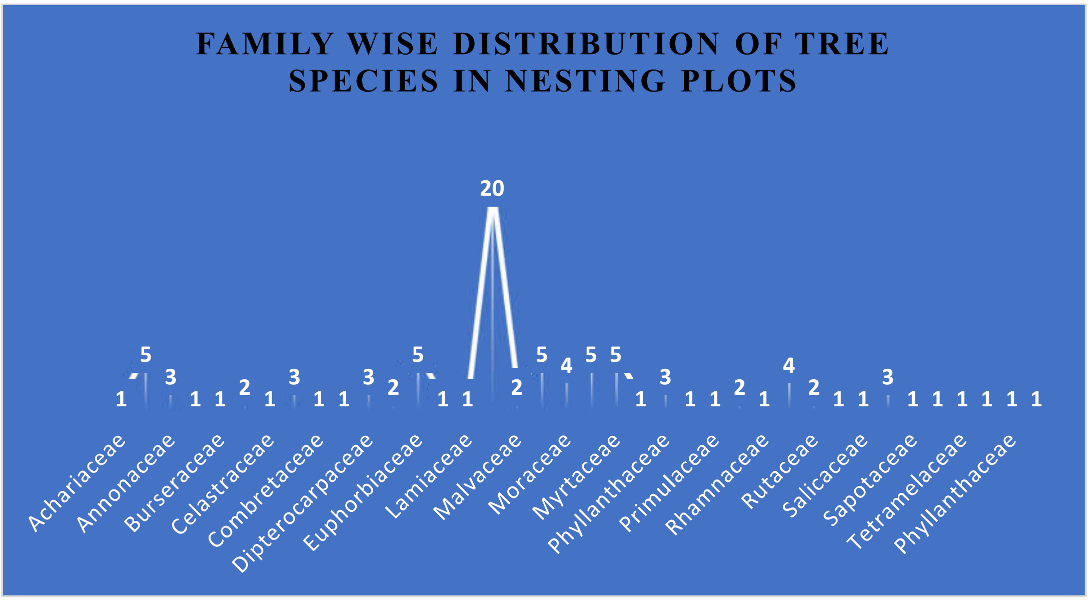


**Figure 7.25. Family wise distribution of tree species in nesting plots**

**Girth class distribution of trees in nesting sites.**

The age class distribution of trees is very important for forest management. It was noticed that in all nesting plots, maximum individuals were found in the lower girth classes that indicated the progressing level of the ecosystem by the sapling population of hornbill dispersed seeds (Figure 7.26.). In the present study, the minimum GBH was found in SPNS1 nesting site 18.02 and maximum GBH was in ATNS, 36.53. A study conducted on major forest ecosystem of Kerala showed that the lowest size of class of 10 to 30 cm GBH was more abundant and are formed 62.91 % of the total density in evergreen forests (Sreejith, *et al.*, 2015). In another study conducted on Western Ghats, similar pattern of girth class distribution was reported by (Pascal & Pelisser, 1996; Ganesh & Davidar, 2001).

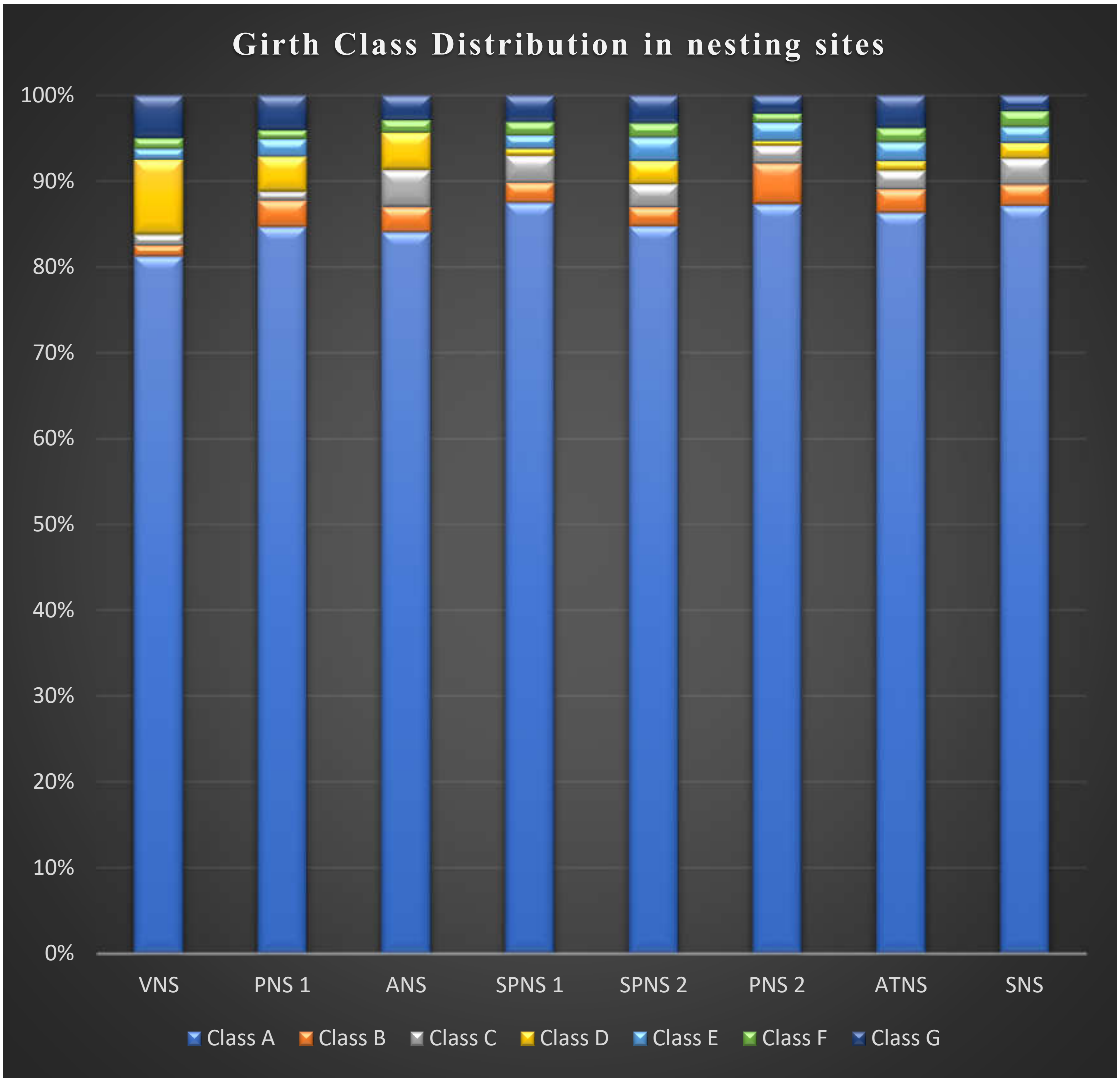


**Figure 7.26. Girth class Distribution in nesting sites.**

**Regeneration of seedlings**

To enumerate the seedlings under the nesting tree, a circular plot was laid around the nesting tree within 2.5 m radius. This 2.5 m circular plot was then divided into four radial quadrants (F1-F4). The quadrants facing the nesting hole was considered F1.

In Plot 1 VNS, a total of 107 seedlings belonging to 17 species were observed. More number of seedlings was present in F1 (48 seedlings 45% of total seedlings), of which 32 seedlings of 6 species were hornbill dispersed. The highest percentage of seedling was *Persea macrantha* (15%) followed by *Cinnamomum malabatrum* and *Elaeocarpus tuberculatus* (12.5% each). *Dipterocarpus indicus* and *Litsea coriaceae* each had 10% of total seedlings. In F2, 27 seedlings were noted (25% of total seedlings) of which hornbill dispersed tree species were only 3. The highest percentage of seedling was *Hopea parviflora* (19%). Other significant species observed were *Terminalia paniculata* and *Kingiodendron pinnatum* (11% each) *Dipterocarpus indicus* and *Chukrasia tabularis* (7% each). In F3, there were 15 seedlings (14% of total seedlings), of which hornbill dispersed tree species were 3. The highest percentage of seedling was *Dipterocarpus indicus* (33%). Other notable species was *Xylia xylocarpa* (13%). In F4, there were 17 seedling (16% of total seedlings), of which no hornbill dispersed tree species were observed (Table 7.17.).

**Table 7.17. Regeneration of Seedlings in Plot 1-VNS**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 4 | 0 | 0 | 0 | 4 |
| 2 | *Hopea parviflora* Bedd. | 1 | 5 | 1 | 2 | 9 |
| 3 | *Dipterocarpus indicus* Bedd. | 5 | 2 | 5 | 4 | 16 |
| 4 | *Chukrasia tabularis* A. Juss. | 2 | 2 | 1 | 1 | 6 |
| 5 | *Schleichera oleosa* (Lour.) Oken | 0 | 1 | 1 | 5 | 7 |
| 6 | *Litsea coriaceae* (B. Heyne ex Nees) Hook.f. | 5 | 0 | 1 | 0 | 2 |
| 7 | *Persea macrantha* (Nees) Kosterm. | 7 | 1 | 1 | 0 | 9 |
| 8 | *Terminalia paniculata* Roth | 0 | 3 | 0 | 3 | 6 |
| 9 | *Elaeocarpus tuberculatus* Roxb. | 6 | 1 | 0 | 0 | 7 |
| 10 | *Alseodaphne semecarpifolia* Nees | 0 | 1 | 1 | 1 | 3 |
| 11 | *Calophyllum polyanthum* Wall.ex Choisy | 1 | 2 | 0 | 0 | 3 |
| 12 | *Bombax ceiba* L. | 3 | 2 | 1 | 0 | 6 |
| 13 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 0 | 3 | 0 | 1 | 4 |
| 14 | *Xylia xylocarpa* (Roxb.)Taub. | 0 | 2 | 2 | 0 | 4 |
| 15 | *Olea dioica* Roxb. | 4 | 1 | 0 | 0 | 5 |
| 16 | *Cinnamomum malabatrum* (Burm.f.) Persl | 6 | 1 | 0 | 0 | 1 |
| 17 | *Myristica beddomei* King | 4 | 0 | 1 | 0 | 5 |
| | | **48** | **27** | **15** | **17** | **107** |

In Plot 2 PNS 1, total 110 seedlings belong to 15 species were observed. More number of seedlings was present in F1, 48 seedlings (44% of total seedlings), of which hornbill dispersed species were 9 (37 seedlings). The highest percentage of seedlings was *Persea macrantha* and *Reinwardtiodendron anamalaiense* (15% each) followed by *Palaquium ellipticum* (13%), *Neolitsea cassia* and *Tetrameles nudiflora* (10% each).

In F2, 20 seedlings were present (18% of total seedlings), of which 3 species were hornbill dispersed (5 seedlings). The highest percentage of seedlings was of *Ziziphus rugosa* and *Tetrameles nudiflora* (25% each) followed by *Schleichera oleosa* (15%). In F3, 19 seedlings were present (17% of total seedlings), of which hornbill dispersed tree species were 3 (*Persea macrantha*, *Palaquium ellipticum* and *Cinnamomum* sps.) (3 seedlings). The highest percentage of seedlings was *Vateria indica* and *Tetrameles nudiflora* (37% each). In F4, 23 seedlings were present (21% of total seedlings), of which *Knema attenuata* was the only hornbill dispersed species. The highest percentage of seedlings was *Tetrameles nudiflora* (52%) (Table 7.18.).

**Table 7.18. Regeneration of Seedlings in Plot 2-PNS 1**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 4 | 2 | 0 | 2 | 8 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 7 | 1 | 1 | 0 | 9 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 6 | 2 | 1 | 0 | 9 |
| 4 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | 7 | 0 | 0 | 0 | 7 |
| 5 | *Vateria indica* L. | 0 | 0 | 7 | 3 | 10 |
| 6 | *Neolitsea cassia* (L.) Kosterm. | 5 | 0 | 0 | 0 | 5 |
| 7 | *Actinodaphne* sps. | 4 | 0 | 0 | 0 | 4 |
| 8 | *Schleichera oleosa* (Lour.) Oken | 3 | 3 | 0 | 1 | 7 |
| 9 | *Cinnamomum* sps. | 0 | 0 | 1 | 0 | 1 |
| 10 | *Terminalia paniculata* Roth | 1 | 2 | 1 | 4 | 8 |
| 11 | *Aglaia* sps. | 1 | 0 | 0 | 0 | 1 |
| 12 | *Ziziphus rugosa* Lam. | 0 | 5 | 1 | 1 | 7 |
| 13 | *Phoebe lanceolata* (Nees) Nees | 2 | 0 | 0 | 0 | 2 |
| 14 | *Myristica beddomei* King | 3 | 0 | 0 | 0 | 3 |
| 15 | *Tetrameles nudiflora* R. Br. | 5 | 5 | 7 | 12 | 29 |
| | | **48** | **20** | **19** | **23** | **110** |

In Plot 3 ANS, 42 seedlings belong to 11 species were observed. More number of seedlings was present in F1, 22 seedlings were present (52% of total seedlings), of which 8 species were hornbill dispersed (19 seedlings). Highest percentage of seedling was *Palaquium ellipticum* (23%) followed by *Persea macrantha* (18%), *Cinnamomum malabatrum* (14%), *Actinodaphne wightiana* (9%), and *Litsea* sps, (9%). *Myristica beddomei* showed 10% of seedlings, *Elaeocarpus tuberculatus* showed least seedlings (5%). In F2, 3 seedlings (7% of total seedlings) of 2 species were present, in which *Palaquium ellipticum* was the only hornbill dispersed tree. The other species present was *Schleichera oleosa.* In F3, 9 seedlings (21% of total seedlings) of 3 species were present in which 2 species were hornbill dispersed, *Palaquium ellipticum* and *Litsea* sp. The other species present was *Holigarna arnottiana*. In F4, 8 seedlings (19% of total seedlings) of 4 species were present of which 2 species were hornbill dispersed, *Palaquium ellipticum* (5 seedlings) and *Cinnamomum malabatrum* (single seedling) (Table 7.19.)

**Table 7.19. Regeneration of Seedlings in Plot 3-ANS**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Actinodaphne wightiana* (Kuntze) Noltie | 2 | 0 | 0 | 0 | 2 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 4 | 0 | 0 | 0 | 4 |
| 3 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 0 | 0 | 1 | 1 |
| 4 | *Elaeocarpus tuberculatus* Roxb. | 1 | 0 | 0 | 0 | 1 |
| 5 | *Holigarna arnottiana* Wall.ex Hook.f. | 1 | 0 | 4 | 0 | 5 |
| 6 | *Elastostema lineolatum* Wight | 0 | 0 | 0 | 1 | 1 |
| 7 | *Litsea* sps. | 2 | 0 | 1 | 0 | 3 |
| 8 | *Myristica beddomei* King | 2 | 0 | 0 | 0 | 2 |
| 9 | *Cinnamomum malabatrum* (Burm.f.) Persl | 3 | 0 | 0 | 1 | 4 |
| 10 | *Schleichera oleosa* (Lour.) Oken | 2 | 1 | 0 | 0 | 3 |
| 11 | *Palaquium ellipticum* (Dalzell) Baill. | 5 | 2 | 4 | 5 | 16 |
| | | **22** | **3** | **9** | **8** | **42** |

In Plot 4 SPNS 1, a total of 128 seedlings belongs to 16 species were observed. More number of seedlings was present in the F1, 54 seedlings (42% of total seedlings) of which 9 species were hornbill dispersed (42 seedlings). Higher percentage of seedlings was of *Myristica beddomei* and *Syzygium* sps (13% each). The other notable seedlings observed were *Knema attenuate* (11%) and *Palaquium ellipticum*, *Aphanamixis polystachya* (9% each), *Dysoxylum malabaricum* (7%), *Reinwardtiodendron anamalaiense* (6%), *Cryptocarya* sps, (6%) and *Diospyros crumenata* (4%). In F2, 25 seedlings were present (20% of total seedlings), of which *Syzygium* sps was the only hornbill dispersed species. Higher percentage of seedlings observed were *Vateria indica* (28%), *Artocarpus heterophyllus* (24%) and *Otonephelium stipulaceum* (20%). In F3, 23 seedlings were present (18% of total seedlings) of which 3 species were hornbill dispersed (3 seedlings). *Knema attenuate, Myristica beddomei* and *Palaquium ellipticum* (4% each). The higher percentage of seedlings was *Otonephelium stipulaceum* (30%). In F4, 26 seedlings were present (20% of total seedlings) in which *Knema attenuata* (4%) was the only hornbill dispersed species (1 seedling). Higher percentage of seedlings was of *Artocarpus heterophyllus* (27%) (Table 7.20.)

**Table 7.20. Regeneration of Seedlings in Plot 4-SPNS 1**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Vateria indica* L. | 3 | 7 | 6 | 4 | 20 |
| 2 | *Cullenia exarillata* A. Robyns | 1 | 0 | 2 | 2 | 5 |
| 3 | *Myristica beddomei* King | 7 | 0 | 1 | 0 | 8 |
| 4 | *Calophyllum polyanthum* Wall.ex Choisy | 0 | 1 | 0 | 3 | 4 |
| 5 | *Schleichera oleosa* (Lour.) Oken | 2 | 4 | 1 | 4 | 11 |
| 6 | *Artocarpus heterophyllus* Lam. | 4 | 6 | 4 | 7 | 21 |
| 7 | *Diospyros crumenata* Thw. | 2 | 0 | 0 | 0 | 2 |
| 8 | *Syzygium* sps. | 7 | 2 | 0 | 0 | 9 |
| 9 | *Aphanamixis polystachya* (Wall). R.N.Parker | 5 | 0 | 0 | 0 | 5 |
| 10 | *Xanthophyllum flavescens* Roxb. | 2 | 0 | 0 | 1 | 3 |
| 11 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 6 | 0 | 1 | 1 | 8 |
| 12 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 5 | 7 | 4 | 16 |
| 13 | *Cryptocarya* sps. | 3 | 0 | 0 | 0 | 3 |
| 14 | *Palaquium ellipticum* (Dalzell) Baill. | 5 | 0 | 1 | 0 | 6 |
| 15 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | 3 | 0 | 0 | 0 | 3 |
| 16 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 4 | 0 | 0 | 0 | 4 |
| | | **54** | **25** | **23** | **26** | **128** |

In Plot 5 SPNS 2, 131 seedlings were present belonging to 20 species. In F1, 36 individuals were found (27% of total seedlings) of which 10 species were hornbill dispersed (25 seedlings). *Phoebe lanceolata* (8% ), *Persea macrantha, Palaquium ellipticum, Litsea* sps, *Actinodaphne* sps, *Litsea oleoides*, (8%), *Dysoxylum malabaricum*, *Elaeocarpus tuberculatus*, *Cryptocarya* sps and *Myristica beddomei* (6%). In F2, 20 seedlings were observed (15% of total seedlings) in which 5 species were hornbill dispersed species (5 seedlings). Higher percentage of seedlings was of *Mallotus philippensis* (25%) and *Bombax ceiba* (20%). In F3, 31 seedlings were found (24% of total seedlings) of which no species were hornbill dispersed. Higher percentage of seedling was of *Chukrasia tabularis* (26%). In F4, 44 seedlings were noted (36% of total seedlings) of which 2 seedlings of 2 species were hornbill dispersed species; *Persea macrantha* and *Phoebe lanceolata* (2% each). Here also higher percentage of seedling was of *Chukrasia tabularis* (26%) (Table 7.21.)

**Table 7.21. Regeneration of Seedlings in Plot 5-SPNS2**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Turpinia malabarica* Gamble | 0 | 1 | 2 | 7 | 6 |
| 2 | *Litsea* sps. | 3 | 0 | 0 | 0 | 3 |
| 3 | *Persea macrantha* (Nees) Kosterm. | 3 | 1 | 0 | 1 | 5 |
| 4 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 1 | 0 | 0 | 4 |
| 5 | *Mallotus philippensis* (Lam.) Mull.Arg. | 1 | 5 | 0 | 4 | 10 |
| 6 | *Myristica beddomei* King | 2 | 2 | 0 | 0 | 4 |
| 7 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 2 | 0 | 0 | 0 | 2 |
| 8 | *Chukrasia tabularis* A. Juss. | 1 | 1 | 8 | 11 | 21 |
| 9 | *Actinodaphne wightiana* (Kuntze) Noltie | 3 | 0 | 0 | 0 | 3 |
| 10 | *Schleichera oleosa* (Lour.) Oken | 0 | 0 | 6 | 4 | 10 |
| 11 | *Aporosa acuminata* Thw. | 1 | 2 | 1 | 1 | 5 |
| 12 | *Bombax ceiba* L. | 5 | 4 | 6 | 10 | 25 |
| 13 | *Garcinia gummi-gutta* (L.) Robs. | 0 | 0 | 0 | 0 | 12 |
| 14 | *Elaeocarpus tuberculatus* Roxb. | 2 | 0 | 0 | 0 | 2 |
| 15 | *Litsea oleoides* (Meissn.) Hook. f. | 3 | 0 | 0 | 0 | 3 |
| 16 | *Phoebe lanceolata* (Nees) Nees | 4 | 1 | 0 | 1 | 6 |
| 17 | *Melicope lunu-ankenda* (Gaertn.) T.G. Hartley | 1 | 0 | 4 | 5 | 10 |
| 18 | *Mesua ferrea* L. | 0 | 1 | 4 | 0 | 5 |
| 19 | *Poeciloneuron indicum* Bedd. | 0 | 1 | 0 | 0 | 1 |
| 20 | *Cryptocarya* sps. | 2 | 0 | 0 | 0 | 2 |
| | | **36** | **20** | **31** | **44** | **131** |

In Plot 6 PNS 2, total 110 seedlings belong to 18 species were observed. In F1, 43 seedlings were found (39%) of which 34 seedlings belonging to 10 species were hornbill dispersed. *Litsea floribunda* (9%), *Dysoxylum malabaricum* (9%), *Phoebe lanceolata* (9%), *Knema attenuate* (9%), *Cinnamomum* sps (12%), *Aglaia* sps (5%), *Litsea oleoides* (5%) *Canarium strictum* (7%), *Myristica beddomei* (7%) and *Cryptocarya* sps. (7%). In F2, 25 seedlings were present (23% of total seedlings) of which hornbill dependent seedlings were of *Cinnamomum* sp., *Aglaia* sps., *Knema attenuata* and *Phoebe lanceolata* (4% each) (1 seedling). Higher percentage of seedlings was of *Schleichera oleosa* (22%). In F3, 23 seedlings were found (21% of total seedlings) of which 2 species were hornbill dependent *Cinnamomum* sps. and *Litsea floribunda* (9% each) (2 seedlings). Higher percentage of seedlings was of *Cullenia exarillata* (21%). In F4, 19 seedlings (17% of total seedlings) were noted of which no species were hornbill dispersed (Table 7.22.)

**Table 7.22. Regeneration of Seedlings in Plot 6-PNS 2**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Cullenia exarillata* A. Robyns. | 0 | 0 | 4 | 4 | 8 |
| 2 | *Cinnamomum* sps. | 5 | 1 | 2 | 0 | 8 |
| 3 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 0 | 0 | 1 | 3 | 4 |
| 4 | *Polyalthia coffeoides* (Thw.) J. Hk &Thoms. | 1 | 1 | 2 | 1 | 5 |
| 5 | *Litsea floribunda* Gamble | 4 | 0 | 2 | 0 | 6 |
| 6 | *Schleichera oleosa* (Lour.) Oken | 2 | 0 | 5 | 4 | 11 |
| 7 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 4 | 0 | 0 | 0 | 4 |
| 8 | *Aglaia* sps. | 2 | 1 | 0 | 0 | 3 |
| 9 | *Litsea oleoides* (Meissn.) Hook. f. | 2 | 0 | 0 | 0 | 2 |
| 10 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 4 | 1 | 0 | 0 | 5 |
| 11 | *Myristica beddomei* King | 3 | 0 | 0 | 0 | 3 |
| 12 | *Alseodaphne semecarpifolia* Nees | 1 | 2 | 1 | 2 | 6 |
| 13 | *Drypetes* sps. | 1 | 4 | 1 | 1 | 7 |
| 14 | *Canarium strictum* Roxb. | 3 | 0 | 0 | 0 | 3 |
| 15 | *Cryptocarya* sps. | 3 | 0 | 0 | 0 | 3 |
| 16 | *Calophyllum polyanthum* Wall.ex Choisy | 4 | 7 | 4 | 3 | 18 |
| 17 | *Phoebe lanceolata* (Nees) Nees | 4 | 1 | 0 | 0 | 5 |
| 18 | *Vateria indic*a L. | 0 | 7 | 1 | 1 | 9 |
| | | **43** | **25** | **23** | **19** | **110** |

In Plot 7 ATNS, total 107 seedlings belong to 14 species were observed. In F1, 47 seedlings were found (44% of total seedlings) of which 33 seedlings belonging to 8 species were hornbill dispersed. *Palaquium ellipticum* (15%), *Litsea oleoides* (13%), *Canarium strictum* (11%), *Myristica beddomei* and *Elaeocarpus tuberculatus* (9% each), *Dysoxylum malabaricum* (6%), *Persea macrantha* (4%) and *Litsea floribunda* (4%). In F2, 25 seedlings were present (23% of total seedlings) of which hornbill dependent seedlings were 3 seedlings of *Myristica beddomei*, *Palaquium ellipticum* and *Persea macrantha* (4% each). Higher percentage of seedlings was of *Mesua ferrea* (40%). In F3, 18 seedlings were found (17% of total seedlings) of which *Litsea floribunda* (6%) was the only hornbill dependent species (1 seedling). Higher percentage of seedlings was of *Mesua ferrea* (56%). In F4, 17 seedlings were found (16% of total seedlings) in which *Litsea floribunda* (12%) was the only hornbill dependant species (1 seedling). Here also higher percentage of seedlings was of *Mesua ferrea* (47%) (Table 7.23.).

**Table 7.23. Regeneration of Seedlings in Plot 7- ATNS**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Persea macrantha (*Nees) Kosterm. | 2 | 1 | 0 | 0 | 3 |
| 2 | *Vateria indica* L. | 2 | 7 | 1 | 0 | 10 |
| 3 | *Litsea oleoides* (Meissn.) Hook. f. | 6 | 0 | 0 | 0 | 6 |
| 4 | *Myristica beddome*i King | 4 | 1 | 0 | 0 | 5 |
| 5 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 3 | 0 | 0 | 0 | 3 |
| 6 | *Palaquium ellipticum* (Dalzell) Baill. | 7 | 1 | 0 | 0 | 8 |
| 7 | *Antidesma montanum* Blume | 0 | 1 | 0 | 4 | 5 |
| 8 | *Litsea floribunda* Gamble | 2 | 0 | 1 | 2 | 5 |
| 9 | *Canarium strictum* Roxb. | 5 | 0 | 0 | 0 | 5 |
| 10 | *Elaeocarpus variabilis* Zmarzty | 4 | 0 | 0 | 0 | 4 |
| 11 | *Elastostema acuminatum* (Poir.) Brongn. | 0 | 1 | 2 | 0 | 3 |
| 12 | *Holigarna arnottiana* Wall.ex Hook.f. | 5 | 1 | 4 | 1 | 11 |
| 13 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 3 | 2 | 0 | 2 | 7 |
| 14 | *Mesua ferrea* L. | 4 | 10 | 10 | 8 | 32 |
| | | **47** | **25** | **18** | **17** | **107** |

In Plot 8 SNS, total 104 seedlings belong to 14 species were observed. In F1, 47 seedlings were found (45% of total seedlings) of which 28 seedlings belonging to 6 species were hornbill dispersed. They were *Knema attenuata* (15%), *Myristica beddomei* (11%), *Litsea floribunda* (9%), *Canarium strictum* (9%), *Cryptocarya* sps, (9%) and *Persea macrantha* (9%). In F2, 23 seedlings were present (22% of total seedlings), of which hornbill dispersed seedlings were 3 seedlings of *Myristica beddomei*, *Litsea floribunda* and *Persea macrantha* (4% each). The highest percentage of seedlings was of *Tetrameles nudiflora* (22%). In F3, 20 seedlings were found (19% of total seedlings) of which no hornbill dependent tree species were noticed. The highest percentage of seedlings was also *Tetrameles nudiflora* (35%). In F4, 14 seedlings were present (13% of total seedlings) of which *Myristica beddomei* (7%) was the only hornbill dispersed species. The highest percentage of seedlings was of *Mesua ferrea* (36%) (Table 7.24.).

**Table 7.24. Regeneration of Seedlings in Plot 8- SNS**

| Sl No | Name of species | F1 | F2 | F3 | F4 | Total |
|---|---|---|---|---|---|---|
| 1 | *Myristica beddomei* King | 5 | 1 | 0 | 1 | 7 |
| 2 | *Eugenia argentea* Bedd. | 1 | 4 | 1 | 3 | 9 |
| 3 | *Psychotria anamalayana* Bedd. | 0 | 1 | 4 | 1 | 6 |
| 4 | *Persea macrantha* (Nees) Kosterm. | 4 | 1 | 0 | 0 | 5 |
| 5 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 7 | 0 | 0 | 0 | 7 |
| 6 | *Mallotus philippensis* (Lam.) Mull.Arg. | 2 | 4 | 5 | 2 | 13 |
| 7 | *Litsea floribunda* Gamble | 4 | 1 | 0 | 0 | 5 |
| 8 | *Dendrocnide sinuata* (Bi.) Chew | 1 | 1 | 0 | 0 | 2 |
| 9 | *Alseodaphne semecarpifolia* Nees | 1 | 1 | 0 | 0 | 2 |
| 10 | *Mesua ferrea* L. | 3 | 4 | 3 | 5 | 15 |
| 11 | *Palaquium ellipticum* (Dalzell) Baill. | 4 | 0 | 0 | 0 | 4 |
| 12 | *Tetrameles nudiflora* R. Br. | 7 | 5 | 7 | 2 | 21 |
| 13 | *Canarium strictum* Roxb. | 4 | 0 | 0 | 0 | 4 |
| 14 | *Cryptocarya* sps. | 4 | 0 | 0 | 0 | 4 |
| | | **47** | **23** | **20** | **14** | **104** |

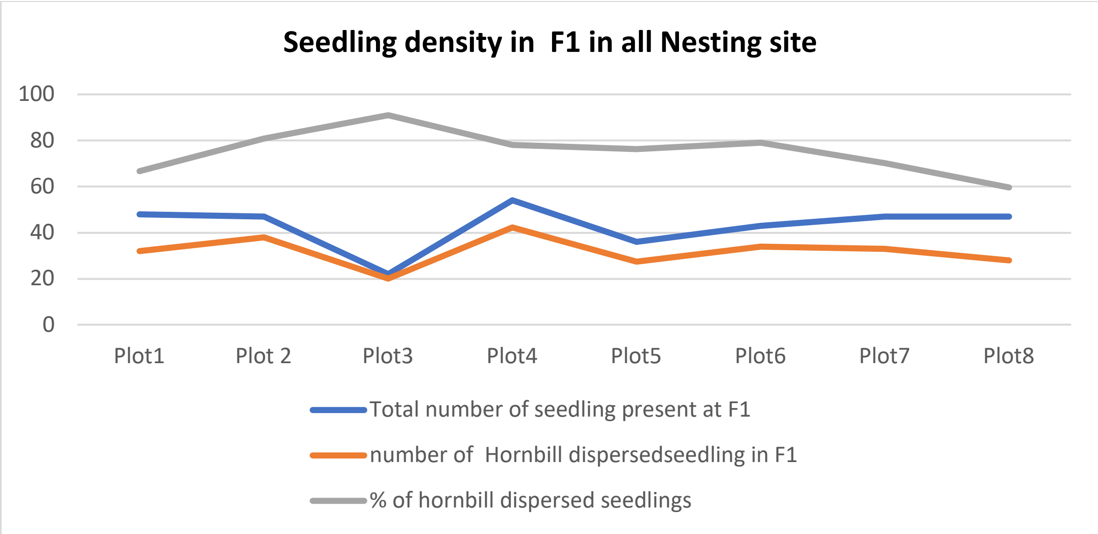


**Figure 7.27. Seedling density in F1 in all Nesting site**

**Seedling density in F1 in all Nesting site**

This study showed that a greater number of seedlings was present in F1 subplot which was facing towards Great hornbill nest. Total 20 species of seedlings were noticed here which were considered as hornbill dispersed. More seedlings were showed by *Myristica beddomei* (30 seedlings), *Persea macrantha* (28), *Palaquium ellipticum* (24), *Knema attenuata* (20), *Dysoxylum malabaricum* and *Litsea* sps. (19) *Elaeocarpus tuberculatus* (13), *Phoebe lanceolata* (16), *Cryptocarya* sps. and *Canarium strictum* (12), *Litsea oleoides* (11), *Reinwardtiodendron anamalaiense* (10), *Cinnamomum* sps. (8), *Syzygium* sps. (7), *Neolitsea* sps , *Actinodaphne* sps. (5), *Aphanamixis polystachya* (5), *Aglaia* sps. (3), *Diospyros* sps. (2), coming under the family Lauraceae 8, Meliaceae 4, Myristicaceae 2, Burseraceae, Ebenaceae, Elaeocarpaceae, Myrtaceae, Sapotaceae one species each (Table 7.25., Figure 7.27.).

**Table 7.25. Number of hornbill dispersed species present in 8 Nesting Plots**

| Sl No | Name of Species | Plot 1 | Plot 2 | Plot 3 | Plot 4 | Plot 5 | Plot 6 | Plot 7 | Plot 8 | Total Number of species |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Myristica beddomei* King | 4 | 3 | 2 | 7 | 2 | 3 | 4 | 5 | 30 |
| 2 | *Persea macrantha* (Nees) Kosterm. | 7 | 7 | 5 | 0 | 3 | 0 | 2 | 4 | 28 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 0 | 5 | 4 | 5 | 3 | 0 | 7 | 0 | 24 |
| 4 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 0 | 4 | 0 | 5 | 0 | 4 | 0 | 7 | 20 |
| 5 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 4 | 0 | 2 | 4 | 2 | 4 | 3 | 0 | 19 |
| 6 | *Litsea* sps. | 8 | 0 | 1 | 0 | 0 | 4 | 2 | 4 | 19 |
| 7 | *Elaeocarpus tuberculatus* Roxb. | 6 | 0 | 1 | 0 | 2 | 0 | 4 | 0 | 13 |
| 8 | *Phoebe lanceolata* (Nees) Nees | 4 | 2 | 2 | 0 | 4 | 4 | 0 | 0 | 16 |
| 9 | Cryptocarya sps. | 0 | 0 | 0 | 3 | 2 | 3 | 0 | 4 | 12 |
| 10 | *Canarium strictum* Roxb. | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 4 | 12 |
| 11 | *Litsea oleoides* (Meisn.) J.Hk | 0 | 0 | 0 | 0 | 3 | 2 | 6 | 0 | 11 |
| 12 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | 0 | 7 | 0 | 3 | 0 | 0 | 0 | 0 | 10 |
| 13 | *Cinnamomum* sps. | 0 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 8 |
| 14 | *Syzygium* sps. | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 7 |
| 15 | *Neolitsea* sps. | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 16 | *Actinodaphne* sps. | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 5 |
| 17 | *Aphanamixis polystachya* (Wall). R.N.Parker | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 5 |
| 18 | *Phoebe lanceolata* (Nees) Nees | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 19 | *Aglaia* sps. | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 3 |
| 20 | *Diospyros crumenata* Thw. | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |

## Discussion

To evaluate the role of hornbill as a primary seed dispersal and germination, detailed phytosociological studies on Great hornbill nesting site were done which showed high percentage hornbill dispersed tree, seedling and saplings. In Vazhachal nesting site, located at low riparian area having 274 m altitudes dominated by nesting tree, the presence of hornbill supported 65 saplings of which 16 were hornbill dispersed one.

In Pottenmopu nesting site, good growth was found and support many trees which come under endangered and threatened category. A good growth of sapling was found, 110 of which 18 species were hornbill dispersed.

In one site at Ambalapara IB, the regeneration was less due to forest fire and secondary forest developed gradually. Species like *Palaquium ellipticum*, *Litsea stocksii*, *Actinodaphne bourdillonii*, *Myristica beddomei* and *Litsea floribunda* were observed here. Presence of *Actinodaphne* is a symbol of secondary forest, 16 species of saplings found here is a sign of regeneration of forest. Hornbill dispersed trees from this site included *Actinodaphne wightiana*, *Persea macrantha*, *Litsea coriaceae*, *Litsea floribunda*, *Myristica beddomei*, *Cinnamomum malabatrum*, *Aphanamixis polystachya* and *Palaquium ellipticum*. In this plot, 16 species were Great hornbill dispersed trees.

In Nesting Plot Sholayar powerhouse, major area was occupied by *Palaquium ellipticum* although the area showed good tree and sapling diversity. There were Great hornbill dispersed trees like *Myristica beddomei*, *Actinodaphne bourdillonii* Gamble and *Palaquium ellipticum Litsea stocksii, Diospyros montana.* Sapling density was good, 112 saplings including the endangered *Diospyros crumenata.*

In Nesting plot Sholayar Puliveenathodu and Pathadipalam the regeneration was very high and supported thick undergrowth. The area was undisturbed, located at 732 m and 954 m altitudes. Tree species observed included Endangered *Dysoxylum malabaricum* and Vulnerable *Litsea oleoides.* An important non forest timber product producing *Canarium strictum* was also present here. The under-growth was very high in these two sites. 156 saplings were recorded in Puliveenathodu and 165 saplings in Pathadipalam.

In Ambalapara Thandu, forest fire happened in 2004, however, hornbill nesting is frequent here. 25 tree species and 158 saplings were found here. Regeneration was very fast here and supported endangered species like and *Dysoxylum malabaricum*, vulnerable *Litsea oleoides,* Near Threatened *Palaquium ellipticum*, *Litsea floribunda* and *Litsea wightiana.*

Nesting plot Sheikalmudi of Parambikulam area, situated at 1100 m altitude, was an undisturbed area, supported 21 tree species including endangered *Myristica beddomei* sub sp *sphaerocarpa, Alseodaphne semecarpifolia* and *Litsea floribunda* which is a Near Threatened species and *Diospyros candolleana* which is a Vulnerable species. The undergrowth was very high with 142 saplings. One new species *Cryptocarya sheikelmudiyana* was reported from here during the study period.

In Nelliyampathy, two nesting sites were selected, one at Lilly estate and another one at Victoria estate. These areas were plantations. Several seed rains were found in these regions but sapling and seedling density was nil due to the application of pesticide. The absence of large old growth tree with a natural hole, the poor availably of hornbill diet reduced the nesting of hornbill thereby reducing the mutualistic relationship between hornbills and their dispersing tree vital for the maintenance of tree diversity in tropical evergreen forests (Figure 7.22.).

A study conducted by (Kannan & James, 1997), suggested that 19 fruit species delivered to the nest midden and nesting plot data showed 20 species of seedlings in F1 sub plot under the family Lauraceae, Meliaceae, Myristicaceae, Burseraceae, Ebenaceae, Elaeocarpaceae, Myrtaceae and Sapotaceae. (Mudappa, 2000) noticed that tree species with large fruits, such as *Myristica* and *Beilschmiedia*, appear to depend exclusively on large frugivores such as hornbills and imperial pigeons for dispersal. In present study, in all nesting location, more seedlings were of *Myristica beddomei* was observed. *Beilschmiedia* sps. was observed only in Victoria estate plot in Nelliyampathy. A study conducted by (Bachan, 2006) in Vazhachal forest area showed that Great hornbills prefer fruits of *Palaquium ellipticum*, *Syzygium* sps., *Vitex altissima*, *Buchanania axillaris* and *Myristica* sps. The present study noticed the occurrence of seeds and seedlings of *Palaquium ellipticum* and *Myristica* sps. in all nesting sites. In all nesting sites, the occurrence of more species diversity of hornbill dispersed tree species were noticed. The same result was observed by (Naniwadekar *et al.,* 2021), hornbills make a fruit orchard consisting of hornbill food species having rare species being with common species thus make a species diversity.

The study by (James & Kannan, 2009;  Das, 2014) showed that the Great hornbill required large old growth trees for their nesting and hence conservation of this species requires the protection of large old growth trees. In the present study, all nesting trees were old growth trees having a GBH of about 4 m. In all nesting sites, the hornbill regurgitated seeds were  undamaged. The same result was obtained by (Kinnaird, 1998)  in Sulawesi Red-Knobbed hornbill.

A study of regeneration by Indian Grey hornbill by (Santhosh Kumar & Balasubramanian, 2011) showed that seedlings of 24 food plant species were recorded under the nest and 4 times a greater number of seedlings found in front of the nest than behind. In the present study also, greater number of seedlings was noticed in front of the hornbill nest.

A study on Ittiani forests of Athirappilly range under Vazhachal forest division revealed the presence of about 83 species of plants belonging to 39 families in the study area. The Simpson value index is 0.17 and Shannon diversity index 2.38 (Sreepriya *et al*., 2007). In another study, assessing the biodiversity in mid elevation undisturbed forest in the Agasthyamala range of Southern Western Ghats established the occurrence of 173 woody plant species from 58 families, 3.82 ha areas should be transected (Ganesh *et al*., 1996). However, present study explored the occurrence of 98 woody plants of 73 genus belonging to 38 family in 1.28 ha. and Shannon diversity index of tree in Sholayar Puliveenathodu nesting site was 2.4 for trees and sapling diversity index at Sheikalmudi nesting site was  3.1.

During breeding season, Great hornbill feed on large amount of fig species and the faecal matter will have a greater amount of fig seed especially during the early period of nesting, however, no seedlings were observed in neither of the quadrat around the nesting tree. Study showed that they required special condition for seed germination and seedling establishment in host plants (Laman, 1995). The occurrence of hornbill diet species in front of the nest than behind established the role of Great hornbills in seed dispersal and germination. All these studies underline the fact that the hornbills are important seed dispersal agents in tropical forests. Regenerations of hornbill diet plants and tree density is more in front of all the hornbill nesting plots and hence protection of hornbill and hornbill nesting tree are essential for the regeneration of natural forests.

Plants with large fruits and seeds are greatly vulnerable to extinction if they lose their natural seed dispersers. Large frugivores therefore play an important role as seed dispersers and are vulnerable to extinction in the face of selective hunting and habitat loss and degradation (Terborgh & Winter, 1980; Bachan *et al.,* 2011).

CHAPTER 8

# SUMMARY AND CONCLUSION

This study entitled 'Taxonomy, Seed morphology and Ecology of Great hornbill dispersed evergreen forest of the Anamalai part of the Southern Western Ghats, Kerala is a botanical, phytosociological and seed germination study. It explores the plant diversity of Great hornbill dependent species in the Anamalai Part of Southern Western Ghats and reveals the immense relation between this large frugivory and their dispersing trees. In Anamalai part of Southern Western Ghats, a good population of Great hornbill was found.

Great hornbill, *Buceros bicornis*, is a charismatic flagship species of Western Ghats and Northeastern India. They were in proximity of evergreen forests at an elevation from 250 meters to 1500 meters above sea level. Higher numbers were encountered in Parambikulam and Vazhachal reserve forests (Mudappa & Raman, 2008). The Great hornbill and large seeded fruit species maintain a mutualistic relationship by seed dispersal and germination. This study is very significant because the role of seed dispersing agent is very important for ensuring distribution of a species in the forest. The hornbills are such a dispersing agent in the tropical evergreen forests, especially for the members of Lauraceae, Myristicaceae and Meliaceae families, the fruits of which constitute important diet of hornbills.

A detailed taxonomic study was done on selected species in which 4 new species were identified in the genus *Actinodaphne*, *Cryptocarya*, *Neolitsea*, and *Litsea*. One species, *Cryptocarya sheikelmudiyana*, is already published in Journal Taiwania and other three are under publication.

Detailed seed morphological studies were poor in large seeded tree species. The Great hornbill usually prefers brightly colored red or purple and arillated large seeds. Detailed study on seed and fruit morphology was done and a family and genus key based on the fruit and seed morphological characters was prepared. Great hornbill diet was very special. During the nesting season, they started with fig species and then diet changed to other species. The present study, constiting of most hornbill dispersed trees come under families Lauraceae (24 species), Meliaceae (6), Myristicaceae (3), Elaeocarpaceae (2), Sapotaceae (1), Myrtaceae (1), Rhamnaceae (1), Burseraceae (1) and Ebenaceae (1).

The fruiting phenology of tree species is very important since they corelate with the hornbill diet. The study showed that in most of the tree species, fruiting period is hornbill nesting period, especially in genus *Litsea*, *Actinodaphne*, *Neolitsea*, *Persea*, *Cryptocarya*, *Phoebe*, *Elaeocarpus*, *Knema. Myristica*, *Reinwardtiodendron*, *Dysoxylum*, *Canarium*, *Aglaia*, *Aphanamixis*, *Dysoxylum*, *Syzygium*, *Maesopsis* and *Beilschmiedia*. Fruiting and flowering phenology was also examined during the study. Ripe fruits were present in March and April in many Great hornbill dispersed species. Similar pattern was observed in many tropical forests (Sun *et al.,* 1997; Kannan & James, 1997; Kitamura *et al*., 2011).

While studying plant frugivory interaction, it is essential to assess the mutualism quantitively by evaluating the germination of dispersed seeds after passing through the guts of hornbills. The present study showed that Great hornbill regurgitated seeds had high germination percentage, especially in *Actinodaphne wightiana*, *Litsea oleoides* and *Canarium strictum*. Detailed phytosociological examination on Great hornbill nesting site revealed high percentage of hornbill dispersed trees, seedlings, and saplings. Many of this hornbill nesting plots possessed vulnerable tree species (*Garcinia indica*, *Vateria indica*, *Diospyros candolleana*, *Mallotus atrovirens*, *Aglaia barberi*, *Gymnacranthera canarica* and *Litsea oleoides*), some species are Near Threatened (*Meiogyne pannosa*, *Actinodaphne bourdillonii*, *Actinodaphne tadulingamii*, *Alseodaphne semecarpifolia*, *Beilschmiedia wightii*, *Litsea bourdillonii*, *Litsea floribunda*, *Litsea stocksii*, *Litsea wightiana*), some are Endangered (*Dipterocarpus indicus*, *Hopea parviflora*, *Diospyros crumenata*, *Cryptocarya anamalayana*, *Litsea oleoides*, *Dysoxylum malabaricum, Syzygium occidentale* and *Tarenna monosperma* and one species is Critically Endangered (*Cryptocarya sheikelmudiyana*).

The phytosociological data of Great hornbill nesting site indicated the occurrence of *Palaquium ellipticum*, *Tetrameles nudiflora*, *Vateria indica*, *Litsea floribunda*, *Myristica beddomei*, *Litsea coriaceae*, *Dysoxylum malabaricum*, *Schleichera oleosa*, *Mesua ferrea*, *Bombax ceiba*, *Knema attenuata*, *Cullenia exarillata*, *Persea macrantha*, *Chukrasia tabularis* and *Calophyllum polyanthum* as the dominant tree species.

Among the saplings, the dominant species were *Palaquium ellipticum*, *Vateria indica*, *Persea macrantha*, *Chukrasia tabularis*, *Litsea coriaceae*, *Schleichera oleosa*, *Litsea floribunda*, *Knema attenuata*, *Cinnamomum malabatrum*, *Litsea floribunda*, *Elaeocarpus tuberculatus, Mesua ferrea*, *Antidesma montanum* and *Drypetes venusta*.

Comparing the diversity indices of tree species in all 8 nesting plots using Shannon index showed that the high diversity observed was 2.4 and the least diversity was 1.9. Diversity index of saplings showed that highest diversity index was 3.2 and least diversity index was 2.6. Phytosociological analysis of nesting site showed 98 species of woody plants of 73 genus belonging to 38 families. The dominant family was Lauraceae represented by 20 species. The other dominant families were Anacardiaceae, Euphorbiaceae, Meliaceae, Myristicaceae, Myrtaceae, Moraceae and Rubiaceae. Analysis of girth class distribution showed that in all nesting plots, maximum individuals were found in the lower girth classes that indicated the progressing level of the ecosystem by the sapling population of hornbill dispersed seeds. The high diversity in saplings and seedlings indicate the role of Great hornbill maintaining an evergreen habitat around the nesting plots.

During breeding season, Great hornbill feeds large amount of fig species and the faecal matter contains more seeds of fig species, especially during early period of nesting. However, no seedlings were observed around the nesting tree. Study by Laman (1995) showed that special conditions were required for seed germination and seedling establishment of fig species in host plants. Seedlings of 21 food plants were recorded beneath the nesting tree, more seedlings were found in front of the nest (in F1) than behind. Most of the seedlings were of *Myristica*, *Persea*, *Palaquium*, *Knema* and *Dysoxylum*. The occurrence of hornbill diet species in front of the nest than behind is a clear indication of the role of Great hornbill in seed dispersal and germination in the forest. All these studies pointed out the fact that the hornbills are important seed dispersal agents in tropical forests. Existence of Great hornbill is essential for the regeneration of natural forests since most of the evergreen forest species are dispersed by Great hornbills. In India, nine species of hornbills are known (Ali & Ripley, 1987) of which four are safe, three are near threatened and two are vulnerable. Most species of hornbills in India are facing severe survival pressure due to fragmentation of the wet evergreen habitats, poaching of adults at the time of nesting (Ali & Ripley, 1987). If timely action is not taken, this will eventually lead to the disappearance of evergreen forests.

# CHAPTER 9
# RECOMMENDATIONS

The present study had resulted in detailed understanding of vegetation and nesting habitat preference of Great hornbills. This knowledge can be extended to other administrative areas to attain better management of the forest ecosystem. The study established the fact that Great hornbill plays an important role in the regeneration of evergreen forests. Monitoring of the hornbill with the involvement of local indigenous community will be a progressive step towards sustainable management of the forest.

- ❖ Awareness porgrammes targeting the communities living in close proximity of the forest about the significance of hornbill in seed germination will also help to minimize the anthropolegic pressure on the forests.
- ❖ Great hornbill prefers large trees for their nesting. It is the need of the hour to take necessary steps to ensure the conservation of large trees. Many of the hornbill dependent trees are medicinally and economically valuable. More studies are needed in this area to explore the potential aspects of these trees.
- ❖ Using advanced technologies like camera traps and computer modeling, tracing of the seed dispersed by hornbill can be effectively done which will help to understand the germination dynamics of these important tree species.
- ❖ Some hornbill nests were found in low lying riparian forests. Necessary changes in the land management practices should be adopted to limit the extension of agricultural activities along the river banks so that these precious ecosystems remain unaffected.

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# APPENDICES

## APPENDIX 1

### Analysis of IVI and Diversity Index of Trees in Nesting Plot 1 VNS

**Nesting tree *Terminalia bellirica* (Gaertn.) Roxb.**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occur | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Terminalia bellirica* (Gaertn.) Roxb. | 1 | 4 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 13.8 | 39.0 | 54.8 | 0.1 | 0.2 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill | 2 | 3 | 1 | 1 | 2 | 1 | 13.3 | 9.1 | 6.2 | 17.3 | 39.8 | 0.1 | 0.3 |
| 3 | *Vateria indica* L. | 1 | 2 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 2.5 | 7.2 | 22.9 | 0.1 | 0.2 |
| 4 | *Calophyllum polyanthum* Wall.ex Choisy | 1 | 2 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 2.5 | 7.2 | 22.9 | 0.1 | 0.2 |
| 5 | *Diospyros crumenata* Thw. | 1 | 2 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 3.5 | 9.8 | 25.5 | 0.1 | 0.2 |
| 6 | *Hopea parviflora* Bedd. | 2 | 2 | 1 | 1 | 2 | 1 | 13.3 | 9.1 | 2.3 | 6.4 | 28.8 | 0.1 | 0.3 |
| 7 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 3 | 1 | 1 | 1 | 3 | 1 | 20.0 | 9.1 | 1.0 | 2.8 | 31.9 | 0.2 | 0.3 |
| 8 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 1 | 1 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 0.8 | 2.4 | 18.1 | 0.1 | 0.2 |
| 9 | *Polyalthia coffeoides* (Thw.) J. Hk&Thoms | 1 | 1 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 0.2 | 0.6 | 16.4 | 0.1 | 0.2 |
| 10 | *Olea dioica* Roxb. | 1 | 1 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 0.8 | 2.3 | 18.0 | 0.1 | 0.2 |
| 11 | *Terminalia paniculata* Roth | 1 | 2 | 1 | 1 | 1 | 1 | 6.7 | 9.1 | 1.8 | 5.0 | 20.7 | 0.1 | 0.2 |
| | | **15** | **20** | **11** | **11** | **15** | **11** | **100** | **100** | **35.5** | **100** | **300** | **1.0** | **2.3** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 2 PNS 1**
**Nesting tree Vateria indica L.**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occurrence | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Litsea floribunda* Gamble | 3 | 1 | 1 | 1 | 4 | 1 | 25.0 | 10 | 0.9 | 1.9 | 37 | 0.250 | 0.35 |
| 2 | *Garcinia gummi-gutta* (L.) Robs | 1 | 1 | 1 | 1 | 1 | 1 | 6.3 | 10 | 0.7 | 1.4 | 18 | 0.063 | 0.17 |
| 3 | *Ficus exasperata* Vahl | 1 | 2 | 1 | 1 | 1 | 1 | 6.3 | 10 | 1.8 | 3.5 | 20 | 0.063 | 0.17 |
| 4 | *Phoebe lanceolata* (Nees) Nees | 1 | 1 | 1 | 1 | 1 | 1 | 6.3 | 10 | 0.7 | 1.4 | 18 | 0.063 | 0.17 |
| 5 | *Myristica beddomei* King | 1 | 3 | 1 | 1 | 1 | 1 | 6.3 | 10 | 6.5 | 12.9 | 29 | 0.063 | 0.17 |
| 6 | *Alseodaphne semecarpifolia* Nees | 1 | 2 | 1 | 1 | 1 | 1 | 6.3 | 10 | 3.2 | 6.3 | 23 | 0.063 | 0.17 |
| 7 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 2 | 3 | 1 | 1 | 2 | 1 | 12.5 | 10 | 6.6 | 13.1 | 36 | 0.125 | 0.26 |
| 8 | *Persea macrantha* (Nees) Kosterm. | 1 | 1 | 1 | 1 | 1 | 1 | 6.3 | 10 | 0.9 | 1.9 | 18 | 0.063 | 0.17 |
| 9 | *Tetrameles nudiflora* (Dalzell) Baill. | 1 | 2 | 1 | 1 | 1 | 1 | 6.3 | 10 | 3.5 | 6.9 | 23 | 0.063 | 0.17 |
| 10 | *Vateria indica* L. | 3 | 6 | 1 | 1 | 3 | 1 | 18.8 | 10 | 25.5 | 50.7 | 79 | 0.188 | 0.31 |
| | | **15** | **21** | **10** | **10** | 16 | **10** | **100** | **100** | **50** | **100** | **300** | **1.0** | **2.1** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 3 ANS**
**Nesting tree *Palaquium ellipticum* (Dalzell) Baill.**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occurrence | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Schleichera oleosa* (Lour.) Oken | 2 | 1.47 | 1 | 1 | 2 | 1 | 18.2 | 12.5 | 1.7 | 5.0 | 35.7 | 0.2 | 0.31 |
| 2 | *Litsea floribunda* Gamble | 2 | 2.1 | 1 | 1 | 2 | 1 | 18.2 | 12.5 | 3.5 | 10.3 | 41.0 | 0.2 | 0.30 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 5.4 | 1 | 1 | 2 | 1 | 18.2 | 12.5 | 22.9 | 68.1 | 98.7 | 0.2 | 0.30 |
| 4 | *Elaeocarpus tuberculatus* Roxb. | 1 | 1.14 | 1 | 1 | 1 | 1 | 9.1 | 12.5 | 1.0 | 3.0 | 24.6 | 0.1 | 0.21 |
| 5 | *Terminalia paniculata* Roth | 1 | 0.88 | 1 | 1 | 1 | 1 | 9.1 | 12.5 | 0.6 | 1.8 | 23.4 | 0.1 | 0.21 |
| 6 | *Macaranga peltata* (Roxb.)Mull.Arg. | 1 | 1.71 | 1 | 1 | 1 | 1 | 9.1 | 12.5 | 2.3 | 6.8 | 28.4 | 0.1 | 0.21 |
| 7 | *Persea macrantha*(Nees) Kosterm. | 1 | 0.95 | 1 | 1 | 1 | 1 | 9.1 | 12.5 | 0.7 | 2.1 | 23.7 | 0.1 | 0.21 |
| 8 | *Alstonia scholaris* (L.) R.Br. | 1 | 1.1 | 1 | 1 | 1 | 1 | 9.1 | 12.5 | 0.9 | 2.8 | 24.4 | 0.1 | 0.21 |
| | | **11** | **13.28** | **8** | **8** | **11** | **8** | **100** | **100** | **34** | **100** | **300** | **0.93** | **1.94** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 4 SPNS1**

**Nesting tree *Vateria indica* L.**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occurrence | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Bombax ceiba* L. | 3 | 4.2 | 1 | 1 | 4 | 1 | 22.2 | 7.1 | 13.8 | 19.0 | 44 | 0.22 | 0.33 |
| 2 | *Chukrasia tabularis* A. Juss | 1 | 1.06 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 0.9 | 1.2 | 13 | 0.06 | 0.16 |
| 3 | *Alseodaphne semecarpifolia* Nees | 2 | 1.92 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 2.9 | 4.0 | 15 | 0.06 | 0.16 |
| 4 | *Vateria indica* L | 2 | 5.4 | 1 | 1 | 2 | 1 | 11.1 | 7.1 | 22.9 | 31.5 | 47 | 0.11 | 0.24 |
| 5 | *Holigarna arnottiana* Wall.ex Hook.f. | 1 | 0.95 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 0.7 | 1.0 | 12 | 0.06 | 0.16 |
| 6 | *Mesua ferrea* L. | 1 | 3.2 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 8.0 | 11.1 | 23 | 0.06 | 0.16 |
| 7 | *Dyospyros montana* Roxb. | 1 | 0.68 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 0.4 | 0.5 | 12 | 0.06 | 0.16 |
| 8 | *Litsea floribunda* Gamble | 1 | 1.1 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 0.9 | 1.3 | 13 | 0.06 | 0.16 |
| 9 | *Myristica beddomei* King | 2 | 2.4 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 4.5 | 6.2 | 18 | 0.06 | 0.16 |
| 10 | *Palaquium ellipticum* (Dalzell) Baill | 1 | 2.1 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 3.5 | 4.8 | 16 | 0.1 | 0.16 |
| 11 | *Cullenia exarillata* A. Robyns | 1 | 2.7 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 5.7 | 7.9 | 19 | 0.1 | 0.16 |
| 12 | *Actinodaphne bourdillonii* Gamble | 4 | 2.14 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 3.6 | 4.9 | 16 | 0.1 | 0.16 |
| 13 | *Litsea stocksi*i Hook. f | 2 | 1.8 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 2.5 | 3.5 | 15 | 0.1 | 0.16 |
| 14 | *Mastixia arborea* (Wight) C.B.Clarke | 1 | 1.7 | 1 | 1 | 1 | 1 | 5.6 | 7.1 | 2.3 | 3.1 | 15 | 0.1 | 0.16 |
| | | **23** | **31.35** | **14** | **14** | **18** | **14** | **100** | **100** | **73** | **100** | **300** | **1** | **2.51** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 5 SPNS 2**

**Nesting tree *Bombax ceiba* L.**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occurrence | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Turpinia malabarica* Gamble | 2 | 2.6 | 1 | 1 | 2 | 1 | 7.1 | 7.7 | 5.3 | 6.8 | 21.6 | 0.1 | 0.2 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill | 5 | 5.7 | 1 | 1 | 5 | 1 | 17.9 | 7.7 | 25.2 | 31.9 | 57.5 | 0.2 | 0.3 |
| 3 | *Knema atteunata* (Hook, fil.&Thomas.)Warb. | 4 | 2.9 | 1 | 1 | 4 | 1 | 14.3 | 7.7 | 6.6 | 8.3 | 30.3 | 0.1 | 0.3 |
| 4 | *Actinodaphne wightiana* (Kuntze) Noltie | 2 | 1.6 | 1 | 1 | 2 | 1 | 7.1 | 7.7 | 1.9 | 2.4 | 17.3 | 0.1 | 0.2 |
| 5 | *Bombax ceiba* L. | 1 | 5.0 | 1 | 1 | 1 | 1 | 3.6 | 7.7 | 12.4 | 15.6 | 26.9 | 0.0 | 0.1 |
| 6 | *Mesua ferrea* L. | 1 | 2.0 | 1 | 1 | 1 | 1 | 3.6 | 7.7 | 3.2 | 4.0 | 15.3 | 0.0 | 0.1 |
| 7 | *Elaeocarpus tuberculatus* Roxb. | 1 | 1.2 | 1 | 1 | 1 | 1 | 3.6 | 7.7 | 1.2 | 1.5 | 12.7 | 0.0 | 0.1 |
| 8 | *Litsea floribunda* Gamble | 1 | 1.1 | 1 | 1 | 1 | 1 | 3.6 | 7.7 | 0.9 | 1.2 | 12.5 | 0.0 | 0.1 |
| 9 | *Litsea oleoides* (Meisn.) Hook.f | 2 | 2.3 | 1 | 1 | 2 | 1 | 7.1 | 7.7 | 4.2 | 5.3 | 20.1 | 0.1 | 0.2 |
| 10 | *Chukrasia tabularis* A. Juss | 4 | 2.9 | 1 | 1 | 4 | 1 | 14.3 | 7.7 | 6.5 | 8.2 | 30.2 | 0.1 | 0.3 |
| 11 | *Myristica beddomei* King | 2 | 3.1 | 1 | 1 | 2 | 1 | 7.1 | 7.7 | 7.5 | 9.5 | 24.4 | 0.1 | 0.2 |
| 12 | *Cinnamomum malabatrum* (Burm.f.)persl. | 2 | 1.8 | 1 | 1 | 2 | 1 | 7.1 | 7.7 | 2.5 | 3.2 | 18.1 | 0.1 | 0.2 |
| 13 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 1 | 1.5 | 1 | 1 | 1 | 1 | 3.6 | 7.7 | 1.7 | 2.1 | 13.4 | 0.0 | 0.1 |
| | | **28** | **32.56** | **13** | **13** | **28** | **13** | **100** | **100** | **79.1** | **100** | **300** | **1** | **2.4** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 6 PNS 2**

**Nesting tree *Calophyllum polyanthum* Wall.ex Choisy**

| Sl.No | Name of the species | Number of individuals | GBH m | Total number of quadrats | Quadrat of occurrence | Stand Density | frequency | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Alseodaphne semecarpifolia* Nees | 2 | 2.3 | 1 | 1 | 2 | 1 | 8.00 | 10 | 4.2 | 5.7 | 24 | 0.080 | 0.202 |
| 2 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 2 | 3.51 | 1 | 1 | 2 | 1 | 8.00 | 10 | 9.7 | 13.3 | 31 | 0.080 | 0.202 |
| 3 | *Drypetes venusta* (Wight) Pax & K.Hoffm. | 1 | 0.7 | 1 | 1 | 1 | 1 | 4.00 | 10 | 0.4 | 0.5 | 15 | 0.040 | 0.129 |
| 4 | *Cullenia exarillata* A. Robyns | 3 | 5.2 | 1 | 1 | 3 | 1 | 12.00 | 10 | 21.2 | 29.1 | 51 | 0.120 | 0.254 |
| 5 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 1 | 1.1 | 1 | 1 | 1 | 1 | 4.00 | 10 | 0.9 | 1.3 | 15 | 0.040 | 0.129 |
| 6 | *Calophyllum polyanthum* Wall.ex Choisy | 1 | 4.74 | 1 | 1 | 1 | 1 | 4.00 | 10 | 17.6 | 24.2 | 38 | 0.040 | 0.129 |
| 7 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 1.9 | 1 | 1 | 2 | 1 | 8.00 | 10 | 2.8 | 3.9 | 22 | 0.080 | 0.202 |
| 8 | *Litsea bourdillonii* Gamble | 6 | 2.1 | 1 | 1 | 6 | 1 | 24.00 | 10 | 3.5 | 4.7 | 39 | 0.240 | 0.343 |
| 9 | *Cinnamomum malabatrum* (Burm.f.) Persl | 1 | 0.5 | 1 | 1 | 1 | 1 | 4.00 | 10 | 0.2 | 0.3 | 14 | 0.040 | 0.129 |
| 10 | *Phoebe lanceolata* (Nees) Nees | 3 | 1.9 | 1 | 1 | 3 | 1 | 12.00 | 10 | 2.8 | 3.9 | 26 | 0.120 | 0.254 |
| 11 | *Canarium strictum* Roxb. | 2 | 3.5 | 1 | 1 | 2 | 1 | 8.00 | 10 | 9.6 | 13.2 | 31 | 0.080 | 0.202 |
| | | **24** | **27.45** | **11** | **11** | **25** | **10** | **100** | **100** | **73** | **100** | **300** | **1.00** | **2.17** |

| **Analysis of IVI and Diversity Index of Trees in Nesting Plot 7 ATNS** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Nesting tree *Mesua ferrea* L.** | | | | | | | | | | | | | |
| **Sl.No** | **Name of the species** | **Number of individual** | **GBH m** | **Total number of quadrats** | **Quadrat of occurrence** | **Stand Density** | **frequency** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 2 | 4.57 | 1 | 1 | 2 | 1 | 9 | 8 | 16 | 15 | 32 | 0.1 | 0.20 |
| 2 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 4 | 1 | 1 | 3 | 1 | 9 | 12 | 13 | 12 | 33 | 0.1 | 0.25 |
| 3 | *Vateria indic*a L. | 2 | 2.7 | 1 | 1 | 2 | 1 | 9 | 8 | 6 | 5 | 22 | 0.1 | 0.20 |
| 4 | *Schleichera oleosa* (Lour.) Oken | 3 | 2.4 | 1 | 1 | 3 | 1 | 9 | 12 | 5 | 4 | 25 | 0.1 | 0.25 |
| 5 | *Persea macrantha (*Nees) Kosterm | 4 | 5.35 | 1 | 1 | 4 | 1 | 9 | 16 | 22 | 21 | 46 | 0.2 | 0.29 |
| 6 | *Mesua ferrea* L. | 1 | 4.1 | 1 | 1 | 1 | 1 | 9 | 4 | 13 | 12 | 25 | 0.0 | 0.13 |
| 7 | *Litsea oleoides* (Meisn) Hook.f. | 3 | 2.43 | 1 | 1 | 3 | 1 | 9 | 12 | 5 | 4 | 25 | 0.1 | 0.25 |
| 8 | *Actinodaphne bourdillonii* Gamble | 1 | 1.78 | 1 | 1 | 1 | 1 | 9 | 4 | 2 | 2 | 15 | 0.0 | 0.13 |
| 9 | *Litsea bourdillonii* Gamble | 1 | 3 | 1 | 1 | 1 | 1 | 9 | 4 | 7 | 7 | 20 | 0.0 | 0.13 |
| 10 | *Chukrasia tabularis* A. Juss | 1 | 1.7 | 1 | 1 | 1 | 1 | 9 | 4 | 2 | 2 | 15 | 0.0 | 0.13 |
| 11 | *Myristica beddomei* King | 4 | 4.5 | 1 | 1 | 4 | 1 | 9 | 16 | 16 | 15 | 40 | 0.2 | 0.29 |
| | | **25** | **36.5** | | | **25** | **11** | **100** | **100** | **107** | **100** | **300** | **1** | **2** |

**Analysis of IVI and Diversity Index of Trees in Nesting Plot 8 SNS**

| **Nesting tree *Tetrameles nudiflora* R.Br.** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl.No** | **Name of the species** | **Number of individuals** | **GBH m** | **Total number of quadrats** | **Quadrat of occurrence** | **Stand Density** | **frequency** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Holigarna arnottiana* Wall.ex Hook.f. | 4 | 4.2 | 1 | 1 | 4 | 1 | 8.3 | 19.0 | 13.8 | 21.3 | 48.7 | 0.19 | 0.32 |
| 2 | *Chukrasia tabulari*s A. Juss | 1 | 1.06 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 0.9 | 1.4 | 14.5 | 0.05 | 0.14 |
| 3 | *Alseodaphne semecarpifoli*a Nees | 1 | 1.92 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 2.9 | 4.4 | 17.5 | 0.05 | 0.14 |
| 4 | *Tetrameles nudiflora* R.Br. | 2 | 5.4 | 1 | 1 | 2 | 1 | 8.3 | 9.5 | 22.9 | 35.2 | 53.0 | 0.10 | 0.22 |
| 5 | *Vateria indica* L. | 1 | 0.95 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 0.7 | 1.1 | 14.2 | 0.05 | 0.14 |
| 6 | *Mesua ferrea* L. | 1 | 3.2 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 8.0 | 12.3 | 25.4 | 0.05 | 0.14 |
| 7 | *Diospyros candolleana Wight* | 1 | 0.68 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 0.4 | 0.6 | 13.7 | 0.05 | 0.14 |
| 8 | *Litsea floribunda* Gamble | 1 | 1.1 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 0.9 | 1.5 | 14.6 | 0.05 | 0.14 |
| 9 | *Myristica beddomei* sub sp sphaerocarpa W.J.de Wilde | 2 | 2.4 | 1 | 1 | 2 | 1 | 8.3 | 9.5 | 4.5 | 6.9 | 24.8 | 0.10 | 0.22 |
| 10 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 2.11 | 1 | 1 | 3 | 1 | 8.3 | 14.3 | 3.5 | 5.4 | 28.0 | 0.14 | 0.28 |
| 11 | *Mallotus atrovirens* Wall. ex. Mull. Arg | 1 | 2.1 | 1 | 1 | 1 | 1 | 8.3 | 4.8 | 3.5 | 5.3 | 18.4 | 0.05 | 0.14 |
| 12 | *Cryptocarya sheikelmudiyana* Fasila *et al.,* | 3 | 1.97 | 1 | 1 | 3 | 1 | 8.3 | 14.3 | 3.0 | 4.7 | 27.3 | 0.1 | 0.28 |
| | | **21** | **27.09** | **12** | **12** | **21** | **12** | **100** | **100** | **65** | **100** | **300** | **1** | **2.3** |

# APPENDIX 2

**Analysis of IVI and Diversity Index of Saplings in Nesting Plot VNS**

| Sl. No | Name of Species | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Total number of Individual | Total number of quadrats | Quadrats of occurance | Density | Frequency | GBH | RD | RF | BA | RBA | IVI | n/N | (n/N)*log (n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 8 | 3 | 0.38 | 0.375 | 0.87 | 4.6 | 5.08 | 0.02 | 7.98 | 17.7 | 0.05 | 0.14 |
| 2 | *Hopea parviflora* Bedd. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 4 | 0.50 | 0.5 | 0.81 | 6.2 | 6.77 | 0.02 | 6.91 | 19.8 | 0.06 | 0.17 |
| 3 | *Hydnocarpus pentandrus* (Buch-Ham.) Oken | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 8 | 3 | 0.38 | 0.375 | 0.65 | 4.6 | 5.08 | 0.01 | 4.45 | 14.1 | 0.05 | 0.14 |
| 4 | *Chukrasia tabularis* A. Juss | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 8 | 4 | 0.50 | 0.5 | 0.78 | 6.2 | 6.77 | 0.01 | 6.41 | 19.3 | 0.06 | 0.17 |
| 5 | *Schleichera oleosa* (Lour.) Oken | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 4 | 0.50 | 0.5 | 0.91 | 6.2 | 6.77 | 0.02 | 8.73 | 21.7 | 0.06 | 0.17 |
| 6 | *Vateria indica* L. | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 4 | 8 | 7 | 0.50 | 0.875 | 0.74 | 6.2 | 11.85 | 0.01 | 5.77 | 23.8 | 0.06 | 0.17 |
| 7 | *Persea macrantha*(Nees) Kosterm | 0 | 0 | 1 | 0 | 1 | 2 | 2 | 2 | 8 | 8 | 5 | 1.00 | 0.625 | 0.9 | 12.3 | 8.46 | 0.02 | 8.53 | 29.3 | 0.12 | 0.26 |
| 8 | *Elaeocarpus tuberculatus* Roxb. | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 6 | 8 | 5 | 0.75 | 0.625 | 1.01 | 9.2 | 8.46 | 0.02 | 10.75 | 28.4 | 0.09 | 0.22 |
| 9 | *Holigarna arnottiana* Wall.ex Hook.f. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 4 | 0.50 | 0.5 | 0.59 | 6.2 | 6.77 | 0.01 | 3.67 | 16.6 | 0.06 | 0.17 |
| 10 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 8 | 3 | 0.63 | 0.375 | 1.04 | 7.7 | 5.08 | 0.03 | 11.40 | 24.2 | 0.08 | 0.20 |
| 11 | *Calophyllum polyanthum* Wall.ex Choisy | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 4 | 8 | 3 | 0.50 | 0.375 | 0.81 | 6.2 | 5.08 | 0.02 | 6.91 | 18.1 | 0.06 | 0.17 |
| 12 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 5 | 8 | 4 | 0.63 | 0.5 | 0.87 | 7.7 | 6.77 | 0.02 | 7.98 | 22.4 | 0.08 | 0.20 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | *Terminalia bellirica* (Gaertn.) Roxb. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 5 | 8 | 4 | 0.63 | 0.5 | 0.83 | 7.7 | 6.77 | 0.02 | 7.26 | 21.7 | 0.08 | 0.20 |
| 14 | *Xylia xylocarpa* (Roxb.) Taub | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.27 | 3.1 | 3.38 | 0.00 | 0.77 | 7.2 | 0.03 | 0.11 |
| 15 | *Cinnamomum malabatrum* (Burm.f.) persl. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 1 | 0.13 | 0.125 | 0.14 | 1.5 | 1.69 | 0.00 | 0.21 | 3.4 | 0.02 | 0.06 |
| 16 | *Myristica beddomei* King | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 8 | 3 | 0.38 | 0.375 | 0.47 | 4.6 | 5.08 | 0.01 | 2.33 | 12.0 | 0.05 | 0.14 |
| | | | | | | | | | | **65** | | | **8.13** | **7.375** | **11.7** | **100** | **100** | **0.22** | **100** | **300** | **1.00** | **2.70** |

| Analysis of IVI and Diversity Index of Saplings in Nesting Plot PNS 1 | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Name of Species** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **Total number of Individual** | **Total number of quadrats** | **Quadrats of occurrence** | **Density** | **Frequency** | **GBH** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 4 | 8 | 6 | 0.5 | 0.8 | 1.9 | 5 | 8.0 | 2.7 | 15.3 | 28 | 0.05 | 0.15 |
| 2 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 2 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 9 | 8 | 6 | 1.1 | 0.8 | 1.1 | 11 | 8.0 | 0.9 | 5.3 | 24 | 0.11 | 0.24 |
| 3 | *Persea macrantha* (Nees) Kosterm. | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 8 | 5 | 0.6 | 0.6 | 0.6 | 6 | 6.7 | 0.3 | 1.4 | 14 | 0.06 | 0.17 |
| 4 | *Cullenia exarillata* A. Robyns | 2 | 0 | 1 | 2 | 0 | 1 | 1 | 0 | 7 | 8 | 5 | 0.9 | 0.6 | 0.8 | 8 | 6.7 | 0.5 | 2.7 | 18 | 0.08 | 0.21 |
| 5 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 6 | 8 | 7 | 0.8 | 0.9 | 2.1 | 7 | 9.3 | 3.5 | 19.3 | 36 | 0.07 | 0.19 |
| 6 | *Polyalthia fragrans* (Dalzell) Hook.f &Thomson | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 8 | 2 | 0.3 | 0.3 | 0.5 | 2 | 2.7 | 0.2 | 1.0 | 6 | 0.02 | 0.09 |
| 7 | *Syzygium occidentale* (Bourd.) Gandhi | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 1 | 0.3 | 0.1 | 0.6 | 2 | 1.3 | 0.3 | 1.5 | 5 | 0.02 | 0.09 |
| 8 | *Vateria indica* L. | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 1 | 7 | 8 | 7 | 0.9 | 0.9 | 1.6 | 8 | 9.3 | 2.0 | 11.2 | 29 | 0.08 | 0.21 |
| 9 | *Neolitsea cassia* (L.) Kosterm | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 8 | 2 | 0.4 | 0.3 | 0.7 | 4 | 2.7 | 0.4 | 2.4 | 9 | 0.04 | 0.12 |
| 10 | *Litsea floribunda* Gamble | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 6 | 8 | 4 | 0.8 | 0.5 | 1.7 | 7 | 5.3 | 2.4 | 13.3 | 26 | 0.07 | 0.19 |
| 11 | *Schleichera oleosa* (Lour.) Oken | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 5 | 8 | 7 | 0.6 | 0.9 | 1.9 | 6 | 9.3 | 2.8 | 15.8 | 31 | 0.06 | 0.17 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | *Cinnamomum sulphuratum* Nees | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 5 | 8 | 5 | 0.6 | 0.6 | 0.8 | 6 | 6.7 | 0.5 | 2.7 | 15 | 0.06 | 0.17 |
| 13 | *Terminalia paniculata* Roth | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 5 | 8 | 3 | 0.6 | 0.4 | 0.7 | 6 | 4.0 | 0.4 | 2.2 | 12 | 0.06 | 0.17 |
| 14 | *Glycosmis mauritiana* (Lam.)Tanaka | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 3 | 7 | 8 | 5 | 0.9 | 0.6 | 0.8 | 8 | 6.7 | 0.5 | 2.9 | 18 | 0.08 | 0.21 |
| 15 | *Macaranga peltat*a (Roxb.) Mull.Arg. | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 8 | 3 | 0.4 | 0.4 | 0.5 | 4 | 4.0 | 0.2 | 0.9 | 8 | 0.04 | 0.12 |
| 16 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 8 | 2 | 0.3 | 0.3 | 0.3 | 2 | 2.7 | 0.1 | 0.4 | 5 | 0.02 | 0.09 |
| 17 | *Ziziphus rugosa* Lam. | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 8 | 1 | 0.1 | 0.1 | 0.1 | 1 | 1.3 | 0.0 | 0.1 | 3 | 0.01 | 0.05 |
| 18 | *Olea dioica* Roxb. | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 4 | 8 | 4 | 0.5 | 0.5 | 0.6 | 5 | 5.3 | 0.3 | 1.5 | 12 | 0.05 | 0.15 |
| | | | | | | | | | | **83** | | | **10** | **9** | **17** | **100** | **100** | **18** | **100** | **300** | **1** | **3** |

**Analysis of IVI and Diversity Index of Saplings in Nesting Plot ANS**

| Sl. No | Name of Species | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Total number of Individual | Total number of quadrats | Quadrats of occurrence | Density | Frequency | GBH | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Actinodaphne wightiana* (Kuntze) Noltie. | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.21 | 3.45 | 4.8 | 0.03 | 0.4 | 8.6 | 0.03 | 0.1 |
| 2 | *Persea macrantha*(Nees) Kosterm | 0 | 0 | 3 | 2 | 1 | 1 | 0 | 0 | 7 | 8 | 4 | 0.88 | 0.5 | 0.89 | 12.07 | 9.5 | 0.62 | 7.5 | 29.1 | 0.12 | 0.3 |
| 3 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 0 | 7 | 8 | 4 | 0.88 | 0.5 | 0.87 | 12.07 | 9.5 | 0.59 | 7.2 | 28.8 | 0.12 | 0.3 |
| 4 | *Hopea parviflora* Bedd. | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 1 | 0.13 | 0.125 | 0.25 | 1.72 | 2.4 | 0.05 | 0.6 | 4.7 | 0.02 | 0.1 |
| 5 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 5 | 8 | 2 | 0.63 | 0.25 | 1.4 | 8.62 | 4.8 | 1.54 | 18.5 | 31.9 | 0.09 | 0.2 |
| 6 | *Alstonia scholaris* (L.) R.Br. | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 8 | 1 | 0.13 | 0.125 | 0.28 | 1.72 | 2.4 | 0.06 | 0.7 | 4.8 | 0.02 | 0.1 |
| 7 | *Elaeocarpus tuberculatus* Roxb. | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.57 | 3.45 | 4.8 | 0.26 | 3.1 | 11.3 | 0.03 | 0.1 |
| 8 | *Terminalia paniculata* Roth | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 8 | 1 | 0.13 | 0.125 | 0.28 | 1.72 | 2.4 | 0.06 | 0.7 | 4.8 | 0.02 | 0.1 |
| 9 | *Holigarna arnottiana* Wall.ex Hook.f. | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 8 | 1 | 0.13 | 0.125 | 0.27 | 1.72 | 2.4 | 0.06 | 0.7 | 4.8 | 0.02 | 0.1 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | *Dipterocarpus indicus Bedd.* | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.56 | 3.45 | 4.8 | 0.25 | 3.0 | 11.2 | 0.03 | 0.1 |
| 11 | *Litsea floribunda* Gamble | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 2 | 0.38 | 0.25 | 0.87 | 5.17 | 4.8 | 0.59 | 7.2 | 17.1 | 0.05 | 0.2 |
| 12 | *Myristica beddomei* King | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 1.25 | 8.62 | 9.5 | 1.23 | 14.8 | 32.9 | 0.09 | 0.2 |
| 13 | *Cinnamomum malabatrum* (Burm.f.) persl. | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 3 | 0.5 | 0.375 | 0.81 | 6.90 | 7.1 | 0.52 | 6.2 | 20.2 | 0.07 | 0.2 |
| 14 | *Aphanamixis polystachya* (Wall). R.N. Parker | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 3 | 0.5 | 0.375 | 0.97 | 6.90 | 7.1 | 0.74 | 8.9 | 22.9 | 0.07 | 0.2 |
| 15 | *Schleichera oleosa* (Lour.) Oken | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 0.93 | 8.62 | 9.5 | 0.68 | 8.2 | 26.3 | 0.09 | 0.2 |
| 16 | *Palaquium ellipticum* (Dalzell) Baill. | 2 | 0 | 1 | 2 | 1 | 0 | 1 | 1 | 8 | 8 | 6 | 1 | 0.75 | 1.12 | 13.79 | 14.3 | 0.98 | 11.9 | 39.9 | 0.14 | 0.3 |
| | | | | | | | | | | **58** | | | **7.25** | **5.25** | **11.5** | **100** | **100** | **8.3** | **100** | **300** | **1.00** | **2.6** |

| Analysis of IVI and Diversity Index of Saplings in Nesting Plot SPNS1 | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Name of Species** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **Total number of Individual** | **Total number of quadrats** | **Quadrats of occurrence** | **Density** | **Frequency** | **GBH** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Vateria indica* L. | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 1 | 7 | 8 | 5 | 0.9 | 0.6 | 0.9 | 6.3 | 6.3 | 0.69 | 5.5 | 18.0 | 0.06 | 0.2 |
| 2 | *Chukrasia tabularis* A. Juss | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 8 | 8 | 7 | 1.0 | 0.9 | 1.0 | 7.1 | 8.8 | 0.75 | 5.9 | 21.9 | 0.07 | 0.16 |
| 3 | *Cullenia exarillata* A. Robyns | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 7 | 8 | 5 | 0.9 | 0.6 | 1.2 | 6.3 | 6.3 | 1.15 | 9.1 | 21.6 | 0.06 | 0.15 |
| 4 | *Myristica beddomei* King | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 6 | 8 | 4 | 0.8 | 0.5 | 1.3 | 5.4 | 5.1 | 1.37 | 10.8 | 21.2 | 0.05 | 0.1 |
| 5 | *Drypetes venusta* (Wight) Pax & K.Hoffm | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 4 | 0.5 | 0.5 | 0.7 | 3.6 | 5.1 | 0.43 | 3.4 | 12.0 | 0.04 | 0.12 |
| 6 | *Mastixia arborea* (Wight) C.B.Clarke | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 8 | 2 | 0.5 | 0.3 | 0.5 | 3.6 | 2.5 | 0.17 | 1.4 | 7.5 | 0.04 | 0.12 |
| 7 | *Calophyllum polyanthum* Wall.ex Choisy | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 4 | 8 | 3 | 0.5 | 0.4 | 0.7 | 3.6 | 3.8 | 0.35 | 2.8 | 10.1 | 0.04 | 0.18 |
| 8 | *Holigarna arnottiana* Wall.ex Hook.f. | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 1 | 6 | 8 | 4 | 0.8 | 0.5 | 0.9 | 5.4 | 5.1 | 0.65 | 5.1 | 15.5 | 0.05 | 0.16 |
| 9 | *Schleichera oleosa* (Lour.) Oken | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 6 | 8 | 6 | 0.8 | 0.8 | 1.2 | 5.4 | 7.6 | 1.21 | 9.5 | 22.4 | 0.05 | 0.05 |
| 10 | *Paracroton pendulus* (Hassk.) Miq. | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 8 | 2 | 0.3 | 0.3 | 0.6 | 1.8 | 2.5 | 0.26 | 2.0 | 6.3 | 0.02 | 0.22 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | *Artocarpus heterophyllus* Lam | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 1 | 6 | 8 | 3 | 0.8 | 0.4 | 0.6 | 5.4 | 3.8 | 0.26 | 2.0 | 11.2 | 0.05 | 0.08 |
| 12 | *Diospyros crumenata* Thw. | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 8 | 3 | 0.4 | 0.4 | 0.4 | 2.7 | 3.8 | 0.13 | 1.0 | 7.5 | 0.03 | 0.13 |
| 13 | *Syzygium occidentale* (Bourd.) Gandhi | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 8 | 3 | 0.5 | 0.4 | 0.9 | 3.6 | 3.8 | 0.59 | 4.7 | 12.0 | 0.04 | 0.21 |
| 14 | *Mesua ferrea* L. | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 7 | 8 | 4 | 0.9 | 0.5 | 1.1 | 6.3 | 5.1 | 0.95 | 7.5 | 18.8 | 0.06 | 0.17 |
| 15 | *Aphanamixis polystachya* (Wall). R.N.Parker | 0 | 0 | 1 | 1 | 5 | 0 | 0 | 0 | 7 | 8 | 3 | 0.9 | 0.4 | 1.0 | 6.3 | 3.8 | 0.74 | 5.8 | 15.9 | 0.06 | 0.1 |
| 16 | *Mitragyna parvifolia* (Roxb.) Korth. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 4 | 8 | 3 | 0.5 | 0.4 | 0.5 | 3.6 | 3.8 | 0.20 | 1.6 | 9.0 | 0.04 | 0.24 |
| 17 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 0 | 0 | 1 | 4 | 2 | 1 | 0 | 8 | 8 | 4 | 1.0 | 0.5 | 0.9 | 7.1 | 5.1 | 0.68 | 5.4 | 17.5 | 0.07 | 0.12 |
| 18 | *Saprosma glomeratum* (Gardner) Bedd | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 5 | 8 | 4 | 0.6 | 0.5 | 0.9 | 4.5 | 5.1 | 0.59 | 4.7 | 14.2 | 0.04 | 0.11 |
| 19 | *Tarenna monosperma* Wight &Arn. | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 4 | 8 | 2 | 0.5 | 0.3 | 0.9 | 3.6 | 2.5 | 0.59 | 4.7 | 10.8 | 0.04 | 0.18 |
| 20 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 0 | 0 | 1 | 1 | 1 | 3 | 0 | 0 | 6 | 8 | 4 | 0.8 | 0.5 | 1.0 | 5.4 | 5.1 | 0.74 | 5.8 | 16.2 | 0.05 | 0.1 |
| 21 | *Mallotus philippensis* (Lam.) Mull.Arg. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | 8 | 4 | 0.5 | 0.5 | 0.5 | 3.6 | 5.1 | 0.17 | 1.4 | 10.0 | 0.04 | 0.12 |
| | | | | | | | | | | **112** | | | **14.0** | **9.9** | | **100** | **100** | **12.7** | **100** | **300** | **1** | **3** |

**Analysis of IVI and Diversity Index of Saplings in Nesting Plot SPNS2**

| Sl. No | Name of Species | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Total number of Individual | Total number of quadrats | Quadrats of occurrence | Density | Frequency | GBH | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Litsea bourdillonii* Gamble | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 2 | 8 | 0.5 | 0.25 | 0.65 | 1.98 | 1.65 | 0.33 | 1.1 | 4.8 | 0.02 | 0.08 |
| 2 | *Persea macrantha* (Nees) Kosterm | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 8 | 0.4 | 0.25 | 0.51 | 1.48 | 1.65 | 0.20 | 0.7 | 3.8 | 0.01 | 0.06 |
| 3 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 1 | 2 | 2 | 2 | 1 | 0 | 0 | 11 | 6 | 8 | 1.4 | 0.75 | 1.92 | 5.43 | 4.96 | 2.89 | 9.8 | 20.2 | 0.05 | 0.16 |
| 4 | *Mallotus philippensis* (Lam.) Mull.Arg. | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 3 | 5 | 8 | 1.0 | 0.63 | 0.94 | 3.95 | 4.13 | 0.69 | 2.4 | 10.4 | 0.04 | 0.13 |
| 5 | *Myristica beddomei* King | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 7 | 4 | 8 | 0.9 | 0.50 | 0.81 | 3.46 | 3.30 | 0.52 | 1.8 | 8.5 | 0.03 | 0.12 |
| 6 | *Dysoxylum malabaricum* Bedd.ex C.DC. | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 5 | 5 | 8 | 1.1 | 0.63 | 1.14 | 4.45 | 4.13 | 1.02 | 3.5 | 12.0 | 0.04 | 0.14 |
| 7 | *Aglaia barberi* Gamble | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 8 | 0.4 | 0.25 | 0.54 | 1.48 | 1.65 | 0.23 | 0.8 | 3.9 | 0.01 | 0.06 |
| 8 | *Chukrasia tabularis* A. Juss | 1 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 7 | 3 | 8 | 0.9 | 0.38 | 1.12 | 3.46 | 2.48 | 0.98 | 3.4 | 9.3 | 0.03 | 0.12 |
| 9 | *Actinodaphne wightiana* (Kuntze) Noltie | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 2 | 8 | 0.5 | 0.25 | 0.74 | 1.98 | 1.65 | 0.43 | 1.5 | 5.1 | 0.02 | 0.08 |
| 10 | *Schleichera oleosa* (Lour.) Oken | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 2 | 8 | 3 | 8 | 1.0 | 0.38 | 1.47 | 3.95 | 2.48 | 1.70 | 5.8 | 12.2 | 0.04 | 0.13 |
| 11 | *Agrostistachys borneensis* Becc | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 1 | 8 | 0.5 | 0.13 | 0.71 | 1.98 | 0.83 | 0.40 | 1.3 | 4.1 | 0.02 | 0.08 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | *Dendrocnide sinuata* (Bi.) Chew | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 5 | 3 | 8 | 0.6 | 0.38 | 0.91 | 2.47 | 2.48 | 0.65 | 2.2 | 7.2 | 0.02 | 0.09 |
| 13 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 8 | 0.5 | 0.13 | 0.41 | 0.99 | 0.83 | 0.13 | 0.4 | 2.3 | 0.01 | 0.05 |
| 14 | *Otonephelium stipulaceum* (Bedd.) Radlk. | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 1 | 6 | 1 | 8 | 0.8 | 0.13 | 0.87 | 2.96 | 0.83 | 0.59 | 2.0 | 5.8 | 0.03 | 0.1 |
| 15 | *Aporosa acuminata* Thw. | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 4 | 8 | 0.6 | 0.50 | 0.68 | 2.47 | 3.30 | 0.36 | 1.2 | 7.0 | 0.02 | 0.09 |
| 16 | *Bombax ceiba* L. | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 3 | 8 | 0.4 | 0.38 | 0.51 | 1.48 | 2.48 | 0.20 | 0.7 | 4.7 | 0.01 | 0.06 |
| 17 | *Garcinia gummi-gutta* (L.) Robs | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 4 | 3 | 8 | 0.5 | 0.38 | 0.57 | 1.98 | 2.48 | 0.26 | 0.9 | 5.3 | 0.02 | 0.08 |
| 18 | *Calophyllum polyanthum* Wall.ex Choisy | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 5 | 4 | 8 | 0.6 | 0.50 | 0.67 | 2.47 | 3.30 | 0.35 | 1.2 | 7.0 | 0.02 | 0.09 |
| 19 | *Litsea oleoides* (Meisn.)J.Hk | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 0.1 | 0.13 | 0.13 | 0.49 | 0.83 | 0.01 | 0.0 | 1.4 | 0.00 | 0.03 |
| 20 | *Ficus* sps. | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 8 | 0.3 | 0.13 | 0.21 | 0.99 | 0.83 | 0.03 | 0.1 | 1.9 | 0.01 | 0.05 |
| 21 | *Polyalthia fragrans* (Dalzell) Hook.f &Thomson | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 4 | 3 | 8 | 0.5 | 0.38 | 0.41 | 1.98 | 2.48 | 0.13 | 0.4 | 4.9 | 0.02 | 0.08 |
| 22 | *Trichilia connaroides* (Wight & Arn.) Bentvelzen | 0 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 5 | 4 | 8 | 0.6 | 0.50 | 0.61 | 2.47 | 3.30 | 0.29 | 1.0 | 6.8 | 0.02 | 0.09 |
| 23 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 3 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 8 | 5 | 8 | 1.0 | 0.63 | 0.91 | 3.95 | 4.13 | 0.65 | 2.2 | 10.3 | 0.04 | 0.13 |
| 24 | *Drypetes malabarica* (Bedd.) Airy Shaw | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 8 | 0.1 | 0.13 | 0.21 | 0.49 | 0.83 | 0.03 | 0.1 | 1.4 | 0.00 | 0.03 |
| 25 | *Knema attenuata (Hook. fil.& Thomas.) Warb.* | 3 | 0 | 3 | 1 | 2 | 2 | 0 | 0 | 11 | 6 | 8 | 1.4 | 0.75 | 2.1 | 5.43 | 4.96 | 3.46 | 11.8 | 22.2 | 0.05 | 0.16 |
| 26 | *Holigarna grahamii* (Wight) Kurz. | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 4 | 3 | 8 | 0.5 | 0.38 | 0.85 | 1.98 | 2.48 | 0.57 | 1.9 | 6.4 | 0.02 | 0.08 |
| 27 | *Mallotus atrovirens* Wall.ex. Mull.Arg. | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 8 | 0.3 | 0.25 | 0.34 | 0.99 | 1.65 | 0.09 | 0.3 | 2.9 | 0.01 | 0.05 |
| 28 | *Mesua ferrea* L. | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 7 | 5 | 8 | 0.9 | 0.63 | 0.91 | 3.46 | 4.13 | 0.65 | 2.2 | 9.8 | 0.03 | 0.12 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | *Spondias pinnata* (L.f) Kurz | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 6 | 4 | 8 | 0.8 | 0.50 | 0.84 | 2.96 | 3.30 | 0.55 | 1.9 | 8.2 | 0.03 | 0.1 |
| 30 | *Cryptocarya lowsonii* Gamble | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 8 | 0.3 | 0.25 | 0.41 | 0.99 | 1.65 | 0.13 | 0.4 | 3.1 | 0.01 | 0.05 |
| 31 | *Cinnamomum malabatrum* (Burm.f.)persl. | 1 | 1 | 0 | 2 | 2 | 3 | 2 | 1 | 12 | 7 | 8 | 1.5 | 0.88 | 1.94 | 5.93 | 5.78 | 2.95 | 10.1 | 21.8 | 0.06 | 0.17 |
| | | | | | | | | | | **156** | | | **25** | **15** | **25** | **100** | **100** | **29.4** | **100** | **300** | **1.0** | **2.8** |

| Analysis of IVI and Diversity Index of Saplings in Nesting Plot PNS 2 | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Name of Species** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **Total no. of individual** | **Total number of quadrats** | **Quadrats of occurrence** | **Density** | **Frequency** | **GBH** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Cinnamomum malabatrum* (Burm.f.) persl. | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 0.8 | 3.0 | 3.9 | 0.5 | 1.4 | 8.4 | 0.03 | 0.11 |
| 2 | *Melicope lunu-ankenda* (Gaertn.)T.G. Hartley | 0 | 0 | 1 | 3 | 5 | 0 | 1 | 0 | 10 | 8 | 4 | 1.25 | 0.5 | 1.7 | 6.1 | 3.9 | 2.4 | 6.6 | 16.6 | 0.06 | 0.17 |
| 3 | *Eugenia mooniana* Wight | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 4 | 8 | 3 | 0.50 | 0.4 | 0.6 | 2.4 | 2.9 | 0.3 | 0.8 | 6.2 | 0.02 | 0.09 |
| 4 | *Gymnacranthera canarica* (Bedd.ex King)Warb. | 0 | 1 | 2 | 0 | 1 | 1 | 2 | 1 | 8 | 8 | 6 | 1.00 | 0.8 | 1.1 | 4.9 | 5.9 | 1.0 | 2.7 | 13.4 | 0.05 | 0.15 |
| 5 | *Drypetus venusta* (Wight) Pax & K.Hoffm | 0 | 0 | 0 | 1 | 3 | 2 | 3 | 0 | 9 | 8 | 4 | 1.13 | 0.5 | 2 | 5.5 | 3.9 | 3.0 | 8.3 | 17.7 | 0.05 | 0.16 |
| 6 | *Polyalthia coffeoides* (Thw.) J. Hk&Thoms | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 2 | 7 | 8 | 5 | 0.88 | 0.6 | 1.3 | 4.2 | 4.9 | 1.2 | 3.4 | 12.5 | 0.04 | 0.13 |
| 7 | *Litsea floribunda* Gamble | 2 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 7 | 8 | 3 | 0.88 | 0.4 | 1.5 | 4.2 | 2.9 | 1.7 | 4.7 | 11.9 | 0.04 | 0.13 |
| 8 | *Canarium strictum* Roxb. | 3 | 0 | 1 | 2 | 0 | 0 | 0 | | 6 | 8 | 3 | 0.75 | 0.4 | 1.4 | 3.6 | 2.9 | 1.4 | 4.0 | 10.5 | 0.04 | 0.12 |
| 9 | *Schleichera oleosa* (Lour.) Oken | 0 | 0 | 1 | 1 | 2 | 1 | 2 | 0 | 7 | 8 | 5 | 0.88 | 0.6 | 1.2 | 4.2 | 4.9 | 1.1 | 3.2 | 12.3 | 0.04 | 0.13 |
| 10 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 7 | 8 | 5 | 0.88 | 0.6 | 1 | 4.2 | 4.9 | 0.7 | 2.1 | 11.2 | 0.04 | 0.13 |
| 11 | *Aglaia* sps | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 8 | 4 | 0.50 | 0.5 | 0.8 | 2.4 | 3.9 | 0.5 | 1.4 | 7.8 | 0.02 | 0.09 |
| 12 | *Syzygium laetum* (Buch.Ham) Gandhi | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 | 6 | 8 | 5 | 0.75 | 0.6 | 0.7 | 3.6 | 4.9 | 0.4 | 1.2 | 9.7 | 0.04 | 0.12 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | *Litsea bourdillonii* Gamble | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 2 | 0.38 | 0.3 | 0.8 | 1.8 | 2.0 | 0.5 | 1.5 | 5.2 | 0.02 | 0.07 |
| 14 | *Solenocarpus indicus Wight & Arn.* | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 0 | 7 | 8 | 3 | 0.88 | 0.4 | 1.4 | 4.2 | 2.9 | 1.6 | 4.3 | 11.5 | 0.04 | 0.13 |
| 15 | *Litsea oleoides* (Meisn) Hook.f. | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 2 | 0.50 | 0.3 | 1 | 2.4 | 2.0 | 0.7 | 2.1 | 6.4 | 0.02 | 0.09 |
| 16 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 2 | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 7 | 8 | 5 | 0.88 | 0.6 | 1.6 | 4.2 | 4.9 | 1.9 | 5.4 | 14.5 | 0.04 | 0.13 |
| 17 | *Myristica beddomei* King | 1 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 8 | 8 | 5 | 1.00 | 0.6 | 1.5 | 4.9 | 4.9 | 1.8 | 4.9 | 14.6 | 0.05 | 0.15 |
| 18 | *Alseodaphne semecarpifolia* Nees | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 4 | 8 | 3 | 0.50 | 0.4 | 0.8 | 2.4 | 2.9 | 0.5 | 1.3 | 6.6 | 0.02 | 0.09 |
| 19 | *Actinodaphne tadulingamii* Gamble | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 3 | 7 | 8 | 3 | 0.88 | 0.4 | 1.2 | 4.2 | 2.9 | 1.1 | 3.2 | 10.4 | 0.04 | 0.13 |
| 20 | *Cryptocarya* sps. | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 8 | 4 | 0.50 | 0.5 | 0.9 | 2.4 | 3.9 | 0.7 | 1.9 | 8.3 | 0.02 | 0.09 |
| 21 | *Calophyllum polyanthum* Wall.ex Choisy | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 2 | 9 | 8 | 4 | 1.13 | 0.5 | 1.7 | 5.5 | 3.9 | 2.2 | 6.1 | 15.4 | 0.05 | 0.16 |
| 22 | *Phoebe lanceolata* (Nees) Nees | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 5 | 8 | 5 | 0.63 | 0.6 | 1 | 3.0 | 4.9 | 0.7 | 2.1 | 10.0 | 0.03 | 0.11 |
| 23 | *Cryptocarya anamalayana* Gamble | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 1.1 | 3.0 | 3.9 | 0.9 | 2.6 | 9.6 | 0.03 | 0.11 |
| 24 | *Paracroton pendulus* (Hassk.) Miq. | 0 | 1 | 0 | 1 | 0 | 2 | 3 | 4 | 11 | 8 | 5 | 1.38 | 0.6 | 2.2 | 6.7 | 4.9 | 3.8 | 10.7 | 22.2 | 0.07 | 0.18 |
| 25 | *Vateria indica* L | 1 | 0 | 1 | 1 | 2 | 4 | 2 | 0 | 11 | 8 | 6 | 1.38 | 0.8 | 2.5 | 6.7 | 5.9 | 4.8 | 13.3 | 25.8 | 0.07 | 0.18 |
| | | | | | | | | | | **165** | | | **20.6** | **12.8** | **32** | **100** | **100** | **36** | **100** | **300** | **1.00** | **3.17** |

| Analysis of IVI and Diversity Index of Saplings in Nesting Plot ATNS | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Name of Species** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **Total no. of individual** | **Total number of quadrats** | **Quadrats of occurrence** | **Density** | **Frequency** | **GBH** | **RD** | **RF** | **BA** | **RBA** | **IVI** | **n/N** | **(n/N)*log(n/N)** |
| 1 | *Vateria indica* L. | 0 | 2 | 2 | 0 | 1 | 4 | 1 | 4 | 14 | 6 | 8 | 1.8 | 0.8 | 2.1 | 8.8 | 6.1 | 3.46 | 14.39 | 29.2 | 0.09 | 0.21 |
| 2 | *Litsea oleoides* (Meisn) Hook.f. | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 4 | 8 | 0.6 | 0.5 | 0.74 | 3.1 | 4.1 | 0.43 | 1.79 | 9.0 | 0.03 | 0.11 |
| 3 | *Myristica beddome*i King | 1 | 1 | 5 | 0 | 0 | 0 | 1 | 0 | 8 | 4 | 8 | 1 | 0.5 | 1.4 | 5.0 | 4.1 | 1.54 | 6.40 | 15.5 | 0.05 | 0.15 |
| 4 | *Dysoxylum malabaricum* Bedd.ex.C.DC. | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 7 | 6 | 8 | 0.9 | 0.8 | 0.97 | 4.4 | 6.1 | 0.74 | 3.07 | 13.5 | 0.04 | 0.14 |
| 5 | *Palaquium ellipticum* (Dalzell) Baill. | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 8 | 0.5 | 0.4 | 0.49 | 2.5 | 3.0 | 0.19 | 0.78 | 6.3 | 0.03 | 0.09 |
| 6 | *Antidesma montanum* Blume | 0 | 1 | 2 | 4 | 4 | 0 | 0 | 1 | 12 | 5 | 8 | 1.5 | 0.6 | 0.98 | 7.5 | 5.1 | 0.75 | 3.13 | 15.7 | 0.08 | 0.19 |
| 7 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 2 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 7 | 4 | 8 | 0.9 | 0.5 | 1.19 | 4.4 | 4.1 | 1.11 | 4.62 | 13.1 | 0.04 | 0.14 |
| 8 | *Mangifera indica* L. | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 8 | 0.3 | 0.3 | 0.47 | 1.3 | 2.0 | 0.17 | 0.72 | 4.0 | 0.01 | 0.05 |
| 9 | *Meliosma pinnata* Roxb. | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 2 | 7 | 4 | 8 | 0.9 | 0.5 | 0.8 | 4.4 | 4.1 | 0.50 | 2.09 | 10.5 | 0.04 | 0.14 |
| 10 | *Poeciloneuron indicum* Bedd. | 1 | 0 | 0 | 2 | 0 | 4 | 1 | 0 | 8 | 4 | 8 | 1 | 0.5 | 0.29 | 5.0 | 4.1 | 0.07 | 0.27 | 9.3 | 0.05 | 0.15 |
| 11 | *Litsea floribunda* Gamble | 1 | 1 | 1 | 2 | 2 | 0 | 1 | 1 | 9 | 7 | 8 | 1.1 | 0.9 | 1.14 | 5.6 | 7.1 | 1.02 | 4.24 | 17.0 | 0.06 | 0.16 |
| 12 | *Lophopetalum wightianum* Arn. | 0 | 0 | 0 | 1 | 3 | 2 | 0 | 1 | 7 | 4 | 8 | 0.9 | 0.5 | 0.54 | 4.4 | 4.1 | 0.23 | 0.95 | 9.4 | 0.04 | 0.14 |
| 13 | *Neolitsea scrobiculata* (Meisn.) Gamble | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 5 | 4 | 8 | 0.6 | 0.5 | 1.4 | 3.1 | 4.1 | 1.54 | 6.40 | 13.6 | 0.03 | 0.11 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | *Canarium strictum* Roxb. | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 4 | 3 | 8 | 0.5 | 0.4 | 1.1 | 2.5 | 3.0 | 0.95 | 3.95 | 9.5 | 0.03 | 0.09 |
| 15 | *Dimocarpus longan* Lour. | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 4 | 2 | 8 | 0.5 | 0.3 | 0.98 | 2.5 | 2.0 | 0.75 | 3.13 | 7.7 | 0.03 | 0.09 |
| 16 | *Syzygium cumini* (L.) Skeels | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 4 | 3 | 8 | 0.5 | 0.4 | 1.12 | 2.5 | 3.0 | 0.98 | 4.09 | 9.6 | 0.03 | 0.09 |
| 17 | *Litsea wightiana* (Nees) Benth. & Hook. | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 1 | 8 | 0.3 | 0.1 | 0.47 | 1.3 | 1.0 | 0.17 | 0.72 | 3.0 | 0.01 | 0.05 |
| 18 | *Elaeocarpus tuberculatus* Roxb. | 1 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 6 | 4 | 8 | 0.8 | 0.5 | 0.74 | 3.8 | 4.1 | 0.43 | 1.79 | 9.6 | 0.04 | 0.12 |
| 19 | *Alstonia scholaris* (L.) R.Br. | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 1 | 8 | 0.3 | 0.1 | 0.34 | 1.3 | 1.0 | 0.09 | 0.38 | 2.6 | 0.01 | 0.05 |
| 20 | *Antidesma montanum* Blume | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 4 | 3 | 8 | 0.5 | 0.4 | 0.57 | 2.5 | 3.0 | 0.26 | 1.06 | 6.6 | 0.03 | 0.09 |
| 21 | *Aporosa acuminata* Thw. | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 2 | 8 | 0.5 | 0.3 | 0.71 | 2.5 | 2.0 | 0.40 | 1.65 | 6.2 | 0.03 | 0.09 |
| 22 | *Actinodaphne tadulingamii* Gamble | 0 | 0 | 2 | 2 | 1 | 1 | 0 | 1 | 7 | 5 | 8 | 0.9 | 0.6 | 1.12 | 4.4 | 5.1 | 0.98 | 4.09 | 13.6 | 0.04 | 0.14 |
| 23 | *Eugenia mooniana* Wight | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 4 | 3 | 8 | 0.5 | 0.4 | 0.91 | 2.5 | 3.0 | 0.65 | 2.70 | 8.3 | 0.03 | 0.09 |
| 24 | *Glochidion ellipticum* Wight | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 5 | 3 | 8 | 0.6 | 0.4 | 0.83 | 3.1 | 3.0 | 0.54 | 2.25 | 8.4 | 0.03 | 0.11 |
| 25 | *Holigarna arnottiana* Wall.ex Hook.f. | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 4 | 2 | 8 | 0.5 | 0.3 | 0.57 | 2.5 | 2.0 | 0.26 | 1.06 | 5.6 | 0.03 | 0.09 |
| 26 | *Meiogyne pannosa* (Dalzell)J. Sinclair | 0 | 1 | 2 | 0 | 2 | 0 | 2 | 1 | 8 | 5 | 8 | 1 | 0.6 | 1.13 | 5.0 | 5.1 | 1.00 | 4.17 | 14.2 | 0.05 | 0.15 |
| 27 | *Melicope lunu-ankenda* (Gaertn.) T.G. Hartley | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 5 | 4 | 8 | 0.6 | 0.5 | 0.98 | 3.1 | 4.1 | 0.75 | 3.13 | 10.3 | 0.03 | 0.11 |
| | | **15** | **14** | **25** | **21** | **33** | **22** | **14** | **15** | **158** | | | **20** | **12** | **24.1** | **100** | **100** | **20** | **83.0** | **300** | **1.00** | **3.16** |

**Analysis of IVI and Diversity Index of Saplings in Nesting Plot SNS**

| Sl. No | Name of Species | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Total no. of individual | Total number of quadrats | Quadrats of occurrence | Density | Frequency | GBH | RD | RF | BA | RBA | IVI | n/N | (n/N)*log(n/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Myristica beddomei* King | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 7 | 8 | 4 | 0.88 | 0.5 | 0.9 | 5.4 | 4.9 | 0.6 | 2.18 | 12.5 | 0.05 | 0.16 |
| 2 | *Cryptocarya sheikelmudiana Fasila* et al., | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 4 | 8 | 4 | 0.50 | 0.5 | 0.5 | 3.1 | 4.9 | 0.2 | 0.58 | 8.6 | 0.03 | 0.11 |
| 3 | *Psychotria anamalayana* Bedd. | 0 | 1 | 2 | 1 | 2 | 1 | 1 | 0 | 8 | 8 | 6 | 1.00 | 0.75 | 1.5 | 6.2 | 7.4 | 1.9 | 6.82 | 20.4 | 0.06 | 0.17 |
| 4 | *Persea macrantha*(Nees) Kosterm | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 0.6 | 3.9 | 4.9 | 0.3 | 0.93 | 9.8 | 0.04 | 0.13 |
| 5 | *Knema attenuata* (Hook.fil.&Thoms.)Warb. | 3 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 8 | 8 | 2 | 1.00 | 0.25 | 1.2 | 6.2 | 2.5 | 1.2 | 4.42 | 13.1 | 0.06 | 0.17 |
| 6 | *Polyalthia coffeoides* (Thw.) J. Hk.&Thoms. | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 5 | 8 | 4 | 0.63 | 0.5 | 0.7 | 3.9 | 4.9 | 0.4 | 1.45 | 10.3 | 0.04 | 0.13 |
| 7 | *Vateria indic*a L | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 11 | 8 | 7 | 1.38 | 0.88 | 1.3 | 8.5 | 8.6 | 1.4 | 5.01 | 22.2 | 0.09 | 0.21 |
| 8 | *Litsea floribunda* Gamble | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 2 | 7 | 8 | 3 | 0.88 | 0.38 | 0.5 | 5.4 | 3.7 | 0.2 | 0.75 | 9.9 | 0.05 | 0.16 |
| 9 | *Dendrocnide sinuata* (Bi.) Chew | 1 | 1 | 0 | 0 | 2 | 2 | 2 | 0 | 8 | 8 | 5 | 1.00 | 0.63 | 1 | 6.2 | 6.2 | 0.8 | 2.76 | 15.1 | 0.06 | 0.17 |
| 10 | *Phoebe lanceolata* (Nees) Nees | 2 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 7 | 8 | 2 | 0.88 | 0.25 | 0.8 | 5.4 | 2.5 | 0.5 | 1.79 | 9.7 | 0.05 | 0.16 |
| 11 | *Chukrasia tabularis* A. Juss | 4 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 11 | 8 | 7 | 1.38 | 0.88 | 2.1 | 8.5 | 8.6 | 3.5 | 12.68 | 29.9 | 0.09 | 0.21 |
| 12 | *Alseodaphne semecarpifolia* Nees | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.5 | 1.6 | 2.5 | 0.2 | 0.75 | 4.8 | 0.02 | 0.06 |
| 13 | *Bombax ceiba* L. | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 5 | 8 | 2 | 0.63 | 0.25 | 0.4 | 3.9 | 2.5 | 0.1 | 0.35 | 6.7 | 0.04 | 0.13 |
| 14 | *Mesua ferrea* L. | 0 | 4 | 3 | 1 | 2 | 1 | 0 | 0 | 11 | 8 | 5 | 1.38 | 0.63 | 2.2 | 8.5 | 6.2 | 3.8 | 14.04 | 28.8 | 0.09 | 0.21 |
| 15 | *Palaquium ellipticum* (Dalzell) Baill. | 3 | 1 | 1 | 4 | 1 | 2 | 0 | 2 | 14 | 8 | 7 | 1.75 | 0.88 | 2.9 | 10.9 | 8.6 | 6.8 | 24.85 | 44.4 | 0.11 | 0.24 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | *Tarenna monosperma* (Wight & Arn.) D.C.S .Raju | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 5 | 8 | 4 | 0.63 | 0.5 | 1.2 | 3.9 | 4.9 | 1.1 | 4.14 | 13.0 | 0.04 | 0.13 |
| 17 | *Mallotus philippensis* (Lam.) *Mull.Arg. | 1 | 1 | 2 | 1 | 4 | 0 | 1 | 1 | 11 | 8 | 7 | 1.38 | 0.88 | 2 | 8.5 | 8.6 | 3.0 | 11.16 | 28.3 | 0.09 | 0.21 |
| 18 | *Canarium strictum* Roxb. | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 8 | 3 | 0.38 | 0.38 | 0.7 | 2.3 | 3.7 | 0.4 | 1.57 | 7.6 | 0.02 | 0.09 |
| 19 | *Hydnocarpus alpina* Wight | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 3 | 8 | **3** | 0.38 | 0.38 | 0.8 | 2.3 | 3.7 | 0.5 | 1.89 | 7.9 | 0.02 | 0.09 |
| 20 | *Beilschmiedia* sps. | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 5 | 8 | 5 | 0.63 | 0.63 | 0.6 | 3.9 | 6.2 | 0.3 | 1.18 | 11.2 | 0.04 | 0.13 |
| 21 | *Aglaia* sps | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 2 | 0.25 | 0.25 | 0.5 | 1.6 | 2.5 | 0.2 | 0.75 | 4.8 | 0.02 | 0.06 |
| | | | | | | | | | | **142** | | | **16** | **10** | **23** | **100** | **100** | **27** | **100** | **300** | **1** | **3.12** |

# APPENDIX 3
## Total trees

| Sl No. | Name of species | Family | IUCN status |
|---|---|---|---|
| 1 | *Hydnocarpus pentandrus* (Buch-Ham.) Oken | Achariaceae | Not evaluated. |
| 2 | *Hydnocarpus alpinus* Wight | Achariaceae | Not evaluated. |
| 3 | *Holigarna arnottiana* Wall.ex Hook.f. | Anacardiaceae | Not evaluated. |
| 4 | *Holigarna grahamii* (Wight) Kurz. | Anacardiaceae | Not evaluated. |
| 5 | *Solenocarpus indicus* Wight & Arn. | Anacardiaceae | Not evaluated. |
| 6 | *Spondias pinnata* (L. f) Kurz | Anacardiaceae | Not evaluated. |
| 7 | *Mangifera indica* L. | Anacardiaceae | Not evaluated. |
| 8 | *Meiogyne pannosa* (Dalzell) J. Sinclair | Annonaceae | Near Threatened |
| 9 | *Polyalthia coffeoides* (Thw.) J. Hk&Thoms | Annonaceae | Not evaluated. |
| 10 | *Polyalthia fragrans* (Dalzell) Hook.f &Thomson | Annonaceae | Not evaluated. |
| 11 | *Alstonia scholaris* (L.) R. Br. | Apocynaceae | Lower Risk/ least concern |
| 12 | *Canarium strictum* Roxb. | Burseraceae | Not evaluated |
| 13 | *Calophyllum polyanthum* Wall. ex Choisy | Calophyllaceae | Not evaluated |
| 14 | *Mesua ferrea* L. | Calophyllaceae | Not evaluated. |
| 15 | *Lophopetalum wightianum* Arn. | Celastraceae | Lower Risk/ least concern |
| 16 | *Garcinia gummi-gutta* (L.) Robs. | Clusiaceae | Least Concern. |
| 17 | *Poeciloneuron indicum* Bedd. | Clusiaceae | Not evaluated. |
| 18 | *Terminalia paniculata* Roth | Combretaceae | Not evaluated. |
| 19 | *Terminalia bellerica* (Gaertn.) Roxb. | Combretaceae | Not evaluated. |
| 20 | *Mastixia arborea* (Wight) C.B.Clarke | Cornaceae | Least Concern. |
| 21 | *Dipterocarpus indicus* Bedd. | Dipterocarpaceae | Endangered |
| 22 | *Hopea parviflora* Bedd. | Dipterocarpaceae | Endangered |
| 23 | *Vateria indica* L | Dipterocarpaceae | Vulnerable |
| 24 | *Diospyros candolleana* Wight | Ebenaceae | Vulnerable |
| 25 | *Diospyros crumenata* Thw. | Ebenaceae | Critically Endangered |
| 26 | *Elaeocarpus tuberculatus* Roxb. | Elaeocarpaceae | Not evaluated. |
| 27 | Elaeocarpus variabilis Zmarzty | Elaeocarpaceae | Not evaluated. |
| 28 | *Agrostistachys borneensis* Becc | Euphorbiaceae | Least Concern. |
| 29 | *Macaranga peltata* (Roxb.) Mull. Arg. | Euphorbiaceae | Not evaluated. |
| 30 | *Mallotus atrovirens* Wall. ex. Mull.Arg | Euphorbiaceae | Vulnerable |
| 31 | *Mallotus philippensis* (Lam.) Mull. Arg. | Euphorbiaceae | Least Concern. |
| 32 | *Paracroton pendulus* (Hassk.) Miq. | Euphorbiaceae | Not evaluated |

| | | | |
|---|---|---|---|
| 33 | *Xylia xylocarpa* (Roxb.) Taub. | Fabaceae | Least Concern. |
| 34 | *Kingiodendron pinnatum* (Roxb.ex Dc.) Harms | Fabaceae | Vulnerable |
| 35 | *Actinodaphne bourdillonii* Gamble | Lauraceae | Near Threatened |
| 36 | *Actinodaphne tadulingamii* Gamble | Lauraceae | Near Threatened |
| 37 | *Actinodaphne wightiana* (Kuntze) Noltie | Lauraceae | Least Concern. |
| 38 | *Actinodaphne* sp. 1 | Lauraceae | |
| 39 | *Alseodaphne semecarpifolia* Nees | Lauraceae | Near Threatened |
| 40 | *Beilschmiedia bourdillonii* Brandis | Lauraceae | Not evaluated |
| 41 | *Beilschmiedia wightii* (Nees) Benth | Lauraceae | Near Threatened |
| 42 | *Cinnamomum malabatrum* (Burm.f.) persl. | Lauraceae | Lower Risk/ least concern |
| 43 | *Cryptocarya anamalayana* Gamble | Lauraceae | Endangered |
| 44 | *Cryptocarya sheikelmudiyana* Fasila *et al*. | Lauraceae | Endangered |
| 45 | *Litsea bourdillonii* Gamble | Lauraceae | Near Threatened |
| 46 | *Litsea coriaceae* (B.Heyne ex Nees) Hook.f. | Lauraceae | Not evaluated. |
| 47 | *Litsea floribunda* Gamble | Lauraceae | Near Threatened |
| 48 | *Litsea oleoides* (Meisn.) J.Hk | Lauraceae | Endangered |
| 49 | *Litsea nigrescens* Gamble | Lauraceae | Endangered |
| 50 | *Litsea stocksii* (Meissn.) Hook | Lauraceae | Near Threatened |
| 51 | *Litsea wightiana* (Nees) Benth. & Hook. | Lauraceae | Near Threatened |
| 52 | *Litsea* sp.1 | Lauraceae | |
| 53 | *Neolitsea cassia* (L.) Kosterm. | Lauraceae | Lower Risk/ least concern |
| 54 | *Neolitsea fischeri* Gamble | Lauraceae | Vulnerable |
| 55 | *Neolitsea scrobiculata* (Meisn.) Gamble | Lauraceae | Not evaluated |
| 56 | *Neolitsea* sp.1 | Lauraceae | |
| 57 | *Persea macrantha* (Nees) Kosterm. | Lauraceae | Not evaluated. |
| 58 | *Phoebe lanceolata* (Nees) Nees | Lauraceae | Lower Risk/ least concern |
| 59 | *Phoebe wightii* Meisn. | Lauraceae | Not evaluated |
| 60 | *Cinnamomum sulphuratum* Nees | Lauraceae | Least Concern. |
| 61 | *Cryptocarya lowsonii* Gamble | Lauraceae | Not evaluated. |
| 62 | *Bombax ceiba* L. | Malvaceae | Least Concern. |
| 63 | *Cullenia exarillata* A. Robyns | Malvaceae | Not evaluated. |
| 64 | *Aglaia barberi* Gamble | Meliaceae | Vulnerable |
| 65 | *Aglaia malabarica* Sasidh. | Meliaceae | Critically Endangered |
| 66 | *Aphanamixis polystachya* (Wall). R.N.Parker | Meliaceae | Lower Risk/ |

| | | | |
|---|---|---|---|
| | | | least concern |
| 67 | *Chukrasia tabularis* A. Juss. | Meliaceae | Lower Risk/ least concern |
| 68 | *Dysoxylum malabaricum* Bedd.ex C.DC. | Meliaceae | Endangered |
| 69 | *Dysoxylum ficiforme* (Wight) Gamble | Meliaceae | Vulnerable |
| 70 | *Reinwardtiodendron anamalaiense* (Bedd.) Mabb. | Meliaceae | Not evaluated. |
| 71 | *Trichilia connaroides* (Wight & Arn.) Bentvelzen | Meliaceae | Not evaluated. |
| 72 | *Artocarpus heterophyllus* Lam. | Moraceae | Not evaluated |
| 73 | *Ficus exasperata* Vahl | Moraceae | Least Concern. |
| 74 | *Gymnacranthera* canarica (Bedd.ex King) Warb. | Myristicaceae | Vulnerable |
| 75 | *Knema attenuata* (Hook.fil.&Thoms.) Warb. | Myristicaceae | Lower Risk /least concern |
| 76 | *Myristica beddomei* King | Myristicaceae | Not evaluated |
| 77 | *Myristica beddomei* sub sp *sphaerocarpa* W.J. de Wilde | Myristicaceae | Endangered |
| 78 | *Myristica malabarica* Lam. | Myristicaceae | Vulnerable |
| 79 | *Eugenia mooniana* Wight | Myrtaceae | Least Concern. |
| 80 | *Syzygium cumini* (L.) Skeels | Myrtaceae | Lower Risk/ least concern |
| 81 | *Syzygium laetum* (Buch.Ham.) Gandhi | Myrtaceae | Not evaluated. |
| 82 | *Syzygium occidentale* (Bourd.) Gandhi | Myrtaceae | Endangered |
| 83 | *Olea dioica* Roxb. | Oleaceae | Not evaluated |
| 84 | *Aporosa acuminata* Thw. | Phyllanthaceae | Not evaluated |
| 85 | *Glochidion ellipticum* Wight | Phyllanthaceae | Not evaluated. |
| 86 | *Antidesma montanum* Blume | Phyllanthaceae | Least Concern. |
| 87 | *Drypetes malabarica* (Bedd.) Airy Shaw | Putranjivaceae | Critically Endangered |
| 88 | *Drypetes venusta* (Wight) Pax & K.Hoffm. | Putranjivaceae | Not evaluated. |
| 89 | *Ziziphus rugosa* Lam. | Rhamnaceae | Not evaluated. |
| 90 | *Maesopsis eminii* Engl. | Rhamnaceae | Not evaluated. |
| 91 | *Mitragyna parvifolia* (Roxb.) Korth. | Rubiaceae | Not evaluated. |
| 92 | *Psychotria anamallayana* Bedd. | Rubiaceae | |
| 93 | *Saprosma glomeratum* (Gardner) Bedd. | Rubiaceae | Not evaluated. |
| 94 | *Tarenna monosperma* (Wight & Arn.) D.C.S .Raju | Rubiaceae | Endangered |
| 95 | *Glycosmis mauritiana* (Lam.)Tanaka | Rutaceae | Least Concern. |
| 96 | *Melicope lunu-ankenda* (Gaertn.) T.G. Hartley | Rutaceae | Least Concern. |
| 97 | *Meliosma pinnata* Roxb. | Sabiaceae | Not evaluated. |
| 98 | *Dimocarpus longan* Lour. | Sapindaceae | Not evaluated. |
| 99 | *Otonephelium stipulaceum* (Bedd.) Radlk. | Sapindaceae | Not evaluated |

| | | | |
|---|---|---|---|
| 100 | *Schleichera oleosa* (Lour.) Oken | Sapindaceae | Least Concern. |
| 101 | *Palaquium ellipticum* (Dalzell) Baill. | Sapotaceae | Not evaluated. |
| 102 | *Turpinia malabarica* Gamble | Staphyleaceae | Not evaluated. |
| 103 | *Tetrameles nudiflora* R.Br. | Tetramelaceae | Not evaluated. |
| 104 | *Dendrocnide sinuata* (Bl.) Chew | Urticaceae | Least Concern. |