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## A NOTE ON THE POPULATION STATUS AND THREATS ON TWO ENDEMIC AND ENDANGERED SPECIES OF *GARCINIA* OF AGASTHYAMALAI BIOSPHERE RESERVE, TAMIL NADU, INDIA

G. Manikandan<sup>1</sup> & R. Ramasubbu<sup>2</sup>

<sup>1,2</sup> Department of Biology, The Gandhigram Rural Institute - Deemed University, Dindigul, Tamil Nadu 624302, India  
<sup>1</sup>rgmani.19@gmail.com, <sup>2</sup>racprabha@gmail.com (corresponding author)

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**Abstract:** The genus *Garcinia* comprises c. 35 species in India many of which are endemic and economically important with immense medicinal properties. The two species viz., *Garcinia imberti* and *G. travancorica* are lesser-known endemic medium-sized straight-stemmed trees with horizontal branches. The trees are distributed in the restricted forest areas (700–1,500 m) of Agasthyamalai Biosphere Reserve. Both the species are dioecious trees and have male and female flowers in two different individuals, sometimes at a distance of a few kilometers from each other. A large number of mature individuals of these species have been over-exploited from Agasthyamalai Biosphere Reserve and therefore a few mature individuals and seedlings alone exist. The populations were severely fragmented and exist in a few locations of natural forest areas. The number of mature individuals recorded in *G. imberti* and *G. travancorica* was 127±14 and 112±14 respectively in the entire distributional areas. There was an extreme fluctuation observed every year in the case of flowering and fruiting and also in the number of individuals due to the disturbance in the forest ecosystem. Both species have been included under IUCN threatened category and therefore they need effective conservation measures.

**Keywords:** Dioecious, *Garcinia imberti*, *Garcinia travancorica*.

The genus *Garcinia* L. (Clusiaceae) is distributed in South and Southeast Asia, ranging from the southern part of Thailand and Peninsular Malaysia to Indonesia and some parts of the Philippines (Richards 1990). About 35 species have been reported from India, many of which

are endemic and economically important, with immense medicinal properties (Singh 1993; Parthasarathy et al. 2013). The species of *Garcinia* generally grow in evergreen to semi-evergreen forests of the tropical or in areas with a relatively mild monsoon climate. The genus *Garcinia* is one of the slowest growing trees known from the tropics. In the forest, *Garcinia* appears as medium-sized, straight-stemmed trees with horizontal branches. They are evergreen monoecious, dioecious and polygamous trees, shrubs and rarely herbs. The flowers may be either monoecious or dioecious and sometimes polygamous. Detailed records by the earlier researchers suggested that, the genus *Garcinia* is also predominantly dioecious and species like *G. mangostana* and *G. scortechinii* have rarely staminate trees (Corner 1952; Jansen 1991; Thomas 1997).

The trees of *Garcinia* are a source of hydroxy citric acid, which is an anti-obesity compound. Hydroxy citric acid (HCA) is found in the fruits of certain members of *Garcinia* which include *G. cambogia*, *G. indica* and *G. atroviridis*. The latex of *G. cowa* is used in Thai folk medicines as an antifever agent (Pattalung et al. 1994). Some species of this genus have different chemical constituents, such as benzophenones and bioflavonoids,

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which are of great importance for the pharmaceutical industries due to the wide spectrum of biological activities. The activities include cytopathic inhibition of in vitro HIV infection, free radical scavenging, iNOS and COX-2 expression inhibition in carcinoma of the colon, induction of apoptosis, antiulcer and trypanocidal properties (Martins et al. 2007).

In India, the species of *Garcinia* grow extensively in a semi-wild state, in the Konkan region of Maharashtra, Goa, coastal areas of Kerala, evergreen forests of Karnataka and Tamil Nadu, Assam, Khasi, Jaintia Hills, West Bengal and Gujarat. Few members of *Garcinia* produce edible fruits and *G. magostana* has the tastiest fruits. The young leaves of some species of *Garcinia* are eaten by some tribes in northeastern India (Jain & Dam 1979; Arora 1981; Rao & Shanpru 1981). The species of *Garcinia* are used for childbirth and menstrual problems, dysentery and fever (Burkill 1935). Some species have been recorded to have potential treatment for HIV (Rukachaisirikul et al. 2003) and Cancer (Nabandith et

al. 2004). They are used in garnishing curries and also as a replacement for Tamarind. In northeastern India, the sundried slices of the fruits are used for culinary purposes and as folk medicine. The seeds of *G. indica* fruits yield valuable edible fat known as kokum butter. The fruits of *Garcinia* are a food source for several animals (Manikandan 2016). Most species of *Garcinia* are known for their gum resin, which is used as a purgative or cathartic. Fruits of some *Garcinia* species are also one of the richest sources of red pigments.

Of the 35 species reported from India, seven are endemic to the Western Ghats, six to Andaman & Nicobar Islands and six to northeastern India (Braganca & Rodrigues 2001). At present 17 species are endemic to India (Singh et al. 2015). Among these, *Garcinia imberti* and *G. travancorica* were reported as endemic to Agasthyamalai Biosphere Reserve with restricted distribution. Due to its high altitude nature, restricted distribution and dioecious nature, these endemic species of *Garcinia* did not receive much attention among researchers. Moreover, the distributional status, vulnerability and the average number of mature individuals died per year (reduction) was not assessed properly. In this background, a study has been attempted to analyze the population status and various threats responsible for the reduction of two strict endemic species, *G. imberti* and *G. travancorica* from the Agasthyamalai Biosphere Reserve, southern Western Ghats (Fig. 1).

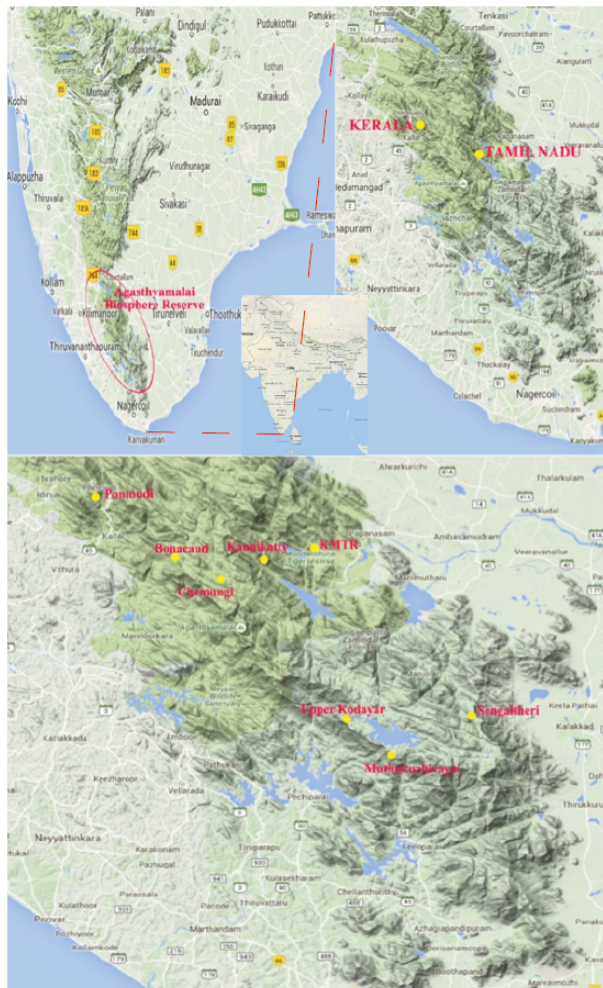


Figure 1. Study area

### *Garcinia imberti* (Images 1 & 3)

Bourd., J. Bombay Nat. Hist. Soc. 12: 349, t. 1.1899 & Forest Trees Travancore: 24, 1908; Gamble, Man. Ind. Timb.: 57. 1902; Rama Rao, Fl. Pl. Travancore: 31. 1914; Dunn in Gamble, Fl. Madras: 74. 1915 [1:53.1967 Repr.]; Maheshw., Bull. Bot. Surv. India 6: 117.1964; N.P. Singh in B.D. Sharma & Sanjappa, Fl. India 3:112.1993; Mohanan et al. Indian J. Forestry 20: 384.1997; Gopalan & A.N. Henry, End. Pl. India; 208. 2000; Ramas. & G. Manik. in C. Buvaneshwaran et al. (eds.) Adv. Tree Seed Sci. Silviculture: 2015; Shareef & Krishnaraj, Taiwania 60: 148. 2015.

Vernacular Name: Mania kanji (Tamil)

A medium-sized evergreen dioecious tree, 9–12 m high; trunk c. 30cm in diam.; bark brown and white, smooth, c. 6mm thick; cut sweet scented, wood yellowish-grey, very hard; pores medium to small, scanty, evenly distributed; medullary rays indistinct. Leaves opposite, elliptic or lanceolate, 4–8 × 1.5–3 cm, apex acuminate, margins entire, base narrowed, dark green;



Image 1. *Garcinia imberti*: A - habitat with adult male and female individual; B - leaf twig; C - flowering twig; D - male flower; E - bisexual flower; F - female flower; G - mature fruit; H - matured viable seed

midrib prominent on both surfaces and raised beneath, nerves 15–25, parallel, close, obscure; petiole c. 3mm long. Male flowers: terminal fascicles 3–9, at the ends of branchlets, yellow, c. 5mm in diam., succulent, sessile. Sepals and petals 4 each, much imbricated. Stamens in a central globose mass,  $31 \pm 6$ . Female flowers: terminal, solitary or geminate, yellow, succulent, sessile. Sepals and petals as in male. Staminodes  $18 \pm 3.19$  in a ring surrounding the ovary inserted on a hypogynous ring. Ovary bilocular; ovules solitary in each locule; stigma broad, sessile, convex. Berry c.  $2.5 \times 2.5$  cm. Seeds 1–2, brown, smooth, enclosed in a leathery covering. Bisexual flowers: terminal fascicles 1–5, at the ends of branchlets, yellow, c. 5mm in diam., succulent, sessile. Sepals and petals 4 each. Stamens long, c.  $7 \pm 2$  cm in a ring surrounding the ovary, inserted on a hypogynous ring. Ovary bilocular; ovules solitary in each locule; stigma broad, sessile and cone shaped, wet and non-papillate convex. Berry c.  $2.5 \times 2.5$  cm. Seeds 1–2, brown, smooth,

enclosed in a leathery covering (Images 1 & 2).

**Flowering & Fruiting:** The flowering started in the month of February and extended up to July with a peak flowering season during May. The fruiting was observed between July to September.

#### Distribution

Bourdillon (1899) collected *G. imberti* from Chemungi hills and Straihmore estates of southern Travancore Hills and described. Beddome (1879) has also collected the same species from Tirunelveli Hills, Tamil Nadu. Later, Bourdillon (1908), Rao (1914), Gamble (1915) and Engler (1925) included this species for their floras and also have commented that, the species is restricted locally to the Agasthyamalai region. Maheshwari (1964) revised the genus *Garcinia* of India taxonomically and confirmed the distribution of this species in Agasthyamalai Biosphere Reserve. After a few decades, *G. imberti* was declared as extinct from its type locality and no more specimens were collected (Mohanani et al. 1997). Mohanani et al. (1997) rediscovered *G. imberti* from its type locality after a long gap of 97 years and reported population decline while exploring Agasthyamalai Hills. The populations of *G. imberti* are distributed at higher altitude evergreen forests of Agasthyamalai Biosphere Reserve at the tail end of the Western Ghats, adjoining forests bordering between Tirunelveli and Kanyakumari districts of Tamil Nadu and Thiruvananthapuram District of Kerala with an altitude ranging from 700–1,500 m. This species is reported only from the above-mentioned forest areas and not reported from elsewhere. Periodical exploration trips conducted at various forests areas of Western Ghats confirmed the species as strictly endemic to Agasthyamalai Biosphere Reserve.

#### Economic importance

Stem, bark, leaves and fruits are repeatedly used in various medicines. The timber is also used for building houses. Further, phytochemical studies on leaf essential oil of this tree yielded medicinally valuable bioactive compounds such as  $\alpha$ -Copaene, Geranyl acetone, Folic Acid,  $\beta$ -Gurjunene, Desacetylanguidine, Caryophyllene oxide, Lupeol acetate,  $\beta$ -Ionone, Cedrene, Hexadecanoic acid, methyl ester, Glycodeoxycholic acid and Bis(2-ethylhexyl) phthalate etc., and these bioactive compounds severely inhibited the growth of microorganisms and implied antimicrobial activity against various human pathogens (Ramasubbu et al. unpublished data). The essential oils of stem bark has four constituents such as humulene,  $\beta$ -caryophyllene,

caryophyllene oxide and humulene oxide and these compounds showed moderate activity against gram positive and gram negative bacteria (Rameshkumar et al. 2006).

### Population status

Previous literature on this species has not clearly described the nature of flowers. However, the species is reported to have male and female flowers. Detailed field work carried out at different forest areas of Tamil Nadu and Kerala has confirmed that it is a strictly dioecious tree. The male and female trees are found growing individually sometimes with many kilometers between them or in close combination. Usually, the male tree produces male flowers whereas; the female tree produces female flowers. Interestingly, at the end of period of the flowering season, the female tree produces considerable amount of bisexual flowers. This is first-hand information about the species. *Garcinia imberti* is closely associated with many evergreen arboreals including *Calophyllum austro-indicum*, *Cullenia exarillata*, *Actephila excelsa*, *Garcinia travancorica*, *G. xanthochymus*, *G. gummi-gutta*, *Schefflera bourdillonii*, *Syzygium zeylanicum*, *S. mundagam*, *Elaeocarpus venustus*, *E. recurvatus*, *E. variabilis*, and *Litsea coriacea*. Based on field observation and standard literature (IUCN), the extent of occurrence was estimated to about less than 50km<sup>2</sup> and the area of occupancy was restricted to less than 10km<sup>2</sup>. The populations were severely fragmented and exist in 15±3 locations. To confirm whether the population further undergoes additional risk by fragmentation into small groups (IUCN), extensive field trips were conducted at various parts of Agasthyamalai Biosphere reserve of Tamil Nadu and Kerala. Usually, the strategies for determining the number of subpopulations may vary from taxon to taxon. In case of both species of *Garcinia*, spatially dissimilar section of the population that experiences irrelevant seed or pollen migration from other subpopulations were analysed. The population of *G. imberti* was identified as 15, whereas, the population of *G. travancorica* was recorded as 13. Further, the fragmented individuals of smaller number of trees from the main populations were analysed with detailed field survey. But there were no subpopulations observed in the entire study area.

The number of mature individuals (individuals which produce new recruits and individuals having reproducing units within the populations were counted as mature individuals) recorded was 127±14 in the entire distributional area. The habitat of the tree species has changed due to the extension of tea estates

by private companies and also by raising commercial plantations by the forest department. There was an extreme fluctuation observed every year in the case of populations and also in the number of individuals due to the disturbance in the forest ecosystem. Since, being an Endangered (B1+2c ver. 2.3) tree species as categorized by IUCN (IUCN 2017-1), authenticated periodical survey reports and other relevant information have to be communicated to IUCN and the strategy or action plan has to be developed to conserve the species in its natural habitat.

### *Garcinia travancorica* (Images 2 & 4)

Bedd. Fl. Sylv. S. India: t. 173. 1872; T. Anderson in Hook. f., Fl. Brit. India 1: 268. 1874; Dunn in Gamble, Fl. Madras: 74. 1915[1.53.1967 Repr.]; Mahesw., Bull. Bot. Surv. India 6: 120. 1964; Raman. in A.N. Henry et al. Fl. Tamil Nadu Ser. I Anal.1: 281983; N.P. Singh in B.D. Sharma & Sanjappa, Fl. India 3:128.1993; Gopalan & A.N. Henry, End. Pl. India: 208. 2000; G. Manik. & Ramas. in P. Mehalingam et al. (eds.) Trends Med. Pl. Herbal Products: 340. 2013; Ramas. & G. Manik.in C. Buvaneswaran et al. (eds.) Adv. Tree Seed Sci. Silviculture: 115. 2015.

Vernacular Name: Halambungu, Petrol kai (Tamil); Malampongu (Malayalam); Travancore Gamboge (English)

A medium-sized, slender evergreen dioecious tree, 12–18 m tall; branches obtusely 4-angled, shining; wood yellowish-brown; sapwood pale yellow, hard, heavy; latex yellow, sticky, Leaves linear-oblong to subspathulate, sometimes broader upwards, 8–10×1.5–2.5 cm, apex rotundate or obtuse, margins revolute, base acute, coriaceous, dark green above, pale beneath; midrib stout, prominent below, lateral nerves slender, numerous, horizontal. Male flowers: few in terminal and subterminal short trichotomous cymes, c. 1cm in diam.; pedicels very short, thickened. Sepals 4, decussate, orbicular, concave, two outer ones much smaller than the inner pair. Petals 4, about twice as long as sepals, shortly clawed, rounded. Stamens numerous (84.5±15.44 in four multifid polyandrous masses; anthers bilocular, versatile, linear-oblong, longitudinally bi-valvular; filaments short. Pistillode columnar, with a circular peltate stigma. Female flowers: solitary in the terminal axils, slightly longer than male flowers. Sepals 4, decussate, orbicular, concave, two outer ones much smaller than the inner pair. Petals 4, twice as long as sepals, shortly clawed, rounded. Stamines many (28.5±2.01 free, inserted in a hypogynous ring; filaments complanate, linear, in bi or trichotomous branches; anther loculi often divaricate,

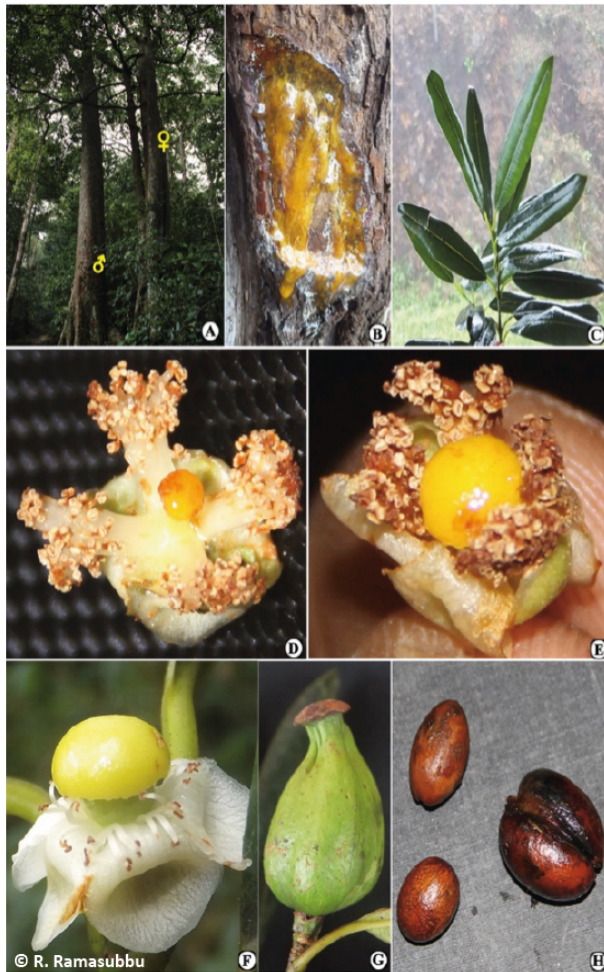


Image 2. *Garcinia travancorica*: A - habitat with adult male and female individual; B - adult tree secretes yellowish gamboges; C - leafy twig; D - male flower; E - bisexual flower; F - female flower; G - mature fruit; H - viable seed

oblong or kidney shaped. Ovary subglobose or pyriform, 4 locular, half concealed by the large convex stigma. Berry oblong to subglobose, as a walnut, contracted into a short, thick style with a broad imbricate stigma; style and stigma persistent. Seeds few, large c. 2.5×1.5 cm, shining, testa brown. Bisexual flowers: trichotomous, short, few-flowered, terminal and subterminal cymes, c. 1cm in diam.; pedicels very short, thickened. Sepals 4, decussate, orbicular, concave, two outer ones much smaller than the inner pair. Petals 4, about twice as long as sepals, shortly clawed, rounded. Stamens numerous (69.5±8.69 in four multifid polyandrous mass; anthers bilocular, versatile, linear-oblong, longitudinally bivalved; filaments very short, sometimes absent. Ovary subglobose or pyriform, 4 locular, half concealed by the large convex stigma. Berry oblong to subglobose, as a walnut, contracted into a short, thick style with a broad imbricate stigma. Seeds few, large c. 2.5×1.5 cm, shining testa brown (Images 3 & 4).

**Flowering & Fruiting:** The flowering period of *G. travancorica* starts in the month of June and extends up to December. The mature buds of male inflorescence are initiated in the month of May and the peak flowering period was observed in the month of August and the blooming gets over by October. The fruiting started in the month of September to December and extended up to April.

#### Distribution

Beddome (1872) collected this species from Chemungi of Agasthyamalai, southern Western Ghats, India and described it as a new species. Later, Rao (1914), Gamble (1915), and Engler (1925) included this species in their floras and confirmed its restricted distribution in the forest areas of Agasthyamalai. The populations of *G. travancorica* are distributed in higher altitude evergreen forests of Agasthyamalai Biosphere Reserve in the tail end of the Western Ghats of adjoining forests bordering between Tirunelveli and Kanyakumari districts in Tamil Nadu and Thiruvananthapuram District of Kerala with an altitude ranging from 700–1,500 m. Periodic field exploration trips conducted of various forests areas of Western Ghats have confirmed the species as strictly endemic to Agasthyamalai Biosphere Reserve.

#### Economic importance

The leaves yields oil which has medicinally valuable bioactive compounds such as  $\alpha$ -Copaene, Geranyl acetone, Humulene, Copaene,  $\delta$ -cadinene, Caryophyllene oxide,  $\beta$ -Ionone, Squalene, Hexahydro farnesyl acetone, Phthalic acid, Farnesyl Acetone, Methyl elaidate and Phytol, etc., and these bioactive compounds severely inhibited the growth of microorganisms and implied antimicrobial activity against various human pathogens (Ramasubbu et al. unpublished data). The tree yields yellow gamboges, which are used for wound healing and ointment. The yellow gamboge, a gum-resin obtained from the plant is used as a yellow dye, as an illuminant and in varnishes and watercolours. The timber is also used for building houses (Maheshwari 1964). The local people use the fruits to flame the fuel wood as substitute for kerosene.

#### Population status

Like other evergreen trees of Western Ghats, *G. travancorica* is a medium sized, slender evergreen tree that grows 12–18 m tall. It is a dioecious slow growing tree, the seed germination and seedling establishment in the natural habitat were very poor. Like *G. imberti*, the information about the species is scarce. The species

was described with male and female flowers. Moreover, it is first-hand information about description of bisexual flower of the species. Since, being a dioecious tree, the female tree produces a considerable percentage of bisexual flowers with a large number of fertile anthers (69.5±8.69). The formation of bisexual flowers in female trees was unpredictable and but can be seen in most of the female trees. *Garcinia travancorica* is closely associated with many other evergreen arboreals including *Calophyllum austro-indicum*, *Actephila excelsa*, *Garcinia imberti*, *G. xanthochymus*, *Schefflera bourdillonii*, *Syzygium munronii*, *S. mundagam*, *Elaeocarpus variabilis* and *Litsea coriacea*. Based on several reports and field study, the extent of occurrence was estimated to about less than 50km<sup>2</sup> and the area of occupancy was restricted to less than 10km<sup>2</sup>. The populations were severely fragmented and exist in less than 13±2 locations. It was also observed that there were no subpopulations in the study area. The number of mature individuals recorded (individuals which produce new recruits and individuals having reproducing units within the populations were counted as mature individuals) was 112±14 in the entire distributional areas. There was an extreme fluctuation observed in every year in the case of populations and also in the number of individuals due to the disturbance in the forest ecosystem. According to IUCN (2017-1), the tree has been included under Vulnerable (B1+2c ver. 2.3) category. But this species can be considered as Critically Endangered on the basis of its reduced geographic range, lesser population and number of individuals.

## CONCLUSION

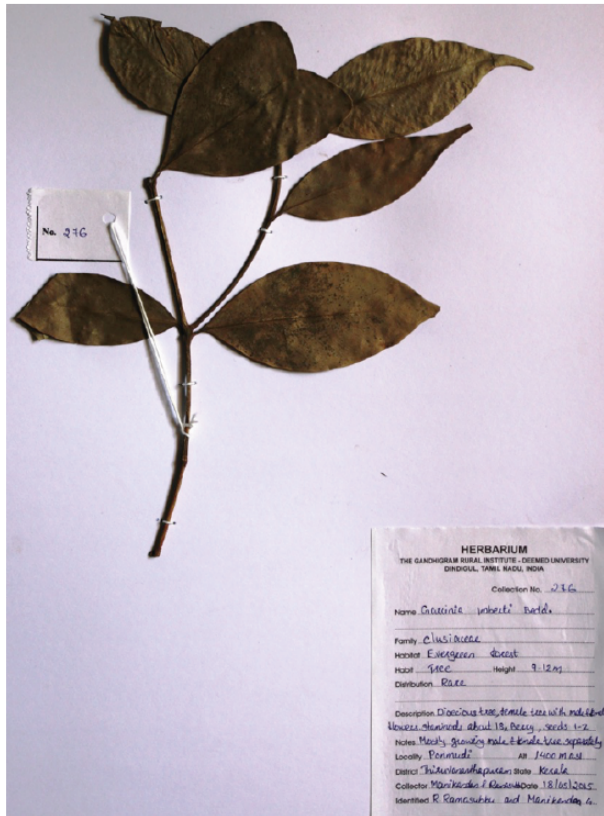
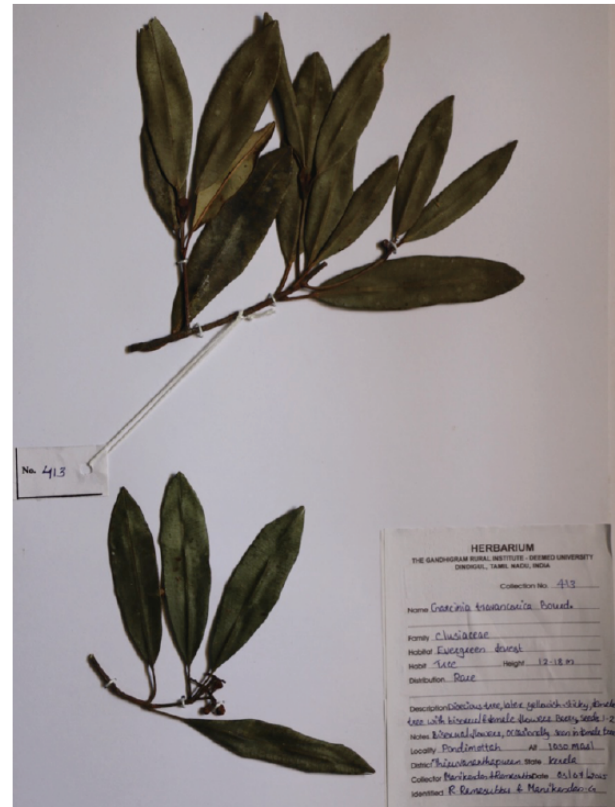
*Garcinia imberti* and *G. travancorica* are strict endemic tree species of Agsthyamalai Biosphere Reserve of the southern Western Ghats. The extent of occurrence of both the species was reported as less than 50km<sup>2</sup> and the area of occupancy was restricted to less than 10km<sup>2</sup>. Both the species were reported as dioecious trees, the tree has male and female flowers on two different individuals. However, the female trees of both species produced considerable numbers of bisexual flowers. The populations of *G. imberti* and *G. travancorica* were severely fragmented and few populations alone exist in the study area. The recent reproductive biological studies on both species confirmed that, the populations were mostly affected by their reproductive inefficiency particularly through insufficient pollination mechanism (Manikandan 2016). A considerable percentage of fruits and seeds were eaten away by most of the tree arboreal particularly, Malabar Giant Squirrel *Ratufa indica* which also causes seed scarcity for germination in the wild.

There was an extreme fluctuation observed in every year in the case of population size and also in the number of individuals due to the unsuccessful pollination in the forest ecosystem. Further, illegal timber cutting and over-exploitation are other major factors for the fast reduction of this tree population in the past few decades. Therefore, alternative strategies have to be developed to for better seedling development and conservation of these two valuable tree species.

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Image 3. Herbarium of *Garcinia imberti*Image 4. Herbarium of *Garcinia travancorica*

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