Chapter 1

Diversity of *Garcinia* species in the Western Ghats

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Abstract
The Western Ghats, being one of the hotspots of biodiversity, support an enormous plant wealth. The genus *Garcinia* is an important component of the flora of the Western Ghats and is well known for their edible fruits and nutraceutical properties. The present chapter elaborates the diversity and distribution of *Garcinia* species in the Western Ghats. Conservation status of *Garcinia* species of the Western Ghats has also been revised. Field surveys, herbarium examinations and literature references revealed that there are 9 species and 2 varieties of the genus indigenous to the Western Ghats of which 7 species and 2 varieties are endemic to the region. The diversity of floral morphology, leaf morphology and fruit morphology were elaborated along with a dichotomous key to the Western Ghats species.

Key words: *Garcinia*, Clusiaceae, Western Ghats, Diversity, Conservation

Introduction
The dioecious genus *Garcinia* is the largest genus within the family Clusiaceae (formerly Guttiferae) and comprises nearly 250 species world over. *Garcinia* species are generally small or medium sized evergreen trees, (occasionally shrubs: *G. buchneri* Engl.), and are distributed in pantropical regions, with high species richness in South-East Asia (Figure 1). The centre of diversity of *Garcinia* species is the Malaysian region, with some species reaching India and the Micronesian islands and also extending to tropical Africa and the Neotropics (Rogers and Sweeney 2007, Stevens, 2007, Jones, 1980, Sharma et al., 2013, Nimanthika and Kaththriarchi 2010).

The genus name *Garcinia* honours the Dutch army doctor and naturalist Laurentius Garcin (1683-1752), who described the fruiting specimen of mangosteen collected from Moluccas, the Maluku islands, Indonesia (Garcin, 1733). This species was later named *Garcinia mangostana* by Linnaeus in 1753, which became the type species for the genus. The family Guttiferae was created by Jussieu (1789) based on the presence of the exudates secreted from cut stems and leaves. Thereafter, several monumental works such as that of Hooker (1875), Engler (1925), Robson (1961), Whitmore (1973) and Bamps (1978) reviewed the taxonomic status of *Garcinia* in different parts of the world. The first review of Indian *Garcinia* was in the ‘Flora of British India’, where Anderson describes 30 species in British India and including the pentamerous group also in section *Xanthochymus* (Anderson, 1874).
Maheshwari in 1964, describes 31 species as naturally distributed in India (Maheshwari, 1964). In Flora of India, Singh (1993) included 34 indigenous *Garcinia* species.

India is one among the 12 megadiversity nations of the world. The wide range of climatic and topographical features have resulted in a high level of ecosystem diversity encompassing forests, wetlands, grasslands, deserts, coastal and marine ecosystems, each with unique assemblage of species. The Western Ghats, a mountain range that runs nearly 1,600 km, extends from the west coast of peninsular India from the river Tapti in north to Kanyakumari in south. It is perhaps the most important centers of biodiversity and floristic wealth in India. The region is a UNESCO World Heritage Site and also one among the 36 global biodiversity hot spots, Western Ghats occupies 5th position in the economic potential of its biological resources. Over 7,500 species of flowering plants, comprising about 27% of the Indian flora, were reported from the region, of which nearly 1250 are endemic to the region (Anonymous, 2014). Moreover, the Western Ghats is the centre of origin and diversity of a number of economically important plants and there exists a variety of wild relatives of important food and spice crops. The rich biodiversity of tropical forest is attributed to a constant amount of energy from the sun, abundant rain fall and year round warmth, which makes life more favourable than any other place on earth.

In India, the genus *Garcinia* is represented by 43 species and 5 varieties, of which 37 species and 4 varieties occur in wild, whereas the rest were introduced into cultivation (Anderson, 1874, Maheshwari, 1964, Singh, 1993, Srivastava, 1994, Mohanan et al., 1997, Sabu et al., 2013, Sarma et al., 2016). Among the 37 indigenous *Garcinia* taxa, 16 species and 4 varieties are endemic to the country. In India, *Garcinia* species are distributed mainly in three phyto-geographical zones; North East India, the Western Ghats and Andaman and Nicobar Islands. North East India hosts 17 species, of which 2 species and 1 variety are endemic to the region. The Western Ghats hosts 9 species and 2 varieties, of which 7 species and 2 varieties are endemic and the Andaman and Nicobar Islands hosts 15 taxa, of which 6 species and 1 variety are endemic.

**Figure 1.** Distribution map of *Garcinia* species in the world (A), in India (B) and in the Western Ghats (C)
1. Distribution of *Garcinia* species in the Western Ghats

In the Western Ghats, most of the *Garcinia* species are distributed in semi evergreen to evergreen habitat, except *G. wightii* which is also found in riparian habitats. Altitude wise they are found from sea shore (G. *gummi-gutta* var. *gummi-gutta*) to high land up to 1500 m (G. *travancorica*). Recent checklist (Nayar et al., 2014) reported the natural occurrence of 10 species and 2 varieties of *Garcinia* in the Western Ghats region. However, field survey and detailed study of various flora revealed the presence of 9 species and 2 varieties as indigenous to the Western Ghats, of which 7 species and 2 varieties are endemic to the region *(Table 1)*. *G. morella*, *G. talbotii* and *G. gummi-gutta* var. *gummi-gutta* are the most widely distributed species in the Western Ghats. Our study revealed that Agasthyamala Biosphere Reserve in the Western Ghats is the centre of maximum diversity of the genus, with 6 species of which three species viz., *G. travancorica*, *G. imberti* and *G. rubro-echinata* are endemic to the region *(Table 1)*.

Among the nine species indigenous in the Western Ghats, *G. gummi-gutta* is an economically important and widely cultivated fruit crop in Southern Western Ghats, while *G. indica* is cultivated widely in Central Western Ghats region for their fruits. Besides, 6 introduced species (*G. cowa* Roxb. ex. DC., *G. hombroniana* Pierre, *G. xanthochymus* Hook. f. ex T. Anderson, *G. cymosa* (K. Schum.) I. M. Turner and P. F. Stevens, *G. intermedia* (Pittier) Hammel, *G. mangostana* L.) are also reported as cultivated in the Western Ghats region either as fruit plants or as ornamental plants. *Garcinia mangostana* L., source of the edible fruit mangosteen, is native to South East Asia and now cultivated throughout the Western Ghats for their delicious fruits. *G. hombroniana*, known as sea shore mangosteen, an allied species is getting popular in the Western Ghats region as source of edible fruits. The introduced tree *G. xanthochymus* is also getting popular as a fruit crop and avenue tree.

*Garcinia echinocarpa* Thw. (1854) was considered as a species distributed in South India and Sri Lanka, until Kostermans (1977) separated the South Indian taxon as a distinct species viz. *G. rubro-echinata*. Though later Singh (1993) reduced *G. echinocarpa* var. *monticola* as a synonym of *G. rubro-echinata*, detailed literature survey and examination of type specimens in the present study revealed that *G. rubro-echinata* is distinct from *G. echinocarpa* var. *monticola*.

*Garcinia talbotii* Raizada ex Santapau was considered as a species distributed in Western Ghats of India and was first reported from Gairsoppah Ghats, North Kanara, Karanataka (Raizada, 1960). This species is closely allied to *Garcinia spicata* Wight and Arn. which is native to Sri Lanka (1875). In most of the Indian Floras, *G. talbotii* has been misidentified as *G. spicata*, which is not naturally occurring in India. Thorough examination of literature, type specimens and live specimens from the Western Ghats, live specimen from AJCB Indian Botanic Garden Kolkata (*G. spicata*, Herb. Wallich 4838, Wight 138) and herbarium specimens housed at various Herbarium like MH, ASSAM, PBL, CAL, FRC, CALI, KFRI and KEW, it was found that *G. talbotii* is distinct from *G. spicata* by the milky exudation turning brownish after exposure, elliptic, ovate-oblong leaf, more number of lateral veins, fascicles or pseudo spikate male inflorescence, number of stamens and stigmatic lobes and globose fruit.
Table 1. *Garcinia* species in the Western Ghats: IUCN status and distribution

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th><em>Garcinia</em> species</th>
<th>IUCN status</th>
<th>Distribution (altitude, meter)</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>G. gummi-gutta</em> (L.) N. Robson var. <em>gummi-gutta</em> N. P. Singh</td>
<td>--</td>
<td>India, Sri Lanka (50- 900 m)</td>
<td>Throughout the evergreen-semi evergreen forests of the Western Ghats</td>
</tr>
<tr>
<td></td>
<td><em>G. gummi-gutta</em> var. <em>conicarpa</em> (Wight) N. P. Singh</td>
<td>--</td>
<td>Endemic to the Western Ghats (1350- 1950 m)</td>
<td>Kerala: Kadllar, Munnar, Rajamala, Chinnar (Idukki); Vellarimala (Kozhikode)</td>
</tr>
<tr>
<td></td>
<td><em>G. gummi-gutta</em> var. <em>papilla</em> (Wight) N. P. Singh</td>
<td>--</td>
<td>Endemic to the Western Ghats (800-1850 m)</td>
<td>Kerala: Wallakkad, Silent Valley (Palakkad) TamilNadu: Nilagiri Biosphere Reserve</td>
</tr>
<tr>
<td>2</td>
<td><em>G. imberti</em> Bourd.</td>
<td>EN</td>
<td>Endemic to South Western Ghats (900-1200 m)</td>
<td>Kerala: Agasthyamala Biosphere Reserve (Thiruvananthapuram), Shankily, Shendaruni (Kollam).</td>
</tr>
<tr>
<td>3</td>
<td><em>G. indica</em> (Thouars) Choisy</td>
<td>VU</td>
<td>Endemic to India. the Western Ghats, North East India (50- 550 m)</td>
<td>Kerala: Badi Baduka, Thaliparamba; Maharashtra: Thungar Hill, North Kanara; Karnataka: Tinai Ghat. Assam: Karbi Anglong Dist.</td>
</tr>
<tr>
<td></td>
<td><em>G. morella</em> (Gaertn.) Desr.</td>
<td>--</td>
<td>Indo-Malay, Sri Lanka (500- 1100 m)</td>
<td>Kerala: Chenathnair, Kuruv Island, Kambamala (Wayanad); Thamarassery, Vellarimala (Kozhikode); Silent Valley (Palakkad); Kodakkalthodu, Payampara (Thrisssur); Pampa (Pathanamthitta); Pandimotta, Chemmunjii, Attayar (Thiruvananthapuram) Karnataka: Horanad Forests; Tamil Nadu: Anamalai Hills, Iyyerpadi, Kannikketty. Assam: Pasighat, Rani Dawa bang</td>
</tr>
<tr>
<td>5</td>
<td><em>G. pushpangadaniana</em> T. Sabu, N. Mohanan, Krishnaraj and Shareef</td>
<td>--</td>
<td>Endemic to the Western Ghats (850-1400 m)</td>
<td>Kerala: Kadalar, Pampadumchola, Munnar (Idukki); Wallakad of Silent Valley (Palakkad); Tamil Nadu: Anamalai Hills</td>
</tr>
<tr>
<td>6</td>
<td><em>G. rubro-echinata</em> Kosterm.</td>
<td>VU</td>
<td>Endemic to South Western Ghats (800-1200 m)</td>
<td>Kerala: Pomруди, Chemmunji Hills (Thiruvananthapuram), Tamil Nadu: Kalakkad Mundanthurai Tiger Reserve (Thirunelveli)</td>
</tr>
<tr>
<td>7</td>
<td><em>G. talbotii</em> Raizada ex Santapau</td>
<td>--</td>
<td>Endemic to the Western Ghats (100 -500 m)</td>
<td>Kerala: Uduma, Cheemani (Kasaragode); Vellarimala (Kozhikode); Vazhachal (Thrisssur); Pampa, Pandarakayam (Pathanamthitta); Pandimotta, Rosemala (Thiruvananthapuram)</td>
</tr>
<tr>
<td>8</td>
<td><em>G. travancorica</em> Bedd.</td>
<td>VU</td>
<td>Endemic to South Western Ghats (950-1500 m)</td>
<td>Kerala: Athirumala, Chemmunji (Thiruvananthapuram), Tamil Nadu: Kalakkad Mundanthuurai Tiger Reserve (Thirunelveli)</td>
</tr>
<tr>
<td>9</td>
<td><em>G. wightii</em> T. Anderson</td>
<td>VU</td>
<td>Endemic to South Western Ghats (250-700 m)</td>
<td>Kerala: Vazhachal, Athirappally (Thrisssur); Paniyeli-poru (Eranakulam)</td>
</tr>
</tbody>
</table>

VU- Vulnerable, EN- Endangered
According to Anderson (1874), Maheshwari (1964) and Singh (1993) *Garcinia xanthochymus* is distributed in the Western Ghats. However, detailed literature survey, herbarium references and field collections revealed that *G. xanthochymus* is naturally found only in the North East India and Andaman Nicobar Islands. *G. xanthochymus* is cultivated elsewhere in the Western Ghats for its delicious fruits. Most of the specimens identified in Indian Herbaria as *G. xanthochymus*, on close examination revealed to be distinct, which resembles to the new species *G. pushpangadaniana*, reported from Kadalar forest Division of Munnar, Southern Western Ghats of India (Sabu et al., 2013).

*Garcinia gummi-gutta* (L.) Robs. is an economically important fruit crop and a vital component of the forest flora of the Western Ghats. Three varieties of the species viz; *G. gummi-gutta* (L.) Robs. var. *gummi-gutta*, *G. gummi-gutta* var. *papilla* (Wight) N. P. Singh and *G. gummi-gutta* var. *conicarpa* (Wight) N. P. Singh are reported from India. Among the three varieties, var. *gummi-gutta* is the most common and economically important one, widely cultivated throughout the Western Ghats region, especially in Kerala, ranging from sea shore to high land and also found in the wild. The variety *conicarpa* and var. *papilla* are rare and distributed restrictedly in highlands of evergreen forest. The large fruit size, pulpy aril and more number of seeds (4-8) per fruit were the favorable features of var. *gummi-gutta* for its wide distribution and preference for cultivation over the other two varieties. The variety *conicarpa* was found morphologically distinct by the absence of leaf ligules and by the arrangement of stamens in convex torus head, in addition to the conical nature of fruits. We suggest reinstating the species status of *G. gummi-gutta* var. *conicarpa* to *G. conicarpa* based on the unique morphological characters.

2. Conservation status

Literature review revealed that *Garcinia* species in the Western Ghats have not been assessed critically for their distribution and conservation and a comprehensive revision on the conservation status of the *Garcinia* species appears to be vital.

*G. travancorica*, *G. imberti* and *G. rubro-echinata* are distributed strictly endemic to the forest regions of Agasthyamala Biosphere Reserve, at an altitude ranging from 800-1400 m. According to the guidelines of IUCN Red List and World Conservation Monitoring Centre (Moat, 2007), *G. imberti* Bourd. is an endangered tree species, while *G. travancorica* and *G. rubro-echinata* belongs to ‘vulnerable’ category. Our field surveys revealed that population size of *G. imberti* is rather larger than that of *G. travancorica* and *G. rubro-echinata*. The two varieties of *G. gummi-gutta*; var. *conicarpa* and var. *papilla* are also very rare in the evergreen forest of Southern Western Ghats, suggesting vulnerable status for these two varieties.

3. Taxonomy

The genus *Garcinia* is considered as a taxonomically difficult one due to the complexity in floral characteristics. While majority of *Garcinia* species are dioecious, a few species or races are reported as hermaphrodite (Dunthorn, 2004). *Garcinia* species generally display an unusual evolutionary plasticity and there are many unresolved phylogenetic issues surrounding the genus. Among the different phylogenetic analytical strategies, morphology in all its aspects, from micromorphology to embryology, palynology, seed, fruit, floral, stem and leaf
morphology, still remains to be the most indispensible tool. Several identification keys have been reported for *Garcinia* species across the globe based on morphological features of flower, fruit and leaf (Jones, 1980, Nimanthika and Kaththiriarachchi, 2010).

### 3.1. Diversity in floral morphology

Male and female flowers are seen on different trees (dioecious) or rarely male or female and hermaphrodites flowers on the same tree (polygamudioecious) in *Garcinia* species. The basic inflorescence type of *Garcinia* is a simple cyme or few flowered (2 to 16) clusters in fascicles. Exceptions are in the case of *G. travancorica* with trichotomous cyme and *G. wightii* with solitary or rarely 2-3 flowers. Flowers of *Garcinia* are generally sessile except *G. talbotii* and *G. pushpangadaniana* with pedicellate (Figure 2). Flowers are solitary or in fascicles, terminal or axillary and variously coloured. Sepals and petals 4-5, stamens usually numerous, very variable in arrangement and structure, sometime with pistillode; ovary 1-12 loculed with a single apical ovule per locule, ovule 1 in each locule; stigma conspicuous and variously lobed, usually peltate. Characteristic differences in the floral architecture were observed even among closely related taxa of *Garcinia* (Pierre, 1883, Jones, 1980, Gustafsson et al., 2002, Sweeney, 2008).

**Male flowers:** Inflorescence of male flowers are observed both in terminal and axillary positions; axillary inflorescence being common. Species like *G. morella*, *G. pushpangadaniana*, *G. wightii* and *G. gummi-gutta* have flowers in axills, whereas in the case of *G. imberti*, *G. indica*, *G. rubro-echinata* and *G. talbotii*, flowers are found both in axillary and terminal position. *G. travancorica* flowers are found only terminal or sub-terminal.

The sepals are usually orbicular and green or yellowish in colour. Species like *G. pushpangadaniana* and *G. talbotii* have ciliate margins. The petals, however, have brighter colour, from yellow (*G. imberti*, *G. gummi-gutta*, *G. indica*) to white (*G. talbotii*, *G. wightii*), cream (*G. morella*), pink or red (*G. pushpangadaniana*), pale greenish (*G. travancorica*) and green (*G. rubro-echinata*). Petal of the male and female flowers of the same species are usually similar, but varies considerably among different species from ovate to oblong, or oblanceolate to obovate. The stamens are always united in a bundle at the centre of the flower. In the case of *G. gummi-gutta*, stamens were arranged usually on tetragonous receptacle and also as androphore. In *Garcinia*, pistillodes have a fungiform-shape, consisting of a cap and the shaft (or stipe), which is homologous to the stigma and ovary respectively. The pistillodes are small in diameter, varied from 1 mm for *G. gummi-gutta* to 5 mm for *G. rubro-echinata*. The stipe can be slender or ovoid and the margin of the cap may be crenate or lobed. However, pistillode is lacking in *G. talbotii* and *G. pushpangadaniana*. 

Female flowers: Inflorescence of female flowers are usually terminal in position. *G. morella*, *G. pushpangadaniana*, *G. talbotii* and *G. wightii* have axillary flowers while *G. gummi-gutta* exhibit both axillary and terminal flowers (Figure 3). The female flowers are fewer compared to male flowers and in the case of *G. rubro-echinata*, *G. imberti* and *G. wightii*, the female flowers are strictly solitary. The female flowers have shorter, stouter pedicels and peduncles comparatively smaller than the male flowers. In general, the ovary in *Garcinia* is superior and very few species have constant locule numbers. Most of the *Garcinia* species have 4 or 5 locules (*G. morella*, *G. wightii*, *G. rubro-echinata* and *G. talbotii*) but rarely 1 or 2 loculed (*G. imberti*, *G. travancorica*) and more than 5 loculed (*G. indica*, *G. gummi-gutta*, *G. pushpangadaniana*). Generally, ovary is globose to ovoid. Variation is also found in the shape of ovary, however, it has less taxonomic value and is not really an important character for species delimitation in *Garcinia*.

The stigma is usually sessile and wide variation exists. In most species the stigma is large and conspicuous, and in some species like *G. travancorica* and *G. imberti* the stigma is larger than the ovary. Lobes are slightly divided (*G. pushpangadaniana*, *G. talbotii*, *G. rubro-echinata* and *G. wightii*) to completely divided into rays (*G. gummi-gutta*, *G. indica* and *G. morella*), whereas in some species stigma exists as broad convex disc (*G. travancorica* and *G. imberti*).
3.2. Diversity in branching and bark exudates

Garcinia species were characterized by their monopodial branching form, where secondary shoots or branches arise behind the growing point but remain subsidiary to the main stem, which continues to grow indefinitely (Tootil, 1984). Hence Garcinia species usually exhibited horizontal spreading branching pattern. However, G. gummi-gutta var. gummi-gutta and G. morella showed pendulous drooping branchlets whereas G. indica showed crown shaped canopy ending with horizontal branchlets. G. pushpangadaniana has pyramidal crown with pendulous drooping branchlets.

Bark is usually grey to brown, inner bark is yellow or occasionally white. The stem and twigs produce yellow, white or cream exudates, known as ‘Gamboge’ (Figure 4). Gamboge is solidified resin and is sticky in nature and is also found in immature fruit rind and leaves in addition to stem bark. Gamboge is used as a pigment in paint and varnishes. The colour of the exudates varies from yellow to white and is a characteristic identification feature for Garcinia species. Species like G. travancorica, G. morella, G. wightii and G. gummi-gutta have yellow exudation. G. pushpangadaniana, G. imberti, G. talbotii, G. indica and G. rubro-echinata have white exudation. Gamboge of G. morella is widely used in the preparation of golden coloured water colours and spirit varnishes for metals and also for dyeing silk fabrics. A golden yellow coloured ink was prepared from the gamboge of G. morella for writing on black paper (Anonymous, 1950).
3.3. Diversity in leaf morphology

Leaves of *Garcinia* species are opposite, usually thick and characterized by the presence of a foveola (an excavation with an extension resembling a ligule) at the base of the petiole. Based on the arrangement of leaf lamina, the Western Ghats species can be classified into two groups, those possess lamina with conspicuous secondary veins and the group with inconspicuous secondary veins. Also, the arrangement of secondary veins falls into two patterns; loose and dense. *G. travancorica* and *G. rubro-echinata* exhibit loosely arranged secondary veins, while all other species showed densely arranged veins. Lamina size and nature of petiole were also distinguishing features. *G. pushpangadaniana* and *G. talbotii* have large leaves (>15 x 8 cm) with stout petiole. Coriaceous leaf texture was prominent in most of the *Garcinia* species except *G. imberti*, *G. wightii* and *G. indica* which possess subcoriaceous leaves. *G. talbotii* and *G. gummi-gutta* were the two species that showed maximum diversity in leaf shape (Figure 5).
Figure 5. Leaf morphology of *Garcinia* species in the Western Ghats (A. *G. rubro-echinata*, B. *G. imberti*, C. *G. wightii*, D. *G. travancorica*, E. *G. morella*, F. *G. talbotii*, G. *G. pushpangadaniana*, H. *G. indica* and I. *G. gummi-gutta*)

3.4. Diversity in fruit morphology

Relatively few investigations have been carried out on fruit and seed morphology of *Garcinia*. Fruits are fleshy to woody berry; seated on the usually persistent calyx. Seed 1-12, often flattened and enclosed in pulp. Regarding fruit size, *G. wightii* has the smallest (10-15 gm), while the largest is that of *G. pushpangadaniana*, weighing upto 750 gm. Most of the fruits are globose in shape except sub-globose to ellipsoid in *G. rubro-echinata*, oblong to sub-globose in *G. imberti* and *G. travancorica*. Texture of fruit surface is another distinguishing feature, where *G. imberti*, *G. travancorica*, *G. morella*, *G. wightii* and *G. indica* possess smooth fruit surface, grooved in *G. gummi-gutta*, warty nature in *G. pushpangadaniana* while the fruit surface of *G. rubro-echinata* is covered with broad sharp tubercles (Figure 6). Species like *G. imberti*, *G. wightii*, *G. travancorica*, *G. morella* and *G. indica* have pulpy aril while the aril of *G. pushpangadaniana* is crispy and that of
Figure 6. Fruit morphology of Garcia species in the Western Ghats (A. G. rubro-echinata, B. G. imberti, C. G. wightii, D. G. travancorica, E. G. morella, F. G. talbotii, G. G. pushpangadaniana, H. G. indica and I. G. gummi-gutta)

G. rubro-echinata is fibrous. The seed shape was oblong in most of the Garcia species, except plano-convex for G. pushpangadania, ovoid-reniform for G. morella and G. gummi-gutta. The fruit colour is a characteristic distinguishing feature which varies from yellowish green in G. travancorica, G. imberti and G. talbotii, brownish yellow in G. pushpangadaniana, yellow in G. gummi-gutta, red in G. wightii and G. morella and purple in G. indica.

4. Key to the Garcia species of the Western Ghats
Vegetative morphological characters among the Garcia species of the Western Ghats were evaluated systematically to construct an identification key, which will be a valuable tool for identification of the Western Ghats species in the field.

1a Fruit surface smooth……………………………………………………..2

2a Fruit less than 3 cm in diam. .................................................3

3a Fruit with 2 loculed ovary, rarely one.................................4

4a Leaf linear-oblong with distinct closely arranged parallel
veins..............................................................................................................G. travancorica

4b Leaf oblanceolate indistinct veins..............................................G. imberti

3b Fruit with more than 2 loculed ovary.................................5

5a Leaves linear-lanceolate, fruit size of a small cherry, with pinkish
5. Western Ghats *Garcinia* species

5.1. *Garcinia gummi-gutta* (L.) N. Robson

Evergreen tree up to 20 m high; exudation pale yellow, sticky.

Leaves: Elliptic, obelliptic-ovate, 6-13 x 2.5-6 cm.

Male flowers: Tetramerous, 3-8 flowers on axillary fascicles, 1-1.7 x 1-1.2 cm, pedicel 7-12 mm long; sepals orbicular, margin membraneous with fimbril like projections; petals oblong, pale yellow or orange yellow, membraneous on margin; stamens in a globose head; rudimentary pistil absent or if present stigma discoid with 4 lobed cleft.

Female flowers: Tetramerous, solitary or 1-3 fascicle on terminal or axillary, 1.5-2 x 1.5 cm; staminodes 10-20; ovary 4-12 locular, *ca.* 1 mm long, ovule one in each locule, subglobeose or ovoid, grooved, stigmatic rays spreading, free nearly to the base, margin crenate, tuberculate.

Fruits: Globose, 6-8 cm in diam., 6-10 grooved, yellow or orange yellow on ripening, pericarp very thick, fleshy.

Seeds: 6-8, ovoid, 2-3.3 x 0.7-0.9 mm, compressed, surrounded by white or red pulpy aril.

*Field identification characters*

i. Leaves elliptic, 6-13 cm long.

ii. Stigmatic lobes 6-10.

iii. Fruit deeply grooved, grooves 6-10.

*Garcinia gummi-gutta var. papilla* (Wight) N. P. Singh

Evergreen tree up to 15 m high; exudation yellow.

Leaves: Elliptic, 6-9 x 1.5-3cm.

Male flowers: Tetramerous, 3-5 flowers in axillary fascicles, ,1-1.5 x 1-1.2 cm; pedicels stout, 5-7 mm long; sepals ovate to oblong, margin membraneous; petals oblong, brick red, margin membraneous; stamens in a globose androphore; rudimentary pistil rarely present.
Female flowers: Tetramerous, 1-3 flowers on solitary or fascicles, terminal or axillary, 1-1.2 x 7-10 mm; staminodes in a ring; ovary 6-8 locular, 1-ovule in each locule, subglobose, grooved, stigmatic rays 4-8.

Fruits: Subglobose, yellowish green, ca. 6 cm in diam., 4-8 grooved with a terminal mamilla, pericarp very thick, fleshy.

Seeds: 3-5, sub-triangular, 2-3 x 0.8-10 mm, enclosed in a thick mass of fibrous aril.

**Field identification characters**

i. Young shoot and margin of leaf shows reddish tinge.

ii. Fruit ovoid-oblong with 4-8 grooves and with terminal mamilla

**Garcinia gummi-gutta var. conicarpa** (Wight) N. P. Singh

Evergreen tree up to 15 m high; exudation yellow.

Leaves: Obovate-ovate, rarely oblong or broader beyond the middle, 6-10 x 4-8 cm.

Male flowers: Tetramerous, solitary or 2-5 flowered fascicles, axillary or terminal, 1-1.5 x 1-1.2 cm, pedicels stout, ca. 5 mm long; sepals ovate, margin membranous with fimbri like projection; petals yellow, oblong-orbicular, slightly membranous margin; stamens in a convex torus head; rudimentary pistil absent or present.

Female flowers: Tetramerous, solitary or 2-3 flowered fascicles, terminal or sub terminal, 1-1.5 x 1-3 cm, sessile; staminodes in a ring; ovary 3-5 locular, ovule one in each locule, ovoid, grooved, stigmatic rays 3-5.

Fruits: Usually conical, rarely ovoid, yellowish green, ca. 5 cm in diam., 3-5 grooves with a terminal mamilla, grooves, pericarp very thick, fleshy.

Seeds: 2-4, ovate-oblong, 2-3 x 0.8-10 mm, enclosed in a thin fibrous aril.

Due to the distinct morphological and chemical characteristics, it is suggested that species status may be reinstated for the variety *conicarpa* (Chapter 8).

**Field identification characters**

i. Absence of leaf ligule on petiole.

ii. Shape of leaf broader beyond the middle.

iii. Conical shape of fruit with 3-5 grooves.

5.2. **Garcinia imberti** Bourd.

Evergreen medium sized tree up to 20 m high; exudation white; branches horizontal spreading.

Leaves oblanceolate, 6-12 x 2-6 cm.

Male flowers: Tetramerous, 3-6 or 9 flowered fascicles, or rarely cyme or paired, terminal 5-6 x 4-5 mm, sessile; sepals sub orbicular, membranous; petals orbicular, pale yellow, membranous; stamens in a central globose mass, pistil rudimentary.

Female flowers: Tetramerous, solitary, or rarely in pairs, terminal, 6-8 x 6 mm; ovary 2-loculed, globose, ovule one in each locule, stigma sessile, convex, capitate; staminodes many, united in a ring around the ovary.

Fruits: Sub-globose, greenish, 2.2-2.5 cm in diam., smooth


**Field identification characters**

i. Bark brown mottled with white.
ii. Leaves less than 12 cm long, oblanceolate with shortly caudate acuminate at apex.
iii. Berry sub-globose, usually 1-2 seeded fruit, crowned by capitated stigma.

5.3. *Garcinia indica* (Thouars) Choisy

Evergreen to semi-evergreen tree up to 15 m high; exudation milky; branches with conical crown or pendulous drooping.

Leaves: Lanceolate or obovate-oblong, 6-12 x 1.5-5 cm,

Male flowers: Tetramerous, 4-8 flowered fascicles, axillary or terminal, 5-9 x 5-8 mm, pedicel stout, ca. 4 mm long; sepals ovate-rotundate, membraneous; petals orbicular, creamy white, membraneous; stamens inserted on hemispheric, sub-quadrate torus; rudimentary pistil absent or if present as long as stamens.

Female flowers: Tetramerous, solitary, terminal, sub-sessile; ovary, subglobose, stigmas convex, 4-8 rayed, coronate, sessile.

Fruits: Spherical, orange-pink, deep purple when ripe, up to 4 cm in diam., pulp red, fleshy.

Seeds: 5-8, compressed.

*Field identification characters*

i. Branches with conical crown or pendulous drooping.

5.4. *Garcinia morella* (Gaertn.) Desr.

Evergreen medium sized tree up to 18 m high; exudation deep yellow, sticky.

Leaves: Elliptic, ovate or obovate, 10-15 x 4-8 cm.

Male flowers: Tetramerous, ca. 3 flowered fascicles, axills of fallen leaves, 1-1.2 x 5-10 mm, sessile or short pedicel, 4-6 mm long; sepals orbicular or elliptic, membraneous; petals rotundate or orbicular, white to pink, membraneous; stamens in a central subglobose mass; rudimentary pistil absent.

Female flowers: Tetramerous, solitary, axillary, ca. 1 x ca. 0.5 cm, sessile; staminodes, connate at base into a ring around ovary; ovary 4-locular, sub-globose; stigma coronate, tubercled.

Fruits: Sub-globose or globose, yellow with reddish tinge, 2.5-3 x 2-3 cm, smooth

Seeds: Ovoid-reniform, 4, laterally compressed and dark brown.

*Field identification characters*

i. Petiole folding longitudinally above.

5.5. *Garcinia pushpangadaniana* T. Sabu, N. Mohanan, Krishnaraj and Shareef

Evergreen to semi-evergreen medium sized tree up to 20 m high; bark exudation milky.

Leaves: Elliptic-oblong, 14-20 x 6-8 cm.

Male flowers: Pentamerous, ca. 2-10 flowered fascicles, axillary, 1-1.5 x 1cm, pedicel 7-10 mm long; sepals orbicular-sub-orbicular, margin ciliate; petals orbicular, pinkish pale greenish white, membraneous margin; stamen 5-phalangiate; rudimentary pistil present.
Female flowers: Pentamerous, ca. 2-8 flowered fascicles, axillary, 1-1.5 x 1-1.3 cm; staminodes arranged in 5-phalanges; ovary 6-8 loculed, 6 mm in diam., globose, stigma 6-8 lobed, oblong, stellate.
Fruits: Globose, pale yellowish brown, 13 x 11 cm, fleshy, without pulpy aril, irregularly ridged surface.
Seeds: 1-4, plano-convex, whitish yellow, up to ca. 2 cm long.

Field identification characters
- i. Tree with pyramidal crown.
- ii. Leaves 14-20 x 6-8 cm long, elliptic-oblong, thick coriaceous, lateral nerves 28-34 pairs.
- iii. Large fruits (600-750g), globose and irregularly ridged on the surface.

Evergreen tree up to 20 m tall; exudate brownish-white.
Leaves: Sub-obovate to broadly elliptic, 8-15 x 3-8 cm.
Male flowers: Tetramerous, fascicled, axillary or terminal, pale green, 1.6-2 x 1.5 cm, sessile; sepal orbicular-obtuse, margin membranous; petals sub-orbicular to oblong, pale green, membranous; stamens in a tetragonal torus; pistil rudimentary.
Female flowers: Tetramerous, solitary, terminal, pale green, 1.8-2.5 x 1.5-1.8 cm, sessile; staminodes ca.22, connate in to a ring at base, disc present at intercalary position; ovary 3-4 locular, covered with numerous fleshy scales; stigmas peltate, irregularly lobed.
Fruits: Sub-globose or ellipsoid, dark red, 4-6 x 2.5-4 cm, covered with spines or broad tubercles.
Seeds: 1-3, oblong, up to 4cm long with scanty aril.

Field identification characters
- i. Bark greenish white with yellow red or white mottles.
- ii. Lamina usually obovate with numerous parallel lateral veins.
- iii. Fruit covered with spines.

5.7. *Garcinia talbotii* Raizada ex Santapau
Evergreen tree up to 20 m tall; exudate white, turning brownish after exposure.
Leaves: Elliptic-ovate, oblong or ovate-oblong, 7.5-18 x 3-10 cm.
Male flowers: Pentamerous, fascicled, axillary or terminal, creamy-white, 1.8-2.3 cm long, pedicel, ca. 1 cm long; sepal orbicular, margin membranous, rarely ciliate; petals orbicular-ovate, rarely sub-orbicular, creamy-white or greenish-yellow, margin membranous; stamens in to 5 phalanges; rudimentary pistil absent.
Female flowers: Pentamerous, fascicled, axillary, creamy-white, 1.8-2.7 cm long, pedicel, ca. 1 cm long; staminodes in 5 delicate phalanges; ovary 3-locular, very rarely 4, globose, stigma peltate, 3 lobed.
Fruits: Globose, greenish-yellow on ripening, 4-6 x 3.8-5 cm, fleshy, rind surface shows an yellow resins.
Seeds: 1-3, oblong, ca. 3cm long with yellow pulpy aril.

Field identification characters
- i. Exudation milky, turning brownish after exposure.
ii. Leaves usually ovate.
iii. Fruit greenish yellow, ripe fruit pulp sweet-scented, stigmatic lobe 3.

5.8. *Garcinia travancorica* Bedd.

Evergreen tree up to 15 m high; exude yellow.
Leaves: Linear-oblong, 5.5-10 x 1-2 cm.
Male flowers: Tetramerous, trichotomous short cymes, terminal or sub terminal, 1.2-1.5 x 0.8-1 cm, pedicel short, ca. 2-3 mm long; sepals orbicular, margin membraneous; petals orbicular, creamy white, membraneous; stamens numerous in 4-tetragone masse; rudimentary pistil columnar, with a circular peltate stigma.
Female flowers: Tetramerous, solitary or paired, terminal or sub terminal, 1.3-1.5 x 8-1.2 cm; staminodes in 5-phalanges; ovary 1-2 locular, subglobose or pyriform; stigma 3-lobed and spreading.
Fruits: Ovoid-oblong, 2-3 x 1-2.5 cm, stigma persistent to fruit.
Seeds: Usually 1, rarely 2, ovoid, up to 2-2.5 x 0.7-1 cm.

*Field identification characters*

i. Leaves narrow oblong, less than 3 cm broad with secondary nerves closely parallel and horizontal.

ii. Male flowers trichotomous cyme.

iii. Female flowers with broad yellow stigma.

5.9. *Garcinia wightii* T. Anderson

Evergreen tree up to 15 m high; exudation deep yellow to orange yellow.
Leaves: Linear-lanceoalte, 6-14 x 1.5-3 cm.
Male flowers: Tetramerous, solitary or 2-3 together, sometimes numerous, axillary, 1-1.2 x 0.8-1 cm, sessile; sepals orbicular, margin membraneous; petals obovate, creamy white, membraneous; stamens in tetragons head.
Female flowers: Tetramerous, solitary, axillary, 1-1.5 x 5-7 mm, sessile; staminodes 4-phalanges; ovary 4-locular, globose; stigma 4-lobed.
Fruits: Sub-globose, rose with pinkish tinged, 1.2-1.5 x 0.9-1 cm, smooth, with persistent stigma and sepals.
Seeds: 4, up to ca. 9.5 x 4.5 mm long.

*Field identification characters*

1. Leaves less than 3 cm wide, linear-lanceolate tapering at both ends, secondary veins very oblique.
2. Fruit colour rose with pinkish tinge.

Conclusions

*Garcinia* species are important components of the flora of the Western Ghats and also an economically important group. Field surveys revealed that 9 species and 2 varieties are indigenous to the Western Ghats of which 7 species and 2 varieties are endemic to the region. Distribution, distinguished morphological features and conservation aspects of *Garcinia* species of the Western Ghats were discussed in detail. Agasthyamala forests in the Western Ghats region, with natural distribution of 6 *Garcinia* species, can be considered as the centre of diversity of *Garcinia* species in the Western Ghats.
References


