

Ex situ conservation of threatened plant species of the Western Ghats

The Western Ghats is one of the world's "Hottest biodiversity hotspots" and one among the 34 global hot spots of biodiversity by means of its rich and varied flora with enormous species diversity abound in endemic taxa (Chandran et al. 2008). There are about 44 monotypic genera, 1,720 species and 135 intraspecific taxa of flowering plants (Ahmedullah & Nayar 1986; Shetty & Kaveriappa 2001). With the disconcerting pace of development and intensification of human activities, our biodiversity is threatened as never before. Nearly, a third of endemic plant species of Western Ghats are rare or threatened and several are believed to be extinct or on the verge of extinction (Shetty & Kaveriappa 2001). The study on the phenology and structural diversity of the rare, endangered, and threatened (RET), endemic, medicinally and economically important species of Western Ghats is required to understand the existing population followed by the conservation of these species (Shivaprasad et al. 2002; Sundarapandian et al. 2005; Sellamuthu & Lalitha 2010).

With the increasing population, demand towards plants for building purposes, as medicines and for nutritive values imparted a great threat to the plants of the Western Ghats in general and to Endemic and RET species in particular. The number of most of

the Endemic and RET plants is diminishing in the natural habitat due to the reasons such as the collection of raw materials, poor regeneration, collection of plants for house hold purposes etc (Chen et al. 2016). Keeping this in mind, the present study was undertaken to identify the threatened species in the Western Ghats and to increase their population in the Arboretum as an ex-situ conservation method.

Seeds/seedlings of 67 endemic and threatened species were collected from their natural habitats in the Western Ghats such as Agumbe (Shimoga District, 13.495°N, 75.080°E), Charmady (Belthangady Taluk, Dakshina Kannada District, 13.073°N and 75.447°E), Bisle Ghat (Sakaleshpura Taluk, Hassan District, 12.709°N and 75.676°E), Gersoppa (Kumta Taluk, North Kanara District, 14.228°N and 74.448°E), Gundya (Sakaleshpura Taluk, Hassan District, 12.827°N and 75.571°E), Hulikal Ghat (Hosanagara Taluk, Shimoga District, 13.724°N and 74.990°E) and Karike (Madikeri Taluk, Kodagu District, 12.443°N and 75.404°E) and transferred to polythene bags filled with soil and sand maintained in the green house for germination, growth and hardening of the seedlings. More than 200 hardened seedlings (3 seedlings each of threatened species) were transferred to the newly established arboretum at Mangalore

Table 1. List of Endemic and Threatened plants conserved at Arboretum of Mangalore University, Karnataka.

	Botanical name	Family	Habit	Status and distribution
1	<i>Actinodaphne malabarica</i> Balakr.	Lauraceae	Tree	Endemic ^{#, ***} Western Ghats – South and Central Sahyadris.
2	<i>Aegle marmelos</i> (L.) Core.	Rutaceae	Tree	Vulnerable ^{**} (Regional)
3	<i>Aglaia elaeagnoidea</i> , (Juss.) Benth.	Meliaceae	Tree	Endemic ^{#, ***} Western Ghats – South and Central Sahyadris.
4	<i>Alangium salvifolium</i> (L.f.) Wang	Alangiaceae	Tree	Vulnerable ^{**} (Regional).
5	<i>Alpinia galangal</i> Sw.	Zingiberaceae	Herb	Data deficient ^{**} Western Ghats – Kerala, Karnataka and Tamil Nadu.
6	<i>Aphanamixis polystachya</i> (Wall.) Parker	Meliaceae	Tree	Least concern [*] Vulnerable ^{**} (Regional)
7	<i>Artocarpus hirsutus</i> Lam.	Moraceae	Tree	Least concern [*] Vulnerable ^{**} , ^{***} (Global)
8	<i>Artocarpus gomezianus</i> Wall ex Trecul	Moraceae	Tree	Western Ghats - South, Central and Maharashtra Sahyadris ^{***} .
9	<i>Baccaurea courtallensis</i> Muell. - Arg.	Euphorbiaceae	Tree	Endemic ^{#, ***} Western Ghats – in evergreen forests of – Kerala, Karnataka and Tamil Nadu.
10	<i>Beilschmiedia wightii</i> (Nees) Benth. Ex Hook. F.	Lauraceae	Tree	Endemic ^{##, ***, \$\$} Western Ghats – occasional in South and Central Sahyadris.
11	<i>Blepharistemma membranifolium</i> (Miq.) Ding Hou	Rhizophoraceae	Tree	Endemic ^{#, ***} Southern Western Ghats.
12	<i>Calophyllum apetalum</i> Willd.	Clusiaceae	Tree	Vulnerable [*] Endemic, Vulnerable ^{**} (Global) Western Ghats – along the river banks in semi-evergreen forests at low altitudes, upto 600m. Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu.
13	<i>Canarium strictum</i> Roxb.	Bruseraceae	Tree	Vulnerable ^{**} , ^{***} (Regional) India, Sri Lanka, Bangladesh.
14	<i>Caryota urens</i> L.	Arecaceae	Tree	Least concern [*] Western Ghats – South and Central Sahyadris.
15	<i>Calamus nagbettai</i> R.R.Fernald & Dey	Arecaceae	Climber	Endemic ^{#, ##, \$\$} South Western Ghats – Kerala.
16	<i>Coscinium fenestratum</i> (Gaertn.) Coleb.	Menispermaceae	Climber	Data Deficient [*] Critically Endangered ^{**} (Regional) Western Ghats – semi evergreen and wet evergreen forests of Karnataka, Kerala, and Tamil Nadu.

	Botanical name	Family	Habit	Status and distribution
17	<i>Dipterocarpus indicus</i> Bedd.	Dipterocarpaceae	Tree	Endangered* Endangered** (Global). Endemic to the Western Ghats – evergreen to semi-evergreen forests upto 1,000m height in Kerala, Karnataka and Tamil Nadu.
18	<i>Dispyros buxifolia</i> (Bl) Heirn.	Ebanaceae	Tree	Western Ghats-Central and North Malanad in Central Sahyadri and in openings of South Sahyadri***.
19	<i>Diospyros malabarica</i> (Desr.) Kostel.	Ebenaceae	Tree	Endemic##,*** Western Ghats – Almost throughout. Common along river banks.
20	<i>Ensete superbum</i> (Roxb.) Cheesman	Musaceae	Herb	Endemic#,\$ Peninsular India.
21	<i>Euodialunu-ankenda</i> (Gaertn.) Merr.	Rutaceae	Tree	Least concern* Endemic to central and south India.
22	<i>Flacourtia montana</i> Graham	Flacourtiaceae	Tree	Endemic#.,*** Western Ghats – common trees in Sahyadris, Central and South Maharashtra Sahyadris.
23	<i>Garcinia gummi-gutta</i> (L.) Robs.	Clusiaceae	Tree	Vulnerable** (Global). Endemic to the Western Ghats – throughout in South and Central Sahyadris.
24	<i>Garcinia indica</i> (Thouars) Choisy	Clusiaceae	Tree	Vulnerable* Vulnerable** (Global). Endemic to the Western Ghats – in evergreen and deciduous forests upto 400m. Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu.
25	<i>Garcinia talbotii</i> Raiz&Sant.	Clusiaceae	Tree	Endemic## Western Ghats – South, Central and south Maharashtra Sahyadris.
26	<i>Gmelina arborea</i> Roxb.	Verbanaceae	Tree	Endemic## Throughout Western Ghats.
27	<i>Gymnacranthera farquhariana</i> (Hook.f.ex. Thomaon) Warb	Myristicaceae	Tree	Endemic#.,*** Western Ghats –Agasthyamali (West) and Central Malanad.
28	<i>Holigarna arnottiana</i> J.Hk.	Anacardiaceae	Tree	Endemic#.,*** Western Ghats – South and Central Sahyadri. Canopy trees in low and medium wet evergreen forests upto 1200m.
29	<i>Holigarna beddomei</i> Hook.f.	Anacardiaceae	Tree	Endemic##,*** Western Ghats – coastal areas and in forests at lower altitudes.
30	<i>Holigarna ferruginea</i> Marchand	Anacardiaceae	Tree	Endemic#.,*** Western Ghats – rare in South Sahyadri and frequent in Central Sahyadri. Canopy trees in low and medium wet evergreen forests upto 1300m.

	Botanical name	Family	Habit	Status and distribution
31	<i>Holigarna grahamii</i> (Wt.) Kurz.	Anacardiaceae	Tree	Endemic ^{#, ***} Moist deciduous to evergreen forests of Western Ghats of Maharashtra, Karnataka, Tamil Nadu and Kerala.
32	<i>Hopea canarensis</i> Hole	Dipterocarpaceae	Tree	Endangered [*] Endangered ^{**} Endemic to the Western Ghats – Kudremukh of Chikmagalur Region, Central Sahyadri.
33	<i>Hopea ponga</i> (Dennst) Mabb.	Dipterocarpaceae	Tree	Endangered [*] Endangered ^{**} Endemic to Western Ghats – South and Central Sahyadris. Common subcanopy trees in wet evergreen forests, upto 900m.
34	<i>Hopea parviflora</i> Bedd.	Dipterocarpaceae	Tree	Least concern [*] Endemic ^{***, ##} Western Ghats – semi evergreen to evergreen forests of Karnataka and Kerala.
35	<i>Humboltia brunonis</i> Wall.	Fabaceae	Tree	Endemic ^{##, ***} Western Ghats –between Wayanad and Sringeri regions of Central Sahyadri.
36	<i>Hydnocarpus pentandra</i> (Buch.-Ham.) Oken	Flacourtiaceae	Tree	Vulnerable ^{**} (Global) Endemic ^{#, ***} Western Ghats – moist deciduous and semi evergreen forests of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu.
37	<i>Ixora brachiata</i> Roxb.	Rubiaceae	Small tree	Endemic ^{#, ***} Western Ghats.
38	<i>Kingiodendron pinnatum</i> (Roxb. ex DC.) Harms	Caesalpiaceae	Tree	Endangered [*] Endangered ^{**} (Global). Endemic to the Western Ghats – in evergreen forests of Karnataka, Kerala and Tamil Nadu.
39	<i>Knema attenuata</i> Warb.	Myristicaceae	Tree	Least concern [*] Endemic ^{***, #} Western Ghats – South, Central and South Maharashtra Sahyadris.
40	<i>Kunstleria keralensis</i> Mohanan & Nair	Fabaceae	Climber	Endemic ^{##, \$\$}
41	<i>Lophopetalum wightianum</i> Arn.	Celastraceae	Tree	Least concern [*] Widespread throughout India, Indo-China, and Malaysia.
42	<i>Madhuca insignis</i> (Radlk.) H. J. Lam.	Sapotaceae	Tree	Extinct [*] Critically endangered. Endemic to South Western Ghats.
43	<i>Madhuca neriifolia</i> (Moon) H.J.Lam	Sapotaceae	Tree	Least concern [*] Vulnerable ^{**} (Regional). Common along the streams and rivers upto 1200m in Western Ghtas – South and Central Sahyadris.

	Botanical name	Family	Habit	Status and distribution
44	<i>Mastixia arborea</i> (Weight) Beddome	Cornaceae	Tree	Least concern* Endemic ^{***, #} Western Ghats South and Central Sahyadris. Subcanopy trees in evergreen forests, upto 1900m.
45	<i>Maytenus rothiana</i> (Walp.) Ramamoorthy	Celastraceae	Small tree	Endemic ^{##, ***} Western Ghats – Maharashtra & Karnataka.
46	<i>Memecylon malabaricum</i> (CL.) Cong.	Melastomataceae	Tree	Endemic [#]
47	<i>Myristica fatua</i> Houtt. var. <i>Magnifica</i> (Beddome) Sinclair	Myristicaceae	Tree	Endangered** Rare and threatened Endemic to the Western Ghats – in swampy areas of evergreen forests of Karnataka, Kerala and Tamil Nadu.
48	<i>Myristica malabarica</i> Lam.	Myristicaceae	Tree	Vulnerable** Endemic to the Western Ghats – in evergreen forests of Maharashtra, Karnataka and Kerala up to 800m.
49	<i>Nilgirianthus barbatus</i> (Nees.) Bremek	Acanthaceae	Shrub	Endemic ^{\$\$\$} Western Ghats.
50	<i>Nilgiriathes ciliates</i> (Nees) Bremek	Acanthaceae	Shrub	Endangered** (Global). Endemic to the Western Ghats.
51	<i>Nothopegia racemose</i> (Dalz.) Ramam.	Anacardiaceae	Tree	Endemic ^{##, ***} Western Ghats South and Central Sahyadris.
52	<i>Nothapodytes nimmoniana</i> (J. Graham) Mabbes	Icacinaceae	Tree	Endangered ^{***} Western Ghats – in openings of evergreen forests upto 2300m in South, Central, and South Maharashtra Sahyadris.
53	<i>Olea dioica</i> Roxb.	Oleaceae	Tree	Endemic ^{##} In evergreen and deciduous forests of the Western Ghats.
54	<i>Oroxylum indicum</i> (L.) Benth. Ex:Kurz	Bignoniaceae	Tree	Vulnerable [™] (Regional). Western Ghats- occasional from South to Central and south Maharashtra Sahyadris and West Coast Region. Along the margins of evergreen and in moist deciduous forests up to 800m.
55	<i>Persea macrantha</i> (Nees) Kosterm.	Lauraceae	Tree	Endangered [*] (Regional). Distributed in peninsular India and Sri Lanka; in the Western Ghats-South, central and south Maharashtra Sahyadris, canopy trees in evergreen forests upto 2000m.
56	<i>Poeciloneuron indicum</i> Beddome	Clusiaceae	Tree	Endemic [#] Southern Western Ghats – in evergreen forests up to 1200m in Kerala, Karnataka and Tamil Nadu.

	Botanical name	Family	Habit	Status and distribution
57	<i>Polyalthia fragrans</i> (Dalz.) Beddome	Annonaceae	Tree	Endemic ^{#,***} Western Ghats – in semi evergreen to evergreen forests up to 1200m in Maharashtra, Karnataka, Kerala and Tamil Nadu.
58	<i>Psychotria flavida</i> Talbot	Rubiaceae	Shrub	Endemic ^{##} Southern Western Ghats.
59	<i>Pterocarpus santalinus</i> L.f.	Fabaceae	Tree	Near Threatened [†] Endangered ^{**} (Global) Distributed in Southern India, hilly regions of Nepal, Pakistan and Sri Lanka.
60	<i>Pterospermum reticulatum</i> Weight. & Arn.	Sterculiaceae	Tree	Vulnerable [†] Endemic to Western Ghats – South and Central Sahyadris.
61	<i>Saraca asoca</i> (Roxb.) Willd	Caesalpiniaceae	Tree	Vulnerable [†] Endangered ^{**} (Regional) Distributed in the Western Ghats – South, Central, and South Maharashtra part of Sahyadris as an understory tree along the streams in evergreen to semi-evergreen forests up to 600m.
62	<i>Spatholobus purpureus</i> Prain. Ex: Baker	Papilionaceae	Climbing shrub	Endemic ^{##} Western Ghats.
63	<i>Sterculia guttata</i> Roxb.	Sterculiaceae	Tree	Distributed throughout the Western Ghats ^{##} .
64	<i>Syzygium travancorium</i> Gamble	Myrtaceae	Tree	Critically Endangered ^{**} (Global) Endemic to Western Ghats of Karnataka, Kerala and Tamil Nadu.
65	<i>Trichopus zeylanicus</i> Gaertn. subsp. <i>travancorius</i> (Bedd.) Burkill	Dioscoreaceae	Herb	Critically Endangered [†] (Global) Endemic to the Western Ghats of Kerala and Tamil Nadu.
66	<i>Vatica chinensis</i> L.	Dipterocarpaceae	Tree	Critically Endangered [†] Critically Endangered (Global) In evergreen forests of the Western Ghats along the streams at low elevation in Karnataka, Kerala and Tamil Nadu.
67	<i>Vateria indica</i> L.	Dipterocarpaceae	Tree	Critically Endangered [†] Vulnerable ^{**} (Global). Endemic to the Western Ghats/western coast – usually in evergreen forests up to 1300m in Karnataka, Kerala and Tamil Nadu.

[†]<https://www.iucnredlist.org>, ^{**}<http://enis.frlht.org/junclist.php>, ^{***}http://www.biotik.org/species_list_india.html, [#]Shetty & Kaveriappa (2001), ^{##}<http://indiabiodiversity.org>, [§]Cheesman 1968, ^{§§}<http://www.kfri.res.in/noticeboard.asp?ID=17>, ^{§§§}<http://florakarnataka.ces.iisc.ac.in/hjcb2/herbsheet>

University Campus, Mangalagangothri (12.816°N, 74.923°E) (Table 1). The maintenance of an arboretum of endemic and RET species not only helps in conservation but also provides an opportunity for the student community to know more about our plant resources, their uses and importance. In addition, the collected plant species also form a study material for further research.

Among the 67 species conserved in the arboretum, *Alpinia galangal* Sw., *Ensete superbum* (Roxb.) Cheesman and *Trichopus zeylanicus* Gaertn. subsp. *travancoricus* (Bedd.) Burkill are herbs. *Calamus nagbetta* R.R. Fernald & Dey, *Cosciniium fenestratum* (Gaertn.) Coleb. and *Kunstleria keralensis* Mohanan & Nair are climbers. *Nilgirianthus barbatus* (Nees.) Bremek, *Nilgirianthus ciliates* (Nees) Bremek and *Psychotria flavida* Talbot are shrubs. *Spatholobus purpureus* Prain. Ex: Baker is a climbing shrub and all the remaining 57 species are trees.

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