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Ecology and Restoration of *Cynometra beddomei* and *Kingiodendron pinnatum* - two endemic and endangered tree legumes of Western Ghats of Kerala

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1. Title of the project **:** Ecology and Restoration of *Cynometra beddomei* and *Kingiodendron pinnatum*- two endemic and endangered tree legumes of Western Ghats of Kerala

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ABSTRACT

A systematic study on the population distribution, ecology, propagation, multiplication and restoration of two endemic and endangered tree legumes of the Western Ghats of Kerala viz., *Cynometra beddomei* Prain and *Kingiodendron pinnatum* (Roxb. ex DC.) Harms were conducted as part of estimating population size, relative dominance, regeneration performance along with analysis of climatic and edaphic factors *in situ*. The study further focused on developing protocols for vegetative and seed propagation, enrichment seedling planting and evaluation of seedling survival performance in order to develop strategies for the sustainable conservation and subsequent management of the populations for the sustainable utilization of these species.

The population survey of *K. pinnatum* enabled to locate 17 populations in 12 forest areas of Kerala. The populations were found out as fragmented and scattered. The population structural data of 12 forests revealed a decrease in set of future (29%) which shows a declining growth trend of the populations though the species exhibited wider distribution. A total of 432 adult individuals of the species were enumerated within 168 km^2 which included both sampled and non sampled areas of the 12 forest sites identified for the species. The population structural analysis revealed

occurrence of species as a top layer in the evergreen - semi evergreen ecosystems. The vegetation grouping of *Hopea- Kingiodendron- Vateria* noticed in its distribution range, spatial arrangement of populations in adjacent watercourse etc. pointing towards the habitat and associate species preferences of the species. The population diversity analysis in three sites, representing North, Central and South zones of the State, exhibited moderately low IVI values for the species, and subsequent low abundance at each site. The occurrence of fairly good percentage of natural regeneration, abundance of reproductive individuals, distribution of populations from lower to medium high elevation, portray the adaptability of the species in different environment gradients. The distribution and ecological data generated thus suggested the reversion of conservation status from Endangered to the Vulnerable (VU) for the species in the State. A moderate to high N, low to moderate content P, moderate to high K soil identified *in situ* could be used for restoring species in identical habitats. The long intervals in flowering, isolated flowering among population, abscission of fruiting primordia, etc. concern over the reproductive barriers of the species.

The vegetative propagation methods through stem cuttings and air layering were standardized in young stands. A cent percent stem rooting success achieved with auxins viz. IAA 1000 and IBA 1000 and 3000ppm.

Ring air layering succeeded at 100% rate with IAA 1000 ppm. The non-avaibility of the seeds during the study period, prevented us to generate seed propagation protocols for the species. The enrichment seedling planting of 1550 seedlings in four population sites recorded with success of 85-92%.

The population survey of *C. beddomei* enabled us to locate 5 populations in Kerala. The distribution of species was found restricted in southern and northern parts of the State. The population structural analysis displayed the composition of species as 2^{nd} - 3^{rd} layer in the evergreen ecosystems. The spatial distribution of individuals adjacent to watercourse indicating the habitat specificity of the species. The extreme reduction in pre reproductive individuals (17%), poor performance in natural regeneration (77% of un established seedlings), etc. show declining trend of the populations. Altogether, 59 adult trees and 273 seedlings were counted among the five population sites of the species. The lower IVI values among five population sites indicated the poor dominance of the species. The fewer number of populations, extreme lower number in adult individuals, poor natural regeneration and lower IVI values suggest upgradation of conservation status from Endangered (EN) to Critically Endangered (CR) for the species. A moderate to high N, low P and a moderate to high K soil along with identified habitat conditions could be used for restoring identical

habitats of the species. The long intervals in flowering, individual flowering among population, abscission of fruiting primordia, seed pest infestation by *Alcidodes* sp. indet. (Coleoptera : Curculionidae), poor seedling bank *in situ*, etc. concern over the reproductive barriers of the species.

The intermediate type seeds exhibited 42-45 days normal viability period. The seeds have shown tolerance towards desiccation as seed attached to hard fruit coat. The Critical Moisture Content (CMC) was noted at 38-40 % with 40% germinability. The overnight water soaking of seeds enhanced the germination five to six days prior than control. The shortage of seeds prevented us to continue various seed trials and to raise sufficient planting stock for the species. However, 40 seedlings planted in two sites at Kakkayam forest resulted 86% survival, foreseen an increase in population growth and genetic base for the species in due course apart from the sample planting carried out *ex situ*.

1. INTRODUCTION

Extinction of species is considered as one of the greatest threats to biodiversity. Unfortunately, many species are threatened due to human activities such as habitat fragmentation, resource exploitation and global climate change. With the alarming increase of species extinction, scientists estimated the rate as high as 1,000–10,000 times higher than the natural extinction rate. If the process continues, we will be losing as many as 30–50% of all species by mid-century (Myers, 1980; Chivian and Berstein, 2008). Therefore, effective conservation and management of the biological diversity is urgently needed to face the challenges of environment degradation, climate change, species loss and over all sustainable development.

The current decline in biodiversity is largely due to the result of human activity such as habitat destruction, over-harvesting plant resources, inappropriate introduction of exotic plants, etc. The populations of endemic tree species having few individuals are more vulnerable to extinction. They are also more likely to experience genetic drift and inbreeding (Fischer and Matthies, 1998; Keller and Waller, 2002). The ultimate result of a dwindling population and genepool is extinction of a species. Endemic plants attained various conservation status because of their restricted distribution, anthropogenic interferences, incidence of pests and pathogens, or

reproductive constraints (Krukebery and Rabinowitz, 1985; Smith, 1976).

Understanding plant rarity has been an important task among plant ecologists. There are many ways by which a species can become rare, and the process has diverse ecological consequences. According to Reveal (1981), plant rarity is a two fold concept associated with the ecology and biology of the species. Knowledge of the biological and ecological constraints leading to restricted distribution of the species is significant to analyse the causes of rarity. The recording and analysis of climatic and edaphic factors, association of plant communities, their dominance, size of populations are the integral elements of the study. The phenological observations of species are also relevant to reveal the dynamics of natural populations which will facilitate to identify factors affecting the population growth and establishment.

Ecological restoration is an approach to conserve species in both *in-situ* and *ex-situ* conditions. Ecological restoration is essential for sustaining the diversity of life on the earth and establishing an ecologically healthy relationship between man and nature. It is also important for provisioning a range of ecosystem services such as provisioning of fuel wood and fodder, NTFPs, biodiversity conservation, soil formation and soil fertility maintenance, watershed protection, carbon sequestration, air and water purification, etc. which

are so essential for survival of human beings on this planet earth. Thus, degradation of ecosystems and its negative impacts on ecosystem services, biological diversity and community livelihoods are interconnected.

India is a biodiversity-rich country with as many as 17,500 flowering plants of which 61% are endemics (Ramesh and Pascal, 1991). The Western Ghats of India is remarkable for their floristic diversity and endemism. At the same time it is considered as one of the threatened landscapes. It is estimated that the region holds around 7,400 flowering species of which 15% plants are currently under threats. The forests of Kerala are along the Southern Western Ghats, which is considered to be the most species rich area and endemism in the Western Ghats. Out of 4078 indigenous flowering plants recorded in the State, 1568 species are endemics of which 553 species are categorized under various threat categories (Nayar *et al*., 2008; Sasidharan, 2017). The endemic species in the flora of a geographical region are very significant. They reveal the biogeography of the area, centre of speciation and adaptive evolution. Therefore, thrust has been given for the conservation and management of endemic and threatened plants on a priority basis for their sustainable use.

As per the studies of Jose *et al*., 2014, out of 760 red listed flowering plants reported from the Southern Western Ghats, more than

500 species are not yet studied for any kind of conservation efforts. A number of other reports on Rare, Endangered and Threatened (RET) plants of the Western Ghats, Peninsular India, Southern Western Ghats and Kerala are also available (Blasco, 1979; Henry *et al.*, 1979; Ramesh *et al.* 2003; Pandurangan, 2003; Sasidharan, 2004, 2011, 2017). The various literature points towards the urgency in conducting research and restoring the depleting endangered plant populations for better forest management and their utilization strategies.

The endemic legumes of Western Ghats of India are of special interest for study as most of them are progenitors of cultivated plants and rich source of variety of economic uses such as food, medicinal and industrial values. Most of the endemic trees have been rediscovered after type collection and having narrow distribution range and sparse population (Sanjappa, 1992). Most of the species occupies in moist deciduous and tropical wet evergreen forests as fragmented populations and their habitats are facing various threats and degradation. It is also observed that many of the endemic legume trees exhibited poor seed setting, in ability for natural regeneration and devoid of dispersal modes. Because of their rarity, as many as 12 tree legumes have been placed under various threatened categories of IUCN (Sasidharan, 1998; 2011; Nayar and Sastry, 1990).

In this context, a systematic study on the ecology, conservation and restoration of two endemic and endangered legume trees of the Western Ghats of Kerala viz., *Cynometra beddomei* Prain and *Kingiodendron pinnatum* (Roxb.ex DC.) Harms were conducted as part of their sustainable conservation and resource base utilization for the posterity.

2. OBJECTIVES

2.1. Survey and identification of two endemic and endangered legume trees in the Western Ghats of Kerala region.

2.2. Setting up of permanent quadrats to study the ecology viz., population structure, diversity including climatic and soil factors in *situ* of the species.

2.3. Study on population dynamics, both vegetative and reproductive phenologies including insect- pest associations.

2.4. Development of conservation strategies (Conventional clonal propagation using auxins; seed germination, viability, storage practices) and seedling production.

2.5. Restoration through augmented seedling planting *in situ*, establishment of conservation plots *ex situ* and post restoration evaluation on the establishment and survival of planted saplings.

3. MATERIALS AND METHODS

3.1. MATERIALS

Cynometra beddomei Prain and *Kingiodendron pinnatum* (Roxb. ex DC.) Harms are the two endemic, endangered tree legumes selected for the study. The relevance of the target spp. is as follows:

Cynometra beddomei, belonging to the family, Fabaceae, Subfamily Caesalpinioideae is an endemic and endangered tree of the Southern Western Ghats. After the rediscovery of the species (Sasidharan, 1998) and subsequent taxonomic documentation (Sasidharan, 2003, 2004, 2011, 2017), not much information is available for the species. Since the distribution is discontinuous with a few fragmented populations in the northern and southern parts of the State, the chances of local extinction are very high for the species.

Kingiodendron pinnatum is an endangered medicinal tree belonging to the family Fabaceae, subfamily Caesalpinioideae. The wood-oil of this plant species is used in gonorrhoea, catarrhal conditions of genito-urinary and respiratory tracts. It is also used in curing sores of elephants. The species is considered as promising sources of natural antioxidants (Komal Kumar, 2011). The population of this species has declined considerably because of overexploitation

and habitat degradation. It is reported in India from Kerala, Tamil Nadu and Karnataka.

Cynometra beddomei Prain, J. Asiat. Soc. Bengal 65: 478. 1897; Gamble, Fl. Pres. Madras 414 (293). 1919; Sanjappa, Legumes Ind. 26. 1992; Mohanan & Sivad., Fl. Agasthyamala 231. 2002; Rao *et al*., 2003; Sasidharan, Biodiv. Doc. Ker. Part 6 : Flowering Plants Ker. 154. 2004, Ratheesh Narayanan, Fl. Stud. Wayanad Dist. 324. 2009; Sasidharan, Flowering Plants of Ker. CD Rom 2.0. 2011, Sasidharan, Handbook Red listed Ker. 2017).

Species description

Evergreen trees, to 20 m high; bark blackish-green. Leaves paripinnate, alternate; stipules free, lateral, cauducous; rachis 30-40 mm, slender, pulvinate, grooved above, pubescent; leaflets 4-6, opposite, estipellate; petiolule 1-2 mm; lamina 2.5-5 x 1-1.8 cm, obliquely obovate-oblong or obovate, base oblique, acute or cuneate, apex obtusely acuminate, emarginate, margin entire, glabrous, coriaceous; lateral nerves 6-8 pairs, pinnate, secondary laterals present, faint; intercostae reticulate, faint. Flowers bisexual, creamy-white, in axillary clusters from conspicuous imbricate bracts; peduncle 12-20 mm, densely-patent-hairy; bracts ovate, appressed, hairy, ciliate, striate, imbricate, at length deciduous, smaller upwards; pedicel 5mm, pubescent; receptacle 1-2 mm deep, campanulate, circum scissile under

the ripening fruit; sepals 3 mm long, hairy, ciliate; petals 5, 3.5 x 1mm, free, oblanceolate, subequal, glabrous; disc 0; stamens 10, alternately 5 and 7mm; filaments filiform, connective cleft at base, apex apiculate; anthers versatile; ovary half inferior, densely long brown hairy; stipe 0.8 mm, exocentric; style 2.5 mm, slender, hairy upto half way; stigma capitate. Fruit a pod, reniform-globose, grooved near sutures, indehiscent; seed one.

Kingiodendron pinnatum (Roxb. ex DC.) Harms in Engl. & Prantl, Naturl. Pflanzenfam. 1(1): 194. 1897; Gamble, Fl. Pres. Madras 412(292). 1919; Mohanan, Fl. Quilon Dist. 163. 1984; Sanjappa, Legumes Ind. 32. 1992; Subram., Fl. Thenmala Div. 119. 1995; Sasidh. & Sivar., Fl. Pl. Thrissur For. 165. 1996; Sasidh., Fl. Shenduruney WLS 109. 1997; Sasidh., Fl. Periyar Tiger Reserve 123. 1998; Ravikumar & Ved, Illustr. Field Guide 100 Red Listed Med. Pl. 215. 2000; Ratheesh Narayanan, Fl. Stud. Wayanad Dist. 326. 2009.

Species description

Evergreen trees, to 30 m high, bark 5-8 mm thick, surface greyish-brown with green blotches, rough; blaze red; exuding a reddish sticky resin. Leaves imparipinnate, alternate; stipules minute, lateral, cauducous; rachis 10-15.2 cm, slender, pulvinate, glabrous; leaflets 5-9, alternate, estipellate; petiolule 5-10 mm, stout, grooved above, glabrous; lamina 4.5-10.5 x 2-4.5 cm, ovate-lanceolate or oblong,

falcate or oblique, apex acuminate, margin entire, glabrous, coriaceous; lateral nerves 8-13, pinnate, slender, prominent, secondary laterals present, intercostae reticulate, prominent. Flowers bisexual, 2-3 mm across, white, in axillary and terminal panicled racemes; calyx tube almost wanting, lobes 5, broadly ovate, imbricate; petals 0; disc very small; stamens 10, equal, filaments filiform, villous at base; anthers versatile; ovary half inferior, sessile, villous at base; ovules 2; style subulate; stigma minute, oblique. Fruit a pod, 4-5 x 2-2.5 cm, ovate-ellipsoid, turgid, obtusely beaked, prominently veined, dark brown, indehiscent; seed one, pendulous.

3.2. STUDY AREA

The study areas were selected after referring species literature from district floras, herbaria and other leading publications. In addition, the field experiences of the investigators also immensely supported to locate the sites.

3.3. METHODS

The entire research programme has been divided into 5 tasks for operational reasons and they are discussed here under.

3.3.1. Population Structure and Diversity

The sampling quadrat size was worked out as per species area curve method to determine the vertical, horizontal, age wise distribution and crown projections of candidate species as well as associations in a community. Individuals of the species were categorized under three age classes such as Set of future (Pre reproductive), Set of present (Reproductive) and Set of past (Post reproductive). Populations of the two species were studied in releves (sample plots) of 0.1 ha (50m x 20m) size. All trees having girth at breast height (gbh) ≥ 30cm in the study plots were identified, enumerated and recorded (Swarupanandan *et al.*, 2013). (The gbh measurements for *C. beddomei* were calculated @ ≥10cm, as mature individuals have shown low girth at different locations). Population structural data were collected from the sampled and non sampled areas in the particular forest area and are presented.

The floristic diversity in terms of relative frequency, relative density, relative dominance and IVI were calculated (Misra, 1968; Sivaram *et al*., 2006). The mature individuals were physically counted in the sampled and non sampled areas. Each candidate species was

enumerated in quadrats ranging 7,000 m^2 according to their availability within the forest areas in order to reach a realistic conclusion on the relative abundance of the species in a community.

Density: Number of individuals of a species per unit area gives its density (d). This is usually computed as trees per hectare (tr ha^{-1}).

Frequency: The chance of finding a species in a particular area in a particular trial sample is called its frequency (f) and is expressed as the number of quadrats in which a species is found per total number of quadrats studied.

Dominance (Basal area): Cover is usually the area covered by crown or shoot area, or the stem. For trees and shrubs, the area occupied by the stem is taken as the cover and is known as the basal area. Basal area= πr^2, where r= gbh/2π.

The *Importance Value Index* (IVI): It is defined as the sum of Relative Density (rd), Relative Frequency (rf) and Relative Dominance (rD) (Muller-Dombois and Ellenberg, 1974). This expresses the relative importance of the species in the community.

Thus, IVI = rd + rf + rD, where,

rd = (Density of the species) / (Density of the stand)

rf = (Frequency of the species) / $\sum$ (frequency of all the species)

rD = (Basal area of the species) / (Basal area of all species)

Strata were classified as per the height of the stands. Girth size was used to determine the age wise distribution. Populations were categorized into set of future, set of present and set of past depending upon the reproductive nature of the species (Pascal, 1988; Parthasarathi and Sethi, 1997).

Population Dynamics

It covers both vegetative and reproductive stages of the species in their natural life cycle (Davy and Jefferies, 1981). Observations on vegetative dynamics were made for leaf initiation, growth, maturity, senescence and insect-pest associations. In reproductive dynamics, different episodes such as flowering, fruiting, including insect-pest, dispersal and regeneration phases were monitored and recorded. (Murali and Sukumar, 1994; Daniel and Jayanthi, 1996; Vivek Menon, 2003; Jose *et al.,* 2000; Jose and Pandurangan, 2002; Jose and Pandurangan, 2003; Jose, *et al.*, 2004).

The small plants of the mature trees having gbh ≤ 10 cm were counted in all the quadrats and are treated as seedlings. The seedlings were further categorized into un-established seedlings (height ≤1 m) and established seedlings (height ≥ 1 m) (Ramachandran *et al.,* 2014).

3.3.2. Climatic and Edaphic factors

The climatic data of the species covering atmosphere temperature (day and night - °C) and atmospheric humidity (night - %)

in three prominent seasons of a year (summer, monsoon and winter) were collected from nearby weather recording stations.

The edaphic parameters were assessed upto 30 cm at a depth interval of 10cm (ie; 0-10cm as surface; 10-20cm as middle and 20-30cm as bottom) with respect to soil texture, pH, macronutrients such as N, P and K; soil moisture content and temperature during three seasons of a year and average values recorded (Bawa, 1983; Gupta and Malik, 1996; Kerala State Planning Board, 2013). The analysis was conducted in the Soil Science Dept. of KFRI.

Soil reaction (pH)

The pH of the soils were determined in 1:2.5 (soil: water) suspension, using combined electrode (glass and calomel) in a digital pH meter.

Available Nitrogen

Available nitrogen was determined by alkaline permanganate distillation method (Subbiah and Asija, 1956).

Available Phosphorous

Available phosphorus in the soil samples were extracted with Bray's No. 1 extractant and P content in the extracts was determined by ascorbic acid method in a spectrophotometer (Watanabe and Olsen 1965).

Available Potassium

Soil samples were extracted with neutral normal ammonium acetate and potassium content was determined by flame photometry (Jackson, 1973).

3.3.3. Conservation strategies

The nursery propagation facilities in the campus were utilized for the propagation, multiplication and establishment of seedlings.

3.3.3.1. Vegetative propagation

Conventional rooting of stem cuttings and air-layering experiments were conducted in mature and vigorously growing young stands of 3-5 year old of the candidate species. Application of rooting hormones viz., IAA, IBA and NAA of different concentrations such as 1000, 2000, 3000, 4000, 5000 ppm were attempted (1 minute dipping) (Jose *et al*., 1995; Jose and Thomas, 1998; Sharma *et al*., 1995).

3.3.3.2. Seed biological studies

The seed collection, processing in relation to moisture content, storage, germination, extension of viability in different storage conditions were studied as per the seed avaibility of the candidate species (Hong and Ellis, 1996; Jose and Pandurangan, 2002, 2011; Kamarudeenkunju, 2003).

3.3.3.3. Restoration

The propagules raised as by product of propagation and multiplication studies were used to implement the restoration of the

species. Both *in situ* and *ex situ* planting of the species were carried out to ensure the survival of seedlings (Groombridge, 1992; Truman, 2000; Jose and Pandurangan, 2003). Pits were prepared in tune with canopy gaps in the population areas. Each seedling was tag- marked for monitoring. The survival of planted seedlings in each site was monitored at 6 months intervals after planting. The height increments of each seedling were also taken during each visit. The planting sites in the natural forest areas have been permanently demarcated by fixing metal display boards with relevant information such as title of the project, funding agency, GPS details of the location, date and number of seedlings planted etc (Jose and Pandurangan, 2003; Jose and Pillai, 2014, 2016; Swarupanandan, *et al*., 2013).

4. RESULTS

4.1. *Kingiodendron pinnatum* (Roxb. ex DC.) Harms

The survey enabled to locate 17 populations of the species in 12 forest areas of Kerala (Fig.1). The entire populations located were categorized under three zones viz., North, Central and South representing the State. The population structural data within the sampled and non sampled areas at 12 sites were worked out and presented. The population diversity analysis in one site representing each zone viz., Kulathupuzha (South), Poringalkuthu (Central), Kottiyoor (North) were worked out and presented.

Population sites of *Kingiodendron pinnatum*

1. Paripode - N 11° 57' 32.3" E 075° 49' 36.9" (Aralam Range, Aralam Wildlife Division), at an altitude of 203±10 m. The population located in an evergreen patch.
2. Kap -N 11°57' 38.5" E 075°49'48.7"(Aralam Range, Aralam Wildlife Division) at an alttitude of 205±10m. The population located in an evergreen patch.
3. Kottiyoor - N 11° 52 ' 05.3" E 075° 53' 53.6" (Kottitoor WLS, Aralam Wildlife Division, Northern Circle), at an alttitude of 242±10 m. The population identified in an evergreen forest.
4. Payyanikotta - N 11° 35' 0.40" E 075° 52' 07.1" (Peruvannamuzhi Range, Kozhikode Division). The population identified in the fringes

of an evergreen forest at an alttitude of 176 ±10m, adjacent to a Rubber plantation.

5. Nadugani- N 11° 26' 02.4" E 076° 23' 11.8" (Vazhikadavu Range, Nilambur North Division). The population identified in the evergreen forest at an alttitude of 565±10 m.
6. Thamarassery- N 11° 30'19.9" E 076° 01' 49.2" (Thamarassery Range, Kozhikod Division). The population identified in the evergreen forest at an alttitude of 644 ±10m.
7. Poringalkuth- N 10^{o} 19'19.0" E 076^{o} 38'24.6" (Vazhachal Range, Vazhachal Division). The population identified in evergreen semi-evergreen forest patches at an alttitude of 471±10 m.
8. Orukomban- N 10^{o} 23'16.4" E 076^{o} 42' 30.6" (Parambikulam Tiger Reserve, Parambikulam Wildlife Division). The population identified in the evergreen forest at an altitude of 475 ±10m.
9. Vazhachal- N 10^{o} 18'13.3" E 076^{o} 35' 54.6" (Vazhachal Range, Vazhachal Division). The population identified at an altitude of 295 ±10m, aside main road to Malakkapara.
10. Karimbani - N10° 12' 12.60" E 076°39' 56.55" (Thundathil Range, Malayattur Division). **T**he population identified in the evergreen forest at an alttitude of 180±10m .
11. Rajathottam - N 08°56' 58.9" E 077°10' 56.6". The population identified in the evergreen forest at an altitude of 611±10m

12. Pallivasal- N 08° 53' 55.8" E 077° 10' 20.5". The populations identified in the evergreen forest at an altitude of 216 ±10m.

13. Vilakkumaram- N 08° 55' 55.6" E 077° 10' 17.7". The populations identified in the evergreen forest at an alttitude of 660±10 m.

14. Palaruvi- N 09° 01'16.5" E 077°06 ' 13.3". The populations identified in the evergreen forest at an altitude of 216 ±10m.

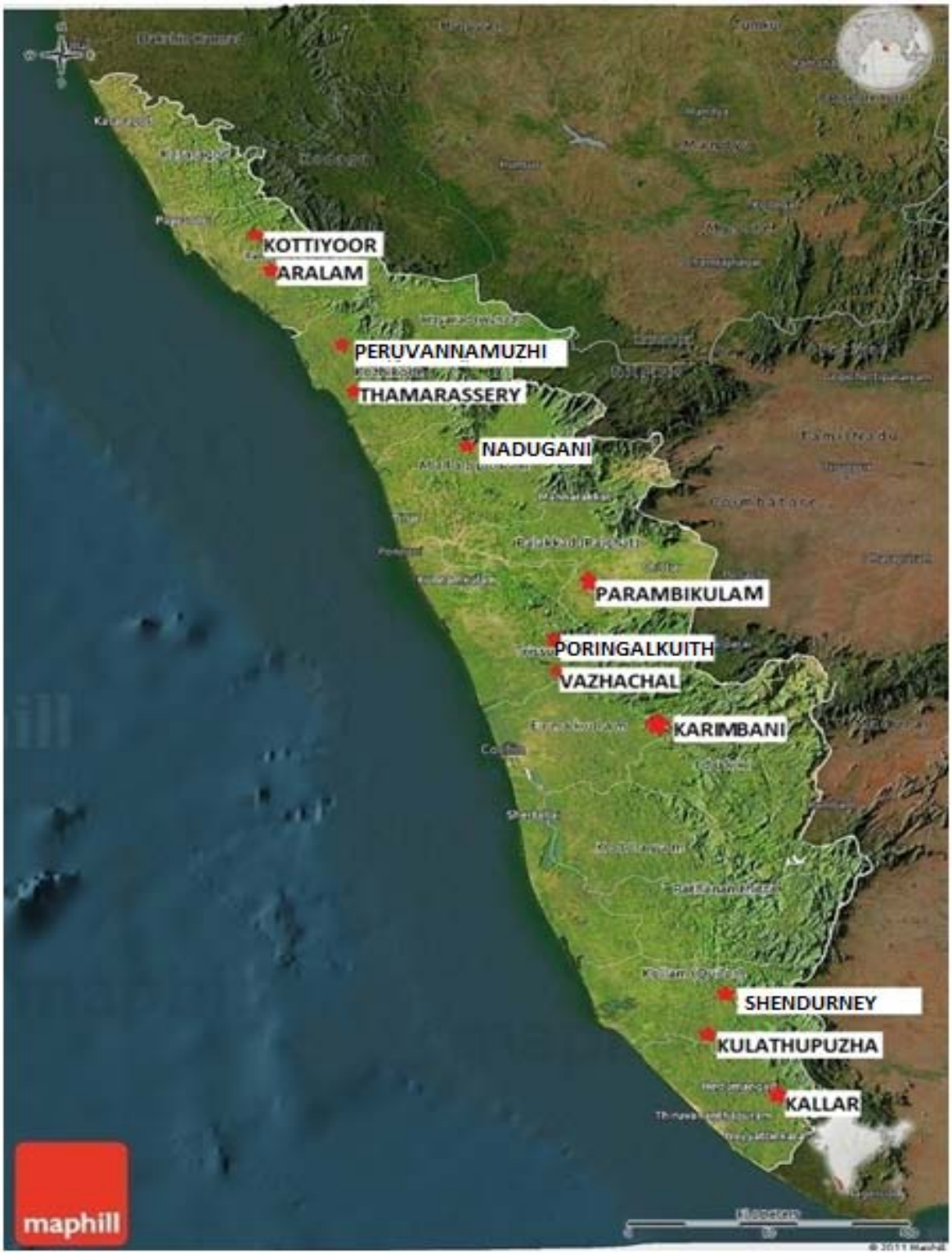
15. Pandimotta- N 08° 54' 68.2" E 077° 06' 78.5". The population identified in the evergreen forest at an alttitude of 180±10 m.

16. 2nd Mile (Kulathupuzha) N 08° 52' 18.11" E 077° 05' 0.68" (Kulathupuzha Range, Thiruvanathapuram Division) at an altitude of 210±10 m.

17. Kallar- N 08° 44' 24.33" E 077° 07' 10.53" (Palode Range, Thiruvananthapuram Division). Population identified at an alttitude of 342 ±10m.

In addition to the above sites, one tree growing in the KFRI, Peechi campus was also monitored.

Fig.1. Population sites of *Kingiodendron pinnatum* in the Western Ghats of Kerala



4.1.1. Population structure

1. Kulathupuzha

(a) Stratification/ vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such as *Hopea parviflora*, *Dipterocarpus indicus*, *Antiaris toxicaria*, *Canarium strictum*, *Terminalia bellirica*, *Artocarpus hirsutus*, *Messua ferrea*, *Dysoxylum malabaricum* etc. along with *Kingiodendron pinnatum* as first layer/ first storey reaching a height range of 26 to 35m. The second storey was represented by *Cinnamomum malabatrum*, *Myristica malabarica*, *Knema attunata*, *Holigarna arnotiana*, *Polyalthiya fragrans*, *Garcinia morella*, *Diospyros candolleana*, *Hopea ponga*, *Hydnocarpus pentandra*, *Sterculia guttata*, *Schleichera oleosa*, *Spondias pinnata*, *Aglaia barberi*, *Myristica beddomei* etc. with a height range of 16 to 25m. Third storey was occupied by *Baccaurea courtallensis*, *Xanthophyllum arnottianum*, *Walsura trifolia*, *Macaranga peltata*, *Naringi crenulata*, *Sapindus emarginatus*, *Psydrax dicoccos* etc with 6-15 m height range. Below this was the shrubby layer constitutes viz. *Thottea siliquosa*, *Ixora nigricans*, *Leea indica*, *Cipadessa baccifera*, *Memecylon randerianum*, *Meiogyne pannosa*, *Helicteres isora*, *Pavetta indica*, *Begonia trichocarpa*, *Atlantia monophylla*, etc. The herb layer was mainly dominated by *Impatiens minor*, *Begonia malabarica*,

Trichopus zeylanicus, Sonerila rheedi, Ophiorrhiza mungos and the seedlings of woody species such as *Memecylon umbellatum, Myristica malabarica*, *Knema attunata, Hopea parviflora,* etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *Kingiodendron pinnatum* in a scattered manner along with their associates in both slope and flat terrain.

(c) Age distribution

The individuals of *Kingiodendron pinnatum* exhibited two age classes such as set of future and set of present with a height range from 5 to 30 m and a girth of 30 to 280 cm, covering the area of occurrence in the forest. Twenty eight individuals represent the set of present covering a height range of 10 to 30 m and gbh range of 80 to 280 cm. Set of future is represented by 14 individuals covering a height of 6 m and gbh of 58 cm.

The population structure within the sampled and non sampled areas of *K. pinnatum* was analysed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 1&2). The occurrence of the species in the sampled and non sampled areas was found to be approximately 12 km^2. Nearly 42 mature trees of the *K. pinnatum* were recorded within the area studied for the species.

The floristic diversity analysis covered 50 species of gbh≥30cm size of 486 individuals in 7,000 sq.m. *Xanthophyllum arnottianum* has highest index value of 0.257 and thus became the dominant species in the particular site whereas, the *Kingiodendron pinnatum* represented 45th position with IVI of 0.017 in the study area (Table 3).

2. Poringalkuth

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such *Vateria indica***,** *Stereospermum colais, Tetrameles nudiflora, Hopea parviflora, Bombax ceiba, Diospyros buxifolia, Lagerstroemia microcarpa, Holoptelea integrifolia, Dysoxylum malabaricum, Mesua ferrea, Terminalia elliptica, Dipterocarpus indicus, Alstonia scholaris, Toona ciliata, Chukrasia tabularis, Pterygota alata, Elaeocarpus serratus, Ficus* sp. etc. along with *Kingiodendron pinnatum* as first layer/ first storey reaching a height range of 26 to 35 m. The second storey represented by *Holigarna arnottiana, Gmelina arborea, Diospyros candolleana, Cinnamomum malabatrum, Dillenia pentagyna, Haldina cordifolia, Hydnocarpus pentandra, Knema attunata, Myristica malabarica, Polyalthia fragrans, Schleichera oleosa, Spondias pinnata, Sterculia guttata, Pterygota alata, Agrostistachys bornensis* with 16-25m height

range. The third storey occupied by *Baccaurea courtallensis*, *Macaranga peltata, Xanthophyllum arnottianum, Naringi crenulata Melicope lunu-ankenda Lagerstroemia speciosa, Pongamia pinnata*, *Bauhinia malabarica*, *Sapindus emarginatus* with 6-15m height range. The shrub layer consists of *Breynia retusa, Callicarpa tomontosa*, *Memecylon umbellatum, Capparis rheedi, Murraya paniculata*, *Memecylon randerianum, Chassalia curviflora, Symplocos rosea*, *Glycosmis sp., Thottea siliquosa, Ixora nigricans* etc. The herb layer was mainly dominated by *Pogostemon paniculatus, Dictoyospermum montanum, Begonia malabarica* and the seedlings of woody spp. such as *Cinnamomum malabatrum, Hydnocarpus pentandra* and *Polyalthia fragrans*.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *Kingiodendron pinnatum* in a scattered manner among its associates adjacent to the Poringalkuth Dam.

(c) Age distribution

The individuals of *Kingiodendron pinnatum* exhibited two age classes such as set of future and set of present with a height range from 5 to 34 m and a girth of 30 to 320 cm covering the area of occurrence in the forest. Twenty eight individuals represented the set of present

covering a height range of 8 to 34 m and gbh range of 80 to 320 cm. Set of future is represented by 12 individuals covering a height of 5 to 6 m and gbh of 30 to 56 cm.

The population structure within the sampled and non sampled areas of *K. pinnatum* was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 4&5). The occurrence of the species in the sampled and non sampled areas was found to be approximately 16 km^2 and nearly 30 mature trees were recorded within the area studied for the species.

The floristic diversity analysis covered 52 species of gbh≥30cm size of 423 individuals in 7000 sq.m. *Vateria indica* has highest index value of 0.185 and thus became the dominant species in the particular quadrat whereas, the *Kingiodendron pinnatum* represented 44^{th} position with IVI of 0.024 in the study area (Table 6).

3. Kottiyoor

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such *Vateria indica*, *Dysoxylum malabaricum*, *Bombax ceiba*, *Canarium strictum*, *Tetremeles nudiflora*, *Terminalia bellirica*, *Diospyros buxifolia*, *Drypetus venusta*, *Artocarpus hirsutus*, *Vitex altissima*, *Persea macarantha*, *Alstonia scholaris*, *Steriospermum colais*, *Bischofia javanica*, *Mesua ferrea*,

Ficus sp. along with *Kingiodendron pinnatum* as first layer/ first storey reaching a height range of 26 to 35m. The second storey represented by *Dimocarpus longan*, *Nothopegia beddomei*, *Knema attunata, Toona ciliata, Holigarna arnotiana, Sterculia guttata, Diospyros candolleana, Syzygium densiflorum, Schleichera oleosa, Garcinia morella, Myristica malabarica, Hopea ponga, Polyalthia fragrans, Solenocarpus indicus, Hydnocarpus pentandra, Olea dioica, Sterculia guttata, Reinwardtiodendron anamalaiense, Actinodaphne malabarica* and *Sterculia villosa,* ranging a height of 16 to 25m. The third storey occupied by small trees such as *Xanthophyllum arnottianum, Holarrhena pubescens, Otonephelium stipulaceum, Aporosa cardiosperma, Baccaurea courtallensis***,** *Sapindus trifoliatus, Euonymus indicus* with 6-15 m height range. The shrubby layer included species such as *Memecylon umbellatum, Debregeasia longifolia, Ixora nigricans, Pavetta tomontosa, Cipadessa baccifera, Isonandra lanceolate, Thottea siliquosa, Memecylon lawsonii* etc. The herb layer is mainly covered by *Pouzolzia meeboldii***,** *Ophiorrhiza mungos, Bosenbergia pulcherima, Arisaema* sp. and seedlings of *Murraya paniculata,* etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *Kingiodendron pinnatum* in a

scattered manner among its associates adjacent to the water course. The area was also characterized by sloppy ground with rock boulders.

(c) Age distribution

The individuals of *Kingiodendron pinnatum* exhibited two age classes such as set of future and set of present with a height ranging from 4 to 26 m and a girth of 30 to 205 cm. Twenty six individuals represent the set of present covering a height range of 9 to 26 m and gbh range of 80 to 205 cm. Set of future is represented by 13 individual covering a height of 4-7 m and gbh of 30-70 cm.

The population structure within the sampled and non sampled areas of *K. pinnatum* was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 7&8). The occurrence of the species in the sampled and non sampled areas was found to be approximately 12 km^2. Nearly 39 mature trees were seen within the area studied for the species.

The floristic diversity analysis covered 51 species of gbh≥30cm with 410 individuals in 7000 sq.m. The *Knema attunata* has attained highest index value of 0.165 and thus became the dominant species in the particular quadrat whereas, the *Kingiodendron pinnatum* represented 34^{th} position with IVI of 0.033 in the study area (Table 9).

Table 1. Population structure of *Kingiodendron pinnatum* within the sampled area: Kulathupuzha

(List of individuals with G≥ 30 cm**)**

Sl. No.	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	68	10.82	326.68	6	Set of present	8	10
2	185	29.45	2723.32	14	Set of present	18	26
3	205	32.64	3345.26	14	Set of present	18	28
4	173	27.54	2381.53	14	Set of present	14	18
5	148	23.56	1742.93	12	Set of present	9	14
6	300	47.77	7165.39	16	Set of present	14	30
7	58	9.23	267.50	5	Set of future	6	9
8	92	14.64	672.99	7	Set of present	8	13
9	94	14.96	702.73	7	Set of present	7	12
10	150	23.88	1790.59	12	Set of present	14	22
11	140	22.29	1560.09	11	Set of present	14	20
12	210	33.439	3509.15	16	Set of present	16	28
13	105	16.71	876.76	8	Set of present	8	14
14	116	18.47	107.18	9	Set of present	10	16

Table 2. Population structure of *Kingiodendron pinnatum* within the sampled and non sampled area*:* Kulathupuzha

(List of individuals with G≥ 30 cm)

Sl. No.	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.77	71.44	3	Set of future	2	5
2		32	5.09	81.35	2	Set of future	1.5	5
3		35	5.57	97.41	3	Set of future	2	5
4		38	6.05	114.93	3	Set of future	1.5	5
5		43	6.84	146.90	5	Set of future	4	6
6		43	6.84	146.90	3	Set of future	2	6
7		45	7.16	160.97	5	Set of future	4	6
8		45	7.16	160.97	5	Set of future	4	6
9	50-100	52	8.28	215.27	4	Set of future	5	7
10		55	8.75	240.40	4	Set of future	5	8
11		58	9.23	267.50	6	Set of future	6	9
12		60	9.55	286.37	6	Set of future	5	9
13		68	10.82	326.68	6	Set of future	8	9
14		68	10.82	326.68	6	Set of future	8	9
15		80	12.90	522.52	6	Set of present	8	10
16		85	13.70	589.34	6	Set of present	8	10
17		90	14.33	644.79	6	Set of present	7	10
18		90	14.33	644.79	6	Set of present	7	10
19		92	14.64	672.99	8	Set of present	7	12
20		95	15.12	717.84	7	Set of present	6	12
21		95	15.32	736.96	7	Set of present	9	12
22		100	15.92	795.82	8	Set of present	7	12
23	100-150	105	16.71	876.76	10	Set of present	7	12
24		110	17.51	962.72	8	Set of present	7	14
25		115	18.31	1052.70	10	Set of present	8	14
26		120	19.10	1145.50	9	Set of present	8	16
27		125	19.90	1243.47	10	Set of present	12	16
28		130	20.70	1345.45	12	Set of present	9	17
29		145	23.08	1672.63	10	Set of present	13	17
30	150-200	155	24.68	1912.58	10	Set of present	7	18
31		155	24.68	1912.8	9	Set of present	11	18
32		160	25.47	2036.98	9	Set of present	8	19
33		170	27.07	2300.94	10	Set of present	9	20
34		170	27.07	2300.94	12	Set of present	13	21
35		180	28.66	2579.18	12	Set of present	12	23
36		180	29.03	2646.20	12	Set of present	12	25
37		185	29.45	2723.32	12	Set of present	10	26
38	200 ABOVE	205	32.64	3345.26	14	Set of present	13	27
39		208	33.12	3444.37	10	Set of present	16	28
40		210	33.43	3509.15	16	Set of present	12	28
41		210	33.43	3509.25	10	Set of present	16	28
42		300	47.77	7165.39	16	set of present	14	30

Table 3.Floristic diversity/ Importance Value Index of *Kingiodendron pinnatum* within the sampled plots: Kulathupuzha
(List of individuals With G≥30cm represented)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.047	0.164	0.045	0.257
2.	*Hopea parviflora*	DIPTEROCARACEAE	0.034	0.051	0.124	0.210
3.	*Psydrax dicoccos*	RUBIACEAE	0.041	0.079	0.033	0.153
4.	*Mesua ferrea*	CLUSIACEAE	0.034	0.035	0.066	0.136
5.	*Dipterocarpus indicus*	DIPTEROCARACEAE	0.047	0.025	0.058	0.132
6.	*Careya arborea*	LECYTHIDACEAE	0.034	0.031	0.054	0.120
7.	*Diospyros candolleana*	EBENACEAE	0.034	0.031	0.043	0.109
8.	*Terminalia elliptica*	COMBRETACEAE	0.027	0.021	0.056	0.105
9.	*Hopea ponga*	DIPTEROCARACEAE	0.027	0.025	0.041	0.094
10.	*Dysoxylum malabaricum*	MELIACEAE	0.027	0.013	0.049	0.090
11.	*Knema attenuata*	MYRISTICACEAE	0.034	0.029	0.016	0.080
12.	*Vitex altissima*	VERBENACEAE	0.020	0.021	0.035	0.078
13.	*Myristica malabarica*	MYRISTICACEAE	0.027	0.027	0.016	0.071
14.	*Strombosia ceylanica*	OLACACEAE	0.020	0.021	0.024	0.067
15.	*Macaranga peltata*	EUPHORBIACEAE	0.027	0.023	0.014	0.066
16.	*Schleichera oleosa*	SAPINDACEAE	0.027	0.023	0.007	0.058
17.	*Syzygium densiflorum*	MYRTACEAE	0.020	0.007	0.027	0.055
18.	*Aporosa cardiosperma*	EUPHORBIACEAE	0.013	0.023	0.014	0.051
19.	*Polyalthia fragrans*	ANNONACEAE	0.020	0.013	0.012	0.047
20.	*Diospyros buxifolia*	EBENACEAE	0.020	0.011	0.012	0.045
21.	*Stereospermum colais*	BIGNONIACEAE	0.013	0.007	0.023	0.045
22.	*Syzygium laetum*	MYRTACEAE	0.020	0.015	0.009	0.045
23.	*Terminalia bellirica*	COMBRETACEAE	0.013	0.015	0.016	0.045
24.	*Mitragyna parvifolia*	RUBIACEAE	0.013	0.013	0.015	0.042
25.	*Sterculia guttata*	STERCULIACEAE	0.020	0.011	0.010	0.042
26.	*Artocarpus hirsutus*	MORACEAE	0.013	0.017	0.010	0.041
27.	*Holigarna arnottiana*	ANACARDIACEAE	0.013	0.019	0.007	0.040
28.	*Cinnamomum malabatrum*	LAURACEAE	0.013	0.011	0.011	0.037
29.	*Lannea coromandelica*	ANACARDIACEAE	0.013	0.007	0.014	0.035
30.	*Aglaia barberi*	MELIACEAE	0.013	0.011	0.008	0.034
31.	*Elaeocarpus serratus*	ELEOCARPACEAE	0.013	0.007	0.013	0.034
32.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.013	0.007	0.012	0.033
33.	*Myristica beddomei*	MYRISTICACEAE	0.020	0.009	0.002	0.033
34.	*Naringi crenulata*	RUTACEAE	0.013	0.017	0.002	0.033
35.	*Spondias pinnata*,	ANACARDIACEAE	0.006	0.009	0.015	0.032

36.	*Annona sp*	ANNONACEAE	0.013	0.011	0.005	0.030
37.	*Mangifera indica*	ANACARDIACEAE	0.013	0.007	0.008	0.029
38.	*Poeciloneuron indicum*	CLUSIACEAE	0.013	0.011	0.000	0.026
39.	*Antiaris toxicaria*	MORACEAE	0.013	0.009	0.002	0.025
40.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.013	0.007	0.003	0.025
41.	*Dimocarpus longan*	SAPINDACEAE	0.013	0.007	0.004	0.025
42.	*Lophopetalum wightianum*	CELASTRACEAE	0.013	0.003	0.005	0.023
43.	*Sapindus emarginatus*	SAPINDACEAE	0.013	0.007	0.002	0.023
44.	*Bombax ceiba*	BOMBACACEAE	0.013	0.005	0.001	0.020
45.	*Kingiodendron pinnatum*	FABACEAE	0.006	0.003	0.006	0.017
46.	*Walsura trifolia*	MELIACEAE	0.006	0.003	0.004	0.015
47.	*Garcinia morella*	CLUSIACEAE	0.006	0.003	0.003	0.014
48.	*Canarium strictum*	BURSERACEAE	0.006	0.003	0.001	0.012
49.	*Tabernaemontana alternifolia*	APOCYNACEAE	0.006	0.003	0.001	0.011
50.	*Hydnocarpus macrocarpa*	FLACOURTIACEAE	0.006	0.001	0.001	0.010

Table 4. Population structure of *Kingiodendron pinnatum* within the sampled area: Poringalkuth

(List of individuals with G≥ 30 cm represented**)**

Sl. No.	**gbh (cm)**	**r (cm)**	**Basal Area (cm^2)**	**Basal Cover (m)**	**Age phase**	**First branching Seen at (m)**	**Height of Stand (m)**
1	123	19.58	1203.80	10	Set of present	10	14
2	130	20.70	1345.45	10.5	Set of present	10	16
3	40	6.36	127.01	5	Set of future	6	7
4	139	22.13	1537.77	10	Set of present	10	15
5	158	25.15	1986.12	10	Set of present	12	17

Table 5. Population structure of *Kingiodendron pinnatum* within the sampled and non sampled area*:* Poringalkuth

(List of individuals with G≥ 30 cm)

Sl No	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.7	71.44	2	Set of future	2	5
2		35	5.51	97.41	2	Set of future	4	5
3		36	5.73	103.09	2	Set of future	3	5
4		38	6.05	114.93	2	Set of future	3	6
5		40	6.36	127.01	3	Set of future	4	5
6		42	6.68	140.11	3	Set of future	2	6
7		45	7.16	160.97	3	Set of future	3	5
8		48	7.64	183.28	3	Set of future	2	5
9		50	7.96	198.95	4	Set of future	4	6
10	50-100	52	8.28	215.27	3	Set of future	2	6
11		55	8.75	240.40	4	Set of future	3	6
12		56	8.91	249.27	3	Set of future	4	6
13		80	12.73	508.846	5	Set of present	6	8
14		85	13.53	574.81	6	Set of present	5	9
15		90	14.33	644.79	7	Set of present	6	10
16		95	15.12	717.84	7	Set of present	6	11
17		97	15.44	748.55	8	Set of present	7	10
18		100	15.92	795.82	8	Set of present	7	10
19	100-150	102	16.24	828.13	7	Set of present	6	10
20		105	16.71	876.76	7	Set of present	8	10
21		110	17.51	962.72	7	Set of present	7	10
22		120	19.10	1145.50	10	Set of present	8	14
23		125	19.90	1243.47	9	Set of present	8	14
24		125	19.90	1243.47	9	Set of present	7	13
25		128	20.38	1304.18	10	Set of present	7	12
26		130	20.70	1345.45	10	Set of present	9	14
27		135	21.49	1450.11	10	Set of present	9	
28		138	21.97	1515.61	9	Set of present	8	13
29		140	22.29	1560.09	10	Set of present	11	16
30		320	50.95	8151.13	14	Set of present	13	34

Table-6. Floristic diversity/ Importance Value Index of *Kingiodendron pinnatum* within the sampled plots: Poringalkuth

(List of individuals With G≥30cm represented)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARACEAE	0.035	0.063	0.086	0.185
2.	*Dipterocarpus indicus*	DIPTEROCARACEAE	0.035	0.046	0.081	0.163
3.	*Polyalthia fragrans*	ANNONACEAE	0.035	0.033	0.027	0.095
4.	*Grewia tiliifolia*	TILIACEAE	0.026	0.038	0.029	0.094
5.	*Schleichera oleosa*	SAPINDACEAE	0.035	0.033	0.024	0.093
6.	*Holigarna arnottiana*	ANACARDIACEAE	0.026	0.033	0.021	0.081
7.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.026	0.033	0.020	0.080
8.	*Gmelina arborea*	VERBENACEAE	0.026	0.024	0.025	0.077
9.	*Terminalia paniculata*	COMBRETACEAE	0.017	0.027	0.028	0.074
10.	*Lagerstroemia microcarpa*	LYTHRACEAE	0.017	0.022	0.033	0.073
11.	*Dillenia pentagyna*	DILLENIACEAE	0.026	0.024	0.021	0.072
12.	*Terminalia catappa*	COMBRETACEAE	0.026	0.022	0.024	0.072
13.	*Bombax ceiba*	BOMBACACEAE	0.026	0.019	0.025	0.071
14.	*Holoptelea integrifolia*	ULMACEAE	0.017	0.019	0.034	0.071
15.	*Spondias pinnata*	ANACARDIACEAE	0.026	0.022	0.020	0.069
16.	*Diospyros candolleana*	EBENACEAE	0.017	0.022	0.026	0.066
17.	*Dysoxylum malabaricum*	MELIACEAE	0.017	0.019	0.026	0.063
18.	*Wrightia tinctoria*	APOCYNACEAE	0.026	0.027	0.009	0.063
19.	*Haldina cordifolia*	RUBIACEAE	0.026	0.019	0.016	0.062
20.	*Tetrameles nudiflora*	DATISCACEAE	0.017	0.013	0.031	0.062
21.	*Mesua ferrea*	CLUSIACEAE	0.017	0.019	0.023	0.060
22.	*Terminalia elliptica*	COMBRETACEAE	0.017	0.024	0.017	0.060
23.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.017	0.019	0.022	0.059
24.	*Macaranga peltata*	EUPHORBIACEAE	0.017	0.019	0.019	0.056
25.	*Myristica malabarica*	MYRISTICACEAE	0.017	0.022	0.015	0.055
26.	*Knema attenuata*	MYRISTICACEAE	0.017	0.024	0.011	0.054
27.	*Cinnamomum verum*	LAURACEAE	0.017	0.019	0.016	0.053
28.	*Syzygium cumini*	MYRTACEAE	0.017	0.013	0.021	0.053
29.	*Alstonia scholaris*	APOCYNACEAE	0.017	0.011	0.019	0.048
30.	*Toona ciliata*	MELIACEAE	0.017	0.013	0.015	0.047
31.	*Melicope lunu-ankenda*	RUTACEAE	0.017	0.013	0.013	0.044
32.	*Stereospermum colais*	BIGNONIACEAE	0.017	0.011	0.015	0.044
33.	*Diospyros buxifolia*	EBENACEAE	0.017	0.013	0.010	0.042
34.	*Lagerstroemia speciosa*	LYTHRACEAE	0.017	0.013	0.009	0.041
35.	*Elaeocarpus serratus*	ELEOCARPACEAE	0.008	0.008	0.023	0.040
36.	*Pterygota alata*	STERCULIACEAE	0.017	0.011	0.009	0.038
37.	*Sapindus emarginatus*	SAPINDACEAE	0.017	0.013	0.003	0.034
38.	*Pongamia pinnata*	FABACEAE	0.008	0.022	0.002	0.033

39.	*Hopea parviflora*	DIPTEROCARACEAE	0.008	0.008	0.015	0.032
40.	*Mangifera indica*	ANACARDIACEAE	0.008	0.011	0.008	0.028
41.	*Chukrasia tabularis*	MELIACEAE	0.008	0.011	0.005	0.025
42.	*Artocarpus heterophyllus*	MORACEAE	0.008	0.005	0.009	0.024
43.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.008	0.008	0.006	0.024
44.	*Kingiodendron pinnatum*	FABACEAE	0.017	0.005	0.001	0.024
45.	*Lannea coromandelica*	ANACARDIACEAE	0.008	0.005	0.008	0.023
46.	*Careya arborea*	LECYTHIDACEAE	0.008	0.008	0.005	0.022
47.	*Agrostistachys bornensis*	EUPHORBIACEAE	0.008	0.005	0.006	0.020
48.	*Naringi crenulata*	RUTACEAE	0.008	0.008	0.003	0.020
49.	*Sterculia guttata*	STERCULIACEAE	0.008	0.005	0.005	0.019
50.	*Ficus racemosa*	MORACEAE	0.008	0.005	0.002	0.016
51.	*Pterocarpus marsupium*	FABACEAE	0.008	0.005	0.001	0.016
52.	*Bauhinia malabarica*	FABACEAE	0.008	0.005	0.001	0.014

Table 7. Population structure of *Kingiodendron pinnatum* within the sampled area: Kottiyoor

(List of individuals with G≥ 30 cm represented**)**

Sl. No.	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	82	12.73	509.48	7	Set of present	7	9
2	190	30.25	2874.05	12	Set of present	12	16
3	25	3.980	49.73	2	Set of future	1.5	3
4	34	5.41	92.03	3	Set of future	2	4
5	120	19.10	1146.46	10	Set of present	8	10
6	135	21.49	1450.92	10	Set of present	9	14
7	160	25.47	2038.10	14	Set of present	9	14

Table-8. Population structure of *Kingiodendron pinnatum* within the sampled and non sampled area: Kottiyoor

(List of individuals with G≥ 30 cm**)**

Sl No `	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.77	66.50	2	Set of future	1.5	4
2		35	5.573	97.52	3	Set of future	2	4
3		38	6.05	114.93	2	Set of future	9.5	4
4		40	6.36	127.01	3	Set of future	2	5
5		42	6.68	140.11	3	Set of future	1.5	5
6		45	7.16	160.97	4	Set of future	3	5
7		50	7.96	198.95	5	Set of future	4	6
8	50-100	52	8.28	215.27	5	Set of future	4	6
9		55	8.75	240.40	6	Set of future	5	8
10		60	9.55	286.37	5	Set of future	3	7
11		60	9.554	286.61	5	Set of future	3	7
12		65	10.35	336.36	5	Set of future	4	7
13		70	11.14	389.67	6	Set of future	7	7
14		80	12.73	508.84	7	Set of present	6	9
15		86	13.69	588.48	6	Set of present	7	9
16		90	14.33	644.79	7	Set of present	6	9
17		94	14.96	702.73	8	Set of present	10	12
18		95	15.12	717.84	6	Set of present	6	10
19	100-150	110	17.515	962.72	12	Set of present	9	12
20		115	18.31	1052.70	9	Set of present	8	10
21		125	19.90	1243.47	10	Set of present	7	10
22		130	20.70	1314.45	10	Set of present	8	12
23		130	20.70	1345.45	9	Set of present	6	14
24		132	21.01	1396.63	10	Set of present	9	16
25		140	22.29	1560.09	10	Set of present	7	14
26		142	22.61	1605.20	10	Set of present	9	14
27		150	23.88	1790.59	12	Set of present	9	14
28	150 ABOVE	155	24.68	1912.58	10	Set of present	8	14
29		160	25.47	2369.44	12	Set of present	9	12
30		165	26.27	2166.95	12	Set of present	8	14
31		170	27.07	2300.94	13	Set of present	12	18
32		175	27.86	2437.20	12	Set of present	10	18
33		175	27.66	2437.20	14	Set of present	12	14
34		176	28.02	2465.27	12	Set of present	9	14
35		180	28.66	2579.18	12	Set of present	9	16
36		185	29.45	2723.32	12	Set of present	9	16
37		195	31.05	3027.28	12	Set of present	10	17
38		198	31.52	3119.62	12	Set of present	9	18
39		205	32.64	3344.26	14	Set of present	12	26

Table -9. Floristic diversity/ Importance Value Index of *Kingiodendron pinnatum* within the sampled plots: Kottiyoor

(List of individuals with G≥30cm represented)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Knema attenuata*	MYRISTICACEAE	0.058	0.062	0.045	0.165
2.	*Vateria indica*	DIPTEROCARPACEAE	0.035	0.039	0.080	0.155
3.	*Drypetes venusta*	EUPHORBIACEAE	0.035	0.039	0.033	0.107
4.	*Tetrameles nudiflora*	DATISACEAE	0.023	0.022	0.060	0.107
5.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.035	0.049	0.020	0.104
6.	*Diospyros candolleana*	EBENACEAE	0.035	0.039	0.029	0.103
7.	*Syzygium densiflorum*	MYRTACEAE	0.035	0.035	0.027	0.098
8.	*Terminalia bellirica*	COMBRETACEAE	0.023	0.026	0.048	0.097
9.	*Pterygota alata*	STERCULIACEAE	0.023	0.026	0.047	0.097
10.	*Diospyros buxifolia*	EBENACEAE	0.023	0.019	0.046	0.090
11.	*Vitex altissima*	VERBENACEAE	0.023	0.026	0.037	0.087
12.	*Dimocarpus longan*	SAPINDACEAE	0.035	0.029	0.020	0.085
13.	*Dysoxylum malabaricum*	MELIACEAE	0.023	0.019	0.038	0.081
14.	*Schleichera oleosa*	APINDACEAE	0.023	0.026	0.026	0.075
15.	*Mesua ferrea*	CLUSIACEAE	0.023	0.019	0.032	0.075
16.	*Nothopegia beddomei*	ANACARDIACEAE	0.023	0.026	0.025	0.074
17.	*Alstonia scholaris*	APOCYNACEAE	0.023	0.019	0.031	0.074
18.	*Persea macrantha*	LAURACEAE	0.023	0.022	0.024	0.071
19.	*Garcinia morella*	CLUSIACEAE	0.023	0.022	0.021	0.068
20.	*Artocarpus heterophyllus*	MORACEAE	0.023	0.016	0.027	0.067
21.	*Holigarna arnottiana*	ANACARDIACEAE	0.023	0.026	0.017	0.066
22.	*Myristica malabarica*	MYRISTICACEAE	0.023	0.022	0.014	0.060
23.	*Hopea ponga*	DIPTEROCARPACEAE	0.023	0.022	0.011	0.058
24.	*Polyalthia fragrans*	ANNONACEAE	0.023	0.019	0.012	0.055
25.	*Holarrhena pubescens*	APOCYNACEAE	0.023	0.022	0.007	0.053
26.	*Artocarpus hirsutus*	MORACEAE	0.011	0.019	0.016	0.048
27.	*Bombax ceiba*	BOMBACACEAE	0.011	0.009	0.019	0.041
28.	*Solenocarpus indicus*	ANACARDIACEAE	0.011	0.016	0.012	0.040
29.	*Ficus sp*	MORACEAE	0.011	0.009	0.016	0.038
30.	*Bischofia javanica*	EUPHORBIACEAE	0.011	0.013	0.012	0.037
31.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.011	0.013	0.010	0.035
32.	*Aporosa cardiosperma*	EUPHORBIACEAE	0.011	0.013	0.010	0.034
33.	*Otonephelium stipulaceum*	SAPINDACEAE	0.011	0.013	0.009	0.034
34.	*Kingiodendron pinnatum*	LEGUMINOSAE	0.011	0.006	0.004	0.033
35.	*Olea dioica*	OLEACEAE	0.011	0.013	0.007	0.032
36.	*Sterculia guttata*	STERCULIACEAE	0.011	0.013	0.006	0.031
37.	*Sterculia villosa*	STERCULIACEAE	0.011	0.013	0.006	0.031
38.	*Reinwardtiodendron anamalaiense*	MELIACEAE	0.011	0.013	0.006	0.031
39.	*Dillenia pentagyna*	DILLENIACEAE	0.011	0.009	0.009	0.030

40.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.011	0.013	0.005	0.030
41.	*Sapindus trifoliatus*	SAPINDACEAE	0.011	0.013	0.005	0.030
42.	*Euonymus indicus*	CELASTRACEAE	0.011	0.013	0.004	0.029
43.	*Dipterocarpus indicus*	DIPTEROCARPACEAE	0.011	0.009	0.006	0.028
44.	*Toona ciliata*	MELIACEAE	0.011	0.009	0.006	0.027
45.	*Holigarna sp*	ANACARDIACEAE	0.011	0.009	0.005	0.027
46.	*Grewia nervosa*	TILIACEAE	0.011	0.009	0.005	0.026
47.	*Canarium strictum*	BURSERACEAE	0.011	0.006	0.008	0.026
48.	*Actinodaphne malabarica*	LAURACEAE	0.011	0.009	0.004	0.026
49.	*Cinnamomum malabatrum*	LAURACEAE	0.011	0.009	0.003	0.025
50.	*Diospyros paniculata*	EBENACEAE	0.011	0.009	0.003	0.025
51.	*Stereospermum colais*	BIGNONIACEAE	0.011	0.006	0.003	0.021

4. Thamarassery

The population structure of *K. pinnatum* at Thamarassery forest covering an area of 7 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 27 adult trees were enumerated of which 9 individuals are set of future and 18 belongs to set of present (Table-10).

Table 10. Population structure of *Kingiodendron pinnatum* : Thamarassery

(List of individuals with G≥ 30 cm present**)**

Sl. No	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.77	71.65	3	Set of future	2	4
2		32	5.09	81.51	2	Set of future	2	4
3		35	5.57	97.41	2	Set of future	2	4
4		38	6.05	114.93	2	Set of future	1.5	4
5		45	7.16	161.19	3	Set of future	1.5	5
6		45	7.16	161.19	3	Set of future	1.5	4
7		50	7.96	198.95	5	Set of future	3.5	6
8	50-100	55	8.75	240.79	5	Set of future	4	6
9		60	9.55	286.61	6	Set of future	5	7
10		80	12.73	508.84	6	Set of present	4	13
11		85	13.53	574.81	6	Set of present	8	12
12		90	14.33	644.79	6	Set of present	4	11
13		95	15.12	717.84	9	Set of present	11	11
14	100-150	105	16.71	876.76	8	Set of present	7	12
15		110	17.51	962.72	8	Set of present	8	11
16		110	17.51	962.72	8	Set of present	8	13
17		115	18.31	1052.70	7	Set of present	9	12
18		120	19.10	1145.50	8	Set of present	8	12
19		125	19.90	1243.47	8	Set of present	9	13
20		128	20.38	1304.18	8	Set of present	9	12
21		130	20.70	1345.45	8	Set of present	8	12
22		135	21.49	1450.11	10	Set of present	11	14
23		140	22.29	1560.09	8	Set of present	9	12
24		150	23.88	1790.59	10	Set of present	10	14
25	150-200	155	24.68	1912.58	10	Set of present	10	15
26		160	25.47	2036.98	10	Set of present	7	18
27		170	54.14	9203.77	8	Set of present	9	18

5. Nadugani

The population structure of *K.pinnatum* at Nadugani forest covering an area of 15 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 22 adult trees were enumerated of which 7 individuals are set of future and 15 belongs to set of present (Table-11).

Table 11. Population structure of *Kingiodendron pinnatum* : Nadugani
(List of individuals with G≥ 30 cm represented**)**

Sl. No	Gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.45	62.57	3	Set of future	1.5	5
2		35	5.57	97.41	3	Set of future	3	6
3		36	5.73	103.09	3	Set of future	2	6
4		40	6.36	127.01	4	Set of future	3	6
5		45	7.16	160.97	4	Set of future	2	6
6		50	7.96	198.95	5	Set of future	4	6
7	50-100	60	9.55	286.375	6	Set of future	5	7
8		98	15.60	764.15	8	Set of present	10	12
9		100	45.92	795.82	8	Set of present	7	12
10	100-150	105	16.71	876.76	8	Set of present	9	12
11		110	17.51	962.72	10	Set of present	12	16
12		120	19.10	1145.50	10	Set of present	11	12
13		120	19.10	1145.50	10	Set of present	12	16
14		125	19.90	1243.47	10	Set of present	10	12
15		130	20.70	1345.45	10	Set of present	9	12
16		140	22.29	1560.09	12	Set of present	9	14
17		145	23.08	1672.63	12	Set of present	10	14
18	150-200	170	27.07	2300.94	14	Set of present	10	18
19		180	28.66	2579.18	14	Set of present	12	18
20		185	29.45	2723.32	14	Set of present	10	18
21		190	30.25	2873.29	14	Set of present	13	16
22		200	31.84	3183.28	16	Set of present	14	26

6. Kallar

The population structure of *K*.pinnatum at Kallar forest covering an area of 9 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 17 adult trees were enumerated of which 7 individuals are set of future and 10 belongs to set of present (Table-12).

Table 12. Population structure of *Kingiodendron pinnatum:* Kallar
(List of individuals with G≥ 30 cm**)**

Sl. No	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.77	71.44	4	Set of future	3	6
2		30	4.7	71.44	3	Set of future	2	5
3		36	5.732	103.16	4	Set of future	4	6
4		45	7.16	160.97	5	Set of future	4	7
5		50	7.96	199.00	5	Set of future	4	7
6	50-100	55	8.75	240.40	6	Set of future	4	8
7		62	9.872	301.56	6	Set of future	5	8
8		98	15.60	764.15	7	Set of present	6	10
9	100-150	105	16.71	876.76	10	Set of present	9	14
10		110	17.51	962.72	8	Set of present	7	10
11		135	21.49	1450.11	10	Set of present	9	12
12		140	22.29	1560.09	10	Set of present	9	14
13	150-200	160	25.47	2036.98	12	Set of present	12	16
14		170	27.07	2300.94	16	Set of present	12	18
15		180	28.66	2579.18	14	Set of present	10	18
16	200-300	210	33.43	3511.04	14	Set of present	11	24
17		280	44.58	6240.36	16	Set of present	12	27

7. Orukomben

The population structure of *K.pinnatum* at Orukomban forest covering an area of 4 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 10 adult trees were

enumerated of which 2 individuals are set of future and 8 belongs to set of present (Table-13).

Table. 13. Population structure of *Kingiodendron pinnatum* : Orukomben

(List of individuals with G≥ 30 cm represented**)**

Sl. No	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	36	5.73	103.09	3	Set of future	3	5
2		45	7.165	160.97	3	Set of future	3	5
3	100-150	135	21.49	14500.11	10	Set of present	11	14
4		145	23.08	1672.63	10	Set of present	11	14
5		150	23.88	1790.59	12	Set of present	10	14
6	150-200	160	25.47	2036.98	12	Set of present	12	14
7		170	27.07	2300.94	14	Set of present	12	18
8		175	27.86	2437.20	14	Set of present	13	18
9		180	28.66	2579.18	14	Set of present	12	18
10		190	30.25	2873.29	16	Set of present	14	20

8. Vazhachal

The population structure of *K.pinnatum* at Vazhachal forest covering an area of 5 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 18 adult trees were enumerated of which 7 individuals are set of future and 11 belongs to set of present (Table-14).

Table. 14. Population structure of *Kingiodendron pinnatum*: Vazhachal
(List of individuals with G≥ 30 cm represented**)**

Sl. No	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.7	71.44	2	Set of future	2	5
2		35	5.57	97.41	3	Set of future	2	5
3		38	6.05	114.93	2	Set of future	3	6
4		40	6.36	127.01	3	Set of future	2	5
5		40	6.36	240.40	6	Set of future	5	7
6	50-100	55	8.75	240.40	4	Set of future	3	7
7		60	9.55	286.37	5	Set of future	4	8
8		95	15.12	717.84	6	Set of present	6	10
9	100-150	105	16.71	876.76	7	Set of present	8	10
10		108	17.19	924.85	7	Set of present	9	11
11		116	18.47	1071.18	6	Set of present	8	12
12		120	19.10	1145.50	8	Set of present	9	12
13		135	21.49	1450.11	7	Set of present	9	14
14		140	22.29	1560.09	10	Set of present	10	16
15		145	23.08	1672.63	8	Set of present	9	11
16	150 Above	155	24.68	1972.63	8	Set of present	8	12
17		160	25.47	2036.98	8	Set of present	7	12
18		180	28.66	2579.18	8	Set of present	10	16

9. Karimbani

The population structure of *K.pinnatum* at Karimbani forest covering an area of 8 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 15 adult trees were enumerated of which 3 individuals are set of future and 12 belongs to set of present (Table-15).

Table. 15. Population structure of *Kingiodendron pinnatum* : Karimbani

(List of individuals with G≥ 30 cm**)**

Sl. No	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	40	6.36	240.40	6	Set of future	5	8
2		55	8.75	240.40	6	Set of future	5	8
3	50-100	70	11.14	389.67	6	Set of future	8	9
4		90	14.33	644.79	7	Set of present	6	10
5		95	15.12	717.84	6	Set of present	5	10
6		100	15.92	795.82	7	Set of present	6	12
7	100-150	105	16.71	876.76	8	Set of present	6	12
8		110	17.51	962.72	8	Set of present	9	12
9		125	19.90	1243.47	7	Set of present	9	13
10		130	20.70	1345.45	9	Set of present	10	13
11		135	21.49	1450.11	7	Set of present	10	14
12		150	23.88	1790.59	8	Set of present	10	16
13	200 ABOVE	200	31.84	3183.28	14	Set of present	9	24
14		250	39.80	4973.88	12	Set of present	12	23
15		280	44.58	6240.36	14	Set of present	16	26

10. Aralam WLS

The population structure of *K. pinnatum* at Aralam WLS covering an area of 22 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 60 adult trees were enumerated of which 13 individuals are set of future and 47 belongs to set of present (Table-16).

Table. 16. Population structure of *Kingiodendron pinnatum*: Aralam WLS

(List of individuals with G≥ 30 cm represented**)**

Sl. No	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.7	71.44	2	Set of future	1	4
2		32	5.04	81.51	2	Set of future	1.5	4
3		35	5.51	97.41	2	Set of future	2	5
4		38	6.05	114.93	3	Set of future	2.5	4
5		40	6.36	127.01	3	Set of future	3	5
6		40	6.36	127.01	2	Set of future	2.5	5
7		50	7.96	198.95	4	Set of future	3	6
8	50-100	55	8.75	240.40	5	Set of future	4	6
9		60	9.55	286.37	5	Set of future	7	7
10		60	9.55	286.37	5	Set of future	3	7
11		65	10.35	336.36	5	Set of future	6	8
12		65	10.35	336.36	5	Set of future	4	8
13		70	11.14	389.67	6	Set of future	5	9
14		90	14.33	644.79	5	Set of present	8	12
15		90	14.33	644.79	7	Set of present	8	12
16		95	15.12	717.84	6	Set of present	7	12
17		100	15.92	795.82	8	Set of present	10	14
18	100-150	105	16.71	576.76	6	Set of present	10	12
19		105	16.73	876.76	6	Set of present	7	14
20		110	17.51	962.71	7	Set of present	13	12
21		110	17.51	962.72	9	Set of present	12	14
22		118	18.78	1107.44	6	Set of present	8	14
23		120	19.10	1145.50	6	Set of present	11	16
24		120	19.10	1145.50	8	Set of present	9	12
25		125	19.90	1243.47	6	Set of present	9	14

26		**128**	**20.38**	**1304.18**	**7**	**Set of present**	**9**	**14**
27		**130**	**20.70**	**1345.45**	**6**	**Set of present**	**10**	**22**
28		**130**	**20.70**	**1345.45**	**10**	**Set of present**	**12**	**14**
29		**135**	**21.49**	**1450.11**	**6**	**Set of present**	**11**	**16**
30		**135**	**21.49**	**1450.11**	**10**	**Set of present**	**9**	**22**
31		**138**	**21.97**	**1515.61**	**10**	**Set of present**	**9**	**22**
32		**138**	**21.97**	**1515.61**	**10**	**Set of present**	**8**	**16**
33		**140**	**22.29**	**1560.09**	**6**	**Set of present**	**13**	**23**
34		**140**	**22.29**	**1560.09**	**10**	**Set of present**	**9**	**16**
35		**140**	**22.29**	**1560.09**	**10**	**Set of present**	**9**	**18**
36		**145**	**23.08**	**1672.63**	**10**	**Set of present**	**7**	**22**
37		**150**	**28.66**	**2579.18**	**7**	**Set of present**	**12**	**24**
38		**150**	**23.88**	**1790.59**	**6**	**Set of present**	**9**	**23**
39	**150-200**	**155**	**24.68**	**1912.58**	**7**	**Set of present**	**13**	**23**
40		**155**	**24.68**	**1912.58**	**10**	**Set of present**	**9**	**22**
41		**160**	**25.7**	**2036.98**	**8**	**Set of present**	**12**	**23**
42		**160**	**25.47**	**2036.98**	**11**	**Set of present**	**12**	**23**
43		**170**	**27.07**	**2300.94**	**11**	**Set of present**	**8**	**24**
44		**175**	**27.86**	**2437.20**	**10**	**Set of present**	**7**	**14**
45		**178**	**28.34**	**2521.90**	**6**	**Set of present**	**11**	**16**
46		**180**	**28.66**	**2579.18**	**14**	**Set of present**	**14**	**23**
47		**185**	**29.45**	**2723.32**	**7**	**Set of present**	**12**	**24**
48		**185**	**29.45**	**2723.32**	**14**	**Set of present**	**10**	**22**
49		**190**	**30.25**	**2873.29**	**9**	**Set of present**	**14**	**25**
50		**190**	**30.25**	**2873.29**	**9**	**Set of present**	**10**	**25**
51		**190**	**30.25**	**2873.29**	**14**	**Set of present**	**16**	**20**
52		**200**	**31.84**	**3183.28**	**7**	**Set of present**	**10**	**25**
53	**200 ABOVE**	**205**	**32.64**	**3345.26**	**12**	**Set of present**	**10**	**26**
54		**210**	**33.43**	**3509.15**	**12**	**Set of present**	**12**	**26**
55		**210**	**33.43**	**3509.15**	**10**	**Set of present**	**12**	**24**
56		**225**	**35.82**	**4028.84**	**10**	**Set of present**	**12**	**27**
57		**230**	**36.62**	**4210.81**	**11**	**Set of present**	**12**	**27**
58		**235**	**37.42**	**4396.80**	**11**	**Set of present**	**12**	**24**
59		**250**	**39.80**	**4973.88**	**12**	**Set of present**	**12**	**28**
60		**250**	**39.80**	**4973.88**	**16**	**Set of present**	**14**	**26**

11. Shendurney WLS

The population structure of *K. pinnatum* at Shendurney WLS covering an area of 40 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 94 adult trees were enumerated of which 28 individuals are set of future and 66 belongs to set of present (Table-17).

Table. 17. Population structure of *Kingiodendron pinnatum* : Shenduruney WLS
(List of individuals with G≥ 30 cm represented**)**

Sl. No	gbh Class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	30	4.7	31.83	3	Set of future	2	4
2		30	4.7	31.79	2	Set of future	2	4
3		30	4.7	31.75	1.5	Set of future	1.5	3
4		30	4.7	91.90	3	Set of future	2	5
5		31	4.9	75.39	2	Set of future	2	4
6		31	4.9	75.39	2	Set of future	2	4
7		32	5.04	81.51	2	Set of future	1.5	4
8		32	5.09	81.51	4	Set of future	2.5	6
9		35	5.57	97.52	3	Set of future	2	7
10		35	5.57	97.52	2	Set of future	3	5
11		38	6.05	114.93	5	Set of future	2	7
12		38	6.05	114.93	5	Set of future	3	7
13		38	6.05	114.93	5	Set of future	3	7
14		38	6.05	114.93	2	Set of future	2	4
15		40	6.36	127.37	3	Set of future	4	7
16		40	3.36	127.01	3	Set of future	3	7
17		42	6.68	140.11	3	Set of future	4	7
18		45	7.16	160.97	5	Set of future	4	6
19		48	7.64	183.42	6	Set of future	3	7
20		48	7.64	183.42	5	Set of future	5	6
21		50	15.92	795.82	5	Set of future	3	7
22		50	7.96	198.95	4	Set of future	3	5
23		50	7.96	198.9	4	Set of future	3	6
24	50-100	55	8.75	240.79	5	Set of future	2	8
25		55	8.75	240.79	5	Set of future	2	8
26		58	9.23	267.50	5	Set of future	3	7
27		58	9.23	267.50	5	Set of future	3	6
28		60	9.55	572.75	5	Set of future	4	7

29		90	14.3	636.58	8	Set of present	9	12
30		94	14.96	702.73	7	Set of present	9	12
31		95	15.12	717.84	8	Set of present	10	12
32		105	16.71	876.76	8	Set of present	9	12
33		105	16.71	876.76	8	Set of present	10	12
34		110	17.51	962.72	12	Set of present	10	14
35		110	17.51	963.27	8	Set of present	10	12
36		115	18.31	1052.70	9	Set of present	10	12
37		115	18.31	1052.70	8	Set of present	10	12
38		116	18.47	107.18	8	Set of present	9	12
39		120	19.10	1145.50	12	Set of present	10	13
40		120	19.10	1145.50	8	Set of present	10	12
41		130	20.70	1345.45	12	Set of present	12	14
42		130	20.70	1345.45	8	Set of present	12	15
43		130	20.70	1345.45	10	Set of present	7	12
44		130	20.70	1345.45	8	Set of present	9	12
45		140	22.29	1560.09	10	Set of present	6	12
46		140	22.29	1560.09	9	Set of present	8	12
47		140	22.29	1560.09	9	Set of present	10	12
48		145	23.08	1672.63	12	Set of present	11	16
49		145	23.08	1673.94	9	Set of present	7	12
50		145	23.08	1672.63	9	Set of present	7	12
51		148	23.50	1742.93	9	Set of present	8	12
52	100-150	150	23.88	1791.34	10	Set of present	10	18
53		150	23.88	1790.59	10	Set of present	12	18
54		150	23.88	1790.59	9	Set of present	8	12
55		155	24.68	1912.73	10	Set of present	9	18
56		160	25.47	2036.98	13	Set of present	12	16
57		160	25.47	2036.98	10	Set of present	10	18
58		160	25.47	2036.98	11	Set of present	12	18
59		170	27.07	2100.94	10	Set of present	9	12
60		170	27.07	2300.94	12	Set of present	10	20
61	150-200	170	27.07	2300.94	12	Set of present	12	20
62		173	27.54	2381.53	12	Set of present	11	20
63		175	27.86	2437.20	12	Set of present	10	20
64		175	27.86	2437.20	13	Set of present	11	20
65		180	28.66	2579.18	12	Set of present	10	22
66		180	28.66	2579.18	12	Set of present	10	20
67		180	28.66	2579.18	12	Set of present	13	20
68		185	29.45	2723.32	10	Set of present	14	20
69		190	30.25	2874.05	10	Set of present	11	20
70		190	30.25	2874.05	10	Set of present	11	20
71		200	31.84	3183.28	14	Set of present	13	24
72		200	31.84	3183.28	14	Set of present	10	20
73		205	32.64	3345.26	14	Set of present	10	24
74		210	33.43	3509.15	14	Set of present	14	28
75		210	33.43	3511.04	12	Set of present	11	24
76		210	33.43	3509.15	14	Set of present	9	24
77	ABOVE 200	210	33.43	3509.15	14	Set of present	10	24
78		220	33.43	3509.15	14	Set of present	12	28
79		220	35.03	3853.31	14	Set of present	13	25
80		225	35.82	4028.84	14	Set of present	12	25
81		230	36.62	4210.81	12	Set of present	10	26

82		**230**	**36.62**	**4211.73**	**12**	**Set of present**	**12**	**25**
83		**230**	**36.62**	**4171.42**	**12**	**Set of present**	**12**	**26**
84		**230**	**36.62**	**4210.81**	**12**	**Set of present**	**10**	**26**
85		**235**	**37.42**	**4396.80**	**14**	**Set of present**	**11**	**26**
86		**235**	**40.60**	**5175.85**	**14**	**Set of present**	**12**	**26**
87		**250**	**39.80**	**4795.55**	**16**	**Set of present**	**13**	**22**
88		**260**	**41.40**	**5381.83**	**16**	**Set of present**	**16**	**28**
89		**270**	**42.99**	**5053.96**	**14**	**Set of present**	**16**	**26**
90		**280**	**44.58**	**6240.36**	**14**	**Set of present**	**12**	**28**
91		**300**	**47.77**	**7165.39**	**16**	**Set of present**	**13**	**29**
92		**300**	**47.77**	**7165.39**	**16**	**Set of present**	**14**	**30**
93		**310**	**49.36**	**7651.25**	**16**	**Set of present**	**15**	**29**
94		**320**	**50.95**	**8151.13**	**16**	**Set of present**	**14**	**30**

12. Peruvannamuzhi

The population structure of *K. pinnatum* at Peruvannamuzhi forest covering an area of 18 km^2 was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual. A total of 58 adult trees were enumerated of which 9 individuals are set of future and 49 belongs to set of present (Table-18).

Table. 18. Population structure of *Kingiodendron pinnatum*: Peruvannamuzhi
(List of individuals with G≥ 30 cm**)**

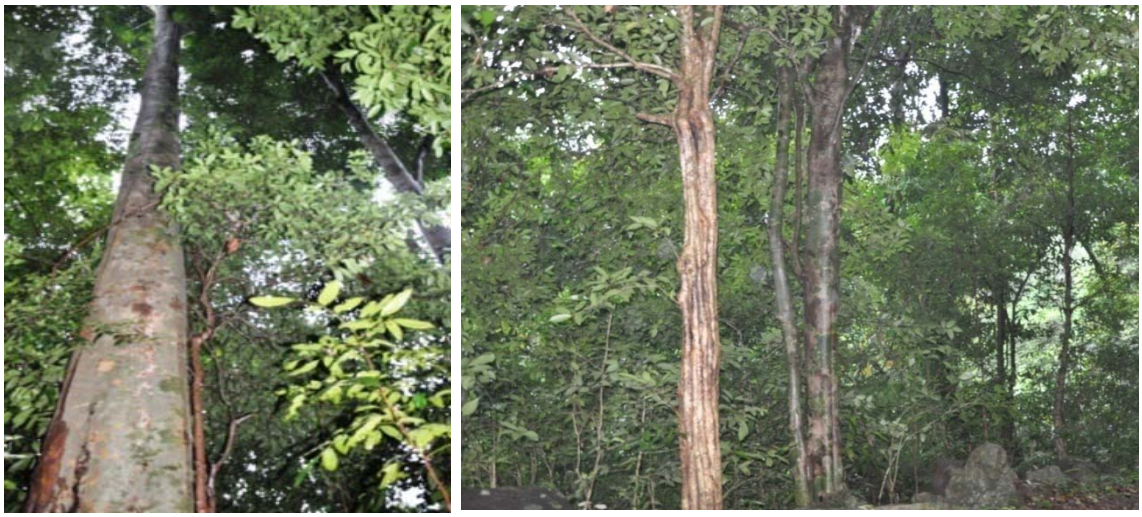
Sl. No `	**gbh Class**	**gbh (cm)**	**r (cm)**	**Basal Area (cm^2)**	**Basal Cover (m)**	**Age phase**	**First branching Seen at (m)**	**Height of Stand (m)**
1	**30-50**	**30**	**4.77**	**71.44**	**3**	**Set of future**	**2.5**	**5**
2		**35**	**5.57**	**97.41**	**4**	**Set of future**	**3**	**6**
3		**38**	**6.05**	**114.93**	**4**	**Set of future**	**2.5**	**6**
4		**40**	**6.36**	**129.01**	**3**	**Set of future**	**3**	**5**
5		**40**	**6.36**	**127.01**	**4**	**Set of future**	**3**	**7**
6		**50**	**7.96**	**198.95**	**6**	**Set of future**	**5**	**7**
7	**50-100**	**75**	**11.94**	**447.79**	**6**	**Set of future**	**7**	**9**
8		**75**	**11.94**	**447.79**	**6**	**Set of future**	**7**	**9**
9		**76**	**12.10**	**146.45**	**5**	**Set of future**	**6**	**9**
10		**80**	**12.73**	**509.48**	**6**	**Set of present**	**10**	**12**
11		**80**	**12.73**	**509.48**	**8**	**Set of present**	**8**	**10**
12		**82**	**13.05**	**170.49**	**6**	**Set of present**	**8**	**10**

13	100-150	110	17.51	306.80	10	Set of present	7	12
14		110	17.51	963.27	7	Set of present	8	10
15		115	18.31	335.33	8	Set of present	10	12
16		115	18.31	1052.93	6	Set of present	7	10
17		115	18.31	1052.70	12	Set of present	10	12
18		118	18.78	1108.50	10	Set of present	10	20
19		120	19.10	365.12	8	Set of present	10	12
20		120	19.10	1146.46	8	Set of present	7	10
21		120	19.10	1145.50	8	Set of present	13	15
22		125	19.90	1243.97	6	Set of present	6	8
23		130	20.70	428.51	8	Set of present	12	14
24		130	20.70	1345.45	9	Set of present	12	16
25		140	22.29	1560.09	9	Set of present	7	12
26		145	23.08	1673.94	10	Set of present	10	12
27		145	23.08	1672.63	9	Set of present	7	16
28		148	23.56	1743.81	8	Set of present	7	9
29	150-200	155	24.68	1912.58	10	Set of present	9	18
30		160	25.47	2036.98	12	Set of present	10	18
31		170	27.07	2300.94	7	Set of present	10	16
32		180	28.66	821.53	12	Set of present	13	16
33		180	28.66	2579.54	7	Set of present	12	16
34		180	28.66	2579.18	12	Set of present	11	18
35		180	28.66	2579.18	14	Set of present	12	22
36		190	30.25	2874.05	13	Set of present	13	26
37		190	30.25	2874.05	13	Set of present	13	26
38		200	31.84	1014.24	14	Set of present	12	18
39		200	31.84	3184.68	14	Set of present	8	11
40		200	31.84	3183.28	14	Set of present	12	20
41	ABOVE 200	210	33.43	3509.15	14	Set of present	10	20
42		215	34.23	1172.08	14	Set of present	16	20
43		215	34.23	3679.11	16	Set of present	12	21
44		225	35.82	4028.84	14	Set of present	13	22
45		230	36.62	1341.33	14	Set of present	15	20
46		230	36.62	4210.81	12	Set of present	10	25
47		235	37.42	1400.28	14	Set of present	12	22
48		245	39.01	1521.99	14	Set of present	12	23
49		250	39.80	4975.88	14	Set of present	14	26
50		250	39.80	4975.88	14	Set of present	14	26
51		253	40.28	1623.01	16	Set of present	14	23
52		255	40.60	1648.77	16	Set of present	16	23
53		260	41.40	5381.83	14	Set of present	13	26
54		265	42.19	1780.62	16	Set of present	12	24
55		270	42.99	1848.45	16	Set of present	14	26
56		275	43.78	1917.54	16	Set of present	14	27
57		300	47.77	7165.39	16	Set of present	15	30
58		302	48.08	2312.56	18	Set of present	15	30

Plate 1. *Kingiodendron pinnatum* : Population structure

Habit and Habitat views from the Kulathupuzha forest

Habit and Habitat views from the Poringalkuth forest



Habit and habitat views from the Kottiyoor forest

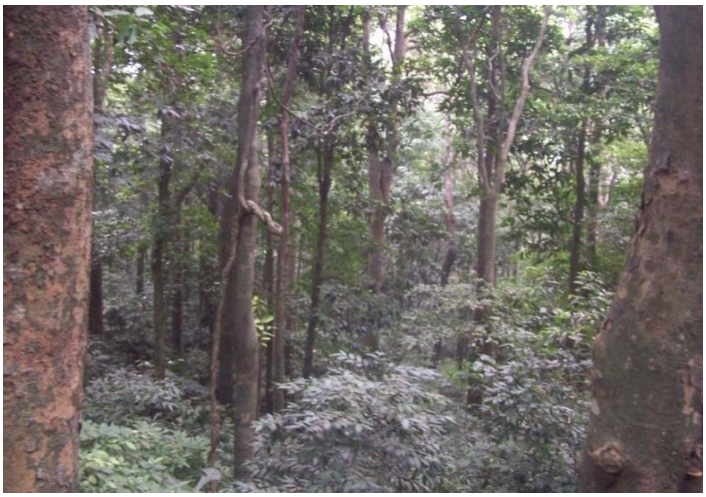
Plate 2. *Kingiodendron pinnatum*- Population structure


Habit and habitat views from the Vazhachal forest


Habit and habitat views from the Orukomben forest


Habit and habitat views from the Karimbani forest

Plate 3. *Kingiodendron pinnatum*: Population structure

Habit and habitat views from the Thamarassery forest


Habit and habitat views from the Peruvannamuzhi forest


Habit and habitat views from the Nadugani forest

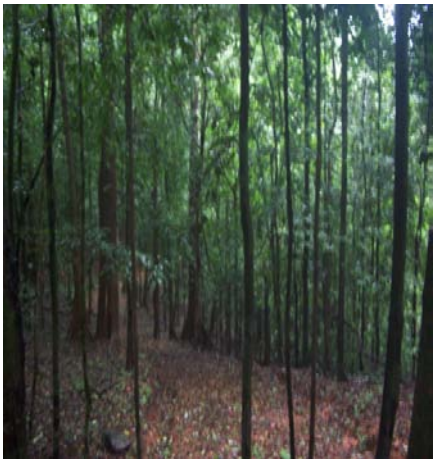
Plate 4. *Kingiodendron pinnatum*: Population structure



Habit and habitat views from the Shendurney forest



Habit and habitat views from the Kallar forest **Measuring gbh**


Habit and habitat views from the Aralam forest **Soil collection-a view**

4.1.2. Population dynamics

4.1.2.1. Vegetative phenology

Peak flushing of leaves was noted from the month of January to March. Flushing initiated with reddish brown colour later changed into pale yellow and to light green and finally attained dark green colour. The entire process took place within a month. During vegetative phenophase, both young and mature leaves of certain branches of the trees were found moderately infested by fungi species and the infection was found persistent throughout the season. On critical analysis, the fungi were identified as viz., *Phenopsis* sp., *Pestacotiopsis* sp., *Colletotrichum* sp., *Curvularia* sp., *Phyllochora* sp. In addition to this, new flush was also found fed by a beetle *Myllocerus viridanus* (Coleoptera: Curculionoidea).

4.1.2.2. Reproductive phenology

(No flowering was recorded for the species *in situ* during thethree year study period. A stray flowering in a tree planted in the KFRI, Peechi Campus was noted and data collected from the same is presented here).

Flower bud initiation was noted from January onwards. Around two weeks were taken from bud to full bloom in a panicled raceme. The anthesis was noted in the early morning hours and stigma found receptive for 48 hours. During anthesis, incidence of high frequency of

small honey bees (*Apis cumin*) was recorded. The flowers exhibited protogynous nature. The blooming period was extended for two days and thereafter flowers withered and ovary starts development.

Pollen -Ovule ratio

As per Haemocytometer reading, one anther contained 27,912 pollen grains. It was noted that 25 anthers were present per flower. Therefore, a single flower had around 6,97,800 pollen grains. A female flower had around 12 ovules and hence the P: O ratio was worked out as 58,150:1 for the species.

Pollen fertility

The Acetocarmine staining technique proved that pollen fertility is 100%.

Fruit devolpment

Fruiting primordia was noted in the last week of January. The ripened and fallen fruits of the previous year (before the commencement of the study) were collected from the populatios growing at Aralam WLS and Vazhachal forests during the month June. It is assumed that fruit phenology was extended upto 5 months.

Natural regeneration

Out of 3064 seedlings counted under an enumerated area of 2.1 ha representing three zones, 1103nos. (35.9%) were under the category of established seedlings and 1961 nos. (64.01%) included under un-

established. It is also noted that among three zones categorized, northern zone recorded maximum seedlings followed by the southern and central zones (Table 19 &20). Seedlings were found gregariously in flat terrain and as scattered in sloppy terrain assuming uniformity in moisture status in the flat terrain than sloppy ground.

Table 19. *K. pinnatum* : Details of seedlings recorded in three Zones

	Sampled area (Ha.)	**Total seedlings (Nos.)**	**Seedling height**	
			Un established (<1 m)	**Established (>1 m)**
Northern zone	0.7	1102	710	392
Central zone	0.7	935	593	342
Southern zone	0.7	1027	658	369
Total	2.1	3064	1961	1103

Table 20. *K.pinnatum* : Statistical analysis of seedlings recorded in three Zones

Zones	**Mean**	**SD**	**SE**
Northern (Un established <1m)	56.707	20.574	0.772
Northern (Established >1m)	160.264	30.385	1.534
Central(Un established <1m)	54.645	20.771	0.0350
Central (Established >1m)	168.483	45.320	2.450
Southern (Un established <1m)	52.355	18.986	0.740
Southern (Established >1m)	162.160	31.961	1.663

Reproductive Constraints

- Assumes long intervals in flowering (During three year field study, no flowering was recorded. A stray flowering was noted in few branches of a tree growing *ex situ* conditions).
- High abscission of fruiting primordia noticed during stray flowering in *ex situ* conditions point towards ineffective pollination.
- Low percentage of pre reproductive individuals (29%) among individuals recorded indicated the declining trend of the populations.

Plate 5. *Kingiodendron pinnatum* : Population Dynamics

Vegetative phenology – Stages of flushing

Vegetative phenology – Stages of leaf maturity

Leaf feeding by the Beetle: Views of the Beetle - *Myllocerus viridanus*

Plate 6. *Kingiodendron pinnatum* : Population Dynamics

Views of foliar fungi infestation

Developing inflorescence

Developing fruiting primodia

4.1.3. Climatic and Edaphic factors

Climatological and edaphic data of the species in respective sites (Zones only) viz., Kulathupuzha, Poringalkuth and Kottiyoor were collected in three seasons of the year and tabulated. Average value of climatic data such as atmospheric temperature (maximum and minimum) atmospheric humidity and rain fall (as per data avaibility) of each season is presented (Table 21, 22 & 23). Similarly, soil samples from three levels were collected and data on texture, pH, nutrients, etc were also recorded. The results among the three zones generally revealed that pH values varied from strongly to moderately acidic. The results in three zones generally revealed N content ranged from moderate to high (318-830 kg/ha); low to moderate content in P (3.6- 16.3 kg/ha) and a moderate to high K content (165- 580 kg/ha) among population sites studied of the species. Soil moisture content and soil temperature of each season were also noted to understand the edaphic environment of species (Table 24, 25 and 26).

Table 21. Climatic data of *Kingiodendron pinnatum*: Kulathupuzha

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	30.1	26.09	60	75
Monsoon	28.3	24.5	76	93
Winter	27.6	22.2	70	84

Table 22. Climatic data of *Kingiodendron pinnatum*: Poringalkuth

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)	Rainfall (cm)
Summer	30	23	60	78	2.60
Monsoon	23	20	75	94	23.38
Winter	22	18	70	87	1.09

Table 23.Climatic data of *Kingiodendron pinnatum*: Kottiyoor

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	30	24	58	68
Monsoon	27	21	75	82
Winter	28	20	78	88

Table 24. Edaphic data of *Kingiodendron pinnatum:* Kulathupuzha

Season	Soil Level	Texture	P^H	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Temp. (^oC)	Moisture (%)
Summer	**Surface** **Middle** **Bottom**	**Silt loam** **Silty clay** **Sandy clay Loam**	**5.8** **5.6** **5.3**	**560.6** **590.6** **496.3**	**8.6** **9.4** **16.3**	**340.6** **190.5** **142.4**	**20**	**20.13**
Monsoon	**Surface** **Middle** **Bottom**	**Silt loam** **Silty clay** **Sandy clay Loam**	**5.7** **5.4** **5.4**	**448.2** **600.6** **326.3**	**29.2** **16.3** **5.9**	**480.1** **520.6** **322.4**	**22**	**29.36**
Winter	**Surface** **Middle** **Bottom**	**Silt loam** **Silty clay** **Sandy clay Loam**	**5.4** **5.1** **5.3**	**820.6** **830.6** **796.6**	**12.3** **4.8** **5.6**	**140.6** **165.5** **267.4**	**23**	**26.84**

Table 25. Edaphic data of *Kingiodendron pinnatum:* Poringalkuth

Season	Soil Level	Texture	P^H	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Temp. (^oC)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Silty clay loam Loam	4.8 4.6 5.1	506.1 540.8 530.3	5.6 5.4 4.3	240.6 200.5 192.4	22	18.10
Monsoon	Surface Middle Bottom	Silt loam Silty clay loam Loam	4.7 4.6 4.6	468.2 412.6 360.2	9.2 6.3 5.8	310.1 200.6 392.4	21	28.56
Winter	Surface Middle Bottom	Silt loam Silty clay loam Loam	5.2 5.3 5	480.6 426.6 318.5	4.6 4.4 3.6	260.6 195.5 245.4	18	25.6

Table 26. Edaphic data of *Kingiodendron pinnatum* : Kottiyoor

season	Soil Level	Texture	P^H	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Temp. (^oC)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Silty clay Sandy clay Loam	5.6 5.3 5.8	660.6 598.6 546.3	9.6 10.4 11.3	440.6 290.5 242.4	21	21.13
Monsoon	Surface Middle Bottom	Silt loam Silty clay Sandy clay Loam	6.1 5.8 5.9	548.2 500.6 426.3	12.2 9.3 7.9	580.1 560.6 522.4	23	30.36
Winter	Surface Middle Bottom	Silt loam Silty clay Sandy clay Loam	5.9 5.3 5.4	720.4 630.6 786.3	11.3 6.8 6.6	340.6 465.5 297.4	24	24.84

4.1.4. Conservation strategies

4.1.4.1. Vegetative propagation

Aged branch cuttings were found difficult for rooting, however, young stands of 3-5 year old have shown rooting success. The auxins IAA 1000 and IBA 1000 and 3000 ppm exhibited 100% success where as control gave 80% within 30-35 days of planting. In air layering, 100% success were recorded with the aid of IAA 1000 ppm within 20 -55 days, wherwas control resulted in 50% success after 25-70 days.

Table 27. Vegetative propagation through stem cuttings in *Kingiodendron pinnatum*

Treatment (ppm)	Rooting (%)	Mean no. of roots (Mean ±S.D) (cm)	Mean length of roots (Mean ± S.D.) (cm)	Survival of Rametes
Control	80	1.75±0.9574	8.928±0.7319	100
IAA 1000	100	1.6±0.8944	9.6±1.7677	100
1AA 3000	80	2±0.816497	9.6±1.767767	100
IBA 1000	100	2.8±1.0954	10.6 ±2.4351	100
IBA 3000	100	1.8 ±0.8366	7±3.1622	80
NAA 1000	40	3±0	9.3±2.3380	100
NAA 3000	80	2.7±1.5	7.9±1.6577	80

Table 28. Vegetative propagation through air layering in *Kingiodendron pinnatum*

Sl No.	Treatment	No of layers	Percent of rooting (%)	Survival (%)
1	IBA 1000 ppm	6	75	100
2	IAA 1000 ppm	6	100	100
3	NAA 1000 ppm	6	75	100
4	IBA 3000 ppm	6	100	100
5	IAA 3000 ppm	6	75	100
6	NAA 3000 ppm	6	100	100
7	CONTROL	6	50	100

4.1.4.2. Seed propagation

Since there was no flowering recorded in the study period, seed studies could not be attended. The ripened and fallen fruits of the previous year (before the commencement of the project study) were enabled for seedling production.

Plate 7. *Kingiodendron pinnatum* : Conservation

Rooting of young stem cuttings with the aid of auxins

Views of Air layering

Air layering success

Plate 8. *Kingiodendron pinnatum* : Conservation

View of matured fruits

Processed Seeds

Seed germination

Establishing planting stock

Views of established poly bagged plants

4.1.5. Restoration

A total of 1450 polybagged seedlings were planted in four population sites of the species (Table 29 &30). Further, 105 seedling were also casuality planted in *situ.* In addition, planting was also carried out in three ex *situ* areas. Fully establishesd two year old polybaged seedlings having an average height of 10-35cm were user for planting.

Peruvannamuzhi

Three hundred and fifty seedlings of 1.5 - 2 year old were planted at Payyanikkotta forest, near Peruvannamuzhi. The mean height of seedlings during planting was 15cm and the maximum height was 28cm. The seedlings showed 91% survival along with average height of 20cm and maximum height of 33cm after 6 months of planting.

Nadugani

Three hundred and fifty seedlings, 1.5 - 2 year old were planted in the site. The mean height of seedlings during planting was 10cm and the maximum height was 35cm. The seedlings showed 85% survival along with average height of 14cm and a maximum height of 30 cm after 6 months of planting. Shortage of SW monsoon contributed to the mortality of few seedlings in the site. In addition, seedlings were also found affected by wild boar incidences.

Poringalkuth

Four hundred seedlings of 1.5 - 2 years old were planted in the site. The mean height of seedlings during planting was 13cm and the maximum height recorded was 33cm. The seedlings showed 90% survival along with average height of 29cm and a maximum height of 51cm after 6 months of field planting.

Kulathupuzha

Three hundred and fifty seedlings of 1.5 - 2 year old were planted at 2nd Mile, near Kulathupuzha. The mean height of seedlings during planting was 14cm and the maximum height was 34cm. The seedlings showed 92% survival along with average height of 28cm and a maximum height of 52cm after 6 months of planting.

***Ex situ* Planting**

Fifty seedlings were planted at KFRI Peechi Campus and five at FRC, Velupadam. The seedling height during planting was 30-40 cm. The seedlings showed 75-80% survival after 6months at both the sites. Survival of few seedlings was found affected by waterlogged conditions in the site.

Table 29. Restoration of *K. pinnatum*: Details of planting

Site No	Status	Planting sites	Geographic coorddinates	Altitude (m)
1.	*In-situ*	2 nd Mile Kulathupuzha Range Kollam Dt.	N 08° 52' 51.4" E 077° 05' 10.7"	190 m
2.	*In-situ*	Irumbupalam Poringalkuth Vazhachal Range Thrissur Dt.	N 10° 19' 46.96 E 076° 38' 27.38"	496 m
3.	*In-situ*	Nadugani Vazhikadavu range Malapuram Dt.	N 11° 26' 09.85 E 076° 23' 22.9 1"	565 m
4.	*In-situ*	Payyanikotta Peruvannamuzhi Range Kozhikod Dt.	N 11° 35' 0.40 E 075° 52' 07.1"	180 m
5.	*Ex-situ*	FRC, Velupadam Thrissur Dt.	N 10° 26' 12.4" E 076°21'28.4"	106 m
6.	*Ex-situ*	KFRI Campus, Peechi Thrissur Dt.	N 10°31' 49.22" E076°20'51.29"	97m

Table 30. Restoration of *K. pinnatum*: Establishment, growth and survival of seedlings

Sl No	Place of planting	GPS points of planting site	Date of planting	No of seedlings planted	Average height during planting (cm)	Average height after 6 months (cm)	Survival after 6 months (%)
	In situ						
1	Kulathupuzha	N 08° 52' 51.4" E 077° 05' 10.7" ; 190 m	04.08.16	350	24	27	92
2	Poringalkuth	N 10° 19' 46.96" E 076° 38' 27.38"; 496 m	12.08.16	400	26	31	90
3	Nadugani	N 11° 26' 09.85" E 076° 23' 22.9 1" ; 565 m	09.08.16	350	23	28	85
4	Peruvannamuzhi	N 11° 35' 0.40 " E 075° 52' 07.1" ; 180 m	17.08.16	350	21	25	91
	Ex situ						
1	KFRI Campus	N 10°31' 49.22" E076°20'51.29"; 97 m	05.06.16	50	35	37	75
	FRC, Velupadam	N 10° 26' 12.4" E 076° 21' 28.4" ; 106 m	15.06.16	05	35	39	80

Plate 9. *Kingiodendron pinnatum* : Restoration *in situ*

Views at Poringalkuth

Views at Kulathupuzha

Views at Peruvannamuzhi

Views at Nadugani

Plate: 10 *Kingiodendron pinnatum* –Planting *ex situ*

Different views of seedling planting and evaluation at KFRI Peechi Campus

Different views of seedling planting at FRC Velupadam

Different views of seedling growing at KFRI Peechi Campus

4.2. *Cynometra beddomei* Prain

The survey enabled to locate 5 populations of the species in 5 forest areas of Kerala (Fig.2). The population structural analysis within the sampled and non sampled areas at 5 sites were worked out and presented. The population diversity analysis at 5 sites were worked out and presented.

Population sites of *Cynometra beddomei*

1. Peruvannamuzhi, N11° 35' 0.40" E 075° 52' 07.1" (Peruvannamuzhi Range, Kozhikode Division), at an alttitude of 176±10m. The population identified in the fringes of an evergreen forest where human habitation is noticed.
2. Kakkayam N 11° 33' 48.7" E 075° 54 ' 10.3" (Peruvannamuzhi Range, Kozhikode Division), at an altitude of 448±10m. Two small populations identified in the fringes of evergreen to semi evergreen forest patches, within 1 km^2 area. Area is moderately disturbed by visitors to the Dam.
3. Thamarassery, N 11° 30'19.9" E 076° 01' 49.2" (Thamarassery Range, Kozhikod Division), at an altitude of 644±10 m. The population identified in the fringes of an evergreen forest.

4. Kallar (Pattanivalavu), N 08° 44' 24.33" E 077°07'10.53" (Palode Range, Thiruvananthapuram Division) at an alttitude of 342±10 m. The population identified in the evergreen forest.

5. Karamanayar N 08° 39'15.9" E 077° 11' 25.4" (Peppara WLS), at an alttitude of 644±10m. The population identified in the evergreen forest.

In addition to the above sites, one tree growing in the Zoological garden and Museum campus, Thrissur was also monitored.

Fig.2. Population sites of *Cynometra beddomei* in the Western Ghats of Kerala

4.2.1. Population structure

1. Thamarassery

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such *Cullenia exarillata*, *Hopea parviflora*, *Dipterocarpus indicus*, *Ficus beddomei*, *Antiaris toxicaria*, *Vateria indica*, *Palaquium elipticum*, *Holigarna nigra*, *Canarium strictum*, *Terminalia bellirica*, *Artocarpus hirsutus*, *Holigarna grahamii*, *Kingiodendron pinnatum*, *Mesua ferrea*, etc. as top layer/ first storey reaching a height range of 26 to 35m. The second storey represented by *Cinnamomum malabatrum*, *Diospyros paniculata*, *Cynometra travancorica*, *Paracroton pendulus*, *Myristica malabarica*, *Knema attunata*, *Holigarna arnotiana*, *Polyalthiya fragrans*, *Garcinia gummigutta*, *Garcinia morella*, *Diospyros crumenata*, *Polyalthiya coffeoides*, *Caryota urens*, *Hopea ponga*, *Prunus ceylanica*, etc. along with *Cynometra beddomei* with a height range of 16 to 25m. Third storey occupied by *Aglaia lawii*, *Otonephelium stipulaceum*, *Sterculia guttata*, *Hydnocarpus pentandra*, *Atalantia wightii*, *Baccaurea courtallensis*, *Croton malabaricus*, *Actinodaphne malabarica* *Flacourtia montana*, *Syzygium lanceolatum*, *Mallotus philipensis*, *Xanthophyllum arnottianum*, *Mangifera indica*, *Humboldita brunonis*, *Walsura trifolia*, *Mallotous beddomei*, *Syzygium caryophyllatum*,

Litsea lavigata, *Litsea coriacea*, *Bischofia javanica*, *Ficus nervosa*, *Isonandra lanceolata*, *Macaranga peltata*, *Meiogynae ramarowii*, etc along with presence of *C. beddomei* with 6-15m height range. The shrub layer consists of *Phaeanthus malabaricus, Breynia retusa*, *Justicia betonica*, *Pittosporum sp*, *Mussaenda frondosa*, *Ixora brachiata etc.* of below 6m height. The herb layer was mainly dominated by the tree seedlings of *Cullenia exarillata*, *Hopea ponga*, *Actinodaphne malabarica* and by *Begonia malabarica*.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *C. beddomei* in a scattered manner along with their associates in adjacent to the water course.

(c) Age distribution

The individuals of *C. beddomei* exhibited two age classes such as set of future and set of present with a height range from 3 to 16m and a girth of 15 to 150 cm. Among 10 individuals of the species presented in the site, 6 individuals represent the set of present covering a height range of 12 to 16m and gbh range of 85 to 150 cm. Set of future is represented by 4 individuals covering a height range of 3 to 6 m and gbh of 15 to 40 cm.

The population structure was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 31).

The occurrence of the species in the forest area was found to be approximately 8 km^2. Nearly 15 mature trees were counted in the forest area.

The floristic diversity analysis covered 57 species of gbh ≥30 cm with 410 individuals in 7000 sq.m. The *Vateria indica* has attained highest index value of 0.244 and thus became the dominant species in the particular quadrat whereas *Cynometra beddomei* becomes 44^{th} position with IVI of 0.013 in the study area (Table 32).

2. Peruvannamuzhi

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such as *Vateria indica*, *Tetrameles nudiflora*, *Hopea parviflora*, *Bombax ceiba*, *Canarium strictum*, *Diospyros buxifolia*, *Ficus* sp., *Vitex altissima*, etc. as top layer/ first storey reaching a height range of 26 to 35m. The second storey represented by *Garcinia gummi-gutta*, *Stereospermum colais*, *Holigarna arnottiana*, *Albizia lebbeck*, *Calophyllum calaba*, *Caryota urens*, *Cinnamomum malabatrum*, *Dillenia pentagyna*, *Dimocarpus longan*, *Diospyros candollena*, *Haldina cordifolia*, *Knema attenuata*, *Lagestromia speciosa*, *Myristica beddomei*, *Myristica malabarica*, *Oroxylum indicum*, *Polyalthia fragrans*, *Reinwaditodendron anamalaiense*, *Schleichera oleosa*, *Spondias pinnata*, *Steriospermum*

colais, etc. along with *Cynometra beddomei* with a height range of 16 to 25m. Third storey occupied by *Sterculia guttata, Hydnocarpus pentandra, Actinodaphnae malabarica, Butea monosperma***,** *Mallotus tetracoccus*, *Baccaurea courtallensis*, *Aporosa cardiosperma*, *Archidendron bigeminum*, *Humbolditia brunonis*, *Mcaranga peltata*, *Xanthophyllum arnottianum* along with presence of *C. beddomei* with 6-15 m height range. The shrub layer consists of *Barleria courtallica*, *Cipadessa baccifera, Ixora malabarica, Memecylon umbellatum*, *Psychotria sp., Strobilanthes ciliates, Thottea siliquosa,* etc. of below 6m. The herb layer was mainly dominated by the seedlings of *Cinnamomum malabatrum, Humboldtia brunonis*, *Albizia lebbeck* etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *C. beddomei* in a scattered manner among its associates adjacent to the water course. The area was also characterized by sloppy ground with rock boulders.

(c) Age distribution

The individuals of *C. beddomei* exhibited two age classes such as set of future and set of present with a height range from 3 to 17m and a girth of 15 to 320cm among 10 individuals of the species presented in the site, 9 individuals represent the set of present covering a height range of 10 to 20 m and gbh range of 110 to 320cm. Set of

future is represented by 1 individual covering a height of 3 m and gbh of 15cm.

The population structure was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 33). The occurrence of the species in the forest area was found to be approximately 4 km^2. Nearly 16 mature trees were seen in the forest area.

The floristic diversity analysis covered 57 species of gbh ≥30 cm with 420 individuals in 7000 sq.m. *Vateria indica* has highest index value of 0.167 and thus became the dominant species in the particular forest whereas; *Cynometra beddomei* becomes the 31st position with IVI of 0.037 in the study area (Table 34).

3. Kakkayam.

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such *Vateria indica*, *Hopea parviflora*, *Dysoxylum malabaricum*, *Bombax ceiba*, *Canarium strictum*, *Tetremeles nudiflora*, *Antiaris toxicaria*, *Dipterocarpus indicus*, *Ficus racemosa*, *Terminalia bellirica*, *Chukeresia tabularis*, *Diospyros buxifolia*, *Lophopetalaum wightianum*, *Poecilonuron indicum*, *Artocarpus hirsutus*, *Vitex altissima*, *Persea macarantha*, *Alstonia scholaris*, *Mesua ferrae*, etc. as top layer/ first storey reaching

a height range of 26 to 35m. The second storey was represented by *Holoptelea integrifolia, Bischofia javanica, Toona ciliata, Steriospermum colais, Myristica beddomei, Dimocarpus longan, Nothopegia beddomei, Knema attenunata, Holigarna arnotiana, Caryota urens, Polyalthia coffeoides, Sterculia guttata, Albizia lebbeck, Cinnamomum malabatrum, Dalbergia latifolia, Ficus virens, Haldina cordifolia, Holoptelia integrifolia, Lannea coramandalica, Meliocope lunu-ankenda* along with *Cynometra beddomei* ranging a height of 16 to 25 m. Third storey was occupied by small trees such as *Humboldtia brunonis, Xanthophyllum arnottianum, Cleistanthus patulus, Lepisanthes tetraphylla, Mangifera indica, Ficus recemosa, Aglea lawii, Syzygium mundagam, Arenga wightii, Chionanthus mala-elengi, Debergia wallichiana, Holerrina pubesence, Memecylon umballatum* along with presence of *Cynometra beddomei* with 6-15 m height range. The shrub layer consists of *Vernonia ornata, Humboldtia brunonis var. raktapushpa, Blachia umbellata, Barleria courtallica, Lobelia nicotianifolia, Thottea sivarajanii, Thottea siliquosa, Nothopegia* sp., *Memecylon talboltii, Litsea mysorensis* etc. The herb layer is mainly covered by *Centella asiatica, Pouzolzia meeboldii* and seedlings of *Helicteres isora, Murraya paniculata* etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *C. beddomei* in a scattered manner among its associates adjacent to water course. The area was also characterized by sloppy ground with rock boulders.

(c) Age distribution

The individuals of *C. beddomei* exhibited two age classes such as set of future and set of present with a height range from 3 to 18m and a girth of 35 to 172 cm. Among 28 individuals of the species presented in the site, 25 individuals represent the set of present covering a height range of 10 to 18m and gbh range of 75 to 172cm. Set of future is represented by 3 individuals covering a height range of 3 to 6m and gbh of 35 to 45cm.

The population structure was analyzed by recording gbh, basal area, basal cover, age phase and height of each individual (Table 35). The occurrence of the species in the forest area was found to be approximately 6 km^2. Nearly 27 mature trees were seen in the forest area.

The floristic diversity analysis covered 54 species of gbh ≥30 cm size of 402 individuals in 7000 sq.m. *Vateria indica* has highest index value of 0.274 and thus became the dominant species in the particular forest whereas, *Cynometra beddomei* attained 48^{th} position with IVI of 0.019 (Table 36).

4. Karamanayar

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such as *Hopea parviflora*, *Vateria indica*, *Tetrameles nudiflora, Dipterocarpus indicus*, *Antiaris toxicaria*, *Artocarpus hirsutus*, *Canarium strictum*, *Chukeresia tabularis Diospyros buxifolia*, *Drypetus venusta*, *Hopea parviflora*, *Lophopetalum wightianum,* etc. as top layer/ first storey reaching a height range of 26 to 35 m. The second storey represented by *Knema attenuata*, *Garcinia gummi-gutta*, *Aphanamixis polystacha*, *Callophyllum calaba*, *Caryota urens*, *Cinamomum malabatram*, *Democarpus longan*, *Hopea erosa*, *Hopea ponga* with a height range of 16-25 m along with *Cynometra beddomei*. Third storey occupied by small trees such as *Otonephelium stipulaceum*, *Macaranga peltata*, *Baccaurea courtallensis*, *Aglaia lawii* with 6-15 m height range along with *Cynometra beddomei*. The Shrub layer consist of *Ixora agasthyamalayana*, *Murraya paniculata*, *Ophiorrhiza eriantha*, *Strobilanthes ciliates*, *Thottea ponmudiana*, *Breynia retusa etc.* Herbs constitutes species such as *Ophiorrhiza mungos*, *Begonia floccifera*, *Impatiens cordata,* etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *C. beddomei* in a scattered manner among its associates adjacent to water course. The area was also characterized by sloppy ground with rock boulders.

(c) Age distribution

The individuals of *C. beddomei* exhibited set of present with a height range from 12 to 16m and a girth of 70 to 130cm. The population structure was analyzed by recording gbh, basal area, basal cover, age phase and height of the each individual (Table 37). The occurrence of the species in the forest area was found to be approximately 4 km^2 and 6 mature trees were recorded.

The floristic diversity analysis covered 40 species of gbh ≥30 cm size with 431 individuals in 7000 sq.m. *Vateria indica* has highest index value of 0.328 and thus became the dominant species in the particular forests whereas; the *Cynometra beddomei* reached 29^{th} position with IVI of 0.027 in the study area (Table 38).

5. Kallar

(a) Stratification/ Vertical distribution

The vegetation profile (vertical) of the population showed the occurrence of major tree species such as *Lophopetalum wightianum, Kingiodendron pinnatum, Hopea ponga, Hopea parviflora, Dysoxylum*

malabaricum, Poeciloneuron indicum, Vateria indica with a height ranging from 26 to 35m. The second layer composed species such as, *Knema attenuata*, *Spondias pinnata*, *Olea dioica* with a height range of 16-25m along with *Cynometra beddomei*. Third layer is composed of *Hydnocarpus macrocarpa, Xanthophyllum arnottianum, Hydnocarpus pentandra, Humboldtia decurrens, Flacourtia montana, Baccaurea courtallensis*, *Wrightia tinctoria, Sterculia guttata,* etc with 6-15 m height range along with *Cynometra beddomei*. The shrub layer consist mainly of *Rauvolfia hookeri, Clausena anisata, Cipadessa baccifera, Osbeckia sp., Psychotria flavida, Thottea siliquosa, Memecylon umbellatum* along with shrubby form of *C. beddomei*. The herbaceous layer is composed by *Ophiorrhiza pectinata, Sonerila rheedei*, *Helicteres isora*, *Torenia courtallensis*, etc.

(b) Horizontal/ Spatial distribution

The horizontal profile of the population exhibited the arrangement of the individuals of *C. beddomei* in a scattered manner among its associates adjacent to the water course. The area was also characterized by sloppy ground.

(c) Age distribution

The individuals of *C. beddomei* exhibited two age classes such as set of future and set of present with a height range from 3 to 20 m and a girth of 22 to 420 cm. among 5 individuals of the species

presented in the site; 63 individuals represent the set of present covering a height range of 12 to 20 m and gbh range of 70 to 420 cm. Set of future is represented by 2 individuals covering a height range of 3 to 5 m and gbh of 22 to 35 cm. Seedlings 19 nos from 20-100 cm range were noted.

The population structure was analyzed by recording gbh, basal area, basal cover, age phase and height of the each individual (Table 39). The occurrence of the species in the forest area was found to be approximately 2 km^2 and 6 mature trees were recorded.

The floristic diversity analysis covered 45 species of gbh ≥30 cm size of 426 individuals in 7000 sq.m. The *Vateria indica* has highest index value of 0.339 and thus became the dominant species in the study area whereas, *Cynometra beddomei* attained 39^{th} position with IVI of 0.020 (Table 40).

Table 31. Population structure of *Cynometra beddomei* within the sampled and non sampled area: Thamarassery

(List of individuals With G≥10cm represented)

Sl. No.	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching seen at (m)	Height of Stand (m)
1	10-50	15	2.388	17.78	3	Set of future	2	3
2		20	3.18	31.752	3	Set of future	2.5	4
3		30	4.77	71.44	6	Set of future	2	4
4		40	6.36	127.01	8	Set of future	4	6
5	50-100	85	13.53	1149.62	10	Set of present	8	12
6		90	14.33	644.79	12	Set of present	8	13
7	Above 100	110	17.51	962.72	14	Set of present	9	14
8		120	19.10	1145.50	12	Set of present	6	14
9		138	21.97	1515.61	14	Set of present	10	15
10		150	23.88	1790.59	16	Set of present	10	16

Table 32. Floristic diversity/ Importance Value Index of *Cynometra beddomei* within the sampled plots*:* Thamarassery

(List of individuals with G≥30cm)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARACEAE	0.714	0.093	0.121	0.244
2.	*Paracroton pendulus*	EUPHORBIACEAE	0.857	0.056	0.117	0.209
3.	*Myristica malabarica*	MYRISTICACEAE	0.857	0.080	0.041	0.163
4.	*Holigarna nigra*	ANACARDIACEAE	0.714	0.052	0.050	0.133
5.	*Syzygium lanceolatum*	MYRTACEAE	0.714	0.034	0.069	0.133
6.	*Knema attenuata*	MYRISTICACEAE	0.857	0.056	0.034	0.126
7.	*Holigarna arnottiana*	ANACARDIACEAE	0.857	0.043	0.042	0.121
8.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.857	0.052	0.011	0.105
9.	*Polyalthia fragrans*	ANNONACEAE	0.714	0.024	0.026	0.080
10.	*Cullenia exarillata*	BOMBACACEAE	0.428	0.015	0.046	0.079
11.	*Canarium strictum*	BURSERACEAE	0.714	0.024	0.016	0.071
12.	*Ficus beddomei*	MORACEAE	0.142	0.003	0.052	0.061
13.	*Croton malabaricus*	EUPHORBIACEAE	0.571	0.021	0.008	0.054
14.	*Mallotus philippensis*	EUPHORBIACEAE	0.285	0.006	0.036	0.054
15.	*Cinnamomum malabatrum*	LAURACEAE	0.428	0.015	0.019	0.053
16.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.714	0.021	0.002	0.053
17.	*Garcinia gummi-gutta*	CLUSIACEAE	0.571	0.021	0.001	0.046
18.	*Garcinia morella*	CLUSIACEAE	0.571	0.015	0.007	0.046
19.	*Mangifera indica*	ANACARDIACEAE	0.285	0.012	0.022	0.046
20.	*Nothopegia beddomei*	ANACARDIACEAE	0.571	0.021	0.001	0.046
21.	*Toona ciliata*	MELIACEAE	0.285	0.006	0.028	0.046
22.	*Humboldtia brunonis*	FABACEAE	0.428	0.021	0.005	0.045
23.	*Walsura trifolia*	MELIACEAE	0.571	0.018	0.002	0.044
24.	*Mallotus beddomei*	EUPHORBIACEAE	0.428	0.012	0.013	0.043
25.	*Terminalia bellirica*	COMBRETACEAE	0.142	0.003	0.033	0.042
26.	*Syzygium caryophyllatum*	MYRTACEAE	0.428	0.015	0.005	0.038
27.	*Artocarpus hirsutus*	MORACEAE	0.571	0.012	0.009	0.037
28.	*Aglaia lawii*	MELIACEAE	0.428	0.012	0.003	0.034
29.	*Atalantia wightii*	RUTACEAE	0.428	0.012	0.003	0.033
30.	*Dimocarpus longan*	SAPINDACEAE	0.428	0.009	0.005	0.033
31.	*Diospyros paniculata*	EBENACEAE	0.428	0.012	0.001	0.031
32.	*Litsea sp*	LAURACEAE	0.142	0.003	0.022	0.031
33.	*Cynometra beddomei*	FABACEAE	0.142	0.006	0.016	0.028
34.	*Bischofia javanica*	EUPHORBIACEAE	0.142	0.006	0.015	0.027
35.	*Otonephelium stipulaceum*	SAPINDACEAE	0.428	0.009	0.005	0.027
36.	*Palaquium ellipticum*	SAPOTACEAE	0.285	0.009	0.006	0.027
37.	*Actinodaphne malabarica*	LAURACEAE	0.142	0.003	0.013	0.022

38.	*Kingiodendron pinnatum*	FABACEAE	0.285	0.006	0.003	0.021
39.	*Flacourtia montana*	FLACOURTIACEAE	0.142	0.003	0.011	0.020
40.	*Mesua ferrea*	CLUSIACEAE	0.285	0.006	0.004	0.018
41	*Gmelina arborea*	VERBENACEAE	0.142	0.006	0.003	0.015
42.	*Nothopegia* sp.	ANACARDIACEAE	0.142	0.006	0.003	0.015
43.	*Polyalthia coffeoides*	ANNONACEAE	0.142	0.003	0.005	0.014
44.	*Cynometra travancorica*	FABACEAE	0.142	0.006	0.001	0.013
45.	*Stereospermum colais*	BIGNONIACEAE	0.142	0.003	0.004	0.013
46.	*Diospyros buxifolia*	EBENACEAE	0.142	0.003	0.007	0.010
47.	*Macaranga peltata*	EUPHORBIACEAE	0.142	0.003	0.007	0.010
48.	*Antiaris toxicaria Lesch.,*	MORACEAE	0.142	0.003	0.007	0.009
49.	*Caryota urens*	ARECACEAE	0.142	0.003	0.006	0.009
50.	*Dipterocarpus indicus*	DIPTEROCARACEAE	0.142	0.003	0.001	0.009
51.	*Hopea ponga*	DIPTEROCARACEAE	0.142	0.003	0.004	0.009
52.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.142	0.003	0.001	0.009
53.	*Meiogyne ramarowii*	ANNONACEAE	0.142	0.003	0.001	0.009
54.	*Phaeanthus malabaricus*	ANNONACEAE	0.142	0.003	0.001	0.009
55.	*Prunus ceylanica*	ROSACEAE	0.142	0.003	0.001	0.009
56.	*Scolopia crenata*	FLACOURTIACEAE	0.142	0.003	0.001	0.0090
57.	*Sterculia guttata*	STERCULIACEAE	0.142	0.003	0.001	0.0090

Table 33. Population Structure of *Cynometra beddomei* : within the sampled and non sampled area : Peruvannamuzhi

(List of individuals with G≥ 10 cm present)

Sl. No.	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	10-50	15	2.38	29.45	3	Set of future	2	3
2	100-200	110	17.51	962.72	12	Set of present	5	10
3		138	21.974	1515.61	14	Set of present	6	12
4		180	28.66	2579.18	14	Set of present	7	14
5		185	29.45	2723.32	18	Set of present	6	13
6	200 above	210	33.43	3509.15	18	Set of present	5	16
7		240	38.21	4584.41	18	Set of present	8	16
8		290	46.178	6693.44	18	Set of present	9	20
9		300	47.77	7165.39	20	Set of present	9	19
10		320	50.955	8152.73	20	Set of present	6	20

Table 34. Floristic diversity/ Importance value index of *Cynometra beddomei* within the sampled plots: Peruvannamuzhi

(List of individuals with G≥30cm)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARACEAE	0.029	0.038	0.100	0.167
2.	*Myristica malabarica*	MYRISTICACEAE	0.044	0.056	0.044	0.145
3.	*Dillenia pentagyna*	DILLENIACEAE	0.037	0.038	0.070	0.145
4.	*Humboldtia brunonis*	FABACEAE	0.051	0.071	0.016	0.140
5.	*Haldina cordifolia*	RUBIACEAE	0.044	0.049	0.043	0.137
6.	*Diospyros buxifolia*	EBENACEAE	0.037	0.033	0.061	0.132
7.	*Cinnamomum malabatrum*	LAURACEAE	0.037	0.035	0.044	0.117
8.	*Spondias pinnata*	ANACARDIACEAE	0.037	0.042	0.034	0.114
9.	*Polyalthia fragrans*	ANNONACEAE	0.037	0.044	0.032	0.114
10.	*Hopea parviflora Bedd.,*	DIPTEROCARACEAE	0.029	0.033	0.050	0.113
11.	*Schleichera oleosa*	SAPINDACEAE	0.037	0.042	0.028	0.108
12.	*Knema attenuate*	MYRISTICACEAE	0.037	0.038	0.028	0.103
13.	*Holigarna arnottiana*	ANACARDIACEAE	0.037	0.035	0.028	0.101
14.	*Vitex altissima*	VERBENACEAE	0.029	0.029	0.041	0.100
15.	*Actinodaphne malabarica*	LAURACEAE	0.037	0.038	0.024	0.099
16.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.037	0.038	0.015	0.090
17.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.029	0.031	0.028	0.089
18.	*Diospyros candolleana*	EBENACEAE	0.029	0.031	0.027	0.088
19.	*Tetrameles nudiflora*	DATISCACEAE	0.014	0.008	0.059	0.083
20.	*Butea monosperma*	FABACEAE	0.029	0.024	0.022	0.076
21.	*Garcinia gummi-gutta*	CLUSIACEAE	0.029	0.024	0.019	0.073
22.	*Oroxylum indicum*	BIGNONIACEAE	0.022	0.020	0.015	0.058
23	*Xanthophyllum arnottianum*	POLYGALACEAE	0.022	0.024	0.010	0.057
23.	*Archidendron bigeminum*	FABACEAE	0.022	0.022	0.032	0.051
24.	*Hopea erosa*	DIPTEROCARACEAE	0.022	0.015	0.010	0.048
25.	*Calophyllum calaba*	CLUSIACEAE	0.014	0.013	0.018	0.046
26.	*Macaranga peltata*	EUPHORBIACEAE	0.022	0.013	0.007	0.043
27.	*Dimocarpus longan*	SAPINDACEAE	0.014	0.015	0.011	0.042
28.	*Cynometra travancorica*	FABACEAE/	0.014	0.011	0.011	0.037
29.	*Ficus spp.*	MORACEAE	0.007	0.004	0.022	0.034
30.	*Cynometra beddomei*	FABACEAE	0.014	0.008	0.009	0.033
31.	*Lagerstroemia speciosa*	LYTHRACEAE	0.007	0.006	0.010	0.025
32.	*Aporosa cardiosperma*	EUPHORBIACEAE	0.007	0.006	0.005	0.019
33.	*Canarium strictum*	BURSERACEAE	0.007	0.006	0.004	0.018
34.	*Stereospermum colais*	BIGNONIACEAE	0.007	0.004	0.004	0.016
35.	*Myristica beddomei*	MYRISTICACEAE	0.007	0.004	0.004	0.016
36.	*Mallotus tetracoccus*	EUPHORBIACEAE	0.007	0.006	0.001	0.016
37.	*Sterculia guttata*	STERCULIACEAE	0.007	0.004	0.003	0.015
38.	*Reinwardtiodendron anamalaiense*	MELIACEAE	0.007	0.004	0.003	0.015
39.	*Caryota urens*	ARECACEAE/	0.007	0.004	0.003	0.015
40.	*Bombax ceiba*	BOMBACACEAE	0.007	0.004	0.004	0.015
41.	*Albizia lebbeck*	FABACEAE/	0.007	0.004	0.002	0.014

Table 35. Population Structure of *Cynometra beddomei* within the sampled and non sampled area: Kakkayam

(List of individuals with G≥ 30 cm)

Sl. No.	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	30-50	35	5.57	97.41	6	Set of future	3	6
2		32	5.09	81.35	6	Set of future	4	6
3		40	6.36	127.01	7	Set of future	4	6
4	50-100	75	11.94	447.64	12	Set of present	6	10
5		80	12.73	508.84	12	Set of present	2	10
6		90	14.33	644.79	12	Set of present	6	11
7		98	15.60	764.15	14	Set of present	7	10
8		90	14.33	644.79	15	Set of present	7	11
9		82	13.05	534.74	12	Set of present	8	10
10		74	11.78	435.73	15	Set of present	6	12
11	100-150	110	17.51	962.72	14	Set of present	8	12
12		120	19.10	1145.50	14	Set of present	8	15
13		125	19.90	1243.47	14	Set of present	4	13
14		130	20.70	1345.45	15	Set of present	5	13
15		148	23.56	1742.93	14	Set of present	12	16
16		120	19.10	1145.50	15	Set of present	6	14
17		112	17.83	998.23	15.	Set of present	5	16
18		134	21.33	1428.60	15	Set of present	7	15
19		120	19.10	1145.50	16	Set of present	8	14
20		105	16.71	876.76	14	Set of present	9	16
21		123	19.58	1203.80	16	Set of present	7	15
22	Above 150 240	160	25.47	2036.98	16	Set of present	3	15
23		170	27.07	2300.94	16	Set of present	5	16
24		158	25.15	1986.12	16	Set of present	6	16
25		163	25.95	2114.48	16	Set of present	5	17
26		172	27.38	2353.94	17	Set of present	7	17
27		167	26.59	2220.06	17	Set of present	6	18
28		172	27.38	2353.94	18	Set of present	5	18

Table 36. Floristic diversity/ Importance Value Index of *Cynometra beddomei* within the sampled plots : Kakkayam.

(List of individuals With G≥30cm represented)

Sl No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARPACEAE	0.041	0.065	0.167	0.274
2.	*Myristica beddomei*	MYRISTICACEAE	0.041	0.071	0.057	0.169
3.	*Alstonia scholaris*	APOCYNACEAE	0.041	0.030	0.062	0.133
4.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.041	0.065	0.020	0.127
5.	*Hopea parviflora*	DIPTEROCARPACEAE	0.033	0.035	0.056	0.125
6.	*Cinnamomum malabatrum*	LAURACEAE	0.033	0.041	0.048	0.122
7.	*Garcinia gummi-gutta*	CLUSIACEAE	0.033	0.032	0.048	0.114
8.	*Holigarna arnottiana*	ANACARDIACEAE	0.041	0.035	0.031	0.108
9.	*Toona ciliata*	MELIACEAE	0.041	0.032	0.027	0.101
10.	*Humboldtia brunonis*	FABACEAE	0.041	0.054	0.004	0.101
11.	*Sterculia guttata*	STERCULIACEAE	0.033	0.027	0.022	0.083
12.	*Knema attenuata*	MYRISTICACEAE	0.033	0.027	0.019	0.080
13.	*Albizia lebbeck*	FABACEAE	0.024	0.021	0.025	0.071
14.	*Arenga wightii*	ARECACEAE	0.024	0.019	0.023	0.067
15.	*Mangifera indica*	ANACARDIACEAE	0.024	0.019	0.021	0.065
16.	*Dimocarpus longan*	SAPINDACEAE	0.016	0.021	0.025	0.063
17.	*Holarrhena pubescens*	APOCYNACEAE	0.024	0.019	0.018	0.062
18.	*Holigarna nigra*	ANACARDIACEAE	0.024	0.019	0.018	0.062
19.	*Macaranga peltata*	EUPHORBIACEAE	0.016	0.019	0.013	0.048
20.	*Nothopegia beddomei*	ANACARDIACEAE	0.024	0.016	0.007	0.048
21.	*Gmelina arborea*	VERBANACEAE	0.016	0.013	0.010	0.040
22.	*Caryota urens*	ARECACEAE	0.016	0.010	0.012	0.039
23.	*Lepisanthes tetraphylla*	SAPINDACEAE	0.016	0.013	0.008	0.038
24.	*Dysoxylum malabaricum*	MELIACEAE	0.008	0.010	0.015	0.035
25.	*Poeciloneuron indicum*	CLUSIACEAE	0.008	0.008	0.016	0.032
26.	*Cleistanthus patulus*	EUPHORBIACEAE	0.016	0.013	0.001	0.031
27.	*Bischofia javanica*	EUPHORBIACEAE	0.008	0.008	0.014	0.031
28.	*Haldina cordifolia*	RUBIACEAE	0.008	0.010	0.010	0.030
29.	*Lannea coromandelica*	ANACARDIACEAE	0.008	0.010	0.010	0.029
30.	*Stereospermum colais*	BIGNONIACEAE	0.008	0.005	0.015	0.029
31.	*Persea macrantha*	LAURACEAE	0.008	0.008	0.012	0.028
32.	*Reinwardtiodendron anamalaiense*	MELIACEAE	0.016	0.005	0.005	0.027
33.	*Otonephelium stipulaceum*	SAPINDACEAE	0.008	0.010	0.008	0.027
34.	*Chukrasia tabularis*	MELIACEAE	0.008	0.010	0.007	0.026
35.	*Polyalthia coffeoides*	ANNONACEAE	0.008	0.010	0.006	0.026
36.	*Mesua ferrea*	CLUSIACEAE	0.008	0.008	0.008	0.024
37.	Elaeocarpus serratus	ELEAEOCARPACEAE	0.008	0.008	0.008	0.024
38.	*Terminalia bellirica*	COMBRETACEAE	0.008	0.008	0.007	0.024

39.	*Syzygium mundagam*	MYRTACEAE	0.008	0.010	0.003	0.023
40.	*Debregeasia wallichiana*	URTICACEAE	0.008	0.008	0.006	0.022
41.	*Aglaia lawii*	MELIACEAE	0.008	0.008	0.004	0.021
42.	*Cinnamomum malabatrum*	LAURACEAE	0.008	0.008	0.004	0.021
43.	*Ficus virens*	MORACEAE	0.008	0.005	0.007	0.020
44.	*Memecylon umbellatum*	MELASTOMATACEAE	0.008	0.010	0.001	0.020
45.	*Nothopegia sp*	ANACARDIACEAE	0.008	0.008	0.003	0.020
46.	*Bombax ceiba*	BOMBACACEAE	0.008	0.005	0.006	0.020
47.	*Chionanthus mala-elengi*	OLEACEAE	0.008	0.008	0.003	0.019
48.	*Cynometra beddomei*	FABACEAE/	0.008	0.002	0.003	0.019
49.	*Syzygium laetum*	MYRTACEAE	0.008	0.008	0.002	0.018
50.	*Ficus sp*	MORACEAE	0.008	0.005	0.004	0.018
51.	*Holoptelea integrifolia*	ULMACEAE	0.008	0.005	0.004	0.018
52.	*Melicope lunu-ankenda*	RUTACEAE	0.008	0.008	0.001	0.017
53.	*Prunus ceylanica*	ROSACEAE	0.008	0.005	0.003	0.017
54.	*Ficus racemosa*	MORACEAE	0.008	0.005	0.003	0.017

Table 37. Population Structure of *Cynometra beddomei* within the sampled and non sampled area *:* Karamanayar

(List of individuals with G≥ 10 cm)

Sl. No.	gbh class (cm)	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	50-100	70	11.14	390.09	12	Set of present	8	12
2		85	13.53	575.23	12	Set of present	8	14
3		90	14.33	644.88	14	Set of present	9	14
4		95	15.12	718.51	12	Set of present	9	13
5	Above 100	110	17.51	963.27	16	Set of present	10	16
6		130	20.70	1345.45	18	Set of present	7	16

Table 38. Floristic diversity/ Importance value index of *Cynometra beddomei* within the sampled plots : Karamanayar

(List of individuals With G≥30cm represented)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARPACEAE	0.068	0.074	0.186	0.328
2.	*Hopea parviflora*	DIPTEROCARPACEAE	0.058	0.071	0.168	0.298
3.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.058	0.076	0.016	0.152
4.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.058	0.068	0.012	0.139
5.	*Cinnamomum malabatrum*	LAURACEAE	0.039	0.045	0.033	0.118
6.	*Diospyros buxifolia*	EBENACEAE	0.029	0.028	0.060	0.117
7.	*Vitex altissima*	VERBENACEAE	0.029	0.031	0.050	0.111
8.	*Myristica malabarica*	MYRISTICACEAE	0.039	0.042	0.026	0.108
9.	*Artocarpus hirsutus*	MORACEAE	0.029	0.022	0.050	0.102
10.	*Canarium strictum*	BURSERACEAE	0.039	0.025	0.036	0.101
11.	*Psydrax dicoccos*	RUBIACEAE	0.039	0.042	0.009	0.091
12.	*Diospyros candolleana*	EBENACEAE	0.029	0.039	0.010	0.080
13.	*Dimocarpus longan*	SAPINDACEAE	0.029	0.034	0.016	0.079
14.	*Otonephelium stipulaceum*	SAPINDACEAE	0.029	0.031	0.018	0.079
15.	*Poeciloneuron indicum*	CLUSIACEAE	0.019	0.019	0.037	0.077
16.	*Antiaris toxicaria*	MORACEAE	0.019	0.011	0.043	0.074
17.	*Terminalia bellirica*	COMBRETACEAE	0.019	0.017	0.034	0.071
18.	*Elaeocarpus serratus*	ELEAEOCARPACEAE	0.029	0.019	0.017	0.066
19.	*Hopea ponga*	DIPTEROCARPACEAE	0.019	0.022	0.020	0.063
20.	*Garcinia gummi-gutta*	CLUSIACEAE	0.019	0.022	0.014	0.057
21.	*Lophopetalum wightianum*	CELASTRACEAE	0.019	0.014	0.020	0.054
22.	*Knema attenuata*	MYRISTICACEAE	0.019	0.022	0.009	0.052
23.	*Garcinia morella*	CLUSIACEAE	0.019	0.017	0.010	0.046
24.	*Flacourtia montana*	FLACOURTIACEAE	0.019	0.019	0.003	0.043
25.	*Caryota urens*	ARECACEAE	0.019	0.014	0.002	0.036
26.	*Holigarna arnottiana*	ANACARDIACEAE	0.009	0.011	0.009	0.030
27.	*Cinnamomum malabatrum*	LAURACEAE	0.009	0.008	0.010	0.028
28.	*Ficus racemosa*	MORACEAE	0.009	0.005	0.013	0.028
29.	*Cynometra beddomei*	FABACEAE	0.009	0.005	0.002	0.027
30.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.009	0.008	0.008	0.027
31.	*Hopea erosa*	DIPTEROCARPACEAE	0.019	0.005	0.001	0.026
32.	*Aphanamixis polystachya*	MELIACEAE	0.009	0.011	0.004	0.025
33.	*Calophyllum calaba*	CLUSIACEAE	0.09	0.008	0.005	0.024
34.	*Drypetes venusta*	EUPHORBIACEAE	0.009	0.008	0.005	0.023

34.	*Polyalthia fragrans*	ANNONACEAE	0.009	0.008	0.004	0.022
35.	*Dipterocarpus indicus*	DIPTEROCARPACEAE	0.009	0.008	0.004	0.022
36.	*Chukrasia tabularis*	MELIACEAE	0.009	0.008	0.004	0.022
37.	*Syzygium* sp	MYRTACEAE	0.009	0.008	0.003	0.021
38.	*Tabernaemontana alternifolia*	APOCYNACEAE	0.009	0.008	0.002	0.021
39.	*Pterocarpus marsupium*	FABACEAE	0.009	0.005	0.002	0.017

Table 39. Population structure of within the sampled and non sampled area of *Cynometra beddomei* : Kallar

(List of individuals with G≥ 10 cm present)

Sl. No.	gbh class	gbh (cm)	r (cm)	Basal Area (cm^2)	Basal Cover (m)	Age phase	First branching Seen at (m)	Height of Stand (m)
1	10-50	22	3.50	38.53	6	Set of future	1.5	3
2		35	5.57	97.41	6	Set of future	3	6
3	50-100	70	11.14	390.09	12	Set of present	8	12
4		90	14.33	644.88	14	Set of present	7	13
5	Above 100	420	66.87	14040.81	20	Set of present	6	20

Table 40. Floristic diversity/ Importance Value Index of *Cynometra beddomei* within the sampled plots : Kallar

(List of individuals With G≥30cm)

Sl. No.	Species	Family	rf (%)	rd (%)	rD (%)	IVI
1.	*Vateria indica*	DIPTEROCARPACEAE	0.066	0.084	0.187	0.339
2.	*Xanthophyllum arnottianum*	POLYGALACEAE	0.057	0.097	0.021	0.176
3.	*Hopea parviflora*	DIPTEROCARPACEAE	0.038	0.035	0.073	0.148
4.	*Baccaurea courtallensis*	EUPHORBIACEAE	0.057	0.059	0.021	0.138
5.	*Myristica beddomei*	MYRISTICACEAE	0.047	0.051	0.026	0.125
6.	*Artocarpus hirsutus*	MORACEAE	0.028	0.023	0.054	0.106
7.	*Vitex altissima*	VERBENACEAE	0.028	0.030	0.044	0.103
8.	*Drypetes venusta*	EUPHORBIACEAE	0.028	0.028	0.045	0.102
9.	*Dysoxylum malabaricum*	MELIACEAE	0.028	0.023	0.045	0.097
10.	*Cinnamomum malabatrum*	LAURACEAE	0.028	0.033	0.032	0.094
11.	*Terminalia bellirica*	COMBRETACEAE	0.019	0.017	0.056	0.093
12.	*Diospyros buxifolia*	EBENACEAE	0.028	0.023	0.035	0.087
13.	*Knema attenuata*	MYRISTICACEAE	0.028	0.033	0.015	0.077
14.	*Lophopetalum wightianum*	CELASTRACEAE	0.019	0.017	0.037	0.074
15.	*Schleichera oleosa*	SAPINDACEAE	0.028	0.030	0.012	0.071
16.	*Holigarna arnottiana*	ANACARDIACEAE	0.028	0.023	0.017	0.069
17.	*Macaranga peltata*	EUPHORBIACEAE	0.028	0.028	0.010	0.066
18.	*Hydnocarpus pentandra*	FLACOURTIACEAE	0.028	0.025	0.011	0.065
19.	*Syzygium sp*	MYRTACEAE	0.019	0.020	0.020	0.059
20.	*Olea dioica*	OLEACEAE	0.019	0.015	0.024	0.058
21.	*Humboldtia decurrens*	FABACEAE	0.028	0.025	0.003	0.058
22.	*Dimocarpus longan*	SAPINDACEAE	0.019	0.020	0.013	0.053
23.	*Garcinia morella*	CLUSIACEAE	0.019	0.020	0.012	0.051
24.	*Garcinia gummi-gutta*	CLUSIACEAE	0.019	0.017	0.013	0.050
25.	*Polyalthia fragrans*	ANNONACEAE	0.019	0.020	0.010	0.050
26.	*Poeciloneuron indicum*	CLUSIACEAE	0.009	0.010	0.027	0.047
27.	*Diospyros candolleana*	EBENACEAE	0.019	0.017	0.009	0.046
28.	*Alstonia scholaris*	APOCYNACEAE	0.009	0.007	0.021	0.038
29.	*Caryota urens*	ARECACEAE	0.019	0.012	0.005	0.037
30.	*Mallotus tetracoccus*	EUPHORBIACEAE	0.019	0.012	0.005	0.037
31.	*Wrightia tinctoria*	APOCYNACEAE	0.019	0.012	0.001	0.033
32.	*Persea macrantha*	LAURACEAE	0.009	0.007	0.013	0.030
33.	*Elaeocarpus serratus*	ELAEOCARPACEAE	0.009	0.010	0.006	0.026
34.	*Ficus sp*	MORACEAE	0.009	0.007	0.009	0.026
35.	*Canarium strictum*	BURSERACEAE	0.009	0.005	0.010	0.025
36.	*Stereospermum colais*	BIGNONIACEAE	0.009	0.010	0.005	0.025

37.	*Hopea ponga*	DIPTEROCARPACEAE	0.009	0.007	0.005	0.0224
38.	*Paracroton pendulus*	EUPHORBIACEAE	0.009	0.007	0.004	0.021
39.	*Cynometra beddomei*	FABACEAE	0.009	0.007	0.003	0.020
40.	*Lagerstroemia microcarpa*	LYTHRACEAE	0.009	0.005	0.006	0.020
41.	*Aporosa cardiosperma*	EUPHORBIACEAE	0.009	0.007	0.003	0.020
42.	*Nothopegia sp*	ANACARDIACEAE	0.009	0.007	0.002	0.020
43.	*Sterculia guttata*	STERCULIACEAE	0.009	0.007	0.001	0.018
44.	*Ficus hispida*	MORACEAE	0.009	0.007	0.001	0.018
45.	*Hydnocarpus macrocarpa*	FLACOURTIACEAE	0.009	0.005	0.002	0.017

Plate 11. *Cynometra beddomei* - Population structure


Habit and Habitat: Different views from Karamanayar forest



Habit and Habitat: Different views from Peruvannamuzhi forest


Habit and Habitat: Different views from Thamarassery forest

Plate 12: *Cynometra beddomei* - Population structure.

Habit and Habitat: Different views from Kallar forest

Habit and Habitat: Different views from Kakkayam forest.

Soil sample collection

Laying quadrat

4.2. 2. Population dynamics

4.2.2.1. Vegetative phenology

Flushing along with matured leaves has been observed from the month January to March. Young foliages were observed as light brown gradually turned to reddish brown and yellowish green and finally to dark green in colour.

4.2.2.2. Reproductive phenology

(Profuse flowering was not recorded for the species *in situ* during three year study period except one tree located at Kakayam site had shown stray flowering during the year March 2016 and January 2017. Therefore, data was deficient to project reproductive phenology of the species).

Around two weeks were taken from bud to full bloom in axillary clusters. Fruit phenology extended from March to September (7 months). The young fruits are smooth in texture, dark brown in color and on maturity turned into light brown and texture becomes rough. Few fruiting primordia abscission was noted *in situ* whereas, 40-50% primordia fall *ex situ*. Mature fruit is a pod, has 28-30 mm length and 23-25 mm breadth and weighs 9-12 gm. 1 kg of fruits weighs 100-120 number. During the course of maturity, fruits were severly found infested by a beetle, *Alcidodes* sp. indet (Coleoptera: Curculionidae).

The adult female pierce into the surface of the developing fruits by using its mandible and lays a single egg inside the seed with its ovipositor. The egg hatches within a week. The larva started feeding on the internal contents of the seed around the hole in which the eggs were laid. The grubs during their development fed on both the cotyledons and embryo. The larvae were 'C' shaped, measuring up to 9-10 mm in length, white in colour. The larvae were found feeding inside the seed for a period of about 20 - 25 days. The pupation period lasted for 12-15 days. The pupae resembled the adult in appearance. The adult emerged out of the circular hole made on the fruit surface. The adults were stout with strong mandible, elongate, oval, black in colour and light brown stripes running alternately throughout the length of the elytra. The fresh adults developed from the pupae were found less active. It was estimated that 80% of the seeds were destroyed by the weevil incidence in a fruit year of the tree. Even the minor damages to the vital part of the embryo like the radicle or hypocotyls may rapidly cause the death of the seed.

Natural regeneration

Out of 273 seedlings counted under an enumerated area of 3.5 ha representing five forest areas; 63 nos. (23%) were under the category of established seedlings and 210 nos. (77%) included under un-established (Table 41 &42).

Table 41. *C.beddomei* : Details of seedlings recorded in the population areas

Forest areas	Sampled area (Ha.)	Total seedlings (Nos.)	Seedling height	
			Established (>1 m)	Unestablished (<1 m)
Thamarassery	0.7	25	8	17
Kakkayam	0.7	64	14	50
Peruvannamoozhi	0.7	125	32	93
Karamanayar	0.7	50	5	45
Kallar	0.7	9	4	5
Total	3.5	273	63	210

Table 42. *C.beddomei* : Statistical analysis of seedlings recorded in the forest areas

Forest areas	Mean	SD	SE
Thamarassery (Unestablished <1m)	48.25	20.02	4.54
Thamarassery (Established >1m)	115.42	10.15	3.78
Kakkayam (Unestablished <1m)	36.95	13.13	1.87
Kakkayam (Established >1m)	138.65	19.15	4.64
Peruvannamuzhi (Unestablished <1m)	35.21	17.43	2.45
Peruvannamuzhi (Established >1m)	137.64	30.14	5.30
Karamanayar (Unestablished <1m)	36.86	19.83	2.94
Karamanayar (Established >1m)	128.32	19.96	7.56
Kallar (Unestablished <1m)	16.24	2.03	1.20
Kallar (Established >1m)	134.97	22.42	7.38

Reproductive Constraints

- Assume long intervals in peak flowering (During three year field study, no peak flowering was recorded except one individual showed stray flowering in a few branches).
- High abscission of fruiting primordia noticed during stray flowering *in situ* and *ex situ* conditions point towards ineffective pollination.
- Seed pest infestation.
- Low percent of prereproductive individuals recorded (17%) indicated the declining trend of the populations.

Plate 13. *Cynometra beddomei* : Population dynamics

Vegetative phenology : Stages of leaf flushing

Stages of leaf maturity

Habit showing views of inflorescence

Plate 14. *Cynometra beddomei* : Population dynamics

Habit showing fruiting primodia **Abscissed fruting primodia**

Fruit phenology : Developing stages

Fruit phenology: Stages of fruit maturity

Plate 15. *Cynometra beddomei* : Fruit phenology and seed infestation showing life forms of *Alcidodes* sp. indet.

Fruit development

Matured Fruits

L.S of fruit

Infected fruits

A view of Pupa

Adult beetle emerging

Adult weevil: *Alcidodes* sp. indet.

4.2.3. Climatic and Edaphic factors

Climatic and edaphic data of the species from respective sites viz., Thamarassery, Peruvannamuzhi, Kakkayam Karamanayar and Kallar were collected in three seasons of the year and tabulated. Average values of climatic data such as atmospheric temperature (maximum and minimum) atmospheric humidity and rainfall of each season is presented (Table 43, 44, 45, 46 and 47). Similarly, soil samples from three levels were collected and data on texture, pH, nutrients etc were recorded. The results among the five population sites revealed that pH values in the study sites varied from strongly to moderately acidic. The N content ranged from moderate to high (320-695 kg/Ha); low content in P (2- 10 kg/ha)) and a moderate to high K content (157- 550 kg/ha) for the species. Soil moisture content and soil temperature of each season were also noted to understand the edaphic environment of species (Table 48, 49, 50 51 and 52).

Table 43. Climatic data: Thamarassery

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	34	22	55	82
Monsoon	28	23	62	81
Winter	32	22	70	92

Table 44. Climatic data: Peruvannamoozhi

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	34	22	55	82
Monsoon	28	22	62	81
Winter	32	22	70	92

Table 45. Climatic data: Kakkayam

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	34	21	55	82
Monsoon	28	22	62	81
Winter	32	22	70	92

Table 46. Climatic data: Karamanayar

Season	Atm. Temperature (°C)	Night Temperature (° C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	30	24	60	70
Monsoon	26	22	70	78
Winter	28	20	74	88

Table 47. Climatic data: Kallar

Season	Atm. Temperature (°C)	Night Temperature (°C)	Atm. Humidity Day (%)	Atm. Humidity Night (%)
Summer	29	24	64	74
Monsoon	24	22	77	88
Winter	27	20	70	84

Table 48. Edaphic data: Thamarassery

season	Soil Level	Texture	p^H	N (kg/ha)	P (kg/ha)	K (kg/ha)	Temp. (^oC)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Sandy loam Loam	5.6 5.3 5.6	510.2 468.1 515.3	3.0 4.6 2.8	350.6 230.5 208.4	25	21.6
Monsoon	Surface Middle Bottom	Silt loam Sandy loam Loam	4.4 4.8 5.2	630.2 520.1 513.2	6.2 5.3 3.8	484.1 518.6 282.4	21	30.2
Winter	Surface Middle Bottom	Silt loam Sandy loam Loam	5.7 5.6 5.8	450.5 433.6 392.5	4.6 6.4 3.6	270.6 157.5 300.4	20	24.4

Table 49. Edaphic data: Peruvannamoozhi

season	Soil Level	Texture	p^H	N (kg/ha)	P (kg/ha)	K (kg/ha)	Temp. (^oC)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Sandy loam Loam	5.6 5 5.2	500 498.1 520.6	2.0 2.6 2.3	340.6 220.5 202.4	24	20.6
Monsoon	Surface Middle Bottom	Silt loam Sandy loam Loam	4.3 4.6 5	650.2 510.1 523.4	6.2 4.3 2.8	480.1 510.6 292.4	20	31.2
Winter	Surface Middle Bottom	Silt loam Sandy loam Loam	5.3 5.2 5.0	440.5 436.6 398.5	3.6 2.4 2.6	250.6 197.5 290.4	19	25.4

Table 50. Edaphic data : Kakkayam

season	Soil Level	Texture	pH	N (kg/ha)	P (kg/ha)	K (kg/ha)	Temp. (°C)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Sandy loam Loam	5.8 6 5.4	510.3 500.1 490.2	2.5 3.5 3.6	336.4 200.5 208.4	23	21.5
Monsoon	Surface Middle Bottom	Silt loam Sandy loam Loam	4.8 5 5.5	630.2 515.8 503.1	6.8 5.3 3.8	476.1 520.6 296.4	21	30.2
Winter	Surface Middle Bottom	Silt loam Sandy loam Loam	5.4 5.8 5.1	450.6 416.5 396.1	4.6 2.3 2.1	240.6 200.5 230.4	20	24.6

Table 51. Edaphic data : Karamanayar

season	Soil Level	Texture	pH	N kg/ha)	P kg/ha)	K kg/ha)	Temp. (°C)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Silt clay Silt clay loam	4.6 4.9 4.2	445.3 378.1 320.6	4.9 4.6 3.3	240.6 190.5 202.4	22	17.12
Monsoon	Surface Middle Bottom	Silt loam Silt clay Silt clay loam	4.4 4.7 5.2	450.2 415.1 393.4	10.2 4.3 5.5	180.1 310.6 192.4	21.5	27.2
Winter	Surface Middle Bottom	Silt loam Silt clay Silt clay loam	4.8 5.6 4.9	640.5 600.6 598.5	2.6 3.4 5.4	270.6 257.5 190.7	22	20.4

Table 52. Edaphic data: Kallar

season	Soil Level	Texture	p^H	N (kg/ha)	P (kg/ha)	K (kg/ha)	Temp. (^oC)	Moisture (%)
Summer	Surface Middle Bottom	Silt loam Sandy loam Loam	5.6 5.9 5.8	529.6 695.1 620.6	8.0 6.6 3.3	300.6 320.5 212.4	23	19.6
Monsoon	Surface Middle Bottom	Silt loam Sandy loam Loam	4.7 5.6 5.2	640.2 530.1 423.4	7.2 7.3 4.8	470.1 550.6 392.4	17	30.2
Winter	Surface Middle Bottom	Silt loam Sandy loam Loam	5.3 5.6 5.9	470.5 486.6 498.5	5.6 3.4 3.6	350.6 189.5 270.4	18	22.4

4.2.4. Conservation strategies

4.2.4.1. Vegetative propagation

Aged branch cuttings were found difficult for rooting, however, young stands of 3 -5 year old have shown rooting success. The auxins IBA 3000 ppm resulted in 75% rooting within 60-75 days. The ramets had shown 100% survival. Though control set of cuttings produced 75% rooting success, the number and length of roots were comaparatively poor and also took long duration for rooting (4-5 months).

In air layering, young plants of 3-4 years old showed 60% success with the aid of IBA 1000 ppm within 2-3 months. The control set did not respond for rooting (Table 53& 54).

Table 53. Vegetative propagation through Stem cutting in *Cynometra beddomei*

Treatment (ppm)	Rooting (%)	Mean no. Of roots (Mean ±SD) (cm)	Mean length of Roots (Mean ± SD) (cm)	Survival of Rametes (%)
Control	75	1±0	3.4±1.0148	66
IAA 1000	50	1.5±0.7071	2.66±0.5773	50
1AA 3000	25	1±0	2.5±0	100
IAA 5000	0	-	-	-
IBA 1000	50	2.5±0.707107	3.25 ±1.0606	50
IBA 3000	75	3.33±1.1547	4.26 ±1.1529	100
IBA 5000	0	-	-	-
NAA 1000	25	1±0	4 ±0	100
NAA 3000	50	1.5 ±0.7071	3.4±0.8544	50
NAA 5000	0	-	-	-

Table 54. Vegetative propagation through air layering in *Cynometra beddomei*

Sl. No	No of layering	Treatment/Control	Rooting (%)	Survival (%)
1	4	Control	Nil	Nil
2	4	IAA 1000	Nil	Nil
3	4	IAA 3000	50	100
4	4	IBA 1000	60	100
	4	IBA 3000	50	100
5	4	NAA 1000	40	100
7	4	NAA 3000	50	100

Plate 16. *Cynometra beddomei* : Conservation

View of air layering in natural stands

Air layering success

Stem rooting success

View of rooted plants

Views of seed germination

Established planting stock

4.2.4.2. Seed propagation

The ripened fruits were collected from Kakkayam forests. The seeds were analyzed for initial moisture content (along with attached fruit coat) for viability and germination studies. The seeds were found tolerant to desiccation and at the same time sensitive towards chilling condition. Therefore, the seeds were categorized as intermediate type. The fresh seeds with initial moisture content of 51% resulted in 100% germination within 23-32 days using river sand as the sowing medium in nursery conditions. In normal conditions, seeds (fruits) lost their viability after 40-45 days when moisture content drops down to 38-40% with 40% germination (Table 55). The seeds have shown dormancy.

In order to break the dormancy, seed pre-treatments were tried. Among various trials, 100 percent seed germination within 18-29 days was noted when the seeds were water soaked over night, which was 5-6 days earlier than the control sets.

Table 56. Desiccation v/s. Moisture content on *Cynometra beddomei* seeds

Seed Type/MC	Condition	Container	Date of treatment	MC (%)	Germination (%)
Fresh seeds (51%)	Open room temperature	Open tray	05.08.15	51	100
			08.08.15	46	80
			10.09.15	42	80
			22.09.15	38	40
			25.09.15	35	0
			29.09.15	33	0
			05.10.15	31	0

4.2.5. Restoration

A total of 40 seedlings were planted at Kakkayam and adjacent Charangad forest areas. One and half year old establishesd polybagged seedlings having an average height of 9-27cm were planted.

Kakkayam

Forty seedlings of 1.5 year old were planted at Orukuzhy and Charangad areas at Kakkyam forest. The mean height of seedlings during planting was 9cm and the maximum height was 27cm. The

seedlings showed 86% survival rate after 6 months of planting along with average height of 13cm and maximum height of 30cm.

***Ex situ* planting**

Fifteen seedlings were planted in KFRI Arboretum, Peechi Campus; FRC, Velupadam and at Sub centre, Nilambur. The mean seedling height during planting was 12cm and the maximum height was 22cm. The seedlings showed 80% survival after 6months.

Table 57. Restoration of *Cynometra beddomei* : Details of seedling establishment, growth and survival

Sl No.	Planting site	Date of planting	No. of seedlings planted	Average height during planting (cm)	Average height after 6months (cm)	Survival after 6 months (%)
1.	Kakkayam	18.10.16	40	14	18.85	86
2.	KFRI - Arboratum	18.08.16	5	13	17.64	60
3.	FRC-Velupadam	16.08.16	5	14	18.6	100
4.	KFRI Sub-center Nilambur	21.09.16	5	16	19.1	80

Plate 17. *Cynometra beddomei:* Restoration



Planting site -a view **Seedling planting** **Planted seedling**



Growing seedlings and evaluation at Kakkyam forest



Planting *ex situ* : FRC Velupadam; Sub- centre Nilambur; Arboretum, Peechi Campus

Table 58. Restoration: Location details

Site No.	Status	Name of site	Geographic coordinates	Altitude (m)
1.	*In-situ*	Kakkayam Peruvannamuzhi Range, Kozhicode Dt.	Lat: 10^0 02′ 35.2″ N. Long: 76^0 50′ 9.4″ E.	512
2.	*Ex-situ*	KFRI-Arboretum,Peechi, Trichur Dt.	Lat: 10° 31' 47" N. Long: 76° 22' 7.5" E.	45
3.	*Ex-situ*	KFRI-Subcenter, Nilambur, Malappuram Dt.	Lat: 11^0 17′ 52.9″ N. Long: 76^0 14′ 56.8E.	39
4.	*Ex-situ*	KFRI-FRC, Velupadam, Trichur Dt.	Lat: 10^0 26′ 12.4″ N. Long: 76^0 21′ 28.4″ E.	106

5. DISCUSSION AND CONCLUSION

The populations of the two target species studied such as *Cynometra beddomei* and *Kingiodendron pinnatum* are generally facing high degree of habitat loss and observed their distribution as fragmented and isolated throught the State. The *K.pinnatum* shows larger extent in occurrence in the Kerala part of the Western Ghtas. Whereas, *Cynometra beddomei* projected restricted distribution of populations, north and southern part of the State.

The high degree of fragmentation of populations and habitats is often resulted the diversity loss in a forest ecosystem which would lead to the endangerment of species (Zhu *et al*. 2004; Bhatt *et al.* 2015). Further, the small and isolated populations are generally prone to biparental inbreeding and chances for reduction in genetic variation are high for such species.. Maintenance of genetic variation is a prerequisite to adapt changing environments of the species and to develop resistance towards pest as well as disease outbreaks. The loss of genetic variation will gradually lead the species to untimely endangerment and local extinction in due course (Barrett and Kohn, 1991). The limited distribution may also possibile due to lesser level of ecological amplitude and thereby resulted in localized distribution of the species (Krishnamoorthi *et al.,* 2015). Therefore, the two species needs urgent *in situ* conservation measures for the management of populations.

In an ecological analysis of threatened species, age class distribution plays a significant role in estimating population size. The number of adults covering pre reproductive and reproductive individuals determines the population size of a species. The reduction in set of pre reproductive individuals, poor rate in natural regeneration accelerates declining growth rate and low population size of a species (Swarupanandan *et al*., 2013; Jose and Pillai, 2014). The reduction in pre reproductive individuals and natural regeneration of *C. beddomei* found more prone for local endangerment in near future compared to *K.pinnatum.* In a population diversity analyzis, the lower IVI values among the associated species in a given forest landscape point towards poor competitive behavior and poor dominance of the species (Pascal, 1988; Jose, 2001). The extreme low abundance of *C. beddomei* due to lower IVI values point out the low occurrence of the species in the identified forest ecosystems than the moderately lower dominance of *K. pinnatum.* Specialized habitats are prerequisites for the growth and reproduction of endemic and threatened plants (Nayar, 1996; Jose, 2001; Pandurangan, 2003; Swarupanandan *et al*., 2013). The altitude specificity, integrity in species association, spatial and temporal distribution pattern, soil factors etc. are a few factors to meet niche specialities of a rare species. The two target spp., distributed as integral components of the evergreen ecosystems and found growing adjacent

water courses, exhibiting vegetation grouping of *Hopea-Kingiodendron- Vateria* etc. emphazising *in situ* requirements for their better performance.

The reproductive constraints faced by the species are other causes leading untimely endangerment and local extinction of a species (Bawa, 1983; Primack, 1994; Daniel and Jayanthi, 1996; Davy and Jefferies, 1981). The two target species exhibit high level of reproductive complexities as in the form of irregular flowering periodicities, flowering of isolated individuals among populations, stray flowering nature, abscission of fruiting primordia, irregularities in fruit set, seed pest infestation, recalcitrant/ intermediate seed behavior etc. No flowering and fruiting was recorded among the identified populations of *K.pinnatum* during three year period of study whereas stray flowering was observed in certain branches in one tree of *C. beddomei*. Nearly 80% of seeds of *C. beddomei* were found infected by the seed pest, *Alcidodes* sp. indet (Coleoptera: Curculionidae) and causing a significant threat to the natural regeneration of the species (Jose *et al*., 2016). The seed pest infestation in the tropical trees severely affected the germination, subsequently leading to the poor natural regeneration as in *Dipterocarpus retuses* (Senthilkumar *et al.*, 2009), *Cinnamomum sulphuratum* (Manivannan *et al.*, 2010), *Gluta travancorica* (Jose *et al*., 2004), *Humboldtia vahliana* (Jose *et al*.,

2008). The density values of seedlings and saplings are considered as indicator of regeneration potential of the species. The presence of good regeneration potential shows suitability of a species to the environment (Choudhury *et al*., 2007). The poor regenerative ability coupled with seed pest infestation drastically reduced seedling bank for the species *in situ*.

The present study revealed that the extent of occurrence of *K.pinnatum* is found in more than 100 km^2 , area of occupancy in more than 10 km^2 and number of mature individuals in more than 250 numbers, the reversion of conservation status from Endangered (EN) to Vulnerable (VU) in the State is suggested for the species Further, the species displayed fairly good percent of natural regeneration, abundance of mature trees with gbh more than 100cm and better adaptability to medium high elevations in the evergreen ecosystems. But, in *C.beddomei,* even though the extent is greater than 100 km^2, criteria like number of mature individuals (less than 250), area of occupancy (less than 10 km^2), etc. suggest upgrading of conservation status from Endangered (EN) to Critically Endangered (CR) in the region (IUCN, 2012).

In ecological study, both climate and soil factors play a key role in the establishment, growth and reproduction of a species. In plants, the nutrient elements are essential for various purposes such as

chlorophyll synthesis, protein synthesis, lignifications, etc. (Ram *et al*. 2004). Microsite conditions such as atmospheric temperature, humidity, rainfall, etc. can often control germination and subsequent establishment of plant species (Dhaulkhandi, 1996). The variation in these conditions found triggered the initiation and development of leafing, flowering, fruit development, dispersal and regeneration, etc. (Kallarackal and Chandrasekhara, 2008). It was noted that the natural regeneration of *K.pinnatum* at North and South zones were in similar rating whereas a reduction was noticed at Central zone populations. It is estimated that the macronutrients level was comparatively lesser at Central Zone than North and South zones. Since natural regeneration of a species is being affected by the microsite conditions particularly by the avaibility of the soil nutrients, the low soil macronutrients might have affected the regeneration at Central zone (Khumbongmayum *et al*., 2005, Sarkar and Devi, 2014). The soil among the zones exhibited moderate to high content of N, low to moderate content in P and moderate to high K content for the species. Therefore, the habitat conditions including altitude and soil factors identified can be selected for creating new populations of the species *in situ.* (Kerala State Planning Board, 2013).

In, *C. beddomei,* it was noted that the natural regeneration was comparatively better at Peruvannamuzhi and extremely poor at Kallar

site. A moderate count was noted at Kakkayam, Karamanayar and Thamarassery sites. The soil among the populations exhibited a moderate to high content of N and K and low content in P for the species. Therefore, the habitat conditions including altitude and soil factors identified can be selected for creating new populations of the species *in situ.* (Kerala State Planning Board, 2013).

The different methods of vegetative propagation such as rooting of stem cuttings, air layering etc. have shown difficulties in rooting success with aged plants of both *K. pinnatum* and *C. beddomei* as reported in *Hydnocarpus macrocarpa*, *Drypetes malabarica* (Jose and Pillai, 2014); *Gluta travancorica* (Jose *et al*., 2011). However, young stands of these species exhibited better results in rooting with the aid of auxins. The young stem cuttings rooted with comparative success rate with different auxins in *K. pinnatum.* A significant observation is that a moderate level of auxin concentration of IAA 1000 ppm, IBA 1000 and 3000ppm found better rooting performance (100%). The application of auxin might have stimulated the cambial activity in young stands at a higher rate than aged cuttings as reported in *Terminalia chebula* by Jose and Thomas (1998). It is also noted that the auxin was influenced the formation of more number and length of roots compared to the control set. In air layering the auxins generally showed positive effect in rooting in young stands than adult trees (Jose

et. al., 2009). A moderate level of auxin concentration such as IAA 1000, IBA 3000 ppm and NAA at 3000 ppm has resulted in maximum rooting success (100%) in young stands of *K. pinnatum.*

In *C. beddomei,* a moderate concentration of auxin (IBA 3000ppm) exhibited maximum stem rooting of 75% but, all other auxins displayed lower rate in rooting success. Interestingly, control sets exhibited same rooting performance as that of auxins treated, but the number, length including survival of ramets were poor. During air layering, moderate auxin concentration, IBA 1000ppm resulted in maximum success (60%) and all other auxins gave lower rooting. This indicates the specificity and optimum concentration of auxin has a significant role in rooting of the species as reported in *Coscinium fenestratum* (Jose *et al*., 2009).

In *C. beddomei*, seeds with initial moisture content of 51% resulted in 100% germination. However, seeds lost their viability within 1-1.5 months after reaching a critical moisture content level of 38-40% at room conditions. Since seeds are attached to hard fruit coat, desiccation was found tolerant and viability prolonged in ambient conditions. However, seeds were sensitive towards lower temperature conditions as reported in *Gluta travancorica* (Jose and Pandurangan, 2013). The hard fruit coat also extended dormancy of seeds which indirectly enhanced the seed longevity of the species (Anilkumar

et. al., 2010). As the seeds when watersoaked overnight, the germination was found 5-6 days advanced than control as reported in hard fruit coat seeds (Bockarie *et al*., 1993; Ali *et al*., 1997). The paucity of seeds prevented us to carry out in depth seed storage studiesin both species.

During enrichment planting, *K. pinnatum,* showed 85- 92% seedling along with 3-4cm height increment after 6 months of planting *in sit*u. Similarly, in *C. beddomei,* 86% seedling survival was recorded along with 3-4cm height increment after 6 months of seedling planting. The success rate thus indicating the ability and growing preference of seedlings to naturalize in its original habitats (Pandurangan, 2003; Swarupanandan *et al*., 2013; Jose and Pillai, 2014, 2016).

The salient findings of the present study are concluded as follows:

1. *Kingiodendron pinnatum*

1.1. A distribution map of *K. pinnatum* covering 17 major populations in 12 forest areas in Kerala part of Western Ghats was prepared based on GPS coordinates.

1.2. Population structure covering number of adult individuals, gbh classes, basal area, age phase and height of individual trees of target species were analyzed within sampled and non sampled areas of 12 forest ares viz. Kulathupuzha, Poringalkuthu, Kottiyoor, Thamarassery Ghats,

Nadugani Ghats, Kallar, Orukomben, Vazhachal, Karimbani, Aralam, Shendurney and Peruvannamoozhy. Among which additional data on Stratification/ Vertical distribution, Spatial/ Horizontal distribution of populations in three sites representing three zones of the State such as Kulathupuzha (South) Poringalkuthu (Central) and Kottiyoor (North) were generated. A total of 432 adult individuals of the species were enumerated within 168 km^2 which included both sampled and non sampled areas of the 12 forest sites identified for the species.

1.3. Population diversity analysis covering an enumerated area of 21,000 m^2 was carried out in three population sites viz. Kulathupuzha (South) Poringalkuthu (Central) and Kottiyoor (North) representing three zones of the State and relative dominance among associate of the species were estimated.

1.4. Natural seedling regeneration account of three sites representing three zones of the State such as Kulathupuzha (South) Poringalkuthu (Central) and Kottiyoor (North) was recorded into 3064 nos. Out of 3064 seedlings counted under an enumerated area of 2.1 ha, 36% were under the category of established seedlings and 1961 nos. 64% included under un-established.

1.5. Bsed on the distribution and ecological data generated, the reversion of conservation status from Endangered to the Vulnerable (VU) in the State is suggested for the species.

1.6. The long intervals in flowering, individual flowering among population, abscission of fruiting primordia, Low percentage of prereproductive individuals (29%) etc. concern over the reproductive barriers of the species.

1.7. Altogether 29 soil samples representing three season of a year were analyzed with respect to texture, pH, N,P,K, temperature and moisture from three populations representing three zones of the State such as Kulathupuzha (South) Poringalkuthu (Central) and Kottiyoor (North).

1.8. Vegetative propagation by stem cuttings in young stands was achieved with 100% success by the auxins viz. IAA 1000 and IBA 1000 and 3000ppm. Ring air layering succeeded at 100% rate with IAA 1000 ppm.

1.9. The enrichment seedling planting of 1550 seedlings in four population sites recorded with 85-92% success after six months of planting.

2. *Cynometra beddomei*

2.1. A distribution map of *C.beddomei* covering 5 populations in 5 forest areas of Kerala part of Western Ghats was prepared based on GPS coordinates.

2.2. Population structure covering Stratification/ Vertical distribution, Spatial/ Horizontal distribution number of adult individuals, gbh classes, basal area, age phase and height of individual trees of target species were analyzed within sampled and non sampled areas of 5

forest ares viz., Peruvannamuzhi, Thamarassery Ghats, Kakkayam, Kallar and Karamanayar. A total of 59 adult individuals of the species were enumerated within 24 km^2 which included both sampled and non sampled areas of the 5forest sites identified for the species.

2.3. Population diversity analysis covering an enumerated area of 35,000 m^2 was carried out in five population sites viz. Peruvannamuzhi, Thamarassery Ghats, Kakkayam, Kallar and Karamanayar and relative dominance among associate of the species were estimated.

2.4. Natural seedling regeneration account was recorded. Out of 273 seedlings counted under an enumerated area of 3.5 ha representing five forest areas; 63 nos. (23%) were under the category of established seedlings and 210 nos. (77%) included under un-established

2.5. Based on the distribution and ecological data generated, an upgradation of conservation status from Endangered to the Critically Endangered (CR) in the State is suggested for the species.

2.6. The long intervals in flowering, individual flowering among population, abscission of fruiting primordia, Seed pest infestation, Low percentage of pre reproductive individuals (17%) etc. concern over the reproductive barriers of the species.

2.7. About 80% of matured fruits were found infested by *Alcidodes* sp. indet. (Coleoptera : Curculionidae).

2.8. Altogether 45 soil samples representing three season of a year from the five populations were analyzed with respect to texture, pH, N,P,K, temperature and moisture.

2.9. Vegetative propagation through stem cuttings in young stands achieved with 75% success with IBA 3000ppm. Ring air layering succeeded at 60% rate with IBA 1000 ppm.

2.10. The intermediate category of seeds with 51% initial mc exhibited 100% germination. The seeds found lose viability at 38-40% mc with 40% germinability. The seeds have shown 40-45 days viability period under ambient conditions.

2.11. The enrichment seedling planting of 40 seedlings in two population sites and 15 seedlings *ex situ* recorded with 80- 86% success.

6. Recommendations

Identification of isolated populations of target species at inaccessible forest areas, long intervals in flowering episodes, low fruit set, etc. creates lacuna in data generation and subsequent incompletion of followup studies envisaged. The present study has no exception, where we couldn't observe peak flowering of target species during three year field study. In this backdrop, followup studies are recommended viz.

6.1. The reproductive phenological studies to be continued for the two species. We couldn't observe peak flowering during three year project period and data thereby lacking.

6.2. Seed biological studies of the two species to be continued except base line data generated for *C. beddomei* .

6.3. Large scale plant production is required for creating new populations of *C.beddomei.*

6.4. Post restoration monitoring is required to assess the survival of planted seedlings *in situ*.

6.5. Genetic variability studies of *C.beddomei* to be initiated as an additional objective as populations of the species are narrowly distributed and confined in isolated niches. Besides to these, species exhibited irregularities in flowering and fruiting episodes and overall dwindling nature of populations.

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