KFRI Research Report No. 526 ISSN 0970-8103

Population evaluation and development of propagation protocol for three Rare, Endangered and Threatened (RET) trees from Kerala part of Western Ghats

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Somen C.K.
Jose P.A.
Sujanapal P.
Sreekumar V.B.

KFRI

Kerala Forest Research Institute, Peechi, Thrissur, Kerala
(An Institution under Kerala State Council for Science Technology and Environment, Sasthra Bhavan, Thiruvananthapuram)

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(Final Report of project KFRI 611/11)

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June 2017

Project Particulars

1. Title of the project	:	Population evaluation and development of propagation protocol for three rare endangered and threatened (RET) trees from Kerala part of Western Ghats
2.Department/ organization implementing the project	:	Kerala Forest Research Institute, Peechi.
3. Principal Investigator		Dr. C.K. Somen Tree Physiology Department Kerala Forest Research Institute
4. Co – investigators		Dr. P. A. Jose Dr. P. Sujanapal Dr. V. B. Sreekumar Kerala Forest Research Institute, Peechi, Thrissur.
5. Project Fellow		R.R. Rajesh
5. Name of the funding agency		Plan Grant of the Kerala Forest Research Institute, Peechi.

Contents

Acknowledgements

We would like to thank Dr. K. Swarupanandan and Dr. R.C. Pandalai who encouraged us to proceed with maximum number of RET species where propagation is needed. The study was made possible with the generous support, kind co-operation and selfless facilitation by a number of Institutions and dignitaries. We place on record our sincere thanks to each of the agencies and personnel.

Let us thank Dr. K.V. Sankaran, former Director of the Kerala Forest Research Institute, for giving full support, taking the project for approval of the Research Council and giving necessary financial support. Continued support was facilitated by Dr. P.S. Easa, during the period of his charge as Director of the Kerala Forest Research Institute.

We offer our immense gratitude to the Wildlife Warden/Divisional Forest Officers and Range Officers, Foresters of various Ranges / WLS, Staff of the various Divisions of Kerala Forest Department Kerala, who offered unparallel help and co-operation for field investigations and surveys.

Research works of Dr. N. Sasidharan, Emeritus Scientist, was of immense help for identifying the locations of some species, characters for identifying the species etc. He also provided details of the RET plants and gave light to the works done in various Institutions including the works done in Swaminathan Foundation for Research at Wayanad. His suggestions were very much useful to us and it is duly acknowledged .

Dr. Jose Kallarackal, Emeritus Scientist, provided valuable suggestions and permitted us to take the help of Mr. T. J. Roby, Research Associate, for solving the remote sensing aspects and helping in field studies. We are very much thankful to both of them.

We gratefully acknowledge the immense support given by Dr. Mukteshkumar, Dr. K.K. Seethalakshmi and Dr. T. Surendran former Scientists of KFRI. Administrative support provided by Registrar and Deputy Registrar of KFRI in selecting staff and financial dealings is gratefully acknowledged. We acknowledge our sincere thanks to KFRI library and herbarium staff. The drivers of various jeeps needs special thanks for taking us to remote forest areas.

Thanks are due to Mr. R.R. Rakesh, Project Fellow, who travelled throughout the forests of Kerala for taking plots, measurements, identification of plants, monitoring populations and analyzing data. Thanks are also due to Mrs. M.K. Sowmya, C.J. Lakshmi for involving in discussions, Technical Assistants of Botany, Silviculture and Physiology divisions, for their assistance in field surveys, collection of plant material for propagation. Mr. K. Rajan, Nursery man and field workers of KFRI Field Research Centre, Velupadam helped us to germinate the seeds and to plant seedlings in the field. Editorial scrutiny done by Dr. K.A. Sreejith, helped us to improve the draft report and is gratefully acknowledged. We are very much thankful to the Research Co-ordinator Dr. E.A. Jayson and Dr. E.M. Muraleedharan and Dr. N. Sasidharan for their editorial comments on the final draft report.

Abstract

Intensive field investigations were carried out to study population structure, distribution and reassessment of conservation status for three RET species viz., *Aporosa bourdillonii* Stapf., *Drypetes confertiflora* (Hook f.), and *Inga cynometroides* (Bedd.) Bedd. Ex. Baker; in different forests of Kerala based on the available literature and herbarium references. The habitat conditions and various threats existing in the habitats of the species were studied during the period, 2011–2014. Each population was marked out using a Global Positioning System (GPS) and a distribution map was prepared. Quantitative analysis of vegetation viz., relative frequency, relative density, relative dominance and Importance value index was performed. Diversity indices such as Simpson's index and Shannon's index [H'] were also computed. Seed collection, processing, storage, germination and viability were studied. Vegetative propagation of different aged stem cuttings of two species, where seeds are found difficult to germinate, were performed with the aid of growth regulators.

Populations of *A. bourdillonii* were declining where human interference are very high in their habitats. Population analysis indicated that the species have low dominance and poor representation facing extremely high risk of threat in the wild. Semi hardwood cuttings with 2 or 3 leaves, treated with Indole Butyric Acid (2000 ppm) solution were found to be successful for vegetative propagation

As *D. confertiflora* is lacking IUCN citation, this taxon has to be assessed for the IUCN Red List. Studies show that the population of *D. confertiflora* is diminishing towards a total of less than 250 mature individuals. Phytosociological analysis reveals that the species have poor representation in its natural habitats and the

species is recommended to include in the "Endangered" category of IUCN. Seeds of *D. confertiflora* have high moisture content and germinate without much delay. Semi hardwood cuttings of *D. confertiflora* treated with different concentrations of growth regulators can induce rooting.

Inca cynometroides, a small critically endangered tree, was rediscovered from the type locality Rosemala, Kollam District, Kerala. Instead of 100 mature trees reported earlier, we could locate only 50 mature trees in this area. During our survey, another population of the species *I. cynometroides* were found grow along the banks of Kallar river in Trivandrum forest Division at an elevation of 250 m along the wet slopes of evergreen forests. This species qualifies the IUCN criteria for "Critically Endangered". Semi hard wood cuttings treated with Indole Acetic Acid (2000 ppm) were can be used for root induction.

The present study reveal that the populations of the three species are diminishing and facing immense threats of destruction. Among the candidate species, *A. bourdillonii* and *I. cynometroides* are facing extremely high risk of extinction in the wild and meet the IUCN criteria for " Critically Endangered" whereas the third species, *D. confertiflora* is facing a very high risk of extinction in the wild in the near future. Population restoration after studying the ecology and biology, by supplementary regeneration, could be an adaptive strategy to combat the declining populations either by introducing vegetatively propagated saplings or nursery-grown seedlings to compensate the lack of natural regeneration.

1.0 Introduction

Our study area belongs to the Kerala part of Western Ghats, which is a mega-biodiversity centre of the world with different types of forests and plant species. Covering nearly five per cent of the country's total land area, Western Ghats contributes more than 27 per cent of country's plant species with high level of endemism ranging from 25 to 60 per cent in various taxa (Pascal, 1992). According to Johnsingh (2001), approximately 63 percent of India's woody evergreen taxa are endemic to the Western Ghats. Looking towards the loss of biodiversity of Western Ghats, the reasons are many, but mainly pressures of poverty and population growth really contribute to it (Myers, 1988). The Western Ghats support 4050 native plant species with 497 species belonging to RET categories deserving immediate conservation strategies (Sasidharan 2003). Scientific evidence strongly indicates that the current rate of extinction is much higher than the natural rate of the past.

Among the RETs, population evaluation and subsequent reassessment on the threat status of a species, have now become essential to prioritize conservation and management programs. The information regarding the extent of distribution, area of occupancy, regenerative capacities etc. are critical to ascertain the conservation status of the species. In order to identify which habitats and species should be protected from degradation and exploitation, conservation biologists require information about specific locations. Mapping the locations of such areas is critical, and GIS have become an important tool in conservation efforts. The mapping of the species distribution using GIS tool in its geographical range is inevitable to relocate the species for future programs.

Propagation and multiplication of plant materials are important tools in modern conservation oriented programmes. This also involves selection of plus trees for

the development of superior clones of true to type. Many RET plants of the Western Ghats, particularly the trees do not have proper propagation methods and are facing untimely endangerment *in-situ.* Recognising the limitations of both *in-situ* and *ex-situ* methods of biodiversity conservation, Kerala Forest Department is now planning to establish a number of large plant conservatories along representative altitudinal and latitudinal regimes, where all species of the eco-climatic zone are to be re-introduced. Re-introduction, therefore stems to be a robust strategy for species recovery, whether it is in protected areas or in any plant conservatories. However, the strategy could be achieved only when alternate methods of propagation and multiplication process are developed for the RET species.

The present study assess the population structure, distribution and conservation status of selected RET species as per IUCN criteria with special focus on tree species in Kerala part of Western Ghats. The project also aims to develop ideal clonal and seed propagation methods and subsequent multiplication as a part of the effective conservation, management and utilization of these depleting plant resources for posterity. The selected RET species for the current study are listed below (Table-1).

Table.1 Species selected for the study

No.	Species	Family	Status
1.	*Aporosa bourdillonii* Stapf.	Euphorbiaceae	EN
2.	*Drypetes confertiflora* (Hook f.)	Euphorbiaceae	EN
3.	*Inga cynometroides* (Bedd.) Bedd. Ex. Baker	Leguminoseae/ Mimosaceae	EN

1.1 Objectives

The main objectives of the study are:

- Survey and exploration of selected three RET trees in the Kerala part of Western Ghats.
- To study the population structure and reassess the conservation status as per IUCN criteria.
- To standardize the clonal and seed propagation protocol for planting stock production.

2.0 Methodology

2.1 Selection of sites and study area

The present study has been carried out in Kerala part of Western Ghats which occupies the southwest corner of peninsular India, lying between $8^{o}18'$N - $12^{o}4'$ N latitude and $74^{o}52'$ - $77^{o}22'$ E longitude. The state of Kerala is bounded by the Western Ghats mountains in the east and the Arabian Sea in the west. The area is ecologically sensitive to development and has been declared as an ecological hotspot in 1988 through the efforts of an ecologist, Norman Myers. Though this area covers barely five percent of India's land, 27% of all species of higher plants in India (4,000 of 15,000 species) are found here. Almost 1,800 of these are endemic to the region. The Western Ghats has over 5000 species of flowering plants, 139 mammal species, 508 bird species and 179 amphibian species. Several of these species are not found elsewhere in the world and are endemic to this region. It is likely that many undiscovered species live in the Western Ghats. At least 325 globally threatened species occur in the Western Ghats. With an average of 10,000 km^2 original patches of tropical forests, Kerala holds about 10,035 species of plants altogether including vascular, non-vascular and lower groups in its pristine habitats (Nayar, 1997). Kerala part of Western Ghats covers 3213.24 Km2 of forest including 5 National parks, 17 Wild Life Sanctuaries and 1 Community Reserve.

2.2 Species description

Information on the candidate species were gathered by surveying relevant literature viz. Beddome (1873); Gamble and Fischer (1915-1935); Mohanan (1984); Sanjappa (1991); Sasidharan (1997, 1998) including local and regional floras,

regional herbaria (Calicut University; Kerala Forest Research Institute; Madras Herbarium) etc.

2.2.1 *Aporosa bourdillonii* Stapf.

Aporosa bourdillonii Stapf in Hook.'s Ic. 23,t. 2204. 1892; Gamble, Fl. Pres. Madras 1309(916). 1925; Chakrab. & Gangop., Journ. Econ. Tax. Bot. 17:158.1993; Subram., Fl. Thenmala Div. 337. 1995; Sasidh. & Sivar., Fl. Pl. Thrissur For. 393. 1996.

Tree, 5-8 m high; young shoots adpressed tawny-pilose; branchlets brown, terete, 1-4 mm thick initially pilose, finally glabrous. Leaves oblong or elliptic-oblong or narrowly so, 10-17 cm long, 3-5.5 or broad, rounded or acute at base, entire along margins, obtusely acuminate or caudate (acumen or cauda 10-20 mm long) at apex, chartaceous to thinly coriaceous, glabrous above, sparsely ochraceous-pilose on midnerve and lateral nerves beneath (particularly towards base), dark brown above when dry, paler beneath; lateral nerves 6-9 pairs, obscure to faint above, prominent beneath, ascending, arcuate; tertiary nerves indistinct above, faint beneath, laxly reticulate to scalariform; petioles 10-20 mm long, 1-2 mm thick, puberulous to glabrous; stipules lanceolate-oblong, 5-8 mm long. Male inflorescence up to 1 cm long. Flowers: sepals 3, ovate-oblong, ca 1 x 0.5 mm; stamens 2-3, ca 1.2 mm long. Female: inflorescence 1-few together; peduncles 5-10 mm long, 1-flowered (at the apex), tawny-hirsute; bracts at intervals on axis, sepaline. Flowers:: sepals 4, oblong-lanceolate, 4-5 x 1.5-2 mm; ovary ovoid, 4-5 mm diameter, 3-locular, with numerous linear-subulate processes (processes up to 2 mm long, tawny-hirtellous); styles 3, 4-7 mm long, bifid, thick, hirtellous. Capsules ovoid, 15-20 x 15-20 mm, 3-locular, processes linear, up to 3 mm long.

Local name: Malavetti.

Fl& Fr: March-April.

Tree is locally known as **Malavetti**. This species is endemic to southern Western Ghats (Chakrabaty & Gangopadhyay 1993) and the species is very rare in evergreen forests of low altitudes. The species is Endangered and said to be a poorly collected species, reported from a few scattered locations as per IUCN (IUCN, 2013). It is a small tree found distributed in areas adjacent to the water course in evergreen forests at altitudes ranging between 200-250m. The species is hardly attended for ecological and conservational studies.

2.2.2 ***Drypetes confertiflora*** (Hook. f.)

Drypetes confertiflora (Hook.f.) Pax & Hoffm. in Engl., Pflanzenr. Euphorb.-Phyllanthoid.-Phyllanth. 246. 1922; Sasidh. & Sivar., Fl. Pl. Thrissur For. 401. 1996; Sasidh., Fl. Shenduruny WLS 286. 1997; Chakrab. et al., Journ. Econ. Tax. Bot. 21: 259. 1997. Cyclostemon confertiflorus Hook.f., Fl. Brit. India 5: 341. 1887; Gamble, Fl. Pres. Madras 1302(911). 1925.

Trees, to 25 m high; bark greyish, smooth; blaze dull yellow; branchlets glabrous, brownish, terete. Leaves simple, alternate; stipules lateral, small, caducous; petiole 5-12 mm long, stout, grooved above, glabrous; lamina 6-22 x 2.5-7.5 cm, oblong or elliptic-oblong, base oblique, apex obtusely acuminate, margin entire or distantly serrate, glabrous and glossy, coriaceous; lateral nerves 7-10 pairs, pinnate, prominent, intercostae reticulate, prominent. Flowers unisexual, axillary but usually in clusters on old wood; male flowers: pedicels 4-5 mm long; tepals 5-6, 4-6 × 3.5-5.5 mm, suborbicular, white, ciliate; stamens 15-20; filaments glabrous; inserted around disc; anthers oblong; disc impressed, large, glabrous, radiately ribbed with inflexed marginal lobe; female flowers: nearly sessile; disc

cupular; ovary superior, brown tomentose, 2-celled, ovules 2. Fruit a drupe, 3.5-5 cm across, subglobose, somewhat flattened, pubescent, 2-locular; endocarp fleshy.

Distribution : (Southern Western Ghats) Thrissur, Shenduruny. (Evergreen and semi-evergreen forests)

Alt: 300- 600 msl.

Fl & Fr: Feb- May.

D. confertiflora is a very rare tree, found in the evergreen forests, growing to a height of 25 meters and is endemic to south India (Chakrabaty et al.1997). It flowers during November. The trees are found growing along the sides of streams or other water bodies. The wood of *D. confertiflora* is moderately hard and used locally. The fruits are usually eaten by Sambar Deers. Seeds are also reported to be used as fish poison. This taxon has not yet been assessed for the IUCN Red List, but is in the Catalogue of Life (IUCN 2013).

2.2.3 *Inga cynometroides* (Bedd.) Bedd. Ex. Baker

Inga cynometroides (Bedd.) Bedd. ex Baker in Hook. f., Fl. Brit. India 2: 306. 1876; Gamble, Fl. Pres. Madras 435(309). 1919; Mohanan, Fl. Quilon Dist. 167. 1984; Sasidh., Higher Plants of Indian Sub-Continent 8: 212. 1998.

Calliandra cynometroides Bedd., Fl. Sylv. t. 317. 1873; Sanjappa, Legumes Ind. 62. 1992; Sasidh., Fl. Shenduruny WLS 112. 1997. Glabrous small trees; to 6 m high; branches spiny; bark greyish-brown. Leaves alternate, bifoliate, stipulate; stipule spiny; rachis 18-35 mm long, stout, pulvinate, glabrous, with a gland at the tip on upper side in between two leaflets and an appendage on the lower side; leaflets 2, petiolule upto 3 mm, estipellate; lamina 4.2-12 x 1.5-5.5 cm, elliptic, elliptic lanceolate or elliptic-oblong, halves dissimilar, base obliquely attenuate, apex acute or acuminate, margin entire, glabrous, coriaceous; lateral nerves 4-8

pairs, pinnate, prominent; intercostae reticulate. Flowers bisexual or unisexual, in axillary solitary globose heads, 16-18 mm long; calyx 3-lobed; petals 3, greenish-yellow, connate, valvate; stamens many, long-exserted, monadelphous; anthers minute; ovary sessile; style filiform; stigma minute. Fruit a pod, 8-12 x 1.5-1.8 cm, pale brown, subsessile, linear, falcate, with a hook at the tip, base narrowed suture thickened, glabrous; seeds 5-6, orbicular or obovate, compressed.

Distribution: Southern Western Ghats (Kerala) Shenduruny -Evergreen forests and Kallar.

Fl & Fr: March- Dec

Alt: 300- 600 msl.

I. cynometroides is a small tree belonging to Leguminoseae family, sub family Mimosaceae and is endemic to Kerala (Sasidharan, 1998), growing in evergreen forests. Beddome was able to collect specimens in 1870 from Rosemala, Kollam District, Kerala. After the type collection, it has not been collected and is placed under indeterminate threat category (Nayer & Sastry, 1990). Repeated surveys lead to relocate the species from the type locality after about 100 years (Sasidharan, 1998). Following the revised IUCN Red list categories (IUCN, 1997) this species was considered as critically endangered or possibly extinct (Nayar, 1997).

2.3. Survey, selection of plots and sampling

Intensive field investigations were undertaken by our research team in the different sites of Kerala part of Western Ghats using the data collected from the literature (Beddome,1873); (Gamble and. Fischer,1915-1935); (Mohanan 1984); (Sanjappa 1991); (Sasidharan 1997, 1998) and various herbaria. Habit, habitat, altitudinal range, population size, distribution range, impacts of multiple threats etc. have been studied for two years in the habitat. Population studies conducted by

Chandrasekhara *etal* (2003) and view of Nair TKS (1998) on biodiversity aspects has encouraged us.

The population status of three species *viz. A. bourdilonii, D. confertiflora* and *I. cynometroides,* were documented through extensive field surveys. During 2011–2013, each population were geographically marked with global positioning system (GPS) and a distribution map has been prepared. Natural regeneration of these species were observed and girth at breast height (gbh) was taken for all stems of these species. To determine the girth class distribution of the species, the natural regenerates of *A. bourdillonii* and *I. cynometroides* were grouped into three classes for further analysis. Here, the stems with <10 cm gbh were classified as saplings, 10– 20 cm gbh as sub adults and 20-30 cm gbh as mature trees. For *Drypetes confertiflora,* the stems with < 30 cm gbh were classified as saplings, 30-60 cm gbh as sub adults and stems > 60 cm gbh as mature trees. For studying the phytosociology of the species, quadrates of 33m × 33m size (covering 0.1 ha area) were laid randomly in and around the locations of tree populations of each species. The vegetation is sampled according to the plot method in various strata. Each individual was identified in the field itself (either by botanical name or local name), later confirmed by regional flora. Quantitative analysis of vegetation for frequency, density, relative density and Importance value index were done using ***Invent NTFP*** Version 1.0 (Sivaram *et al*., 2006). Diversity indices such as Simpson's index and Shannon's index [H'] were also computed using formulae. The phytosociological parameters were also worked out for each plot using the formulae (Curtis and M, 1956; Phillips, 1959; Misra, 1968). Importance Value Index (IVI) of each species was derived from the sum of Relative density, Relative frequency and Relative dominance of each of them (Muller-Dombois and Ellenberg, 1974). The Area of occurrence and area of occupancy were estimated

as per IUCN norms. The quadrat data were then processed for quantitative and qualitative analysis to evaluate structural composition and organization of the community. From the quadrat data so obtained from the field, primary and secondary analysis were done. Details of calculation of Density, Frequency, Abundance, IVI (Importance Value Index) and biodiversity indices etc. are given below.

2.3.1 Density (No. of individuals/ha)

Density is defined as the number of individuals of a species in a unit area and is an expression of numerical strength of a species in a community. From the sampling data the density was calculated as follows:

$$\text{Density (D)} = \frac{Number\ of\ individuals\ encountered}{Total\ area\ sampled\ in\ m^2} \times 10{,}000$$

2.3.2 Relative Density (*RDi*)

Relative density is the study of numerical strength of a species in relation to total number of all species and is calculated as:

$$\text{Relative density } (RDi) = \frac{Number\ of\ individuals\ belonging\ to\ species\ i}{Total\ number\ of\ individuals} \times 100$$

2.3.3 Abundance

Abundance is described as the number of individuals per quadrat of occurrence.

$$\text{Abundance (Ab)} = \frac{\text{Total number of individuals}}{\text{Number of quadrats of occurrence}}$$

2.3.4 Frequency

It is expressed as the percentage of occurrence of a given species in the sample plots studied. It denotes the homogeneity of distribution of various species in the ecosystem. For comparison of different communities, frequency is expressed in terms of percentage values (frequency %).

Frequency (Fi)

$$= \frac{Number\ of\ quadrats\ in\ which\ Species\ i\ was\ present}{Total\ number\ of\ quadrats\ sampled} \times 100$$

The species which is well distributed and have a chance of being recorded in any part of the ecosystem will have frequency 100%, while a species which is restricted to a certain areas will be encountered in low frequency values.

Relative Frequency (*RFi*) = $\frac{Fi}{\sum Fi}$

2.3.5 Basal area and Relative Basal Area

Basal area refers to the ground actually occupied by the stems and is one of the chief characters that determine the dominance and the nature of community. As a general rule, high basal area indicates greater dominance. The average basal area and the relative basal area were calculated out of the average diameter of the stem at breast height using the following formulae:

$$Basal\ Area\ of\ trees = \pi r^2$$

$$r = \frac{gbh}{2\pi}$$

Relative Basal Area (RBAi) = $\frac{BAi}{BP} X 100$

Where BAi = Sum of basal area of the trees belonging to a species

BP = Sum of basal areas of all the trees in a plot

2.3.6 Importance Value Index (IVI)

It is used to express dominance and ecological success of any species. IVI provides an overall importance of a species in a community. This index was derived from three characteristics of vegetation *viz*., relative frequency, relative density, and relative basal area as:

Importance Value Index (IVI) = Relative Density (*RDi*) + Relative Frequency (*RFi*) + Relative Basal Area (*RBA*i)

2.4 Biodiversity indices

Diversity lies at the root of some of the most fundamental and exciting questions in theoretical and applied ecology (Magurran, 1988). Krebs (1989) has pointed out that mapping and measuring ecological diversity by qualitative and quantitative are fundamental. Hence standard sampling methods of Muller-Dombois and Ellenberg (1974) also were adopted, to fulfil the objectives.

2.4.1. Simpson's index

Diversity indices incorporate both species richness and evenness to a single value as it takes into account the number of species present as well as the relative abundance of each species. It represents the probability of two randomly selected individuals in the habitat belonging to the same species. If the probability is high, the diversity of the community sampled is low. Simpson's index was the first diversity index used in ecology. The concentration of dominance was determined by Simpson's (1949) index as given below

$$\lambda = \sum_{i=1}^{s} Pi^{2}$$

Where $pi = \frac{ni}{N}$

and *ni* = total number of individual of species *'i'*, and *N* = total number of individuals of all species in the area.

This index varies from 0 to 1 and gives the probability that two individuals drawn at random from a population belong to the same species. If the probability is high, then the diversity of the community sampled is low.

2.4.2. Shannon's index [H']

The Shannon index, H' (also called the Shannon- weaver index or the Shannon - wiener index) is one of several diversity indices used to measure biodiversity. It has probably been the most widely used index in community ecology. The

advantage of this index is that, it takes into account the number of species and the evenness of the species. The index is increased either by having more unique species or by having greater species evenness.

$$H' = -\sum_{i=1}^{r} (p_i \log p_i)$$

Where, $p_i = \frac{n_i}{n}$

Where *ni* = total number of individual of species *'i',* and *N* = total number of individuals of all species in the area.

As in Simpson index by applying calculus, it can be shown that for any given number of species, there is a maximum possible *H'*, $H'_{max} = ln\ (S)$ which occurs when all the species are present in equal numbers.

2.5. Richness indices

2.5.1 *Margalef's index*

$$R = \frac{S-1}{\ln(n)}$$

Where S=Number of species recorded

N=Total number of individuals observed.

2.5.2 Menhinick's index

$$R2 = \frac{S}{\sqrt{n}}$$

where S = Number of species recorded n = Total number of individuals summed over all the species.

The extent of occurrence is the extent of distribution of a species within the shortest continuous imaginary boundary of the species. Area of occupancy is the area occupied by the species within its extent of occurrence wherein the species satisfy its survival.

2.6 Conservation strategies

2.6.1 Seed biological studies

The seed collection, processing in relation to moisture content, storage, germination, extension of viability in different storage conditions were studied as part of long term germplasm conservation of the species. Propagules of the three species were collected from its natural habitat for clonal and seed studies. Freshly collected mature seeds were subjected to viability tests *viz.* Tetrazolium (TTZ) staining test as per ISTA (1998) and Hydrogen Peroxide Test (Ching and Parker (1958).

2.6.1.1 Moisture content

Moisture content of seed samples was determined on fresh weight basis by placing the seeds in hot air oven at 103^0c for 17 hours and is calculated using the formula.

$$\text{Percentage of moisture content} = \frac{(\text{Fresh weight} - \text{Dry weight})}{\text{Fresh weight}} \times 100$$

2.6.2 Seed storage

Seeds samples were stored in three storage conditions 4^0c, 20^0c and room temperature viz.. in polythene bags, closed polycarbonate bottles and open trays. Seeds from all the storage conditions were tested for moisture content and germination percentage at weekly intervals till sixth month. Germination tests were carried out in vermiculate, sand and soil.

2.6.2.1 Tetrazolium Test

For TTZ test, the seeds were soaked in water overnight. The seed coats were then removed and immersed in 1 % Tetrazolium solution (prepared by dissolving 1 g Tetrazolium salt in 100 ml of distilled water) for 48 hours in dark. The colour of the different parts of the seeds was recorded. The staining was classified as light

pink, moderately pink and dark pink and also in terms of parts (plumule, embryonic axis, radicle and cotyledons) stained.

2.6.2.2 Hydrogen Peroxide Test

For Hydrogen Peroxide Test, Seeds were soaked in 1% H_2O_2 solution and incubated in darkness at room temperature for three days and observed. At the end of the third day, H_2O_2 solution was discarded and replaced with fresh solution. Seeds were again incubated in darkness for another three days and evaluated for viability by recording the emergence of radicle.

2.7 Vegetative propagation

Clonal propagation was carried out with three growth regulators using different aged stem cuttings against different concentrations. Stem cuttings of *A. bourdillonii, I. cynometroides and D. confertiflora* were collected from the field and treated with growth regulators including IAA, IBA and NAA. The treated stem cuttings were placed in mist chamber for rooting with vermiculite as medium and the rooting percentage was recorded. Stem cuttings of *A. bourdillonii , I. cynometroides* and *D. confertiflora were* collected from the field in three seasons *viz*; season I (January-April), season II (May-August) and season III (August-December). Semi hardwood leafy shoot cuttings having a length 10-15 cm and 1-2 pairs of leaves intact were prepared. The leaf areas of the cuttings were reduced by trimming away 2 to 3 leaflets of compound leaves. To check any possible fungal attack during propagation, cuttings were treated with 0.05 percent aqueous solution of Bavistin for 30-45 minutes. Then the cuttings were treated with different concentrations of Indole Butyric Acid (IBA), Naphthalene Acetic Acid (NAA) and Indole Acetic Acid (IAA) prepared in solution (Table.2). The treated cuttings

were inserted immediately in vermiculite kept in root trainers and placed in mist chamber for rooting.

Regular misting was provided for 10 seconds at an interval of 30 minutes. Within a period of 20-30 days the cuttings began to sprout and root. Rooting was completed within a period of 60 days and they were transferred to polythene bags filled with sand and soil in equal proportions (1:1) and kept in the hardening room for about 30 days. All the rooted cuttings were properly hardened before being taken to the field.

Table 2. Different concentrations of IBA, NAA & IAA used for the study

Growth Regulators used	Concentrations tested (ppm)		
IBA	2000	3000	5000
NAA	2000	3000	5000
IAA	2000	3000	5000

2.8 Field planting

For field planting an area near the conservation plot of ex-situ semi-evergreen plot at Field Research centre, Palappilly has been selected. Six month old saplings of the three species (30 nos.) were planted with a spacing of 3 meters in 30 cm x 30 cm pits in between naturally growing trees with proper support.

3.0 Results and Discussion

Extensive survey were conducted in the Kerala Part of Western Ghats and distribution maps were prepared using GPS & GIS techniques. Surveys were conducted to Peechi –Vazhani wild life sanctuary, Shenduruny WLS, Aralam WLS, Athirappilly, Vazhachal forest areas, Nellliampathy forests, Parambikulam WLS, Ponmudi forests, Achankoil forests, Neyyar WLS to locate the selected species *Aporosa bourdillonii, Drypetes confertiflora* and *Inca cynometroides* .

3.1 *Aporosa bourdillonii* Stapf.

3.1.1 Habit and Distribution

The species, *A. bourdillonii* is a medium sized tree growing to a height of about 5-8 meters. The usual flowering and fruiting season is during December- April. During the present study, this species is found growing only in Athirappilly-Vazhachal evergreen forests along the shores of Chalakkudy river, Kerala in an altitudinal range of 250 msl**.** The Physical parameters of distribution of *A.* are given in Table 3.

The present survey indicates that population of *A. bourdillonii* is severely fragmented with an estimated area of occupancy less than 100 km^2. The population has been identified only from a single location with less than 50 mature individuals. A total number of 56 individual species were recorded from the whole study area, the Kerala part of Western Ghats of which 37 were mature individuals, 9 were sub adults and 10 were saplings (Fig.2.). Chakrabarty and Gangopadhyay (1993) have reported that the species is endemic to Western Ghats, very rare in evergreen forests of low altitudes.

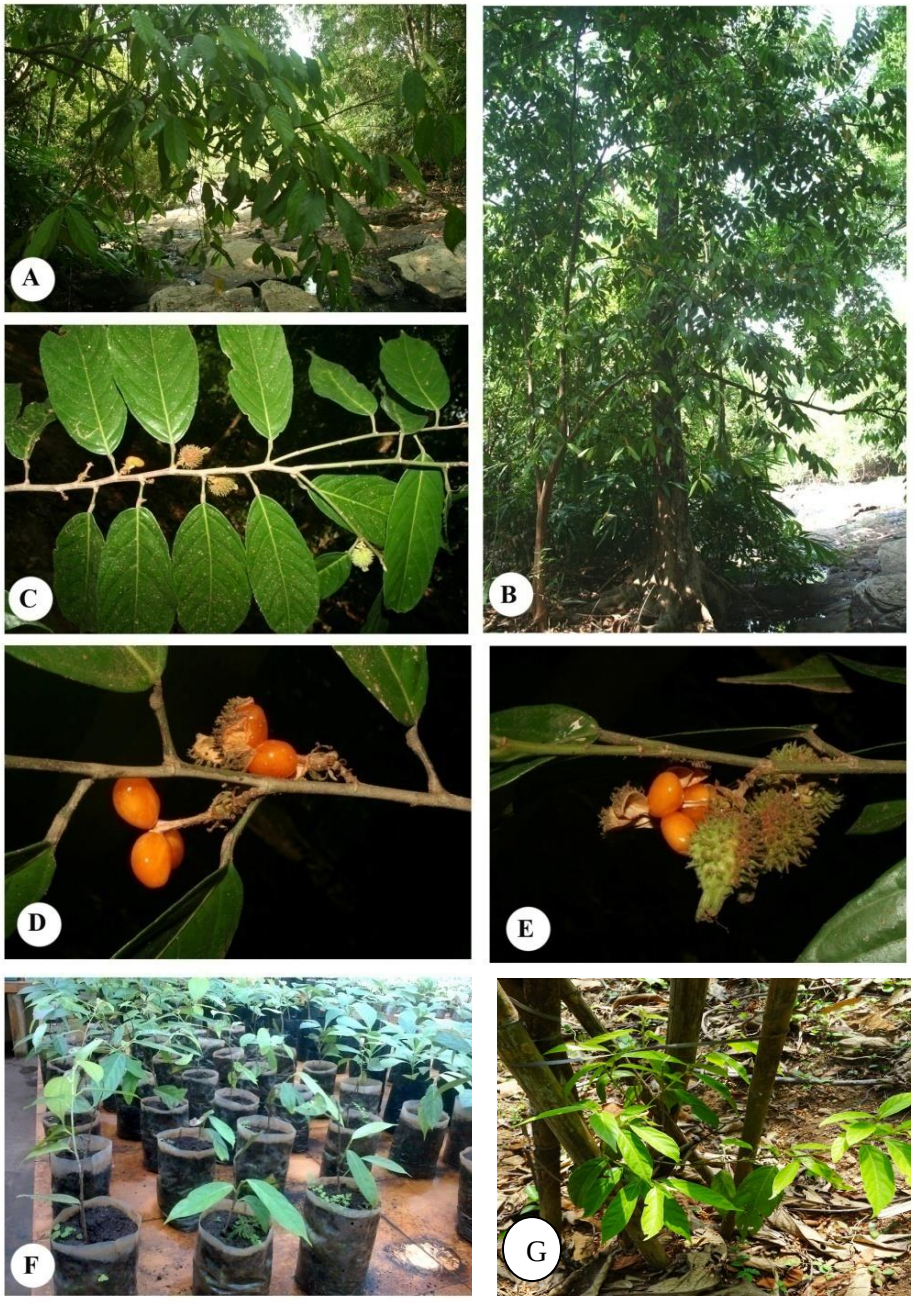
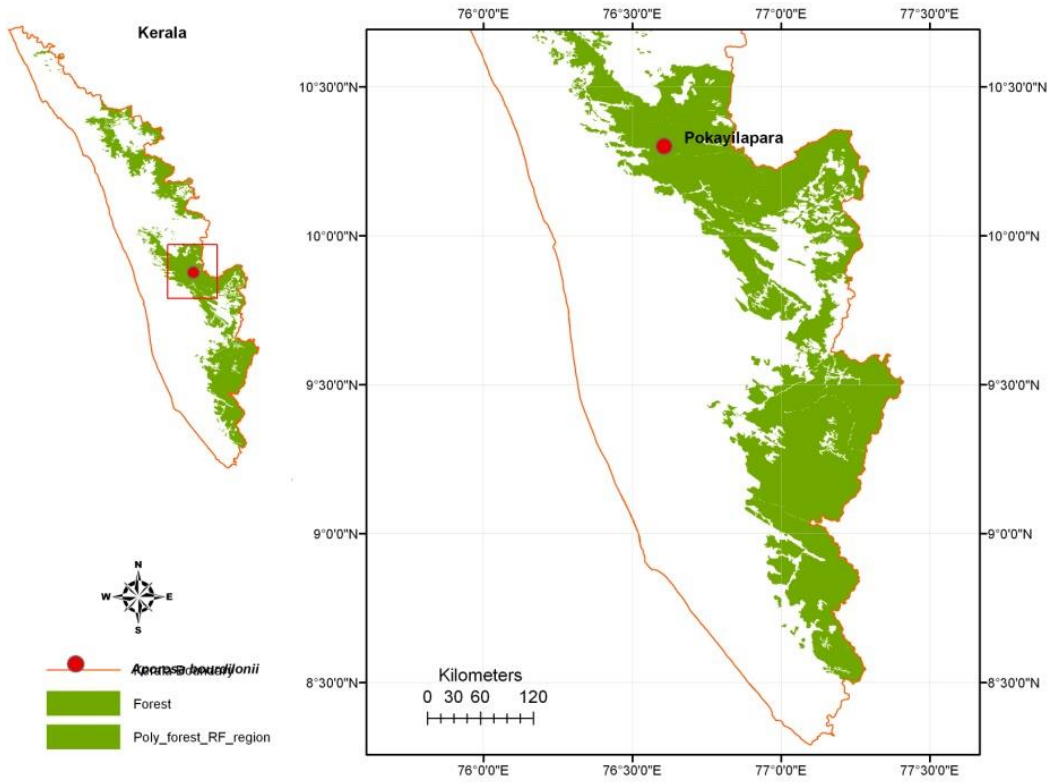


Plate 1. ***A. bourdilonii*** **A-Habitat, B-Habit ,C- Twig with fruit, D&E.-mature fruits, F-Vegetatively propageted seedlings, G - Vegetatively propagated seedlings planted in field.**

Table.3. Distribution of *A. bourdilonii*: Physical parameters

Species	Location	Latitude	Longitude	Vegetation Type	Altitude
Aporosa bourdilonii	**Pokayilappara**	**10.300472**	**76.608083**	**Evergreen**	**250 m**

Fig. 1. Map showing distribution of *A. bourdillonii* in the study area.



The calculated IVI (0.65/hector) of the species *A.* indicates that the species have low dominance and poor ecological success in its natural habitats. During the study about 186 individuals belonging to 51 species under 28 families were recorded from the study area. The family Euphorbiaceae represents highest number of species (9 species), followed by Dipterocarpaceae (4 species), Lauraceae (4 species), Ebenaceae (4species) and Myristicaceae (3 species). Fig.3. represents the percentage of species in different families.

Fig.2. Population structure of *A.* in the study area

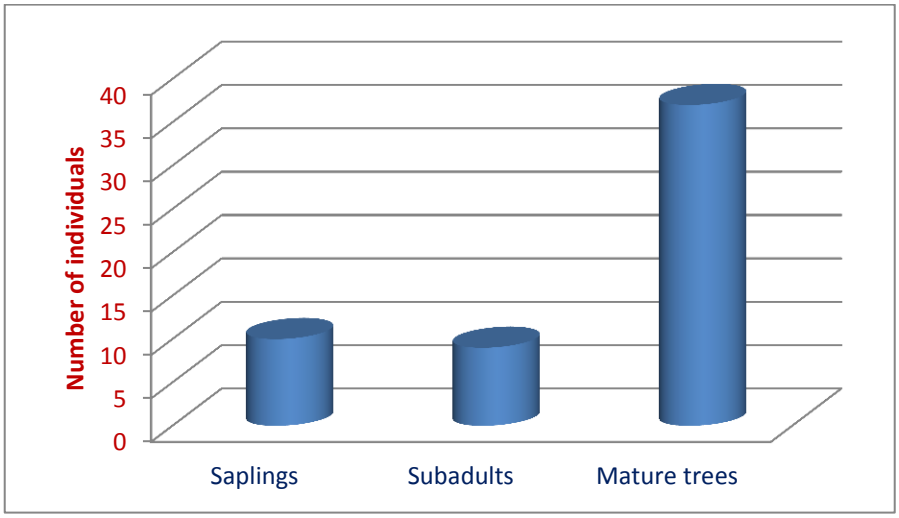
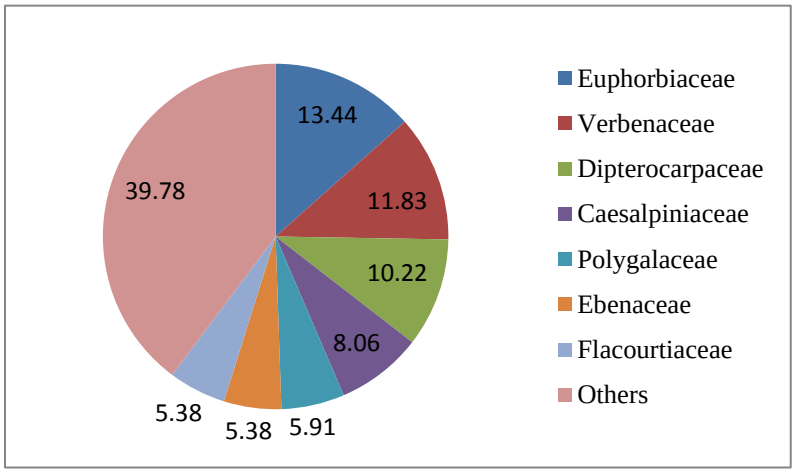


Fig.3- Percentage of species in different families (*A. bourdilonii*)



3.1.2 IUCN status

The present study reveals that the species *A. bourdillonii* is facing threats of destruction leading to a diminishing population. According to IUCN (2013), this species is categorized as Endangered and is said to be a poorly collected species. The species satisfies IUCN criteria B1a+C2b+C for "critically endangered" and hence the status of the species *A. bourdillonii* can be changed from Endangered (EN) to Critically Endangered (CR).

3.1.3 Population structure

Population analysis carried out in the experimental plots having a total area of 4356 Sq.mts in and around the natural habitat of the species, viz Pokayilappara, in the Athirappilly- Vazhachal evergreen forests shows the following details. Diversity analysis indicates that successive tree species mostly associated with *Aporosa bourdillonii* are *Cynometra travancorica*, *Tectona grandis*, *Hopea parviflora* and *Calophyllum polyanthum*. Species density has been found to be maximum for *Tectona grandis* (48.20), followed by *Cynometra travancorica* (34.43), *Xanthophyllum arnotianum* (25.25) and *Hopea parviflora* (25.25). The top ten dominant species in the study area is given in Table.4.

Table 4. Dominant species having highest value of IVI in the study area (*A. bourdilonii*).

Species	No. of individuals	Density (No./ha)	Rel. Density	Rel. Frequency	Rel. Basal Area	IVI
Cynometra travancorica	15	34.43	0.08	0.03	0.16	0.27
Tectona grandis	21	48.20	0.11	0.020	0.07	0.20
Hopea parviflora	11	25.25	0.05	0.03	0.092	0.18
Calophyllum polyanthum	5	11.47	0.026	0.03	0.06	0.12
Xanthophyllum arnotianum	11	25.25	0.05	0.040	0.005	0.10
Myristica beddomei ssp.beddomei	5	11.47	0.026	0.030	0.037	0.09
Hidnocarpus pendadra	8	18.36	0.043	0.030	0.019	0.09
Glochidion ellipticum	7	16.06	0.037	0.04	0.010	0.08
Dysoxylum malabaricum	2	4.59	0.01	0.020	0.057	0.08
Bombax ceiba	4	9.18	0.02	0.020	0.04	0.08

Diversity analysis indicate that *Aporosa* represent 19th position with an IVI of 0.065 (Table 5).

Table 5 Phytosociology ; *Aporosa bourdilonii*

S no	Species	D	RD	F	RF	RBA	IVI
1.	*Actinodaphne malabarica*	2.295684	0.005376	0.25	0.0102	0.00245	0.018
2.	*Alstonia scholaris*	2.295684	0.005376	0.25	0.0102	0.001317	0.017
3.	***Aporosa bourdilonii***	**13.774105**	**0.032258**	**0.75**	**0.0306**	**0.002172**	**0.065**
4.	*Aporosa lindleyana*	13.774105	0.032258	0.5	0.0204	0.008264	0.061
5.	*Baccaurea courtallensis*	4.591368	0.010753	0.5	0.0204	0.001171	0.032
6.	*Bombax ceiba*	9.182736	0.021505	0.5	0.0204	0.041636	0.084
7.	*Calophyllum polyanthum*	11.478421	0.026882	0.75	0.0306	0.069392	0.127
8.	*Carallia brachiata*	4.591368	0.010753	0.5	0.0204	0.02865	0.06
9.	*Cinnamomum malabatrum*	4.591368	0.010753	0.5	0.0204	0.001636	0.033
10.	*Croton malabaricus*	4.591368	0.010753	0.5	0.0204	0.016392	0.048
11.	*Cynometra travancorica*	34.435262	0.080645	0.75	0.0306	0.161644	0.273
12.	*Dimocarpus logan*	2.295684	0.005376	0.25	0.0102	0.000915	0.016
13.	*Diospyros buxifolia*	6.887052	0.016129	0.5	0.0204	0.031485	0.068
14.	*Diospyros sylvatica*	16.06979	0.037635	1	0.0408	0.030396	0.109
15.	*Dipterocarpus bourdillonii*	2.295684	0.005376	0.25	0.0102	0.001936	0.018
16.	*Dysoxylum malabaricum*	4.591368	0.010753	0.5	0.0204	0.057405	0.089
17.	*Elaeocarpus tuberculatus*	11.47842	0.026881	1	0.0408	0.008647	0.076
18.	*Flacourtia montana*	4.591368	0.010753	0.5	0.0204	0.002964	0.034
19.	*Glochidion ellipticum*	16.069789	0.037634	1	0.0408	0.010194	0.089
20.	*Gnetum edule*	2.295684	0.005376	0.25	0.0102	0.001089	0.017
21.	*Hidnocarpus pendadra*	18.365473	0.043011	0.75	0.0306	0.01952	0.093
22.	*Holigarna arnottiana*	6.887052	0.016129	0.5	0.0204	0.030033	0.067
23.	*Holygarna grahamii*	9.182736	0.021505	0.5	0.0204	0.022374	0.064
24.	*Hopea parviflora*	25.252525	0.05914	0.75	0.0306	0.092706	0.182
25.	*Hopea ponga*	4.591368	0.010753	0.5	0.0204	0.002068	0.033
26.	*Ixora bracteata*	2.295684	0.005376	0.25	0.0102	0.001701	0.017
27.	*Knema attenuata*	6.887052	0.016129	0.5	0.0204	0.023258	0.06
28.	*Lagerstroemia microcarpa*	2.295684	0.005376	0.25	0.0102	0.000272	0.016
29.	*Lagerstroemia speciosa*	6.887052	0.016129	0.5	0.0204	0.003049	0.04
30.	*Lea indica*	6.887052	0.016129	0.5	0.0204	0.001225	0.038
31.	*Litsea coriacea*	4.591368	0.010753	0.5	0.0204	0.002478	0.034
32.	*Lophopetallum paniculatum*	4.591368	0.010753	0.5	0.0204	0.001897	0.033
33.	*Macaranga peltata*	2.295684	0.005376	0.25	0.0102	0.005928	0.022
34.	*Madhuca neriifolia*	9.182736	0.021505	0.5	0.0204	0.004975	0.047
35.	*Mallotus philippensis*	2.295684	0.005376	0.25	0.0102	0.000371	0.016
36.	*Myristica beddomei ssp.beddomei*	11.478421	0.026882	0.75	0.0306	0.03781	0.095
37.	*Myristica malabarica*	4.591368	0.010753	0.5	0.0204	0.019599	0.051
38.	*Persea macrantha*	9.182736	0.021505	0.75	0.0306	0.029105	0.081

S no	Species	D	RD	F	RF	RBA	IVI
39.	*Polyalthia fragrans*	11.478421	0.026882	0.75	0.0306	0.006945	0.064
40.	*Strombosia ceylanica*	11.478421	0.026882	0.75	0.0306	0.0173	0.075
41.	*Syzygium cumini*	2.295684	0.005376	0.25	0.0102	0.001936	0.018
42.	*Tectona grandis*	48.209366	0.112903	0.5	0.0204	0.07454	0.208
43.	*Terminalia bellerica*	2.295684	0.005376	0.25	0.0102	0.061246	0.077
44.	*Tetrameles nudiflora*	2.295684	0.005376	0.25	0.0102	0.048392	0.064
45.	*Vateria indica*	11.478421	0.026882	0.5	0.0204	0.003513	0.051
46.	*Viex ulticema*	2.295684	0.005376	0.25	0.0102	0.002034	0.018
47.	*Xanthophyllum arnotianum*	25.252525	0.05914	1	0.0408	0.005971	0.106

During the present study, Species diversity indices such as Simpson's Index (0.03) and Shannon's Index (3.53) were calculated which indicates high diversity of the species in the study area. Shannon-Weiner and Simpson diversity indices also indicate high diversity in the area and are in close relation with the earlier works of Ayyappan and Parthasarathy (1999) and Srinivas and Parthasarathy (2000). The Climax evergreen forests of the Western Ghats have shown Shannon-Weiner indices (H') between 3.6 to 4.3 and Simpson's indices (D) between 0.86 to 0.90 (Rajendraprasad, 1995).

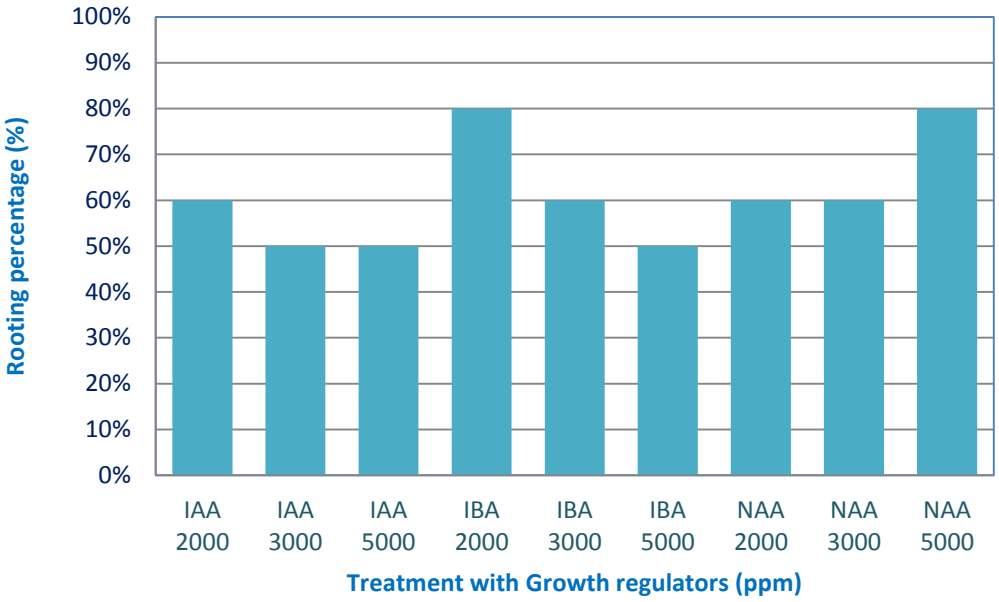
A total number of 56 individual species were recorded from the whole study area, the Kerala part of Western Ghats with low level of regeneration of the species *Aporosa bourdilonii*. The area of occurrence of the species in the forest area was found to be about 2 km^2 and the area of occupancy (area sampled plus non-sampled area) 0. 0.004 km^2 having nearly 40 mature trees occurring in the site, Vazhachal.

3.1.4 Vegetative Propagation

Propagation trials with different concentrations of GRS against type of stem cuttings and season were done in vermiculite medium in mist chamber. The maximum percentage of rooting was achieved with semi hardwood cuttings treated

with IBA-2000 ppm in season I and III (80%), followed by IAA-2000 ppm, in season II and III (60%). This clearly reveals that, IBA 2000 ppm is effective in root induction of semi hardwood leafy cuttings. Semi hardwood cuttings collected from young trees also showed very good success irrespective of seasons. NAA treated cuttings also showed rooting irrespective of the season and type of stem cutting. Maximum percentage of rooting occurred for different treatments is given in Figure.4.

Fig.4. Graph showing maximum percentage of rooting in *A. bourdillonii* with different Growth regulators.



Studies carried out (Richard 1999) in *Prosopis africana* and *Bauhinia rufescens* show similar results obtained during summer months. Semi hardwood cuttings with 2 or 3 leaves, treated with IBA in 2000 ppm solution appears to be a successful GRS treatment for vegetative propagation of the species *A. bourdillonii* for producing sufficient number of propagules. Plantlets raised through cuttings were planted in the field and have shown remarkable establishment (Plate 1- F and G).

3.1.5 Seed Biological Studies

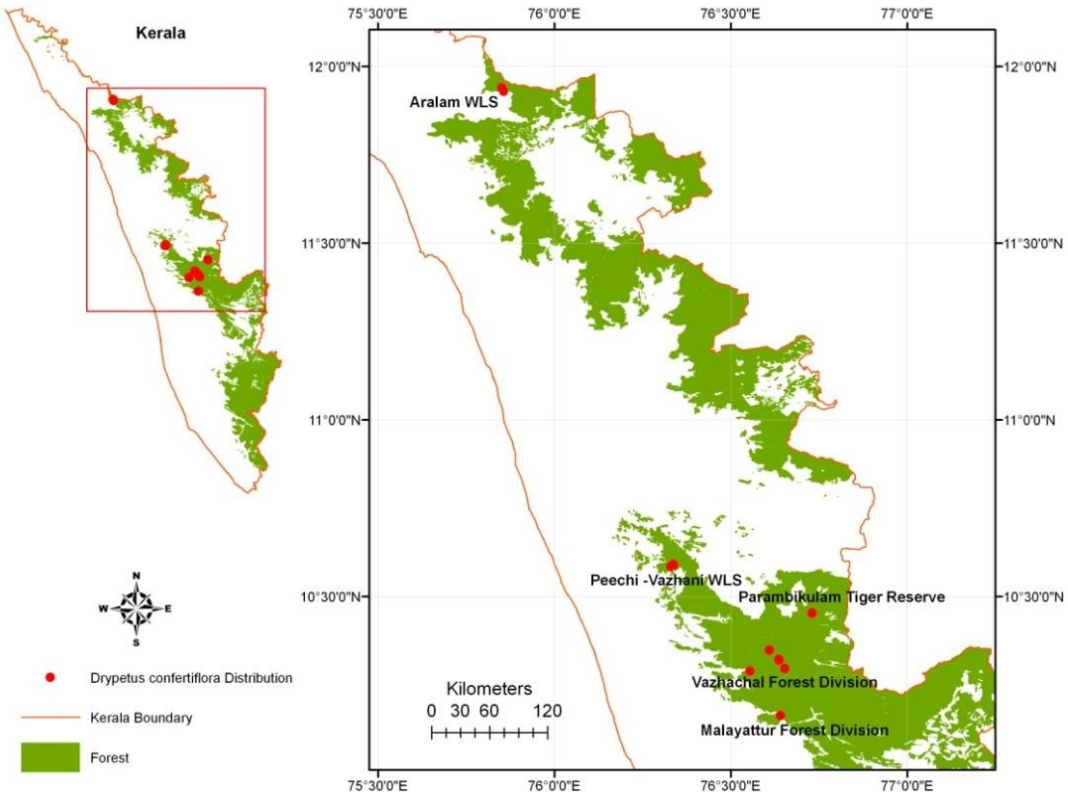
Fleshy fruits of *A. bourdillonii* were collected and checked for seeds. The seeds were tested for viability, but none of them were found viable and did not germinate. Seed biological studies were not possible with the seeds.

3.2 *Drypetes confertiflora* (Hook f.)

3.2.1 Habit and Distribution

Drypetes confertiflora is found growing in Vellanippacha area of Peechi- Vazhani Wild Life Sanctuary, Athirappilly- Vazhachal Forests, Aaralam Wild Life Sanctuary, Parambikulam Tiger Reserve of Kerala State, and Malayatur forest division (Fig- 7). This is an endemic tree species of South Indian Evergreen forests growing up to 25 meters (Plate 2). It flowers during November. Our surveys reveal that the number of mature trees exceed the number of saplings and the total number of sub adults was relatively poor indicating the unsuccessful regeneration of the species in the natural habitat of the species.

Figure .7.Map showing distribution *of Drypetes confertiflora* in the study area.



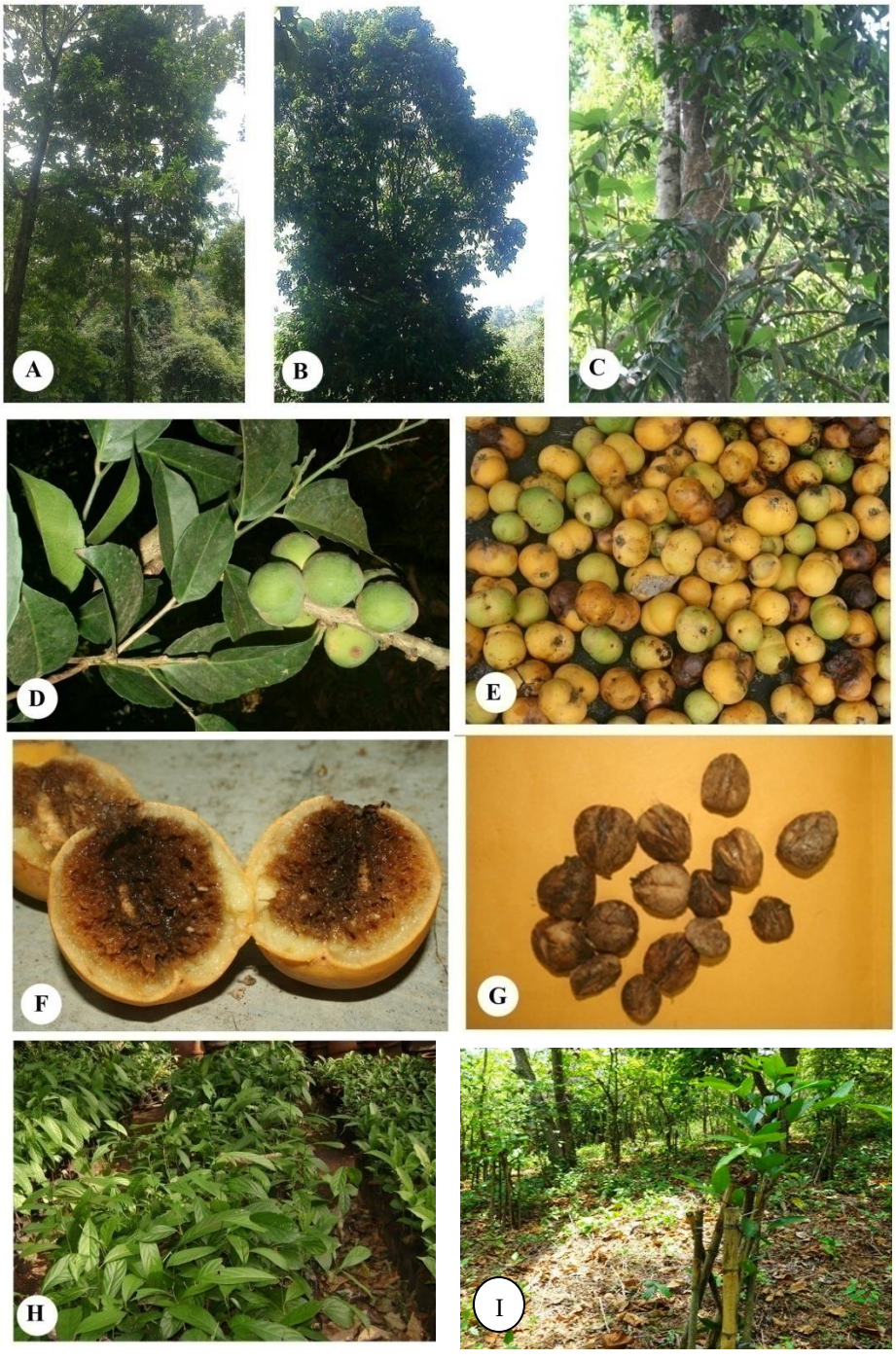


Plate 2. *D. confertiflora* A, B & C-Habit. D-Twig with fruit. E&F-mature fruits, G-Seeds, H -seedlings, I- Seedlings planted in the field.

Table.6. Distribution of *D.confertiflora*: Physical parameters

Species	Location	Latitude	Longitude	Vegetation Type	Altitude
Drypetes confertiflora	**Aralam WLS**	11.9454	75.8336	Evergreen	300 m
	Poringalkuth	10.31815556	76.63761111	Evergreen	150 m
	Peechi- Vazhani	10.58871667	76.339225	Evergreen	250 m
	Malayattoor	10.16196111	76.64171389	Evergreen	250 m
	Vazhachal	10.28744444	76.55561111	Evergreen	200 m
	Parambikkulam	10.45222778	76.73152222	Evergreen	250 m

Flowering, fruiting and seed germination in *D. confertiflora* have been found to be regular. But problems were noticed during the growth stage of saplings to sub adults. The saplings of this species fail to attain further growth which may be due to fungal attack during the transition stage from sapling to sub adult. At the same time, the saplings show no growth problems in the nursery conditions, treated with fungicide. Further studies are needed to ascertain the actual cause behind this phenomenon. Anthropogenic activities like expansion of agricultural activities in forest land and construction of roads and houses in and around forest areas are also causing destruction of the existing population of the species by habitat degradation. As the species yields good quality timber and thus invariably used for furniture, agricultural implements or various other wooden materials, people are cutting the trees for various purposes. Such activities may be adversely affecting the population of seedlings and saplings.

3.2.2 IUCN status

D. confertiflora is very rare in evergreen forests and endemic to south India and this taxon has not yet been assessed for the IUCN Red List (IUCN 2013). During the present study it is noted that the population of *D. confertiflora* is found to be diminishing and a total of 250 mature individuals were recorded from the whole study area, the Kerala part of Western Ghats. Geographic range may be in the form of either B1 (extent of occurrence) or B2 (area of occupancy) or both. The estimated area of occupancy is less than 500 km^2, where the populations are severely fragmented and known to exist in five locations. So according to the present study, the species *D. confertiflora* can be included under the Endangered (EN) category of RET species, as it meets IUCN criteria for endangered species (B1a+B2a+D).

3.2.3 Population Structure

Experimental plots were taken and population analysis were carried out in a total area of 7623 Sq.mts in different locations of Kerala part of Western Ghats. During the study about 502 individuals belonging to 55 species under 29 families were recorded from the study area. Among the families, Euphorbiaceae dominates with 10 species, followed by Dipterocarpaceae (4 species), Elaeocarpaceae (4 species), Lauraceae (4 species) and Myristicaceae (3 species). The Percentage representation of individuals/ species in each families is given in Fig.6.

In the present study, the phytosociological analysis revealed that the species have shown low dominance and poor ecological success in its natural habitats with an IVI value 0.032/hector. IVI values indicate that the most successive tree species in the natural habitats of *D. confertiflora* are *Cynometra travancorica*, *Tectona grandis*, *Tetrameles nudiflora*, *Hopea parviflora* and *Otonephelium stipulaceum*.

Inga cynometroides represent only 44th position with an IVI value of 0.032698 (Table-7).

Fig.6- Percentage of individuals/species in each families in the habitats of D. confertiflora

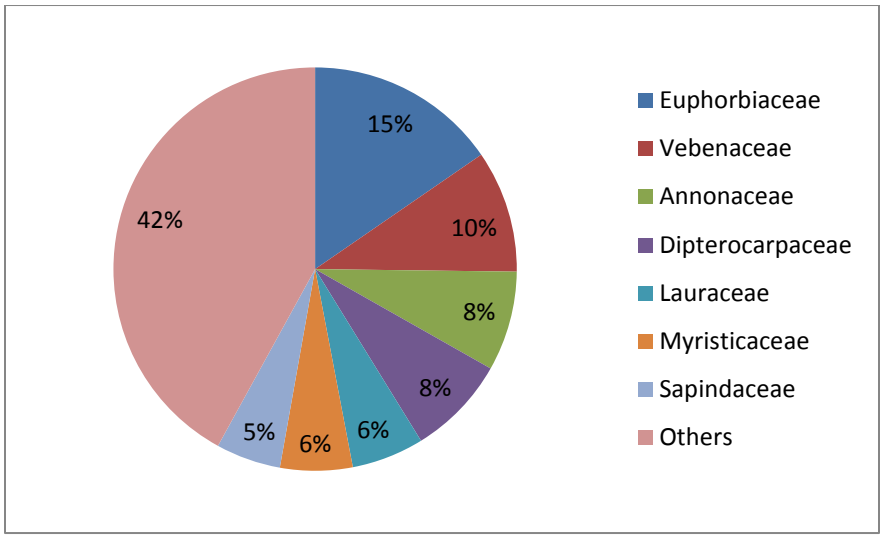


Table-7. Phytosociology - *Drypetes confertiflora*

S.No	Species	D	RD	F	RF	RBA	IVI
1.	*Actinodaphne malabarica*	5.509642	0.001992	0.142857	0.016129	0.001563	0.019684
2.	*Alstonia scholaris*	1.836547	0.003984	0.142857	0.016129	0.001432	0.021545
3.	*Aporosa bourdilonii*	9.182736	0.011952	0.142857	0.016129	0.001252	0.029333
4.	*Aporosa lindleyana*	11.01928	0.011952	0.142857	0.016129	0.004823	0.032904
5.	*Artocarpus hirsutus*	5.509642	0.007968	0.142857	0.016129	0.003356	0.027453
6.	*Baccaurea courtallensis*	14.69238	0.003984	0.142857	0.016129	0.000735	0.020848
7.	*Bombax ceiba*	1.836547	0.011952	0.142857	0.016129	0.03535	0.063431
8.	*Callicarpa tomentosa*	1.836547	0.021912	0.142857	0.016129	0.014235	0.052276
9.	*Calophyllum polyanthum*	1.836547	0.013944	0.142857	0.016129	0.049288	0.079361
10.	*Carallia brachiata*	1.836547	0.003984	0.142857	0.016129	0.016435	0.036548
11.	*Cinnamomum malabatrum*	1.836547	0.00996	0.142857	0.016129	0.002099	0.028188
12.	*Croton malabaricus*	1.836547	0.005976	0.142857	0.016129	0.010426	0.032531
13.	*Cynometra travancorica*	1.836547	0.035857	0.285714	0.032258	0.120359	0.188474
14.	*Dimocarpus logan*	7.346189	0.001992	0.142857	0.016129	0.000482	0.018603
15.	*Diospyros buxifolia*	23.87512	0.007968	0.142857	0.016129	0.021319	0.045416

S.No	Species	D	RD	F	RF	RBA	IVI
16.	*Diospyros sylvatica*	3.673095	0.013944	0.142857	0.016129	0.013	0.043073
17.	*Dipterocarpus bourdillonii*	1.836547	0.001992	0.142857	0.016129	0.00102	0.019141
18.	***Drypetes confertiflora***	**3.673095**	**0.00996**	**0.142857**	**0.016129**	**0.006609**	**0.032698**
19.	*Drypetes venusta*	1.311819	0.031873	0.142857	0.016129	0.020091	0.068093
20.	*Drypetes weightii*	2.623639	0.007968	0.142857	0.016129	0.005756	0.029853
21.	*Dysoxylum malabaricum*	7.870917	0.005976	0.142857	0.016129	0.060113	0.082218
22.	*Elaeocarpus serratus*	7.870917	0.015936	0.285714	0.032258	0.035525	0.083719
23.	*Eleocarpus tuberculatus*	5.247278	0.033865	0.142857	0.016129	0.033062	0.083056
24.	*Flacourtia montana*	2.623639	0.005976	0.142857	0.016129	0.002598	0.024703
25.	*Glochidion ellipticum*	7.870917	0.037849	0.142857	0.016129	0.00973	0.063708
26.	*Holigarna grahamii*	14.430014	0.041833	0.142857	0.016129	0.032496	0.090458
27.	*Hopea parviflora*	9.182736	0.045817	0.285714	0.032258	0.028093	0.106168
28.	*Hopea ponga*	2.623639	0.011952	0.142857	0.016129	0.002819	0.0309
29.	*Hydnocarpus pentandra*	6.559097	0.02988	0.285714	0.032258	0.036388	0.098526
30.	*Ixora bracteata*	3.935458	0.001992	0.142857	0.016129	0.00097	0.019091
31.	*Knema attenuata*	23.612751	0.007968	0.142857	0.016129	0.017923	0.04202
32.	*Lagerstroemia microcarpa*	1.311819	0.007968	0.142857	0.016129	0.010779	0.034876
33.	*Lagerstroemia speciosa*	5.247278	0.01992	0.142857	0.016129	0.011501	0.04755
34.	*Leea indica*	9.182736	0.011952	0.142857	0.016129	0.001363	0.029444
35.	*Litsea coriacea*	1.311819	0.033865	0.142857	0.016129	0.008439	0.058433
36.	*Lophopetallum paniculatum*	6.559097	0.00996	0.142857	0.016129	0.002683	0.028772
37.	*Macaranga peltata*	20.989112	0.025896	0.285714	0.032258	0.025165	0.083319
38.	*Madhuca neriifolia*	5.247278	0.007968	0.142857	0.016129	0.002769	0.026866
39.	*Mallotus philippensis*	3.935458	0.005976	0.142857	0.016129	0.000597	0.022702
40.	*Melia arborea*	10.494556	0.015936	0.142857	0.016129	0.003217	0.035282
41.	*Myristica beddomei ssp.beddomei*	22.300931	0.011952	0.142857	0.016129	0.022317	0.050398
42.	*Myristica malabarica*	3.935458	0.037849	0.142857	0.016129	0.033779	0.087757
43.	*Otonephelium stipulaceum*	24.92457	0.051793	0.285714	0.032258	0.020697	0.104748
44.	*Persea macrantha*	27.548209	0.011952	0.142857	0.016129	0.017148	0.045229
45.	*Polyalthia coffeoides*	30.171848	0.047809	0.142857	0.016129	0.018847	0.082785
46.	*Polyalthia fragrans*	7.870917	0.031873	0.142857	0.016129	0.021801	0.069803
47.	*Stereospermum colais*	19.677292	0.007968	0.142857	0.016129	0.007717	0.031814
48.	*Strombosia ceylanica*	1.311819	0.015936	0.142857	0.016129	0.013761	0.045826
49.	*Syzygium cumini*	5.247278	0.001992	0.142857	0.016129	0.001235	0.019356

S.No	Species	D	RD	F	RF	RBA	IVI
50.	*Syzygium lanceolatum*	5.247278	0.007968	0.142857	0.016129	0.000574	0.024671
51.	*Tectona grandis*	13.118195	0.075697	0.285714	0.032258	0.067179	0.175134
52.	*Terminalia bellirica*	7.870917	0.00996	0.142857	0.016129	0.018496	0.044585
53.	*Tetrameles nudiflora*	22.300931	0.02988	0.142857	0.016129	0.091811	0.13782
54.	*Vateria indica*	6.559097	0.01992	0.142857	0.016129	0.003364	0.039413
55.	*Xanthophyllum arnottianum*	17.053653	0.037849	0.142857	0.016129	0.005413	0.059391
56.	*Actinodaphne malabarica*	5.247278	0.001992	0.142857	0.016129	0.001563	0.019684
57.	*Alstonia scholaris*	3.935458	0.003984	0.142857	0.016129	0.001432	0.021545
58.	*Aporosa bourdilonii*	10.494556	0.011952	0.142857	0.016129	0.001252	0.029333
59.	*Aporosa lindleyana*	7.870917	0.011952	0.142857	0.016129	0.004823	0.032904
60.	*Artocarpus hirsutus*	24.92457	0.007968	0.142857	0.016129	0.003356	0.027453
61.	*Baccaurea courtallensis*	34.107307	0.003984	0.142857	0.016129	0.000735	0.020848
62.	*Bombax ceiba*	7.870917	0.011952	0.142857	0.016129	0.03535	0.063431
63.	*Callicarpa tomentosa*	31.483668	0.021912	0.142857	0.016129	0.014235	0.052276
64.	*Calophyllum polyanthum*	20.989112	0.013944	0.142857	0.016129	0.049288	0.079361
65.	*Carallia brachiata*	5.247278	0.003984	0.142857	0.016129	0.016435	0.036548
66.	*Tetrameles nudiflora*	10.494556	0.00996	0.142857	0.016129	0.002099	0.028188
67.	*Toona ciliata*	1.311819	0.005976	0.142857	0.016129	0.010426	0.032531
68.	*Turpinia malabarica*	5.247278	0.035857	0.285714	0.032258	0.120359	0.188474
69.	*Vateria indica*	49.849141	0.001992	0.142857	0.016129	0.000482	0.018603
70.	*Vitex altissima*	6.559097	0.007968	0.142857	0.016129	0.021319	0.045416
71.	*Xanthophyllum arnottianum*	19.677292	0.013944	0.142857	0.016129	0.013	0.043073

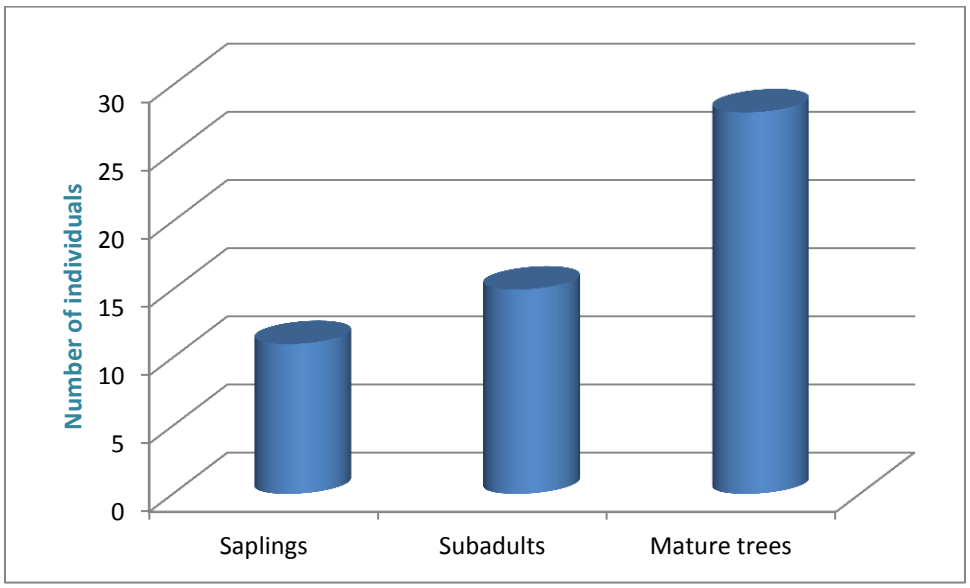
Density of the dominating species were found to be maximum for *Actinodaphne malabarica* (49.84) followed by *Cinnamomum malabatrum* (34.10), *Madhuca neriifolia* (31.48) and *Terminalia bellirica* (30.17). The top ten dominant species in the study area is given in Table.8. The calculated species diversity indices such as Simpson's Index (0.02) and Shannon's Index (3.68) indicate the high diversity in the natural habitats of the species *D. confertiflora*. In the present study, the population of *D.confertiflora* is found to be diminishing with a total of only 54 individual trees in the whole study area of which 28 were mature individuals, 15 sub adults and 11 saplings (Fig-5). The area of occurrence of the species in the

forest area was found to be approximately 10 km^2 and the area of occupancy (area sampled plus non-sampled area) 0.007 km^2 and nearly 50 mature trees were seen in the site.

Table 8. dominant species having highest value of IVI in the study area (*D. confertiflora*).

Species	No. of individuals	Density (No./ha)	Rel. Density	Rel. Frequency	Rel.Basal Area	IVI
Cynometra travancorica	18	23.61	0.03	0.032258	0.12	0.188
Tectona grandis	38	49.84	0.07	0.032258	0.06	0.175
Tetrameles nudiflora	15	19.67	0.02	0.016129	0.09	0.137
Hopea parviflora	23	30.17	0.04	0.032258	0.02	0.106
Otonephelium stipulaceum	26	34.10	0.05	0.032258	0.02	0.104
Hydnocarpus pentandra	15	19.67	0.02	0.032258	0.03	0.098
Holigarna grahamii	21	27.54	0.04	0.016129	0.03	0.090
Myristica malabarica	19	24.92	0.03	0.016129	0.03	0.087
Elaeocarpus serratus	8	10.49	0.01	0.032258	0.03	0.083
Macaranga peltata	13	17.05	0.02	0.032258	0.02	0.083

Fig.5-Population structure of *D. confertiflora* in the study area



3.2.4 Vegetative propagation

The semi hardwood cuttings collected from field were treated with different concentrations of growth regulators *viz*. IAA, IBA and NAA for inducting rooting. IBA 2000 ppm was effective in induction of rooting. IAA and NAA treated cuttings also showed rooting irrespective of the season and type of stem cutting. As enough seedling were available from seeds and considering the suggestions of the members of KFRI Internal Research Committee we discontinued detailed vegetative propagation trials.

Fig- 6. Vegetative propagation trials.

3.2.5 Seed biological studies

Ripe fruits were collected and the fleshy fruit rind removed (Plate 2). The processed seeds were analyzed for initial moisture content. The seeds were subsequently surface dried and kept for storage and germination studies. The fresh seeds with an initial moisture content of 36.34% resulted in 100 % germination within 18-20 days where river sand is used as sowing medium in the nursery. This is a characteristic feature of recalcitrant seeds, which are shed from parent plant with high moisture content ranging from 30 to 70%. Effect of

temperature on storability of seeds reveals that under ambient (25±2°C) conditions seeds lose their viability drastically from 100% initial germination to 50% within three weeks of storage. In normal conditions, seeds may lose its viability within 45 days with critical a moisture content 18% along with 33% germination under room conditions. The seeds had shown desiccation and chilling sensitivity towards storage temperature conditions. Therefore the seeds were categorized in the recalcitrant group.

For extending the viability of the seeds, different storage trials were done with different containers under different storage conditions. The results indicate that the seeds stored in closed polycarbonate bottles at 20±2°C in seed bank conditions extended the viability up to 120 days with 30% germinability compared to other storage trials (Table-9). However, seeds can be stored for more than two months in the closed poly carbonate bottles, kept at seed bank conditions maintained at 20°C with 40% r.h. has been reported in different forest tree species (Anilkumar *et al*., 2002). Therefore, a standardized method of storage can be adopted for germplasm preservation of the species. The *D.confertiflora* seeds are recalcitrant and thus high moisture content of the seeds makes them sensitive to desiccation and chilling injury. The seeds do not withstand drying or are unable to survive low temperatures during storage. Thus, they are difficult to store for longer periods (Ellis 1984, Hanson 1984). The exact causes of recalcitrant seed death and its relationship with moisture content are not fully understood (Fu. *etal*. 1993). It is stated that loss of viability could be either due to the moisture content falling below a certain critical value or simply a general physiological deterioration with time (Chin *et al.*,1984).

3.3 *Inga cynometroides* (Bedd.) Bedd. Ex. Baker

3.3.1 Distribution and Habit

Inca cynometroides is a small tree of belonging to Leguminoseae family, endemic to Kerala, growing in Rosemala, Kollam District, Kerala (Plate 3.). After the type collection it has not been collected and is placed under indeterminate threat category (Nayer and Sastry, 1990). Then the species *I. cynometroides* was rediscovered from the type locality after 100 years (Sasidharan, 1998). Following the revised IUCN Red list categories (IUCN, 1995) this species has been assigned critically endangered category. This study gives a new record of the species *I.cynometroides* from other than the type locality.

Table.9. Distribution of *I. cynometroides*: Physical parameters

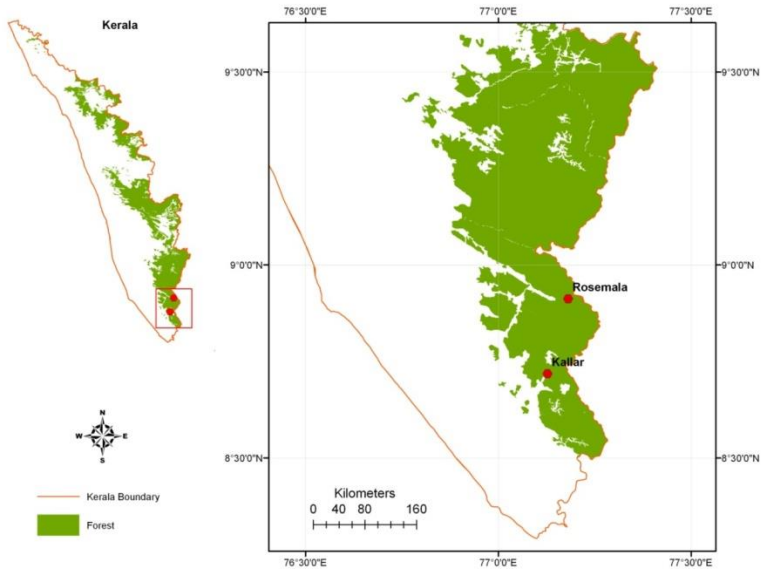
Species	Location	Latitude	Longitude	Vegetation Type	Altitude
Inga cynometroides	Rosemala	08.911639	77.181417	Evergreen	300 m
	Kallar	08.717383	77.128050	Evergreen	150 m

Our team located a declining population of the species *I. cynometroides* along the banks of Kallar river in Trivandrum forest division. After the rediscovery of the species by Sasidharan, (1998), this is the very first report of the species other than from the type locality of the species *I. cynometroides* viz. from Rosemala, Kollam (Quilon) district. Sasidharan, (1998) noted that the population of *I. cynometroides* comes up to 100 mature trees confined to an area of less than 1 sq. km. Present studies reveal that at Rosemala, Kollam (Quilon) district, the population of *I. cynometroides* is declining with less than 50 mature individuals.

Plate 3. *I. cynometroides* A-Habitat, B-Habit ,C- Twig with flower buds, D-Flower,E- Fruit, F-Seeds,G -Vegetatively propageted seedlings, H &I.Ve getatively propagated seedlings planted in field.

The plants are confined to an area of 1 sq. km along the sides of a stream facing great threats of destruction. The present collection, from an elevation range of 250 m along the wet slopes in evergreen forest of Kallar area of Trivandrum forest division, is outside the type locality, and extends its distribution towards the eastern part of Western Ghats. The physical parameters are given in the Table- 9 and the distribution map is shown in Figure-7.

Fig- 7. Map showing distribution of *I.cynametroides* in the study area.



Major threats to natural habitats are expansion of agricultural activities in forest land and construction of roads and houses in and around forest areas. A rubber plantation is situated near its habitat and people are cutting the trees for various purposes. Such activities may be adversely affecting population of seedlings and saplings in Rosemala Forest Area of Shendurney wild life sanctuary, the type locality of the species. In Kallar of Trivandrum forest division the plants are growing along the roadside near an ecotourism view point suffering public intrusion.

3.3.2 IUCN Status

The present investigation revealed that the population of *I. cynometroides* is extremely small and species have low dominance and poor ecological success in the study area. The total number of reproducing individuals is less than fifty confined to an area of less than 1 sq. Km, and is facing great threat of destruction. Therefore, the species can be placed under "critically endangered" category. Hence, active protection measures and continuous monitoring of the existing populations should be given top priority. As the number of mature trees is very limited, all the populations should be preserved.

3.3.3 Population Structure

Experimental plots were taken and population analysis has been carried out in a total area of 5445 Sq.mts in and around the natural habitats of *I. cynometroides,* Shendurney Wild life sanctuary and Kallar forest area (Table 9). During the study about 244 individuals belonging to 73 species under 32 families were recorded. Among the families, Euphorbiaceae is the largest one which constitutes 10 species, followed by Dipterocarpaceae (5 species), Lauraceae (5 species), Anonaceae (4species) and Meliaceae (Fig-8).

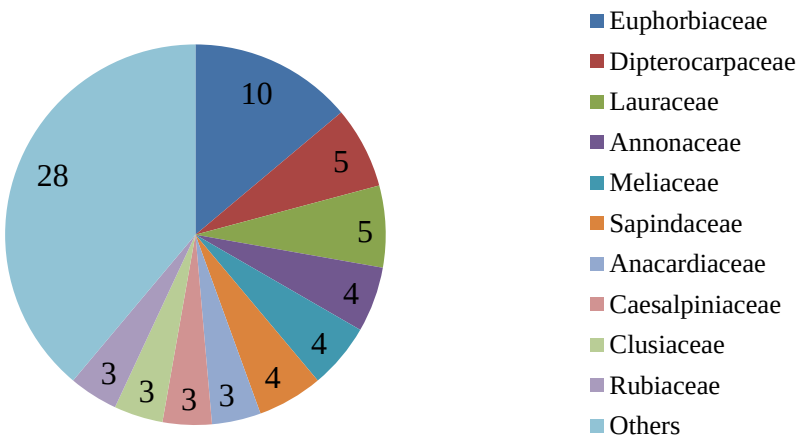


Fig-8. Number of species from each family in the in the natural habitats of *I.cynametroides*

Table 10. Phytosociology - *Inga cynometroides*

SNo	Species	D	RD	F	RF	RBA	IVI
1.	*Actinodaphne malabarica*	5.509642	0.012295	0.4	0.016949	0.001943	0.031187
2.	*Aglaia barberi*	1.836547	0.004098	0.2	0.008475	0.002443	0.015016
3.	*Aglaia tomentosa*	9.182736	0.020492	0.4	0.016949	0.020717	0.058158
4.	*Anacolosa densiflora*	11.01928	0.02459	0.6	0.025424	0.014855	0.064869
5.	*Baccaurea courtallensis*	5.509642	0.012295	0.4	0.016949	0.001535	0.030779
6.	*Bischofia javanica*	14.69238	0.032787	0.4	0.016949	0.107471	0.157207
7.	*Bombax ceiba*	1.836547	0.004098	0.2	0.008475	0.003625	0.016198
8.	*Calophyllum polyanthum*	1.836547	0.004098	0.2	0.008475	0.035616	0.048189
9.	*Canarium strictum*	1.836547	0.004098	0.2	0.008475	0.000801	0.013374
10.	*Cinnamomum malabatrum*	1.836547	0.004098	0.2	0.008475	0.023203	0.035776
11.	*Croton malabaricus*	1.836547	0.004098	0.2	0.008475	0.002811	0.015384
12.	*Cryptocarya beddomei*	1.836547	0.004098	0.2	0.008475	0.000656	0.013229
13.	*Cullenia exarillata*	1.836547	0.004098	0.2	0.008475	0.010681	0.023254
14.	*Cynometra travancorica*	7.346189	0.016393	0.4	0.016949	0.013619	0.046961
15.	*Dimocarpus logan*	23.87512	0.053279	0.8	0.033898	0.025573	0.11275
16.	*Dimorphocalyx glabellus var. glabellus*	3.673095	0.008197	0.2	0.008475	0.000704	0.017376
17.	*Diospyros bourdillonii*	1.836547	0.004098	0.2	0.008475	0.000633	0.013206
18.	*Diospyros candolleana*	3.673095	0.008197	0.4	0.016949	0.0053	0.030446
19.	*Diospyros sylvatica*	1.836547	0.004098	0.2	0.008475	0.001047	0.01362
20.	*Dipterocarpus indicus*	5.509642	0.012295	0.6	0.025424	0.051405	0.089124
21.	*Drypetes venusta*	1.836547	0.004098	0.2	0.008475	0.001106	0.013679
22.	*Dysoxylum malabaricum*	11.01928	0.02459	0.4	0.016949	0.006679	0.048218
23.	*Elaeocarpus tuberculatus*	3.673095	0.008197	0.4	0.016949	0.000597	0.025743
24.	*Ellipanthus tomentosus*	1.836547	0.004098	0.2	0.008475	0.005835	0.018408
25.	*Erythroxylum lanceolatum*	1.836547	0.004098	0.2	0.008475	0.01163	0.024203
26.	*Ficus arnottiana*	3.673095	0.008197	0.2	0.008475	0.037507	0.054179
27.	*Filicium decipiens*	3.673095	0.008197	0.4	0.016949	0.013351	0.038497
28.	*Flacourtia montana*	1.836547	0.004098	0.2	0.008475	0.002019	0.014592
29.	*Garcinia gummi-gutta var. gummi-gutta*	5.509642	0.012295	0.4	0.016949	0.001837	0.031081
30.	*Garcinia spicata*	1.836547	0.004098	0.2	0.008475	0.000427	0.013
31.	*Glochidion ellipticum*	3.673095	0.008197	0.2	0.008475	0.000568	0.01724
32.	*Gluta travancorica*	25.71166	0.057377	0.4	0.016949	0.059638	0.133964
33.	*Gomphandra tetrandra*	3.673095	0.008197	0.4	0.016949	0.000761	0.025907
34.	*Grewia tiliifolia*	5.509642	0.012295	0.2	0.008475	0.007959	0.028729
35.	*Harpullia arborea*	3.673095	0.008197	0.4	0.016949	0.001667	0.026813
36.	*Holigarna arnottiana*	3.673095	0.008197	0.2	0.008475	0.003476	0.020148

37.	***Hopea erosa***	3.673095	0.008197	0.2	0.008475	0.002958	0.01963
38.	***Hopea parviflora***	3.673095	0.008197	0.4	0.016949	0.001575	0.026721
39.	***Hopea racophloea***	9.182736	0.020492	0.8	0.033898	0.046827	0.101217
40.	***Hydnocarpus pentandra***	3.673095	0.008197	0.2	0.008475	0.011648	0.02832
41.	***Inga cynometroides***	9.182736	0.020492	0.2	0.008475	0.001037	0.030004
42.	***Ixora bractiata***	29.38476	0.065574	0.6	0.025424	0.01359	0.104588
43.	***Kingiodendron pinnatum***	11.01928	0.02459	0.6	0.025424	0.049345	0.099359
44.	***Knema attenuata***	23.87512	0.053279	1	0.042373	0.015837	0.111489
45.	***Leea indica***	1.836547	0.004098	0.2	0.008475	0.000182	0.012755
46.	***Litsea floribunda***	3.673095	0.008197	0.2	0.008475	0.004188	0.02086
47.	***Litsea travancorica***	7.346189	0.016393	0.2	0.008475	0.002538	0.027406
48.	***Lophopetalum wightianum***	5.509642	0.012295	0.2	0.008475	0.030383	0.051153
49.	***Macaranga peltata***	5.509642	0.012295	0.2	0.008475	0.004856	0.025626
50.	***Mangifera indica***	1.836547	0.004098	0.2	0.008475	0.000934	0.013507
51.	***Meiogyne pannosa***	1.836547	0.004098	0.2	0.008475	0.001459	0.014032
52.	***Myristica beddomei ssp. beddomei***	11.01928	0.02459	0.6	0.025424	0.023899	0.073913
53.	***Orophea erythrocarpa***	1.836547	0.004098	0.2	0.008475	0.000427	0.013
54.	***Palaquium ellipticum***	5.509642	0.012295	0.4	0.016949	0.022271	0.051515
55.	***Pallaquim bourdillonii***	1.836547	0.004098	0.2	0.008475	0.002019	0.014592
56.	***Polyalthia coffeoides***	3.673095	0.008197	0.2	0.008475	0.000466	0.017138
57.	***Polyalthia fragrans***	5.509642	0.012295	0.2	0.008475	0.001515	0.022285
58.	***Psychotria anamalayana***	1.836547	0.004098	0.2	0.008475	0.014719	0.027292
59.	***Pterospermum rubiginosum***	1.836547	0.004098	0.2	0.008475	0.005299	0.017872
60.	***Pterygota alata***	1.836547	0.004098	0.2	0.008475	0.004129	0.016702
61.	***Strombosia ceylanica***	7.346189	0.016393	0.4	0.016949	0.002049	0.035391
62.	***Syzygium laetum***	11.01928	0.02459	0.4	0.016949	0.002039	0.043578
63.	***Syzygium lanceolatum***	16.52893	0.036885	0.6	0.025424	0.026212	0.088521
64.	***Tabernaemontana alternifolia***	1.836547	0.004098	0.2	0.008475	0.000427	0.013
65.	***Terminalia bellirica***	3.673095	0.008197	0.2	0.008475	0.146381	0.163053
66.	***Tetrameles nudiflora***	1.836547	0.004098	0.2	0.008475	0.005835	0.018408
67.	***Toona ciliata***	1.836547	0.004098	0.2	0.008475	0.006688	0.019261
68.	***Turpinia malabarica***	1.836547	0.004098	0.2	0.008475	0.005169	0.017742
69.	***Vateria indica***	31.2213	0.069672	0.8	0.033898	0.04286	0.14643
70.	***Vitex altissima***	1.836547	0.004098	0.2	0.008475	0.002399	0.014972
71.	***Xanthophyllum arnottianum***	20.20202	0.045082	1	0.042373	0.009243	0.096698

IVI values are used to express dominance and ecological success of the species according to its density, frequency and dominance in relation to all other species.

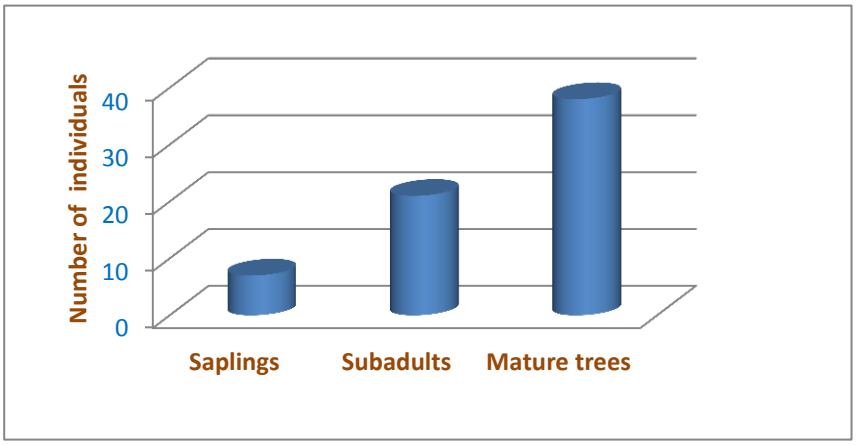
The calculated IVI of the species *I. cynometroides* 0.13/hector indicates that the species have low dominance and poor ecological success in the study area. IVI values indicates that the most successive tree species in the study area are *Bischofia javanica*, *Terminalia bellirica*, *Vateria indica*, *Gluta travancorica* and *Knema attenuata* (Table 11).

Species density is found to be maximum for *Vateria indica* (31.22) followed by *Ixora bractiata* (29.38), *Gluta travancorica* (25.71) and *Knema attenuata* (23.88), whereas, *I. cynometroides* represent 30th position with IVI of 0.030004 (Table 10). Species diversity indices such as Simpson's Index (0.04) and Shannon's Index (2.98) were calculated which indicates the high diversity in the study area. *Bischofia javanica* was the dominant species in the study area, followed by *Terminalia bellirica*, *Vateria indica*, *Gluta travancorica* and *Knema attenuate*. In the present study, a total number of 66 individual species were recorded from the whole study area, of which 38 were mature individuals, 21 were sub adults and 7 were saplings.(Fig-9).

Table- 11. Dominant species having highest value of IVI in the study area (*I. cynometroides*).

Species	No. of individuals	Density (No./ha)	Rel. Density	Rel. Frequency	Rel. Basal Area	IVI
Bischofia javanica	8	14.69	0.03	0.02	0.11	0.16
Terminalia bellirica	2	3.67	0.01	0.01	0.15	0.16
Vateria indica	1	**31.22**	0.07	0.03	0.40	0.15
Gluta travancorica	14	25.71	0.06	0.02	0.06	0.13
Knema attenuata	13	23.88	0.05	0.04	0.02	0.11
Hopea racophloea	5	9.18	0.02	0.03	0,05	0.10
Ixora bractiata	16	29.38	0.07	0.03	0.01	0.10
Kingiodendron pinnatum	6	11.02	0.02	0.03	0.01	0.10
Xanthophyllum arnottianum	11	20.2	0.05	0.04	0.01	0.10
Dipterocarpus indicus	3	5.51	0.01	0.03	0.05	0.09

Fig.9-Population structure of *Inga cynometroides* in the study area



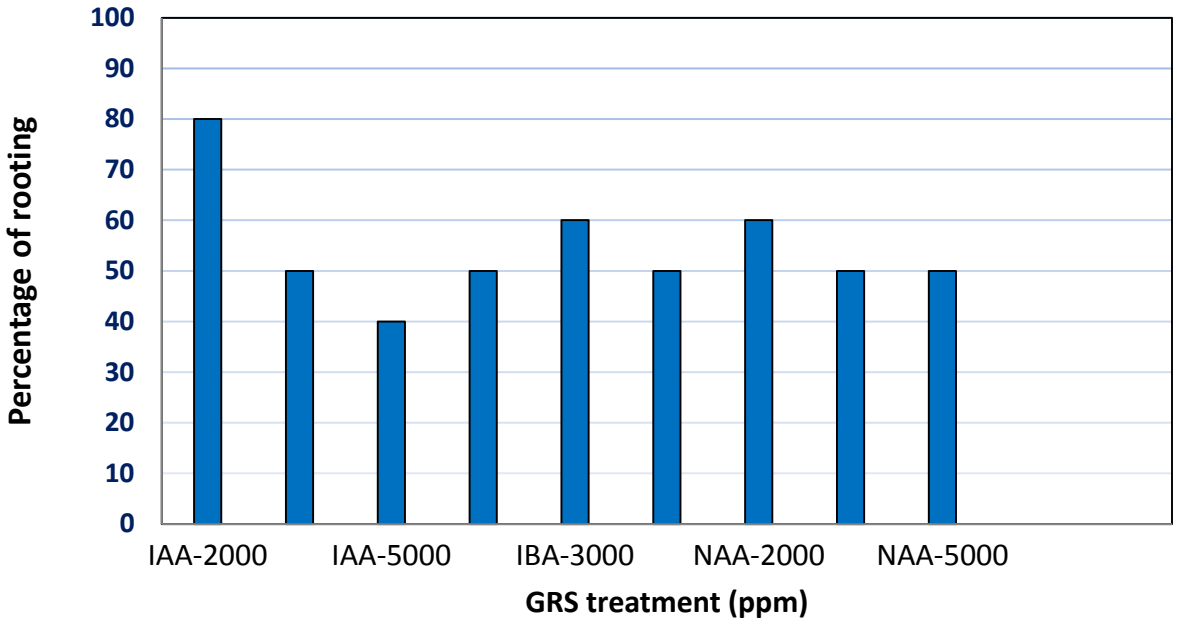
The area of occurrence of the species in the forest area was found to be approximately 1.5 km^2 and the area of occupancy (area sampled plus non-sampled area) 0.005 km^2 and nearly 40 mature trees were seen in the site. The number of mature individuals was more than sub-adults whereas the number of saplings was very poor. Earlier studies by Sasidharan (1998) indicate that the flowering and fruiting were regular in *I. cynometroides*, but the present study reveals that some irregularity is associated with the fruiting and flowering of *I. cynometroides.* Though fruit set seems to be sufficient, other extrinsic and intrinsic constraints to natural regeneration were not identified in *I. cynometroides.*). The revised IUCN Red list categorises (IUCN, 1995) this species in the critically endangered category.

3.3.4 Vegetative propagation

The semi hardwood cuttings treated with IAA 2000 ppm in season 1 and III showed maximum percentage of rooting (80 %), followed by IBA-3000 ppm and NAA- 2000 ppm treated cuttings in season II and III (60%). NAA treated cuttings

showed pure rooting irrespective of the seasons. It appears that for vegetative propagation of the RET species *I. cynometroides* is possible with semi hard wood cuttings treated with IAA 2000 ppm solution, in season I (January-April) and season III (August-December). The graph showing percentage of rooting in different hormone treatments is shown in the Figure.11.

Figure-11. Graph showing percentage of rooting of *I. cynometroides* in different hormone concentrations .



Vegetatively propagated saplings were planted in the field at KFRI Field Research Centre, Velupadam, showing remarkable establishment in the field.

3.3.5 Seed biological studies

With limited number of seeds germination tests were carried out and it has been found that seeds are viable and 100 percent germination is observed with good seeds. Enough fresh seeds were not available in the field to conduct seed biological studies. Some preliminary observations were done and while germination radicle emergence was observed.

4.0 Propagation protocols

4.1 *Aporosa bourdillonii* Stapf.

- Prepare GRS powder viz. by mixing Indole Butyric Acid (IBA) 20 mg with 100 gm of chalk powder with the help of a Micro-Dismembrator and keep it in a closed container in the Freezer. Take a few grams of the mixed powder in a petridish for use in the mist chamber.
- Fill the rooting containers with sterilized vermiculite and keep it in the mist chamber.
- Collect a few semi hardwood stem cuttings of *A. bourdillonii*, from the field during evening hours and keep it in big polythene bags and tie it. Bring the cuttings to the laboratory.
- Prepare semi hardwood leafy shoot cuttings having a length 10-15 cm with 1or 2 pairs of leaves intact. The leaf area of each cutting may be reduced by trimming away 2 to 3 leaflets of compound leaves. To check any possible fungal attack during propagation, cuttings may be treated with 0.05 percent aqueous solution of Bavistin for 30-45 minutes.
- Treat the cut end of the semi-hardwood cuttings with the GRS mix and then insert immediately in vermiculite kept in root trainers placed in mist chamber for rooting. Misting may be given for 10 seconds at an interval of 30 minutes or whenever relative humidity falls below 80 percent. Spraying of water on the leaves also can be done in the absence of mist chamber.
- Keep the plant cuttings for a period of 20-30 days in the mist chamber condition. The cuttings will show sprouting with young leaves and then begin to root. Rooting will be completed within a period of 60 days.
- The rooted cuttings have to be transferred to polythene bags filled with sand and soil in equal proportions (1:1) and keep them in the hardening room for about 30 days. The rooted cuttings should be properly hardened before taking to the field approximately having 30 cm height.
- The best season for collection and GRS treatment is during summer months (Season I (January-April). Apart from Indole Butyric Acid (IBA),

Naphthalene Acetic Acid (NAA) and Indole Acetic Acid (IAA) also can be used to induce roots.

4.2. *Drypetes confertiflora* (Hook f.)

The semi hardwood cuttings collected from field were treated with different IBA 2000 ppm was effective in induction of rooting. It was found that fruits are available and therefore seeds may be collected and propagated at a lower cost.

- In the case of *Drypetes confertiflora* seedlings can be produced easily from fruits.
- During the months of May-June, ripe fruits can be collected from the mother trees. Seeds can be separated from the fruit by removing the fleshy fruit rind.
- The fresh seeds are sown in beds filled with river sand. Germination will be complete within 18-20 days and may be allowed to grow in the beds for about one month. As the seeds are recalcitrant it cannot be stored for more than 3 weeks in natural conditions.
- The seedlings can be potted in polythene bags filled with garden soil mix, allow to grow for 30cm height and can be used for planting in the field during rainy season. The seedlings are susceptible to insect attack.

4.3 *Inga cynometroides* (Bedd.) Bedd. Ex. Baker

Very few seeds are available and not easy to germinate. Therefore we have to depend on vegetative propagation. Three growth regulating substances were found to be effective in rooting irrespective of seasons. But IAA is found promising and NAA to be cheap.

- Prepare GRS powder viz. by mixing Indole Acetic Acid (IAA) 20 mg with 100 gm of chalk powder with the help of a mixer and keep it in a closed container in the Freezer. Now we have 2000 ppm of IAA powder for root induction. Take a few grams of the mixed powder in a petridish to treat semi hardwood cuttings of *Inga cynometroides* in the mist chamber.
- Side by side fill the root trainers with sterilized vermiculite may be kept in the mist chamber.
- Bring the semi hardwood stem cuttings of *Inga cynometroides*, collected during evening hours and kept in closed polythene bags with high humidity. Select healthy branches and prepare semi hardwood leafy shoot cuttings limited to a length 10-15 cm with 1or 2 pairs of leaves intact. The leaf area of each cutting may be reduced by trimming leaves. To check any possible fungal attack during propagation, cuttings may be treated with 0.05 percent aqueous solution of Bavistin for 30-45 minutes.
- Treat the cut end of the semi-hardwood cuttings with the GRS mix (IAA 2000 ppm) and then insert immediately in vermiculite kept in root trainers placed in mist chamber for rooting. Instead of IAA, IBA 3000 ppm or NAA 2000 ppm also can be used as they also give slightly lower percentage of rooting in the case of *Inga cynometroides*. Misting may be given for 10 seconds at an interval of 30 minutes or whenever relative humidity falls below 80 percent. Spraying of water on the leaves also can be done in the absence of mist chamber.
- Keep the plant cuttings for a period of 20-30 days in the mist chamber condition. The cuttings will show sprouting with young leaves and then begin to root. Rooting will be completed within a period of 60 days.

- The rooted cuttings have to be transferred to polythene bags filled with sand and soil in equal proportions (1:1) and keep them in the hardening room for about 30 days. The rooted cuttings should be properly hardened before taking to the field after attaining 30 cm height.
- Enough seeds are not available from the field, for the species *A. bourdillonii* and *I. cynometroides*.

5.0 Conclusion

Rare, Endangered and Threatened (RET) species constitute the weaker sections of the biota and often exist as relatively small populations and are subject to population bottlenecks. During the present study it is noted that the populations of the three species are diminishing and facing immense threat of destruction. Among the candidate species, *A. bourdillonii* and *I. cynometroides* are facing extremely high risk of extinction in the wild and meets the c IUCN criteria for " Critically Endangered" whereas the third species, *D. confertiflora* is facing a very high risk of extinction in the wild in the near future. So a short-term conservation goal should be adopted to ensure that the vigour of a population is maintained or restored in the face of inbreeding through appropriate manipulation of the remaining genetic variations. According to the demographic characteristics of these species, it is found that the seedling and sapling populations do not contribute to the maintenance of natural regeneration stock. Thus, an artificial introduction of these species in suitable ecological habitats may be one of the options to restore the populations of these species. Population restoration by supplementary regeneration could be an adaptive strategy to combat the declining populations by introducing nursery-grown seedlings or vegetatively propagated seedlings to compensate the lack of natural regeneration.

Seed studies were not possible for the species *A. bourdillonii* and *I. cynometroides* because of the non availability of fresh seeds in the field. Vegetative propagation may be considered as an alternative to produce saplings. In *D. confertiflora,* fresh seeds with an initial moisture content of 36.34% resulted in 100 % germination within 18-20 days. But seeds lost its viability within 45 days with critical moisture content 18% along with germination 33% under room conditions. The seeds show desiccation and chilling sensitivity towards storage

temperature conditions. Therefore the seeds were categorized in the recalcitrant group are recommended for storage in closed polycarbonate bottles at 20±2°C in seed bank conditions. Vegetative propagation by rooting of stem cuttings is a promising, less expensive technology for production of planting stocks of RET plants. The present study indicates that the RET species *A.bourdillonii* and *I. cynometroides* shows maximum favourable responses to the method of vegetative propagation by rooting semi hard wood cuttings.

Since major threats to all these three species are habitat degradation and over-harvesting of mature trees, awareness among local people, preservation of existing reproducing individuals, and sustainable harvest of mature trees may be effective in successful preservation of these species. As most of the extraction is from natural populations, enormous pressure is a true threat towards the plant populations and consequently to the survival of the species. Successful long-term conservation efforts require thorough investigation of the species distribution, genetic status and anthropological use (Shaanker *et al.* 2006). Bawa (2004) emphasizes the importance of flexible and locally adapted conservation policies. It should be based on modern science as well as local practices and involve local institutions. The overall goal with conservation should be to promote the well-being of human communities as well as the natural resources they rely upon. Government agencies such as State Forest Department, NGOs, and other conservation agencies may take initiatives in developing, distributing, as well as planting nursery-grown seedlings of these species in suitable habitats. Planting of seedlings in home gardens, boundaries of traditional agricultural lands or in wayside plantations is also recommended. Such locations are generally protected and for this growth and survival of seedlings may be ensured. Identification of unique sites, locating the habitats of selected species with Global Positioning

System (GPS), mapping of plants with their density status, *etc*. can be used for conservation purpose these species.

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