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CONSERVATION OF THE CRITICALLY ENDANGERED TREE *SYZYGIUM PALGHATENSE* GAMBLE (MYRTACEAE), IN THE WESTERN GHATS OF KERALA

K. Yesodharan
K. Mohanadas
P.K. Chandrasekhara Pillai

KERALA FOREST RESEARCH INSTITUTE
(An Institution of Kerala State Council for Science, Technology and Environment)
Peechi 680 653, Thrissur, Kerala

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ABSTRACT OF THE PROJECT PROPOSAL

1.Project No.	:	KFRI 428/2004
2. Title	:	Conservation of the critically endangered tree *Syzygium palghatense* Gamble(Myrtaceae), in the Western Ghats of Kerala
3.Objectives	:	i. To assess the population status of *Syzygium palghatense* and to identify constraints, if any, in natural regeneration. ii.To study the reproductive biology of the species, i.e., flowering, pollination, seed set and germination.
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7.Investigators	:	Principal Investigator : Dr. K.Yesodharan Forest Ecology and Biodiversity Conservation Division
		Co- investigators : Dr. K. Mohanadas Forest Protection Division
		Sri. P.K. Chandrasekhara Pillai Sustainable Natural and Plantation Forest Management Division

CONTENTS

ABSTRACT

Syzygium palghatense Gamble (Myrtaceae) is a critically endangered evergreen tree found in the southern Western Ghats of Kerala, reported only from Parambikulam Wildlife Sanctuary in Palakkad District. The species is known only by the 17 plants (six trees, eight saplings and three seedlings) found in the Pandaravarai of Parambikulam Wildlife Sanctuary of which only two trees were found in flower during the study. Flowering was recorded in one tree in November and another, in January. Only a few flowers were found here and there in the tree that flowered in January.

The trees were found on a slope at about 1200 m.asl. Insects visited the inflorescences during midday and they comprised Hymenopterans (honeybees, smaller wasps), Dipterans (blue bottle flies), Hemipterans and some Lepidopterans (butterflies). Except butterflies, all the other insect groups had pollen deposits sticking on their body parts suggesting their role in the pollination of the species. Dithane M45 (0.1%), a fungicide, was sprayed four times at an interval of 15 days on the flowering branches of the tree in order to control fungal infection. The fungicide was effective in controlling the infection, as it led to profuse flowering and fruiting. Infestation of fruits by insects was controlled by the application of mixture of the insecticide (Rogor) with the fungicide which was sprayed one time on the inflorescences.

The small quantity of healthy seeds collected were sown in vermiculite and kept in germination chamber for germination trial. Germination commenced on 31st day of sowing and was complete in 5 days. Seedlings potted in polythene containers with soil, sand and cowdung (in 2:1:1 proportion) displayed a moderately fast growth. Attempts on vegetative propagation of the species using Indole-3 Butyric Acid (IBA) showed that 1000 ppm treated stem cuttings rooted well.

Adequate member of plants produced vegetatively and through seeds have been planted in the Arboretum and in the main campus of KFRI.

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1. INTRODUCTION

The Western Ghats is a chain of mountains running parallel to the West Coast of the Peninsular India from the river Tapti to Kanyakumari. It is characterized by a wide array of diversity in terms of climate, geology, soils and biota. Thirteen major geological formations are encountered in the Western Ghats and six main types of soils. Dense forests are most continuous, but fragmented by disturbed vegetation. About 27 per cent of the higher plants known from India occur along this mountain range. It is one of the mega diversity centres in India and also a biodiversity hotspot.

Geographically the forests of Kerala are distributed along the Southern Western Ghats, which is a region rich in species diversity and endemism. This region is under severe biotic pressure; hence, conserving its biodiversity is a challenging task. Kerala State has a relatively high percentage of forest lands under Protected Areas. About 24 per cent of the forests have been brought under protected areas, in Wildlife Sanctuaries and National Parks. Parambikulam Wildlife Sanctuary is the third largest protected area in the State. Though, the flora of Palakkad District has been studied intensively (Vajravelu, 1990), several endemic as well as threatened species reported earlier from this region have not been relocated. Recent floristic studies (Sasidharan, 2002) conducted in the Parambikulam Wildlife Sanctuary revealed that the population of the tree, *Syzygium palghatense,* is critically endangered as earlier listed by IUCN (2000). The study revealed that even though profuse flowering occurred in the species, fruit setting was low and seedlings and saplings were almost absent. Sasidharan (2002) could locate only three trees of *S. palghatense* at Pandaravarai of the Sanctuary (Fig. 1), and indicated the poor regeneration potential of the species and recommended for reproductive biological studies in order to identify the constraints for regeneration.

The Western Ghats of Peninsular India, a treasure house for medicinal and other economically important plants, have been identified as one of the 18 hotspots of biodiversity. Out of over 5000 flowering plants reported from the region, 2015 are categorized as endemics and many of them are facing severe threats in their highly specialized microhabitats. The threats are mainly due to habitat changes induced by anthropogenic activities like deforestation and forest

degradation. Out of 620 species listed as threatened in the Red Data Book of Indian plants, about 550 species are endemics. It is also estimated that in the near future, 1950 narrow endemic plant species would become extinct in India, particularly those of the Peninsular India (Nayar and Sastry, 1987, 1988, 1990 and Nayar, 1996).

The Southern part of Western Ghats in Kerala is identified as one of the most important biodiversity centres as it harbours a rich flora. However, the flora is under severe threat due to heavy pressure on land, forest cover and changing socio-economic scenarios. Habitat destruction, unsustainable exploitation of rare medicinal plants, land use pattern, etc., are the major threats which reduce the population size of the species and create intense fragmentation of habitats (Pandurangan, 1995; Nayar, 1997). Apart from these anthropogenic causes, some species become rare or even extinct due to reproductive anomalies resulting from lack of adaptability to the changing environment (Bawa *et al.*, 1990; Harper, 1977; Pijl, 1978; Shaw and Burns, 1997). In fact, both physical (anthropogenic) and intrinsic (biological) constraints operate together to accelerate the process of rarity. Many of the endemic species are either medicinal or economically important and therefore the exploitation pressure on these plants increase many fold. Tragically enough, endemics on their way to extinction are seldom recovered. Prediction goes that by the time the population of India stabilizes by 2025 AD, one fifth of our species would become extinct. It is high time that immediate actions for protection and conservation of endemic and threatened plants be undertaken on a priority basis (Nayar, 1996). Sometimes, rarity stems from ecological and biological features of the species (Reveal, 1981). Therefore, in order to understand the factors responsible for the rarity of a species, a detailed knowledge of the population structure, population dynamics and an analysis of climatic and edaphic factors becomes inevitable.

The existence of a species in the community largely depends on its regeneration potential under varied environmental conditions. Regeneration is a critical phase of a plant that sustains a species and the regeneration potential can assessed from the composition of life stages. Evaluation of regeneration status of tree species based on age/diameter distribution is generally accepted. A population structure proficient in seedlings, saplings and young trees depicts a normal regeneration behaviour, and deficient number of seedlings and saplings indicates poor

regeneration. It is in this context the floral biology assumes importance. Studies on the floral biology would provide a better insight to the breeding behaviour and reproductive biology of the species. Flowering features, pollination, anthesis, pollen viability and fertility, stigmatic receptivity, pollen ovule ratio, rate of fertilization, etc., become relevant in the context. Successful regeneration of a tree species depends on its ability to produce enough seedlings, and the ability of seedlings and saplings to survive and grow. However, this is greatly influenced by biotic and abiotic factors. The dispersal and regeneration mechanisms together with the conditions of the habitat become quite relevant in the dynamics of the species. Insects and pests are other factors that mould the regeneration behaviour of the species. Defoliators, leaf and floral eaters, fruits/seed borers, etc., are some of the major threats to species distribution and survival (Pushpangadan, 1992).

Syzygium palghatense Gamble (Myrtaceae) is a critically endangered tree found at Pandaravarai in the Parambikulam Wildlife Sanctuary. The specimens of *S. palghatense* first collected by Col. Beddome from Palakkad Hills during 1860's were wrongly identified as *Eugenia beddomei* by Duthie. Later, Gamble (1915-35) studied the specimens and identified them as a new species, *Syzygium palghatense*. Nayar and Sastry (1987) and Nayar (1997) considered it as 'possibly extinct'.

The present study was undertaken to look into the possible causes of decrease in the population of *S. palghatense* and analyse its regeneration potential. The objectives of the study are:

(i) To assess the population status of *Syzygium palghatense* and to identify constraints, if any, in natural regeneration.

(ii) To study the reproductive biology of the species, i.e., flowering, pollination, seed set, and germination.

Study Area

The trees of *Syzygium palghatense* were located in an evergreen forest patch at about 1200 m above MSL in the Parambikulam Wildlife Sanctuary. The Sanctuary lying between 76° 35' and 76° 51' E longitude and between 10° 20' and 10° 32' N latitude in the Palakkad revenue District of Kerala has an area of 274 km^2. The Sanctuary is bordered by Vazhachal forest Division in the South, Chalakkudy in the West, Nelliyampathi Ghats continuous to the Palghat gap on the North and the Indira Gandhi Wildlife Sanctuary on the East (Fig.1).

The sanctuary receives both South-west and North-east monsoons, South-west being the most active. The pattern of monthly distribution of rainfall during 2004-2007 is given in Fig.2. February - April are the hottest months and the temperature fluctuates between 24°C and 35°C. The minimum temperature varies between 18° C and 23° C during November and December. In the hilly regions, the minimum temperature is still lower during night.

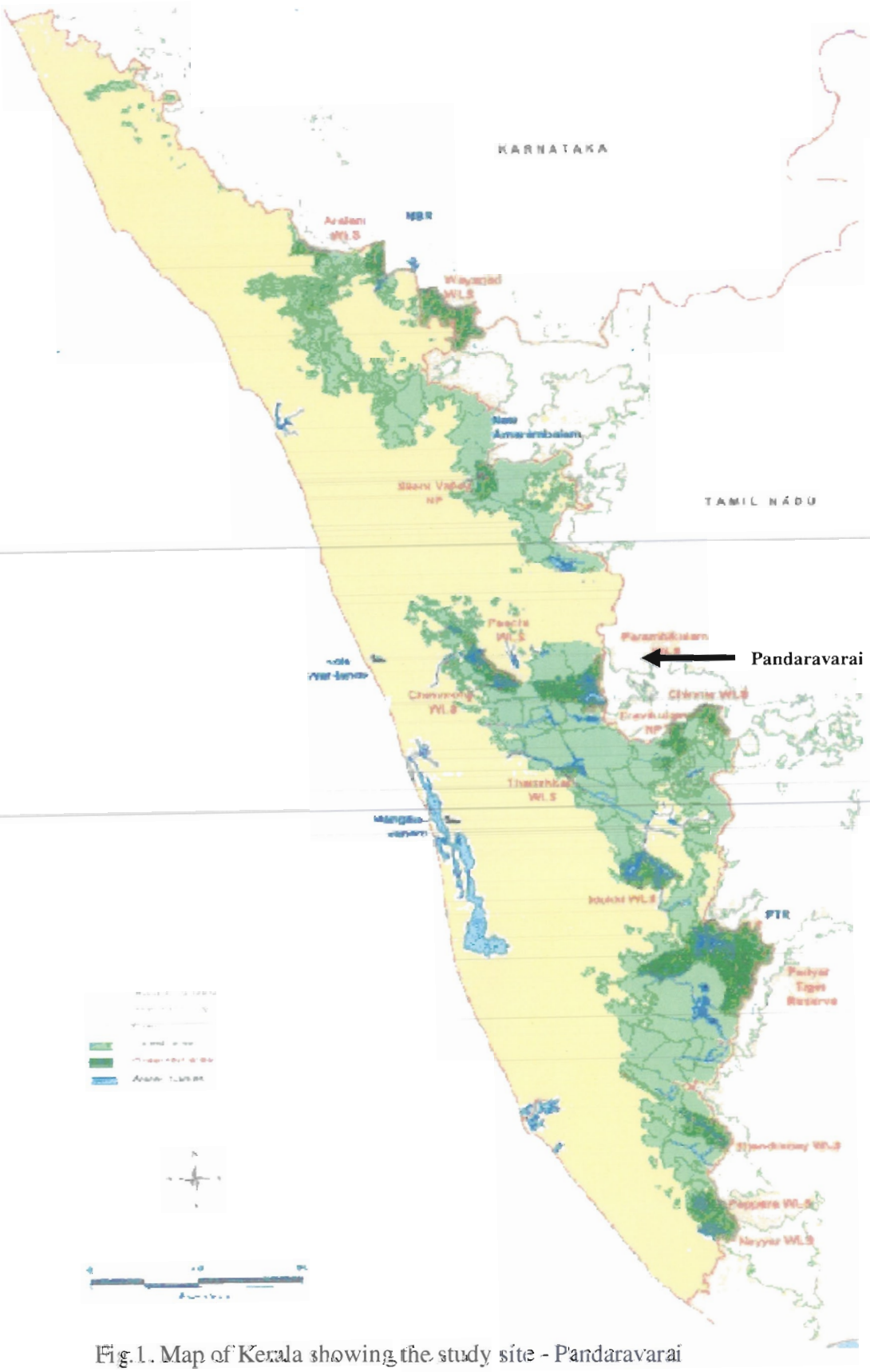


Fig.1. Map of Kerala showing the study site - Pandaravarai

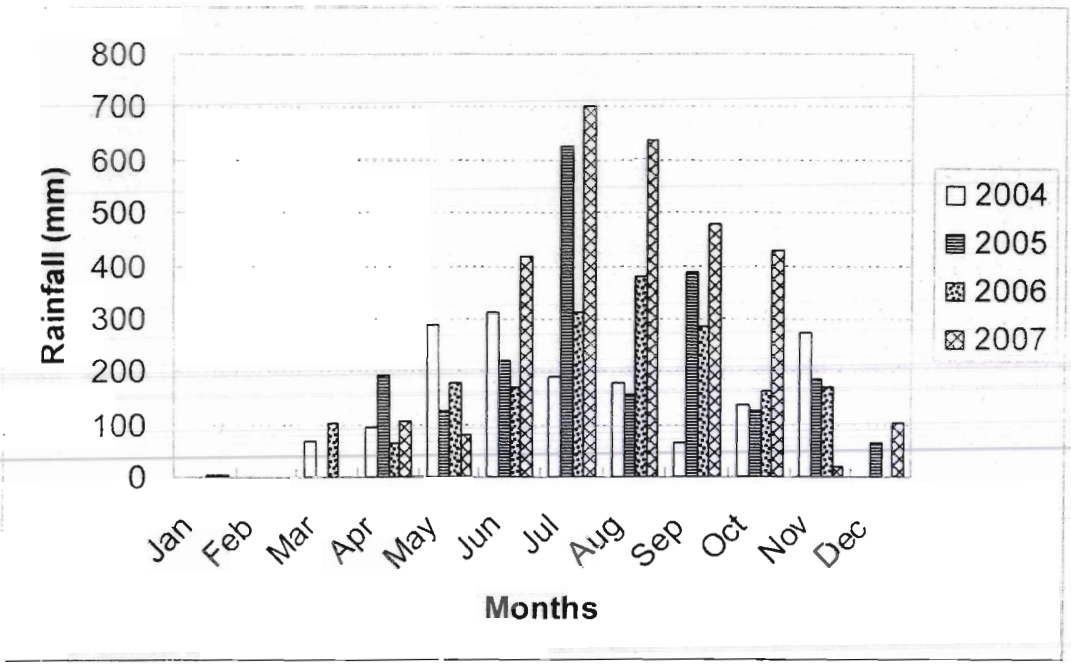


Fig. 2 Rainfall during 2004 – 2007 at Pandaravarai, Parambikulam Wildlife Sanctuary.

(Source : Parambikulam Aliyar Project (PAP), Parambikulam)

2. MATERIALS AND METHODS

Reconnaissance survey for locating population of *Syzygium palghatense* was done and the species was located at Pandaravarai in the forests of Parambikulam Wildlife Sanctuary. A detailed population study of the species was done by both quadrat and transect methods. In quadrat method, three circular plots were laid out around the mother tree. The first circular plot covered 100 m round the mother tree, second plot, between 100-200 m and the third plot, between 200-300 m. Subsequently all the *S. palghatense* plants and its associated trees in the circular plots were enumerated. Besides quadrat method, a transect (belt) of 1 km length and 5m width was also laid out and all the trees having 10 cm or more girth at breast height (gbh) were enumerated. Parameters of dominance such as relative frequency, relative density, relative dominance and Importance Value Index (IVI) were computed following the methods suggested by Misra (1968).

Frequent visits were made to the study site (Pandaravarai of Parambikulam Wildlife Sanctuary) to know the flowering season. Owing to fungal infection, profuse flowering and fruiting was not found. In order to check the fungal infection on the branchlets, leaves and flowers of the tree were sprayed with 0.1% Dithane M45 four times at intervals of 15 days.

Woody branches and tender shoots of *S. palghatense* were collected during the month of December 2004 from a vigorously growing 15–20 year old tree. Twelve woody branch pieces of 30 cm length and 10–15 cm diameter were collected and packed in wet gunny bags to prevent desiccation. They were brought to the Institute's mist chamber and potted in pots containing vermiculite as the medium, after dipping the base of the cuttings in a rooting hormone, Rootex. Two cuttings, without hormone treatment, were kept as control. All the potted cuttings were then kept in the mist chamber (Fig.3). From a set of 11 tender shoots of 15 cm length, ten were potted with half cut leaves in root trainers containing vermiculite as the medium, after dipping them in Rootex. One branch cutting was kept as control. From another set of 11 tender shoots ten cuttings were potted after complete removal of leaves and dipping their base in Rootex. One leafless tender shoot cutting was potted as the untreated control.

Fig. 3. Juvenile shoot formation from large branch cutting

Misting of 10 second duration was provided once in every ten minutes in the mist chamber. Temperature and the relative humidity were maintained at 28-32^{0}C and 70-80% respectively. Usually, cuttings with 2-4 nodes with half cut leaves were dipped in different concentrations of Indole-3-Butyric Acid (IBA) (1000, 2000, 3000, 4000, 5000 and 6000 ppm.). They were planted in root trainers containing vermiculite. Data was collected on sprouting of leaves, rooting, number of roots per cutting and length of roots after 30 days of root initiation.

In addition to vegetative methods, propagation through seeds was also attempted. Fruits were collected from the tree (from branches sprayed with fungicides and insecticides and also from untreated branches) during March 2006 for propagation. The fruits were depulped and sown in vermiculite and kept for germination in the germination chamber.

All the seedlings produced were transferred and potted in polythene bags (10 x 20 cm size) containing soil, sand and cowdung in the proportion 2: 1: 1. Polypotted seedlings were kept in nursery for the study of growth performance. Height measurement of the seedlings was made eight times at an interval of seven days and mean values calculated. Thirty-five seedlings derived from untreated branches and twenty-five seedlings from treated branches were used for the study.

3. RESULTS

Syzygium palghatense Gamble (Myrtaceae) is a small tree upto 15 m in height. The bark is smooth, grayish outside and muddy brown within. Leaves are opposite, 3-8 x 2-3.5 cm, elliptic to elliptic-oblong, base acute, apex acute, sometimes obtusely acuminate, sparsely gland dotted on lower surface. Lateral nerves are slender, many, 2-4 mm apart with numerous secondary laterals. Intramarginal nerves close to the margin. Petiole 3-5 mm long. Flowers in terminal or axillary cymes. Pedicel upto 2 mm long. Calyx tube funnel-shaped, 8-10 mm long. Petals creamy white, caducous. Stamens to 8 mm long. Berry 10 -13 x 4 -5 mm, apex depressed.

Population study of *Syzygium palghatense* revealed that the species was represented by only 17 plants of which six were trees, eight, saplings and the rest, seedlings. All the seventeen plants of *S. palghatense* and their associate trees were located in the first circular plot around the mother plant. The Importance Value of *S. palghatense* and other trees ≥ 10cm gbh are given in Table 1.

Major tree species found associated with *S. palghatense* in its natural habitat were *Scheflera wallichiana* (Wight & Arn.) Harms (Araliaceae), *Xantolis tomentosa* (Roxb.) Rafn. (Sapotaceae), *Cinnamomum sulphuratum* Nees, (Lauraceae), *Beilschmiedia wightii* Benth. Ex Hook. F (Lauraceae), *Phoebe wightii* Meisuer, (Lauraceae), *Nostolachma crassifolia* (Gamble) Deb & Lahiri (Rubiaceae), etc.

It was observed that the leaves and branches of the trees were often infected by fungi. The high rate of abscission of flowers was due to fungal attack. The premature abscission of fruits and predation of fruits by birds apparently reduced the regeneration of the species. Even though cross pollination was common, there was little chance of effecting cross pollination with flowers of other trees of the same species since flowering across the trees was not synchronized. Further, there were only a few flowers on the trees.

During the first year (2004-2005) no fruit setting was observed in trees; some of the branches were found leafless and there were some leaf spots on fallen leaves. Laboratory tests confirmed fungal infection on both leaves and branches. The fungi responsible for leaf and stem infection

were species of *Phoma* and *Alternaria*. A wood-rotting fungus was also collected from the lower part of the tree. The heartwood of the lower trunk of the main bole was completely damaged from the collar up to the breast height. The Dithane M45(0.1%) sprayed four times at fortnightly intervals was found effective in managing the fungal infection and this resulted in better fruit, setting.

The seeds were found attacked by insects belonging to a species of *Euderus* Fig 4; Order Hymenoptera, F-Eulophidae. The infestation of seeds could be controlled by spraying a mixture of Dithane M 45 and Roger insecticide once. After fungicidal and insecticidal spray the tree exhibited increased fruit set. There was considerable reduction in premature fruit fall. Fruits were collected from the treated and untreated branches for germination trial. The fruit is a berry (Fig 5) and is eaten by birds and squirrels. Those fruits which had fallen in thick bushes were found infected by fungi (Fig 6) and hence could not be used for germination purposes.

The insect activity started only by noon when the temperature was at its maximum and the climate was windy or sometimes foggy. Insect activity was noticed only on those inflorescences which received enough sunlight. The shaded region of the tree canopy did not attract any insects at all. This clearly indicates and necessity of favourable climatic factors in activating the insects for pollination.

The species seems to be pollinated by insect pollinators. Among the insect that visited the flowers except the butterflies, all the other groups had deposits of pollen grains sticking on their body parts. This indicates that they play a major role, in the pollination ecology of *S. palghatense*. The insect groups involved in the pollination were the Hymenopterans (honey bees, smaller wasps), Dipterans and Hemipterans (Fig 7 a).

Vegetative propagation techniques tried to produce the propagules by rooting of stem cuttings showed the suitability of Indole 3 – Butyric Acid (IBA) for easy rooting. Out of the various concentrations of IBA (1000, 2000, 3000, 4000, 5000 and 6000 ppm) tried for rooting stem cuttings, 1000 ppm gave the best result with 80% rooting (Table 2). The plants were hardened

under shade for two months and were outplanted in the KFRI Arboretum and other locations in the KFRI main campus.

Germination experiments showed that the seeds started to germinate after 30 days of sowing. The germination continued for about 2 weeks. Seeds collected from the fungicide treated branches and control branches gave approximately similar percentage of germination (35 – 37%) and thus the treatment did not help in enhanced germination

Seedlings were potted in polythene containers with soil, sand and cowdung in the proportion of 2:1:1. Growth performance of the seedlings was observed for twenty four weeks under the nursery conditions. Measurements presented in the fig. 8 showed the growth performance of the
polypotted seedlings at different periods collected from treated and untreated branches.
Fig.8 depicts the growth performance of seedlings for 24 weeks.

Fig. 4. Adult of the fruit borer larva, *Euderus* sp. (F: Eulophidae: Hymeonoptera)

Fig. 5. Ripened fruit

Fig. 6. Infested fruits

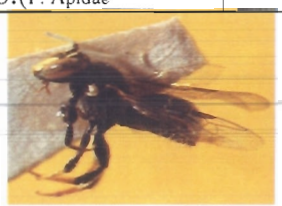
Syzygium palghatense Gamble

Hymenopterans Pollinator of *Syzygium palghatense*

(a) *Apis cerana indica* Fb.(F: Apidae

(b)Unidentified sp.

(c) Unidentified sp.



(d) *Halictus tectonae* Narendran & Joberaj (F: Halictidae)

(e) Unidentified sp.

Dipteran pollinator of *Syzygium palghatense*

(f) Unidentified sp.

Fig. 7. a – f. Insect pollinators of *S. palghatense*

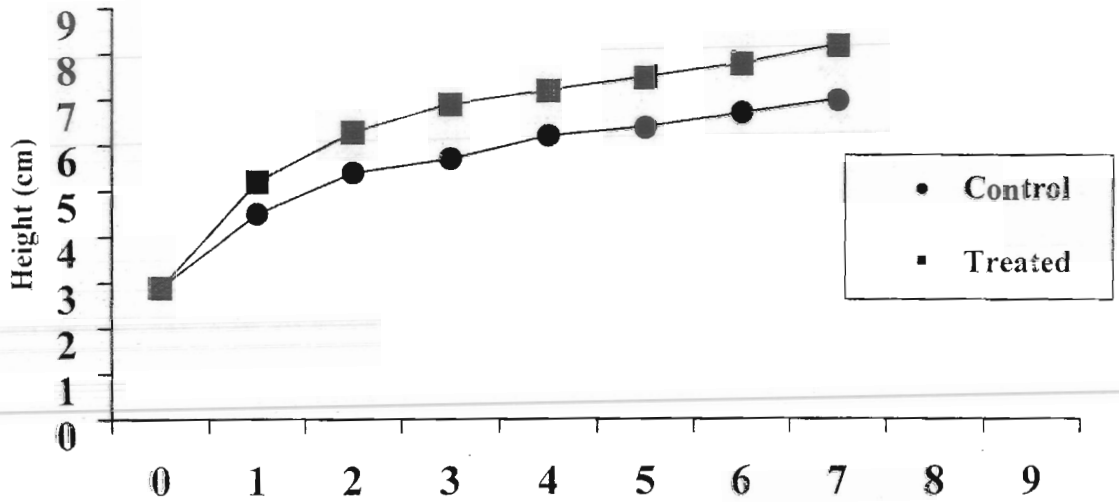


Fig. 8 Mean seedling height of *Syzygium palghatense*

Table 1. Stand structure of the semi evergreen forest where *Syzygium palghatense* is found (gbh ≥10 cm)

Sl.No	Species	Rel. Density	Rel. Frequency	Rel. Basal Area	IVI *
1	*Grewia tiliifolia*	0.005	0.026	0.001	0.030
2	*Cassia fistula*	0.005	0.026	0.001	0.031
3	*Cordia monoica*	0.005	0.026	0.001	0.031
4	*Scheflera wallichiana*	0.005	0.026	0.003	0.034
5	*Bauhinia malabarica*	0.005	0.026	0.003	0.034
6	*Cinnamomum keralaense*	0.009	0.026	0.001	0.035
7	*Phyllanthus emblica*	0.005	0.026	0.004	0.035
8	*Gyrocarpus asiaticus*	0.009	0.026	0.002	0.037
9	*Beilschmiedia wightii*	0.009	0.026	0.002	0.038
10	*Bridelia crenulata*	0.005	0.026	0.007	0.038
11	*Nostolachma crassifolia*	0.009	0.026	0.002	0.039
12	*Anogeissus latifolia*	0.014	0.026	0.001	0.040
13	*Cinnamomum wightii*	0.014	0.026	0.001	0.040
14	*Dalbergia latifolia*	0.005	0.026	0.001	0.042
15	*Diospyros montana*	0.009	0.026	0.008	0.043
16	*Syzygium cumini*	0.009	0.026	0.009	0.044
17	*Tectona grandis*	0.009	0.026	0.012	0.048
18	*Bridelia retusa*	0.014	0.026	0.010	0.049
19	*Terminalia paniculata*	0.005	0.026	0.022	0.053
20	*Catunaregam spinosa*	0.032	0.026	0.004	0.062
21	*Xantolis tomentose.*	0.009	0.053	0.002	0.064
22	*Diospyros cordifolia*	0.036	0.026	0.004	0.066
23	*Olea dioica*	0.023	0.026	0.019	0.068
24	*Cinnamomum sulphuratum*	0.014	0.053	0.002	0.069
25	*Neolitsea scrobiculata*	0.018	0.053	0.004	0.075
26	*Phoebe wightii*	0.018	0.052	0.004	0.075
27	*Vernonia arborea*	0.018	0.026	0.049	0.094
28	*Syzygium palghatense*	0.027	0.026	0.056	0.109
29	*Artocarpus heterophyllus*	0.014	0.053	0.046	0.112
30	*Lagestroemia microcarpa*	0.108	0.026	0.075	0.210
31	*Buchanania lanzan*	0.108	0.026	0.154	0.289
32	*Schleichera oleosa*	0.432	0.053	0.481	0.966

* IVI-Importance value Index

Table 2. Percentage of rooted juvenile stem cuttings of *S. palghatense* in different concentrations of Indole Butyric Acid (IBA)

No	Concentration of I BA (in ppm)	No. of juvenile stem cuttings treated	No. of stem cuttings rooted	% of rooting
1	1000	10	8	80
2	2000	10	6	50
3	3000	10	5	50
4	4000	10	3	30
5	5000	10	2	20
6	6000	10	2	20

4. DISCUSSION

The present study on the critically endangered tree *S. palghatense* was carried out to analyse the population status of the species in Parambikulam Wildlife Sanctuary, major associate species, reproductive anomalies and constraints in regeneration. The study also focused on the vegetative and reproductive phenological aspects including features of flowering, fruit and seed characters, disease problems and other factors responsible for the dwindling population of the species in their natural habitats. The investigation on the climatic factors enabled to identify the *in situ* requirements of the species which in turn could be utilized to standardize restoration practices.

Population study reinforced the need for restoration of the species since the existing habitats of the species were found deteriorating day by day. Vegetation analysis shows its low occurrence in the stands. The habitat specificity of the species in the evergreen background also seems to influence the establishment of seedlings which were found sensitive to temperature conditions.

The causes of the plant rarity, endangerment and extinction are interconnected. Extrinsic factors such as habitats loss, fragmentation of populations and, over-exploitation are the major threats (Lucas and Synge, 1978; Raven, 1988; Angermeir, 1995; Pandurangan, 1995; Anonymous, 1998, Saul, 2000). Biological constraints include plants inherent problems such as irregular flowering periodicities, specificity of pollination, obligate self pollination, nature of flowers, premature fruit fall, insect/pest damage, low natural regeneration, lack of dispersal agent etc. (Pushpangadan, 1991; Daniel and Jayanthi, 1996; Jose *et al.*, 2000). In addition to this, climatic and edaphic conditions also play a decisive role in determine the population behaviour and establishment (Murali and Sukumar, 1993; Parthasarthi and Sethi, 1997).

In agreement with some of the above observations, *S. palghatense* also exhibits high degree of flower/inflorescence abscission. Besides, the species also displays premature abscission of fruits either just after fertilization or during the course of fruit development. Abscission of flowers is indicative of ineffective pollination. In certain cases, abscission of flowers/fruits is due to the injuries made by weevils/hoppers by sucking juice from the peduncle, pedicel, etc. But in

S. palghatense abscission of flowers/fruits was due to fungal attack; not because of any intrinsic reproductive anomalies. The disease could be controlled by the application of fungicides and the flowering and fruiting was improved substantially. Pollination was effected by insects; however, the low incidence of pollination during the receptivity period of stigma probably caused ineffective pollination. The latter has been reported as one of the causes for the abnormal fall of flowers (Cruden, 1977, 1990; Faegri and Pijl, 1979).

The infestation on the forest seeds have been discussed by several authors (Hocker, 1979; Nair *et al.*, 1986; Srivastava, 1995; Mathew and Seethalakshmi, 1998). The seeds of *S. palghatense* were attacked by an insect species of *Euderus* belonging to Order Hymenoptera. This could be controlled by the application of an insecticide Rogor. Similarly, the pre-and post-dispersal predation of the fruits was also responsible for the poor soil seed/seedling bank. Many workers have reported that in many cases, the mechanisms that limit the natural regeneration of the species of most endemics are highly specific to their natural habitats for the survival and establishment of the seedlings (Campose and Ojeda, 1977; Howe, 1984; Thornton *et al.*, 1996). In *S. palghatense* predation of fruits, irregularities in the flowering of the species, seedling mortality due to saprophytic/pathogenic infection, nigh seed dormancy, etc., were found to be the biological constraints leading to the paucity of the species.

Development of propagation methods towards the conservation of the species is considered as a major objective in many biological conservation programmes (Angermeir, 1995). It provides planting stocks needed for the restoration of the species. Clonal propagation methods are also important for genetic improvement (Nagpal *et al.*, 1982; Rai, 1985; Jose *et al.*, 1995; Palaniswamy and Bisen, 2001). Rooting of juvenile stem cuttings of *S. palghatense* is also a promising method for the propagation of the species.

Studies on germination strategies, viz., seed storage, viability and seedling development, have great significance in order to exploit wider genetic resources in the context of individual species recovery. The viability of seeds is lost within a week or so, under ambient conditions as reported in some forest tree species (Farrant *et al.*, 1998; Anil Kumar *et al.*, 1996; Tompsett, 1992;

Fn *et al.*, 1993). Therefore improved storage techniques are inevitable to maintain or even extend the seed viability and longevity for the species.

In the present study the established seedlings of the species were planted in the KFRI Arboretum and also in other locations of KFRI main campus at Peechi. A better percentage of survival and performance has been observed in the Arboretum and KFRI campus. The restoration trials conducted provided valuable information on the environmental requirements of the species, size of a viable population of the species, associated species and methods for successful regeneration. This information can be used for the ex-situ conservation of the species.

5. CONCLUSIONS

The scientific data gathered on population studies along with climatic factors enabled to determine the causal factors responsible for reduction of the population in its natural habitat which subsequently led to the rarity of species. Understanding climatic and edaphic requirements *in situ* will be of use while implementing the restoration of the species.

Since *S. palghatense* is critically endangered species vegetative propagation technique such as rooting of stem cuttings and seed propagation technique can be adopted for its multiplication. Planting seedlings of the species in its natural habitat, in botanical gardens and including the species in the rehabilitation programmes are suggested for the recovery of the species.

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