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Short Communication

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SHORT COMMUNICATION

Distribution of *Syzygium travancoricum* Gamble (Myrtaceae), a Critically Endangered tree species from Kerala part of Western Ghats, India

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Abstract: *Syzygium travancoricum* Gamble is an endemic, Critically Endangered tree species found in marshy swamps of the Western Ghats. An assessment was conducted on existing distribution pattern and population structure of this species in Kerala. Most of the existing populations are mainly located in sacred groves and this tree is an ideal example on role of sacred groves in conserving biodiversity especially IUCN red listed species. A total of 465 individuals were recorded in which maximum number of sapling density was recorded in Kalasamala Sacred grove followed by patches of Myristica swamps in Kulathupuzha. Fragmentation of populations, habitat modification, over exploitation, pollution and invasion of exotics are major threats to *S. travancoricum*. Hence urgent intervention is required for restoration programmes, management of habitat and subsequently delisting this species from IUCN red list of threatened species.

Keywords: Endemic, Kalasamala, Myrtaceae, population structure, southern Western Ghats.

The genus *Syzygium* Gaertner (Myrtaceae) comprises more than 1,200 species all over the world, distributed in tropical regions of Asia, Africa, Australia, and in southwestern Pacific regions (Parnell et al. 2007; Govaerts et al. 2008). As an economically and ecologically important genus, *Syzygium* species are commercially cultivated for their fruits (*S. cumini* (L.) Skeels, *S. jambos* (L.) Alston), timber (*S. aqueum* (Burm. f.) Alston, *S. malaccense* (L.) Merr. & L. M. Perry), or for medicinal properties (*S. aromaticum* (L.) Merr. & L. M. Perry) or as spices. In India, 54 species have been so far reported (Govaerts et al. 2008) with the highest concentration in the Western Ghats with 48 species, among which 27 species are exclusively endemic to this region (Sujanapal & Kunhikannan 2017). The forests of the Western Ghats, especially tropical wet evergreen and high-altitude Shola peaks are ideal habitats for the *Syzygium*, however, most of these species are threatened and as per the IUCN (v1.18-2019) Red List, three species are Critically Endangered, eight as Endangered, five Vulnerable and four as Least Concern. The species like *S. palghatense* and *S. courtallense* are known from single locality and *S. beddomei* and *S. rubicundum* are known only by their type collections. *Syzygium travancoricum* Gamble is an evergreen tree species endemic to the Western Ghats and it was first discovered in the swampy lowlands (altitude <65m) of Travancore by Bourdillon (1908). Later Gamble described it in 1918 in Kew Bulletin and Flora of the Presidency of Madras in 1919. According to Byng et

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al. (2015), *S. travancoricum* is conspecific with *S. stocksii* (Duthie) Gamble, as both share long petioles, elliptic leaves and highly branched inflorescences, however, Sujanapal & Kunhikannan (2017) treated this as different species and commented that detailed studies based on molecular and population data are essential for fixing the status of *S. travancoricum*. This is a medium sized tree growing up to 25m in height. The bark surface is longitudinally fissured, grayish-brown in colour and inner bark is grey. Leaves are simple, opposite, 8–16.5 × 5–8.5 cm, exstipulate and large in size; lateral nerves are 10–15 pairs, parallel, distant, with intra-marginal nerve; petiole 10–20 mm long, grooved above. Flowers are bisexual, white, mostly in axillary lax cymose corymbose with peduncle 4.5–5 (8) cm long, their branches are also long and ascending. Stamens are numerous, free, bent inwards at middle when in bud. Ovary is inferior, two-celled with many ovules. Fruit is a berry, oblong-obtuse on sides, 1 × 0.5 cm, deep violet, and pericarp juicy containing single seed (Image 1). As per IUCN Red list (2019), only 200 trees are found in the Western Ghats and treated as Critically Endangered C2a ver 2.3. It is also reported that the sacred grove of Aikad reported to harbour four individuals and another subpopulation of 15 to 20 trees has been seen at Guddrikal. Nair & Mohanan (1981) quoted that "Apparently no tree is surviving in the type locality. Recently only four trees have been spotted in a sacred grove of Aikad in Quilon District". In Kerala, *S. travancoricum* have been reported from evergreen and semi-evergreen forests and few sacred groves in Thiruvananthapuram, Kollam, Pathanamthitta, Alapuzha, Thrissur, and Kasaragod districts (Sasidharan 2004) and locally known as Poriyal, Vathamkollimaram or Kulavetty. Ray (2011) reported this species from three groves namely, Devaravattibana (Mattigar), Kadkod Choudammabana (Aralihonda) and Choudammabana (Dugdimane) with high seedlings and sapling density in Karnataka region. It has also been reported from the freshwater Myristica swamps of Kaan forests of Uttara Kannada (Chandran et al. 2008 & 2010), Kulathupuzha (Robi 2009) and from a relic Myristica swamp at Brahma Karmali of Valpoi Taluka in Goa (Prabhugaonkar et al. 2014). From Tamil Nadu, this species was reported in five sites, viz., Pandiar, Nadugani, Tropical Gene Pool Garden, Kilnadugani and Poonoor forest areas in Nadugani Village of Gudalur Taluk in Nilgiri District (Udhayavani et al. 2013) and Megamalai Wildlife Sanctuary (Karuppusamy & Ravichandran 2016). Udhayavani et al. (2013) also recorded *S. travancoricum* from the Nilgiri District growing in association with species like *Aporosa lindleyana*, *Sterculia guttata*, *Syzygium cumini* and *Litsea coriacea*. The population of *S. travancoricum* has declined considerably mainly because of over exploitation and habitat destruction. A vast stretch of virgin forest is being converted for agriculture purpose and pressure from exotics plants, grazing and forest fire also caused decline in regeneration (Udhayavani et al. 2013). The swampy wetland habitat has been widely drained and converted into paddy fields have also caused the reduction of its population, leading to a critically endangered state (IUCN 2019). The plants are under great threat due to fragmentation of populations, high rate of inbreeding and habitat specificity which accounts for poor regeneration and seed viability (Sujanapal & Kunhikannan 2017; present observation). In this context, a thorough understanding of existing population structure and composition of *S. travancoricum* will be helpful in developing a proper conservation plan.

Material and Methods

The forest areas and sacred groves in Kerala part of the Western Ghats were thoroughly surveyed during 2016, samples were collected and identified using relevant literature (Gamble 1919; Sasidharan 2004). All specimens were deposited at Kerala Forest Research Institute herbarium (KFRI). Several new locations were identified and total number of individuals in a population, site characteristics, important threats, and pattern of regeneration in each site were noted. Moreover, all previous literature available in Kerala part of Western Ghats were also compiled and revisited.

Results

It was found that among newly identified populations in Kerala, except for the population at Kalasamala Sacred grove, others are represented with few isolated, scattered individuals. In this context, we conducted a detailed investigation on Kalasamala population including total enumeration of individuals with detailed vegetation analysis, especially on population structure, species composition and contribution of individuals. This population might be the second largest population represented with mature reproductively viable individuals distributed outside in the protected areas in the state.

Kalasamala is situated at Thrissur District (Figure 1) and the area lies between 11.128^0 N & 76.150^0 E at 30 m above the sea level with an annual average rainfall of over 2,600 mm. The major proportion (77%) of annual rainfall occurs from the south-west monsoon which usually starts in early June and continues until

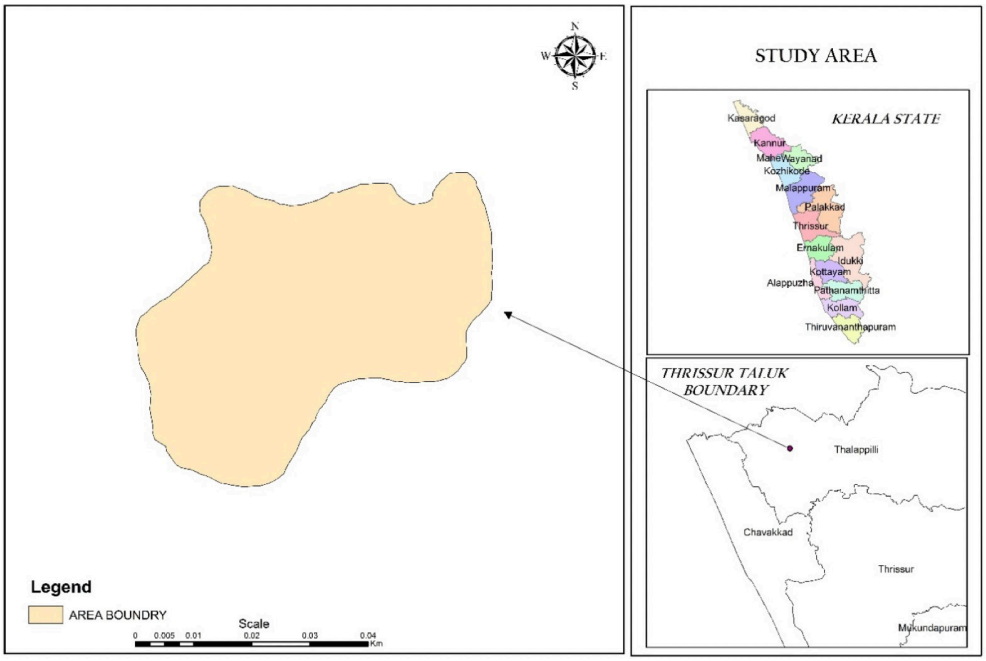

Figure 1. Study area of *Syzygium travancoricum*in Kalasamala Sacred grove.

September. The north-east monsoon starts in October and lasts until the end of November. The mean annual maximum and minimum temperature is 37^{0}C and 19^{0}C, respectively. There is a small sacred groove under private ownership in this area with an extent of 3.5 acres of land crammed with an isolated patch of *S. travancoricum*. For getting effective protection measures, the last author initiated legal procedures to declare this as a 'biodiversity heritage site' and the process has almost in completion. Total stem count was carried out for the population with an area of 0.21ha which in turn divided into 21 blocks of 10m × 10m size for enumeration of tree species. All individuals above 10cm GBH (Girth at Breast Height) girth at 1.37m above ground were measured and identified. Population density, frequency, basal area, IVI (Important value index) and girth class distribution were calculated.

Since *S. travancoricum* is a critically endangered species, our survey throughout the Kerala State located six new localities in which five were represented with very small population size (<10 individuals) except for Kalasamala. The results of total enumeration of individuals in Kalasamala population shows presence of 246 stems (>10.1cm) representing in 236 individuals highlights conservation significance of this area (Table 1). This population covers a total area of 0.21ha and results of vegetation structure shows that the vegetation is over dominated by *S. travancoricum* which represent 86.74% of total Important Value Index (Table 1). The basal area

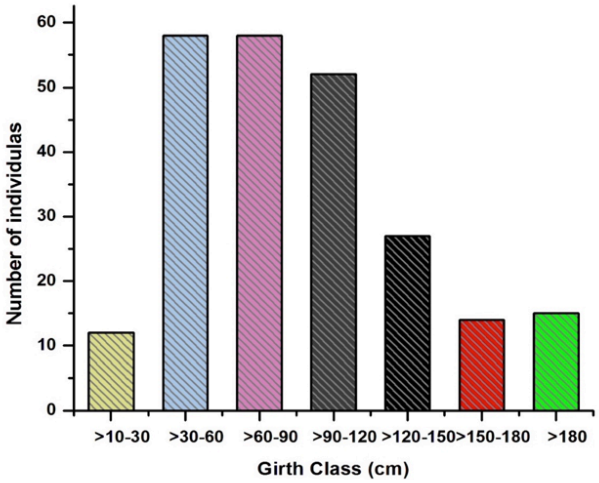

Figure 2. Girth class distribution of *Syzygium travancoricum* population in Kalasamala, Kerala, India.

of *S. travancoricum* was accounting for 109.37m^2/ha. The basal area value is higher than the normal value may be due to the presence of more number of higher girth class trees and higher density value. *S. travancoricum* also represents the 100% frequency of distribution (Table 1) and associated species are *Alstonia scholaris*, *Caryota urens*, *Holigarna arnottiana*. In Uttara Kannada (Chandran et al. 2008, 2010), reported the position of *S. travancoricum* in terms of IVI as 17th and the values range from 0.1065 to 0.5483. The mean IVI of 0.3044 is slightly higher than 0.2988, the mean of the IVI recorded

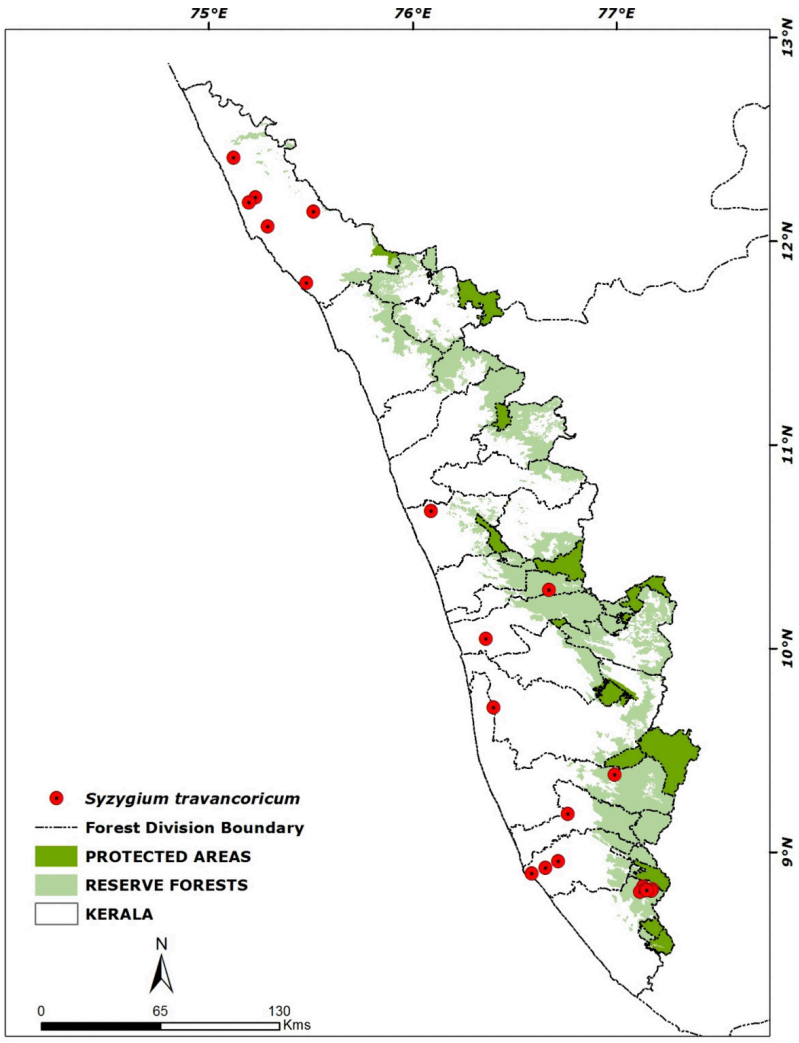

Figure 3. Distribution of *Syzygium travancoricum* in Kerala.

Table 1. Plant species and their contribution to the population dominated by *Syzygium travancoricum* in Kalasamala, Kerala, India.

Species	Basal area m^2/ha	Density (Individuals/ ha)	Percentage of Frequency	IVI	Relative IVI
Alstonia scholaris	3.46	14	10	11.20	3.73
Caryota urens	6.48	14	10	13.65	4.55
Holigarna arnottiana	3.17	19	14	14.92	4.98
Syzygium travancoricum	109.37	1171	100	260.23	86.74

from transects in six swamps of southern Kerala. In Uttara Kannada (Chandran et al. 2008), reported that *Aglaia anamallayana*, *Calophyllum apetalum*, *Diospyros paniculata*, *D. pruriens*, *Dipterocarpus indicus*, *Gymnocranthera canarica*, *Holigarna grahamii*, *Hydnocarpus pentandra*, *Hopea ponga*, *Mastixia arborea*, *Myristica fatua* var. *magnifica*, and *Pinanga dicksonii* as the main associates of *S. travancoricum*. Robi (2009) surveyed different swamp patches in Kulathupuzha and counted only 20 trees from 17 transects in six specific swamps like Emponge, Karinkurinji, Marappalam Major, PerumPadappy, PlavuChal, and Pullu Mala. Density was 11 trees/ha and sixth most important position with an IVI of 0.1198 girth class distribution shows that there was less number of individuals in the smaller girth size which means the lowest size class of 10–30cm gbh was less abundant and formed 5.08% of the total density. The highest number of individuals were record in girth

Image 1. A—habit | B—flowering branch; C—inflorescence | D & E—fruiting twigs. (© A–C - M.S. Sanil | D–E - V.B. Sreekumar)

class 30–60 and 60–90 cm gbh which is accounting for 49.14% of the total density and the density of large trees (girth >180cm) was 6.36%. The study on size class distribution in five sites of Nadugani Village (Udhayavani et al. 2013) shows that 37% of mature stems, 50% sub-adults, 13% saplings. Here in the present study, the size

Table 2. Details of existing status *Syzygium travancoricum* reported from forest areas and sacred groves in Kerala.

	Number of individuals	Place	Current status of the population	References
1	236	Kalasamala, Kunnamkulam, Thrissur	Alteration of swampy habitat, moderate regeneration, very low seedling establishment.	Present study
2	2	Konginichal Kavu, Alakkadu, Kannur	No regeneration, poor fruit set	Present study
3	2	Mazhuvancheril Sree Khandakarna Kavu, Vaikom, Kottayam	No regeneration, poor fruit set	Present study
4	2	Paliyerikavu, Kannur	No regeneration, poor fruit set	Present study
5	2	Ponnakkudam Sacred grove, Ernakulum; Kerala	No regeneration, poor fruit set	Present study
6	16	Vazhachal forests, Thrissur; Kerala	No regeneration.	Present study
7	2	Andallur Kavu, Dharmadam Kannur	No regeneration, poor fruit set	Present study
8	5	Pariyaram, Kannur	Habitat modification,	Present study
9	4	Aickad Sacred grove Kodumon, Pathanamthitta	No regeneration and unhealthy trees	IUCN, 2017
10	20	Goodrical, Kerala	Population was not traced	IUCN, 2017
11	153	Emponge, Karinkurinji, Marappalam Major, PerumPadappy, PlavuChal, Pullu Mala and other swampy patches, Kulathupuzha (Kerala)	Habitat modification, moderate regeneration and fruit set.	Robi 2009
12	8	Kuzhumathikkad Chirakkadavu Bhagavathi Temple Sacred grove, Kollam	No regeneration and unhealthy trees	Present study
13	5	Mampuzha Shri Indaliyappan Temple, Kottamkara, Kollam	Invasion of exotics, very low fruit set and regeneration	Present study
14	3	Moonamkadavu Sacred grove, Kasaragod district	Habitat modification	Present study
15	5	Asramam, Kollam	Habitat modification	Present study

class distribution of tree species shows that inadequate or poor regeneration status with most of the trees in medium to large size class and few are young trees (Figure 2) which need to be investigated thoroughly. In Kulathupuzha, the girth class distribution for *S. travancoricum* (Robi 2009) shows reduced number of individuals in the lower girth classes and the graph plotted is an almost perfect 'J' instead of the expected inverted 'J'. Whereas, in the Uttara Kannada sub-population of *S. travancoricum,* graphical representations of girth class distribution return an almost perfect inverted 'J' indicating a healthy regeneration pattern (Chandran et al. 2010). Similarly, the seedlings density reported from the sacred groves of Karnataka (Ray 2011) is 8235.44/ha (Mattigar, Devarabatti Bana), 4549.52/ha (Aralihonda, Kadkod Choudamma Bana) and 52.736/ha (Dugdimane, Choudi Bana), however, in the present study, observation of phenological pattern indicates normal fruiting and seed germination patterns for *S. travancoricum*, whereas germinated seedlings do not survive after the two-leaf seedling stage as other studies (Chandran et al. 2008; Robi 2009) and consider that swamps might be inundated at the time of fruit fall and seed germination. It was also presumed that fungal attack in the intense humid nature of swamp conditions is the major problem of the survival of *S. travancoricum*. In Kalasamala, seedlings are totally absent and the main threat to the population is degradation of swampy habitat due to intense soil erosion from the top hill. Table 2 shows the compilation of number of individuals recorded so far from different localities of Kerala and a total of 465 individuals were counted in which the maximum number of sapling density was found in Kalasamala followed by Myristica patches of Kulathupuzha. Figure 3 shows that the current distribution locations of *S. travancoricum* in Kerala region. As a part of this study, we could revisit all populations reported by the previous authors (Table 2), except the population in Goodrical which is not traceable. In most cases, alteration of swampy habitat is the major factor for poor seedling establishment which gradually result in declining total number of the individuals.

In conclusion, disjunct distribution pattern, alteration of habitats, changes in landuse pattern and poor fruit set affected the distribution pattern of *S. travancoricum*. In Kalasamala, the swampy habitat of this species has altered due to deposition of silt and waste as a result of construction activities and other human interventions. The State Biodiversity Board has already taken urgent steps to declare this site as 'heritage site', and to support the temple management for protection of this highly threatened species. As a first step towards eco-restoration programmes, Kerala Forest Research Institute (KFRI) has raised sufficient seedlings, around

100 seedlings were restored at Kalasamala initially and planning to restore 2,000 seedlings in different sites of sacred groves involving officials of concerned panchayat, temple management, students as well as through public support.

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