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Distribution of *Shorea roxburghii* G. don (Dipterocarpaceae) in tropical dry deciduous forests of Tumakuru district, Karnataka

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Abstract
Shorea roxburghii G. Don is also called the lac tree, and the lac insect is propagated on it and the tree species is endemic to peninsular India. Besides, a kind of dammar is obtained from the tree. Devarayanadurga reserve forest hosts '*Shorea'* groves (SG) with *Shorea roxburghii* species in single spot with 8 large trees. *Shorea roxburghii* G. Don was previously listed as an Endangered (EN) species in 1998 but now it is listed as Vulnerable (VU) species in the IUCN Red List of Threatened Species 2017. The tree is prone to timber logging and threatened due to habitat loss as forests are cleared for agricultural purposes. The dispersal of winged fruits takes place much more efficiently by wind since the forest is of the open, seasonal, dry deciduous type. The function of a pollination system involving both wind and insects as vectors of pollen transfer is referred to as 'ambophily' and hence S. roxburghii is functionally ambophilous. Flowering is for a very short period only. Seeds mature quickly and seed dormancy is absent. This species is recorded from protected areas only. Hence this tree species must be conserved in *ex situ* conservation, harvesting should be monitored to reduce population decline. Newer and even more effective propagation methods need to be designed to increase the population in natural habitats and forestry.

Keywords: *Shorea*, vulnerable, distribution, propagation

Introduction
Tumkur belongs to the group of districts called the *maidan* (plains) districts and is situated in the east – central part of the Karnataka State and to the south and south – east of Chitradurga district. It is situated between 12^0 45^1 and 14^0 20^l north latitude and between 76^0 20^l and 77^0 31^l east longitude. The forests in the district are confined mostly to the lower slopes of the hill ranges and are spread over the entire district in small blocks. The forests are mostly open and consist of mixed species varying from dry deciduous to thorny bushes. Because of the scanty rainfall, which is about 70cm per year, the tree growth in the dry – belt zone never attains a height more than 25 feet. The forest consists mostly of fuel trees, providing fuel throughout the year. Characteristic of the zone to which the forest region belongs, the vegetative growth is of the dry deciduous type, typical of the *maidan* tracts [1]. Classified technically according to the champion method, the area of forests in the district comes under the southern tropical thorn forest series [2]. *Shorea roxburghii* G. Don (Kannada name – '*Jalari*') is also called the lac tree, and the lac insect is propagated on it. Besides, a kind of dammar is obtained from the tree. The wood of this species is yellowish in color and is capable of taking polish. Mostly, its timber is used for building purposes [1].

Materials and Methods
Study area: Devarayanadurga reserve forest is comparatively dense forest with predominant tree species. It is known for harboring varieties of medicinal plants. This RF is in district headquarters under Tumakuru subdivision. It is elevated at a height of 1188m above mean sea level.

Table 1

Range	Notified Forest Area (in Ha.)						Deemed forest	Total
Tumkur (Devarayanadurga)	Reserved Forest	Protected/Minor Forest	Village forest	Private forest	Section – 4 Forest	Other		
	6194.57	82.17	-	-	65.58	-	4581.62	10923.94

Soil and Climatic conditions
The average annual rainfall in the district is about 680 mm. The soil type here is Red loamy with neutral pH of 7.2, Electrical conductivity being normal of 0.22. Available Nitrogen is 156.6 kg per acre, P_2O_5 is 26.3 kg per acre and K_2O is 44.83 kg per acre which is moderate.

Survey, Collection, and identification
Survey was undertaken in the month of March since it is the flowering season for *Shorea roxburghii*. Few twigs with inflorescence were collected. The tree was identified using Flora of Tumkur District by Bhaskar and Kushalappa, 2013 [3].

Preparation of Herbarium
The plant specimen was dried and pressed in pressing board, poisoned using 0.2 % mercuric chloride solution and herbarium was prepared.

Results and Discussion
Devarayanadurga reserve forest hosts '*Shorea'* groves (SG) with *Shorea roxburghii* species in single spot with 8 large trees in 13^0 21^1 40^{11} N 77^0 11^1 17^{11} E, 49^0 NE at 890 m Elevation. *Shorea roxburghii* is endemic to peninsular India [4, 5]. Single tree sequesters about 44.1 g/species carbon and the whole *Shorea* grove sequesters 352.8 g of carbon. This species of *Shorea roxburghii* is documented as restricted to southern Western Ghats of Karnataka [6]. Rainfall in Western Ghats ranges from lowest of 3,007 mm to wettest being 7,624 mm annually and elevated at 2,695 m above mean sea level. Even with such a significant difference in the climatic conditions of Western Ghats to Tumkur district *Shorea roxburghii* is found to grow in slightly lower elevations and scanty rainfall conditions as well. Similar *Shorea* grove is recorded at a height of 800 – 850 m in the foothill of Siddarabetta in Kortagere taluq of the district [7]. Whereas this species is known to be occasional occurrence in deciduous forests above 800m, here in Devarayanadurga Reserve Forest it is found in groves. Flowering is for a very short period only. Seeds mature quickly and seed dormancy is absent. This species is recorded from protected areas only. Hence this tree species must be conserved in *ex situ* conservation, harvesting should be monitored to reduce population decline.

Etymology: Latin *Shorea*, commemorating Sir John Shore (1751–1834), a Governor-General of India; Latin *roxburghii*, commemorating William Roxburgh (1751-1815), superintendent of the Calcutta Botanic Garden, India.
Dipterocarpaceae Blume. Accepted by APG IV (2016). First published in Bijdr. Fl. Ned. Ind. 4:222. 1825 (1825).
Unarmed, resiniferous, large trees. Leaves alternate; stipules usually deciduous; blade simple, coriaceous, entire, or crenate, pinnately veined. Inflorescence a panicle of racemes or spikes, axillary or terminal; flowers bisexual, regular, bracteolate. Sepals connate, 5 – lobed, imbricate, persistent; petals 5, free, contorted. Stamens 5, 10 or 15, sometimes numerous, in 1 – many whorls; filaments usually free, short, dilated below and connate (this part persistent); anthers 2 – celled, dehiscing longitudinally; connectives mostly prolonged into awns. Ovary superior, rarely inferior, generally 3 – locular; ovules 2 in each locule, parietal; style simple; stigma rarely divided. Fruit 3 – valved, 1 – seeded, either a dry nut, enclosed by accrescent calyx, 1-3 lobes of which elongate and stimulate wings, or fleshy. Cotyledons usually lobed [8, 9].
Shorea Roxb. ex C. F. Gaertn. First published in Suppl. Carp.: 47 (1805)
Stipules small and deciduous or large and persistent. Inflorescence a panicle of racemes, axillary. Sepals glabrous, subequal; petals pubescent. Stamens 15 – many; anthers linear. Ovary hairy. Fruit nut – like, enclosed in calyx tube, with 3 lobes accrescent [8, 9].
Shorea roxburghii G. Don. First published in Gen. Hist. 1:813 (1831)
Deciduous trees to 10 – 12 m. Leaves to 8 x 5 cm, elliptic, acute and emarginate at tip, subcordate at base. Petals white, pubescent on the outside. Stamens 15; stigma 3 – fid. Accrescent lobes of fruiting calyx to 5 x 1.5 cm, oblong, erect, turning red [8, 9].
Fruit calyx is yellowish initially turning orange then red after maturity making the crown visibly attractive from a distance [3].

Vernacular names: It is commonly known as White Meranti or Talura lac tree or Sal tree. Saal, Shaal (Hindi); Jalari (Kannada); Kungilium, Jalari, Talura (Tamil); Talaru, Talari, Jalari (Telugu); Saal, Aswakarnah (Sanskrit).

Specimen Examined: The tree in this region grows up to 40 m in height and Girth at Breast Height was measured to be 2.2 to 2.8 m. The canopy is spread about 14 – 18 m. The tree shows massive blooming from the month of February to March with white, pendulous flowers and its fragrance spreading up to half a kilometer range. Wood density of S. roxburghii is 0.70 g/cm^3 (World agroforestry database). The fruiting was seen by the end of March month.

Ethnobotanical uses: The tree is harvested for timber used as fuel, building furniture, construction of beam in temples, and other tools. The species also produces a resin which is used as a stimulant for fumigation and preparation of incense. The white fragrant flowers are offered to Lord Shiva and extensively collected during local carnivals and as hair accessory by local women [14]. The tree has medicinal properties [10].

Conservation Status: *Shorea roxburghii* G. Don was previously listed as an Endangered (EN) species in 1998 but now it is listed as Vulnerable (VU) species in the IUCN Red List of Threatened Species 2017. The tree is prone to timber logging and threatened due to habitat loss as forests are cleared for agricultural purposes [11].

Seed Dispersal: Seeds may be dispersed by autochory i.e., self-dispersal, anemochory i.e., wind dispersal, zoochory i.e., dispersal by birds or animals, anthropochory i.e., dispersal by humans. The winged structure of the sepals allows 1 – seeded fruits to gyrate toward the ground and hence the seed dispersal is anemochorous. The dispersal of winged fruits takes place much more efficiently by wind since the forest is of the open, seasonal, dry deciduous type [5].

Pollinators: In S. roxburghii, the flowers are nectariferous and produce hexose – rich nectar with low sugar concentration. Since the flowers offer both nectar and pollen, they attract nectar and pollen foraging bees, nectar foraging wasps, flies, and butterflies; flies are important for self – pollination and all the other insects for both self and cross – pollination [5].

Propagation Techniques: Development of axillary shoots induced in embryonic axes of *S. roxburghii* cultured on a modified MS medium containing 6-benzyl-aminopuring (BAP) at an optimum concentration of 5 mg/L is reported [12]. First ever report of efficient mass – clonal propagation of *S. roxburghii* by shoot – apex culture and rejuvenation in all of the multiple buds cultured is also available [13].

Conclusion

With increased logging of *Shorea roxburghii* trees the species is vulnerable and soon might decrease in population. The tree is useful medicinally and large-scale production of lac. Even though tropical evergreen forests are favorable environment for the tree, it is known to be thriving in tropical dry deciduous forest as well. Hence newer and even more effective propagation methods need to be designed to increase the population in natural habitats and forestry.

Supplementary data

Fig 1: *Shorea roxburghii* G. Don. 1. Habit; 2 to 5. Flowering twig; 5. Enlarged flower; 6. Young fruits; 7 to 8. Mature fruits.

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Authors' contributions
MS carried out the field survey and carbon sequestration calculations. KK carried out identification and description of the specimen. All authors read and approved the final manuscript.

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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