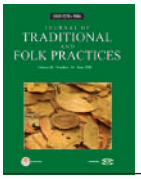

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Stochastic stress and survivability of *Garcinia imberti* Bourd. (Clusiaceae) an endangered tree of the Western Ghats, India

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Abstract

Garcinia imberti Bourd. is an endangered tree endemic to the southern Western Ghats. Their populations are highly distracted due to habitat degradation, slow growth and low seedling recruitment. *In-situ* studies at the Agasthyamala Biosphere Reserve revealed many male and female trees distracted by various stochastic effects like unusual heavy rain lightning *etc*. Recently many stands were felled by the unprecedented Ochki cyclone during the month of December 2017 added more tree toiling and strong winds and rain were also resulted in extensive soil erosion, seedling destruction and canopy gap formations. Nevertheless, studies on conservation aspects of *G. imberti* showed certain ecological adaptations for ensuring survivability.

Keywords: Agasthyamala Biosphere Reserve, Endemism, *Garcinia imberti*, Ockhi cyclone, Predation, Survivability.

1. Introduction

The Agasthyamala Biosphere Reserve of southern Western Ghats harbours high percentage of endemic as well as endangered species (Gupta *et al.,* 2014). The diversity of genus *Garcinia* is maximum in this area of which *G. imberti, G. travancorica, G. rubro-echinata* (Shameer *et al.,* 2016) and *G. gamblei* (Shameer *et al.,* 2017) are endemics. *G. imberti* Bourd. is an evergreen, niche specific endangered tree species (IUCN, 1998) growing up to 8-14 m height. It thrives to grow between an altitudinal range of 600 to 1200 msl (Mohanan *et al.,* 1997). Specific eco-physiological factors like soil conditions and atmospheric parameters are the prime factors that determine the survival aspects of the endemics.

The species are toiled by many stochastic events in terms of recent cyclone related unusual heavy rain, strong winds and lightning which accelerates extensive depletion of individuals in the population. According to Endels *et al.* (2007) habitat fragmentation, degradation and abiotic disturbances may sturdily affect the population structure and genetic diversity of plant populations. Field observations over a period of three years have revealed the probable role of phenotypic variants in terms of flower and fruit colour, size and number of seeds per fruit for species sustenance. Observations on fruit predation and related durability of seeds provided basic aspects of seedling recruitment. In this background, present study aims to describe certain adaptive features of *G. imberti* for facing natural calamities of above stature.

2. Materials and Methods

Field trips were conducted frequently during three consecutive years (2014 - 2017) to the following areas of Agasthyamala Biosphere Reserve in Thiruvananthapuram district, Kerala. Populations were located in different altitudinal gradients. They are;

Chemunji (1168 msl, N $08^0$41'28.0", E $077^0$11'04.8").

Ponmudi (1003 msl, N $08^0$45'50.2, E $077^0$06'48.5").

Bonacaud (643 msl, N $08^0$45'25", E $77^0$11'20").

In each population, demographic data were obtained by mapping all the trees in permanently established 28 quadrats (10×10m) following Gupta Yadav, 2005. Altitude and geographical locations were measured for each quadrat using Garmin eTrex GPS. In each quadrat, the number of male and female individuals of the candidate as well as the associate species along with its height were recorded. A belt transect of 1.5 km was established at the Chemunji hills along the trek path where trees and juveniles were numbered. Floral colour female variants at Ponmudi and fruit variants with more than two seeds at Bonacaud were located. The populations were monitored on monthly basis to understand the stochastic effects and survival adaptability of the species measuring the natality and mortality rates operating in the habitat. Among all the populations, inclined individual trees produced adventitious roots from their hole. Juveniles that emerged in the populations were observed and mapped.

3. Results and Discussion

At the sloughy forest floor of Agasthyamala forests of southern Western Ghats, as the veil of mist moves to the vale at 800 msl, the very site of this endemic species *G. imberti* was quite charming as a vignette for its lush green canopy and curvy branches (Fig.1.*a*). As we reached northern side of the hillock, suddenly a sense of great loss felt for the site of many trees felled by the recent Ockhi cyclone (Fig. 2. *a, b, c, d, e* and *g*). The Caritas India, (8th December 2017) reported that, the cyclone Ockhi uprooted tens of thousands of trees along the neighboring coastal villages of Trivandrum and Kanyakumari. Our field observation revealed that not only in the coastal areas but also many forest regions were affected this types of calamities and destroyed floristic diversity especially trees including many endangered and endemic species.

For the last three years, we have been recording many living enigmatic tale of these few marked male and female trees. It was observed that their populations are highly distracted due to habitat degradation, slow growth, high rate of seed predation and low seedling recruitment. Almost 20 of the fallen trees especially the mature stands were at their phenology of leaf flushing and flower initiation. This year's stochastic effect added more momentum to population depletion. To add more, few mature trees were struck by lightning leaving no chances for the sprouting of foliage as an innate struggle for survival (Fig. 2. *h-i*). The unusual heavy rain and winds shattered the forest that resulted in extensive soil erosion and canopy gap formation (Fig. 1. *b*).

Our previous studies on more inclined *G. imberti* trees at the sloppy areas indicated production of more adventitious, positively geotropic roots from their bole as an adaptation to face landslide (Prajith *et al.,* 2016) (Fig.2. *j-k*). Generally, the adventitious roots formation is a quantitative genetic trait regulated by both environmental (light, temperature, relative humidity) and endogenous factors (sugars, hormones, mineral salts and other molecules) (Krajnc *et al.,* 2013). A similar case of flood related lenticel hypertrophy initiated adventitious root development was reported in *Calophyllum brasiliense* (de Oliveira and Joly, 2009). Even the characteristic 'Garcinia type' of seed germination with secondary root replacing the primary one for developing into tap root system (de Vogel, 1980) usually reinforces the possible anchorage of *G. imberti* trees in the sloppy areas. But on contrary to such previous assumptions, our observation on the uprooted trees revealed the development of poor tap root system and

even the absence of lateral root system due to spatial competition among associate species in the habitat.

Previous observations on some trees provided some cues on ecological scope of floral (colour variant female flowers, Fig. 3. *c*) and fruit variations (unusual 2-4 seeded fruit, Fig. 3. *d*) with respect to enhanced chance of pollination, fruit set and subsequent seed dispersal to ensure species survival (Anto *et al.,* 2016). Flower colour is one of the best studied floral traits which relate the genetic and ecological diversity (Smith and Goldberg, 2015) and it is thought to play an important role in attracting pollinators to patches and may mediate competition or facilitation for pollinators within patches (Levin and Anderson 1970; Ghazoul, 2006). Many such trees were uprooted making necessity of scientific interventions for stabilizing population by restoration of plants. Shift of climate and terrain would be a serious threat to the survival of *G. imberti* either by direct killing or by specific habitat alterations. How such changes affected the behavior of pollinators or seed predators/ dispersers in particular that already devour at a devastating rate is a matter of great concern.

In the previous seasons it was observed that 80 percentage fruits of all populations were gnawed by Malabar Giant Squirrel (*Ratufa indica*) and smaller extent by Nilgiri Langur (*Trachypithecus johnii*) (Fig. 3 *e*). Seed biology revealed the endurance of even pieced seeds to produce seedlings (Fig. 3. *f*) though they remained stunted up to four leafed stage. It was also witnessed that number of juveniles are very less when compared to the middle aged stands. A total of 218 mature trees and 97 juveniles were recorded from the quadrat. They were periodically observed for natality/growth/mortality rate. According to Anilkumar *et al.* (2015), the average mortality rate of *G. imberti* at various populations were 14.9 ± 3.5% caused by elephant trampling and mud sliding. However, the average growth rate was very low in these areas as 0.16 ± 0.04 %. It may indicate the decline/ constrained nature of the populations. What restricted the spread of populations up and down of the existing range, the matter of being gathered as clumped population, edge effects and influence of associated plants or even allied species of the same family of Clusiaceae all remains as an enigma.

Fig. 1. ***a:*** Thick population of *G. imberti* 3 years ago; ***b*****:** Declining *G. imberti* population showing canopy gap by various natural calamities. (#, * indicate the same individual trees surviving after years of observation amidst the lost *G. imberti* trees).

Fig. 2. ***a, b, c, d, e*** and ***g*****:** Recent Ockhicyclone affected *Garcinia imberti* trees; ***f*****:** Habitat;Mature ***h-i*****:** trees toiled by lightning; ***j-k*****:** Adventitious, positively geotropic roots from their bole

Fig. 3. ***a, b*** and ***c:*** *Garcinia imberti* male, female and colour variant female flower; ***d:*** unusual 2-4 seeded fruit; ***e:*** predated fruit/seeds; ***f:*** germinated predated seeds

4. Conclusion

In situ observations revealed the natural trimming of *G. imberti* populations due to stochastic effects as of the recent cyclone hit at Agasthyamala Biosphere Reserve. Adaptive traits like the floral and fruit variants, adventitious roots supporting tilted trees and seed durability support species survivability. Managing seedling recruitment may also ensure conservation of this elusive endemic populations at one of the chosen world heritage sites.

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