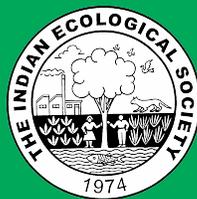


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# Seed Traits and Germination in *Syzygium caryophyllatum* (L.) Alston: An Endangered Species of the Western Ghats

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**Abstract:** *Syzygium caryophyllatum* (L.) Alston is one of the ecologically important tree species of Western Ghats, a global biodiversity hotspot. According to the IUCN assessment, this species belonged to the 'Endangered' category. Present study was designed to assess the fruit and seed traits as well as germination pattern in *S. caryophyllatum*. Reproductive phenology observations revealed that flowering period spread over four months from March to June; while, overall fruiting period ranged between May to July. Individual fresh fruit weight ranged from 0.74 to 3.45 g with highly positive skewed distribution. Seed weight varied from 0.04 to 0.59 g with 83 per cent of seeds being represented in seed weight class of 0.04 to 0.34 g. Seed germination initiated after 13<sup>th</sup> day of sowing and overall germination success was 90 per cent in germination chamber @ 28-35°C temperature and 70-75% relative humidity. However, natural regeneration was very poor in the study area necessitating the need for further focused studies to understand factors that delimit the population build-up of the species.

**Keywords:** *Syzygium caryophyllatum*, Endangered species, Seed traits, Seed germination, Natural regeneration

*Syzygium*, an Old-World Genus, is one of the largest generic groups of family Myrtaceae with about 1200 species (Parnell et al 2007). Fifty-two species of *Syzygium* have been recorded from the Western Ghats, one of the global biodiversity hotspots; of which, 26 species have been listed in IUCN red list (Ramasubbu et al 2016). *Syzygium* exhibits different life forms that range from large sized canopy trees, small to medium sized understorey trees/shrubs and is distributed widely across evergreen to deciduous forest types. *Syzygium* species provide various ecosystem services, pollination being one of the most significant ones. Majority of the *Syzygium* species possess high economic potential in terms of timber, fuel wood and medicinal properties. 'Honey' branded in the name of '*Syzygium* honey' is one of the most popular traded commodities. *Syzygium* is also found as one of the most dominant and abundant genera in the protected and reserved forests of Northern Western Ghats (NWGs, Kanade et al 2008, Joglekar et al 2015, Tadwalkar et al 2020). *Syzygium caryophyllatum* (L.) Alston is one such species that is categorized as 'Endangered' as per IUCN assessment. This medium sized evergreen tree species prefers forest edge as habitat and is sparsely distributed along the margins of evergreen forests and in nearby open patches (Stalin 2015). Though listed as endangered, very few studies have been conducted on current population status, reproductive biology and ecological importance of *S. caryophyllatum*. Seed traits

studies have an important role in understanding dispersal potential, germination success, seedling survival and establishment and community composition (Gunaga 2011, Poschlod 2013, Osuri et al 2016, Hegde et al 2018, Tadwalkar et al 2020). Regeneration which is a fundamental in maintenance of natural population of the species needs to be studied to understand population structure especially for the species which is already 'Endangered' (Gunaga et al 2011, Mirgal et al 2013, Patwardhan et al 2016). Present study focused on all the important life cycle events of the *S. caryophyllatum* like flowering and fruiting, fruit and seed traits and most importantly germination success under controlled conditions and present natural regeneration status of the species in the study area.

## MATERIAL AND METHODS

Field studies were conducted at 'Amboli' forests of Northern Western Ghats (15°57' N latitude, 74°00' E longitude and altitude of 697 m), a part of Sahyadri-Konkan Ecological Corridor (CEPF 2007, Patwardhan et al 2016; Plate 1). Rainy season spans primarily over June to September with occasional pre-monsoon showers in May. The area receives >6000 mm rainfall annually during this period. Present study was conducted for the period from 2017 to 2019. The taxonomic identification of *S. caryophyllatum* was confirmed by referring to the taxonomic literature (Singh et al 2001) and referring to the herbaria.

**Fruit and seed traits assessment:** Flowering and fruiting (reproductive phenology) of *S. caryophyllatum* was regularly monitored during monthly field visits to study area. Buds and open flower duration were recorded under flowering period; while, immature fruits and mature fruits duration was recorded under fruiting period. Mature fruits with dark purple to black colour (Plate 2) were collected from crown of the standing trees using telescopic cutting pole from distantly placed six trees. The fruits collected (N=230) were immediately subjected to the measurement of various traits such as fruit weight (g), fruit length (mm), fruit breadth (mm), pulp weight (g), seed weight (g), seed length (mm) and seed breadth (mm) using pocket balance and digital vernier caliper on the field. Individual tree wise record was maintained. Tree wise numbered fruits were manually de-pulped and then shade dried. Measurements of seeds were taken using precision balance (CONTECH-CA SERIES Model and SHIMADZU ATY224) and vernier caliper in the laboratory. Pulp weight (g) was calculated as a difference between fruit and seed weight. Pulp to seed ratio was also calculated.

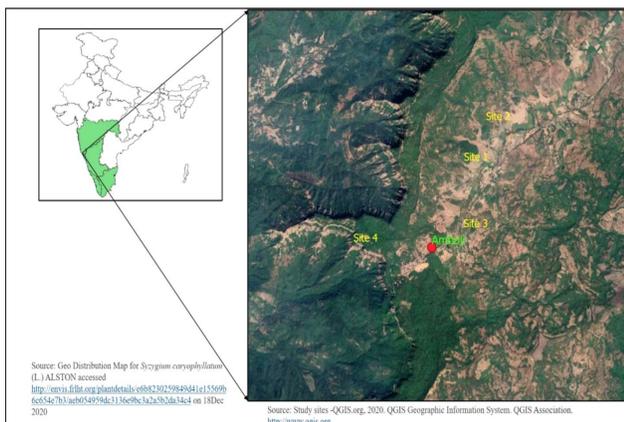
**Natural regeneration:** Natural regeneration was assessed by quadrat method of sampling. Ten quadrats of 10 m x 10 m were randomly laid in open forest patches where adult population was recorded. In addition to this, 13 permanently laid vegetation study quadrats (20 m x 20 m) were also assessed for species regeneration status. In total, 0.62 ha was surveyed for natural regeneration count. Regeneration status was assessed by classifying individuals into four classes based on girth and height viz., Class I (<40 cm height), Class II (40-100 cm height), Class III (> 100 cm height, and < 10 cm Girth at breast height (GBH)) and Class IV (GBH between 10-15 cm).

**Germination trials:** Bulk fruit collection was carried out from distantly located trees. Each seed was measured for its weight and numbered separately. Germination trials were

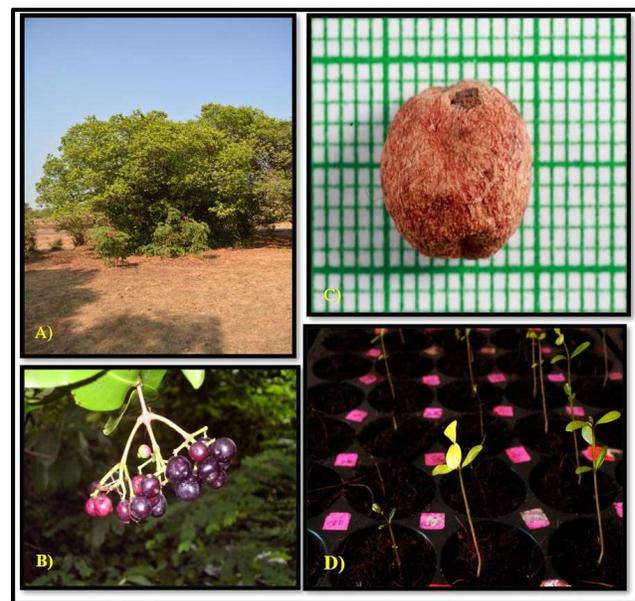
conducted for two consecutive years. Total 300 seeds were subjected to germination trials (100 seeds in year 2017 and 200 seeds in year 2018). Germination trials were conducted in germination chamber under controlled conditions of temperature (28-35°C) and relative humidity (70-75%). No external nutrient support was provided to seeds while performing germination trials. Since seeds of *Syzygium* are considered as recalcitrant in nature, seeds were sown within four days of fruit collection at a depth of 0.5-1.0 cm in the germination trays (1 seed per germination well) filled with moistened cocopeat. No pre-sowing treatment was given to the seed. Regular moistening of the germination tray was carried out till the last day of observation. Germination was marked as positive after seeing radicle emergence. Days required for radicle emergence were grouped into class of 10 days. The number of days required to attain 50 per cent germination in each trial was also recorded. Germination success was monitored upto 90 days from the date of sowing. The summary statistics for the fruit and seed measurements was calculated. Pearson's correlation coefficients were computed for natural log transformed fruit and seed traits. All statistical analysis was conducted using PAST (version 4.0) and JASP (Version 0.14.1).

## RESULTS AND DISCUSSION

In *S. caryophyllatum*, flowering and fruiting was observed for a period of five months spreading across March to July. Bud initiation started in the first half of the March and peak flowering was observed in the last week of April. Fruit formation started in the month of May and mature fruits were



**Plate 1.** Study area map with species population locations



**Plate 2.** Profile of *S. caryophyllatum*- A) Entire plant, B) Fruits, C) Seed, D) Seedlings

observed in rainy season from mid-June to mid-July (Fig. 1). Fruits of *S. caryophyllatum* are single seeded berries with a round shape. Unripe fruits are green and pink in colour and turn dark purple or black at the time of maturity (Plate 2). Red vented bulbul (*Pycnonotus cafer*) was observed feeding on mature fruits. Average fruit weight was 1.52 g ( $\pm 0.45$ ) and exhibited positively skewed distribution (skewness= 1.24). Average fruit length and breadth were 11.04 and 13.02 mm respectively. Seed weight ranged across one order of magnitude with average of 0.25 g. Average pulp weight was 1.27 (Table 1). Out of six classes, 83 per cent of the seeds were distributed between 0.04 to 0.34 g (Fig. 2).

There was significant variation in fruit weight (1.02 to 2.19 g), fruit length (9.77 to 12.94 mm), fruit breadth (12.18 to 14.36 mm), seed weight (0.14 to 0.43 g), seed length (4.86 to 6.71 mm), seed breadth (6.79 to 9.25 mm) and pulp weight

(0.83 to 1.76 g) recorded among six accessions (Table 2). Natural log transformed fruit and seed traits showed highly significant correlation ( $p < 0.001$ ) with each other; however, correlation coefficient values between seed length with fruit traits were relatively low (Table 3). Out of 23 quadrats (0.62 ha) assessed for the regeneration status of the species, regeneration of *S. caryophyllatum* was seen only in 7 quadrats and representing 21 recruits only. Highest number of recruits were found in class IV (N=9), followed by Class II (N=5) and class III (N=5); however, it was least in Class I (only two recruits). Sixty seven per cent regenerating individuals were recorded near adult trees in open forest. It was interesting to note that regeneration was not observed in the adjoining closed forest quadrats. Out of total 300 sown seeds, 90 per cent of seeds showed successful germination. The germination percentage recorded during 2017 and 2018

**Table 1.** Descriptive statistics of fruit and seed traits of *S. caryophyllatum* (N=230)

Descriptive statistic	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Seed weight (g)	Seed length (mm)	Seed breadth (mm)	Pulp Weight (g)	Pulp to seed ratio
Minimum	0.74	7.85	9.67	0.04	3.73	4.86	0.56	2.22
Maximum	3.45	15.41	16.73	0.59	8.52	10.61	3.14	35.21
Mean	1.52	11.04	13.02	0.25	5.88	7.85	1.27	5.98
Std. error of mean	0.03	0.08	0.08	0.01	0.06	0.07	0.02	0.21
Variance	0.20	1.64	1.65	0.01	0.91	1.25	0.14	10.57
Standard deviation	0.45	1.28	1.28	0.11	0.95	1.12	0.38	3.25
Median	1.44	10.91	12.97	0.23	5.83	7.88	1.20	5.20
25 <sup>th</sup> percentile	1.22	10.12	12.09	0.17	5.26	7.07	1.01	4.12
75 <sup>th</sup> percentile	1.7	11.76	13.78	0.31	6.52	8.70	1.44	6.74
Skewness	1.239	0.627	0.217	0.904	0.219	-0.086	1.282	4.052
Kurtosis	2.078	0.654	0.078	0.570	-0.275	-0.412	2.917	29.094
Geom. mean	1.46	10.97	12.95	0.22	5.80	7.77	1.22	5.44
Coeff. Var (%)	29.68	11.61	9.86	44.77	16.22	14.25	29.82	54.35

**Table 2.** Variation in fruit and seed traits among six accessions of *S. caryophyllatum*

Tree accession	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Seed weight (g)	Seed length (mm)	Seed breadth (mm)	Pulp weight (g)
SCAP-01	1.46	11.19	12.79	0.24	5.70	7.86	1.22
SCAP-02	1.33	10.29	12.26	0.14	4.86	6.81	1.18
SCAP-03	2.19	12.94	14.36	0.43	6.70	9.25	1.76
SCAP-04	1.02	9.77	12.18	0.18	5.34	6.79	0.83
SCAP-05	1.37	10.73	12.87	0.25	6.71	8.45	1.12
SCAP-06	1.52	10.92	13.10	0.24	5.68	7.61	1.28
Mean	1.48	10.97	12.93	0.25	5.83	7.79	1.23
SEm ( $\pm$ )	0.11	0.30	0.39	0.02	0.14	0.18	0.10
CD ( $p < 0.05$ )	0.33	0.94	1.23	0.05	0.44	0.55	0.30
CV (%)	12.27	4.75	5.27	10.74	4.19	3.89	13.43

SCA= *Syzygium caryophyllatum* Amboli population; SEm = Standard Error of Mean; CD= Critical Difference; CV= Coefficient of variation

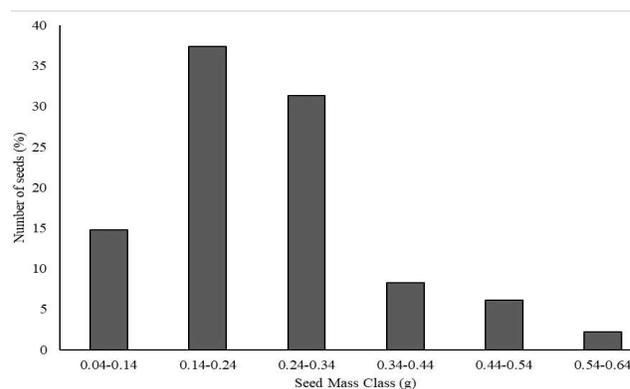
was 89 and 91 per cent, respectively. Germination was highest in smaller seeds (with less seed weight) than bigger ones. Seed germination initiated after 13<sup>th</sup> day of sowing and extended up to 83<sup>rd</sup> day. There was a difference between the time period for 50 per cent germination, where number of days for 50 per cent germination was 19 days for the year 2017 as against 46 days for the year 2018 (Table 4). Maximum germination was observed within 13 to 20 days of sowing. Plant growth abnormalities such as twin shoot formation was seen for a few germinated seeds. Between twin shoots, taller shoot of the seedling showed blackening at the tip and no further leaf production, whereas dwarf shoot showed delayed leaf development.

There are very few studies available on fruit and seed traits of woody species of Western Ghats. *Syzygium*, a dominant genus of the Western Ghats, is also under-researched for fruit and seed traits. Sivasubramaniam and Selvarani (2012) recorded fruit weight of *S. cumini* within range of 2 to 5 g. Moreover, tree to tree variation in *S. caryophyllatum* for fruit and seed traits was also recorded indicating genotypic effect. Such variability has also been recorded for threatened species like *Dysoxylum binectariferum* (Gunaga et al 2015) and *Mammea suriga* (Gunaga and Vasudeva 2009). Tree to tree variation for germination success was also recorded in this species. Such genotypic variation was also recorded in *Melia dubia*, *Sterculia urens* for germination attributes (Chauhan et al 2019, Bhuvu et al 2019). Data shows that *S. caryophyllatum* can be classified as an intermediate fruit and seed size as compared to other *Syzygium* species in study area (Table 5). *S. caryophyllatum* showed fruit initiation and maturation

coinciding with pre-monsoon and rainy season in the study area. Season of fruit maturation can be considered as suitable for *in-situ* germination of pulpy and recalcitrant nature species. Despite profuse fruiting, very poor natural (*in-situ*) regeneration of the species was observed. Reverse-J pattern, a characteristic of healthy regeneration dynamics was also not seen in the *S. caryophyllatum*. The disproportionate regeneration across classes and poor regeneration in class I indicates non favorable conditions for

**Table 4.** Germination observation of *S. caryophyllatum*

Year of experiment	Number of seeds sown	50% germination period	Germination success
2017	100	19 days	89 %
2018	200	46 days	91 %
Mean	-	32.5 days	90 %



**Fig. 2.** Distribution of seeds across different seed weight classes (N=230)

**Fig. 1.** Phenogram of flowering and fruiting of *S. caryophyllatum*

Stages of reproductive phenology	January	February	March	April	May	June	July	August	September	October	November	December
Flower bud												
Open flower												
Immature fruit												
Mature fruit												

**Table 3.** Correlation between natural log transformed weight, length and breadth of *S. caryophyllatum*

Traits	Fruit weight	Fruit length	Fruit breadth	Seed weight	Seed length	Seed breadth
Fruit weight	—					
Fruit length	0.851*	—				
Fruit breadth	0.877*	0.733*	—			
Seed weight	0.651*	0.682*	0.577*	—		
Seed length	0.436*	0.509*	0.431*	0.789*	—	
Seed breadth	0.611*	0.649*	0.536*	0.906*	0.782*	—

\* p < .001

**Table 5.** Fruit and Seed weight of *Syzygium* species from Amboli, Maharashtra

Species	Fruit weight (g) Mean $\pm$ SD	Seed weight (g) Mean $\pm$ SD	Pulp weight Mean $\pm$ SD	Pulp to seed ratio Mean $\pm$ SD	Remarks
<i>Syzygium caryophyllatum</i> (L.) Alston	1.52 $\pm$ 0.45	0.25 $\pm$ 0.11	1.27 $\pm$ 0.38	5.98 $\pm$ 3.25	Prefers forest edge
<i>S. cumini</i> (L.) Skeels	1.82 $\pm$ 0.62	0.40 $\pm$ 0.15	1.41 $\pm$ 0.59	4.03 $\pm$ 2.57	Dominant species along NWG crestline and in Amboli forest
<i>S. hemisphericum</i> (Wight) Alst.	7.32 $\pm$ 3.43	1.77 $\pm$ 0.85	5.54 $\pm$ 2.80	3.64 $\pm$ 3.15	Canopy species in Amboli forest
<i>S. phillyraeoides</i> (Trim.) Sant.	0.83 $\pm$ 0.35	0.27 $\pm$ 0.14	0.55 $\pm$ 0.29	2.60 $\pm$ 1.78	Understorey species in evergreen forests
<i>S. zeylanicum</i> (L.) DC.	0.33 $\pm$ 0.06	0.05 $\pm$ 0.01	0.28 $\pm$ 0.05	6.26 $\pm$ 3.16	Riparian species

natural regeneration and disturbances in ecological process due to climatic and/or biotic factors (Gunaga et al 2011, Mirgal et al 2013, Hegde et al 2018). Species showed clumped distribution in the study area mainly along stream banks which makes habitat inimical to the seedling establishment (Patwardhan et al 2016). During regeneration studies, it was difficult to differentiate whether class III and IV individuals were separate or were vegetative outgrowth of the same adult clump (GBH>15 cm). No seed germination was observed on the ground; but two fruits showed radicle emergence on the plant itself like vivipary. Long term natural regeneration monitoring can be the next step to understand factors affecting natural germination and overall demographic structure of the species (Patwardhan et al 2016, Hegde et al 2018). Though very poor natural regeneration in the forest was observed, species showed 90 per cent *ex-situ* germination success under controlled conditions without any presowing treatment. *S. caryophyllatum* showed twin shoot formation like *S. cumini* (Sivasubramaniam and Selvarani 2012) and *S. mundagom* (Jose et al 2009). The double embryony is also reported in *S. cumini* (Wanage et al 2012). Large scale germination trials to check relation between seed weight and germination success and to examine possibility of polyembryony can form the future step of action in standardization of mass multiplication protocols. Further, studies on possible causes for lack of natural regeneration are needs to be attempted, especially in endangered species like *S. caryophyllatum* in the Sahyadri-Konkan Ecological Corridor.

### CONCLUSION

Fruit and seed size data of an endangered species like *S. caryophyllatum* can be used as an important addition to the global seed database. Poor regeneration on field and high germination success under controlled germination conditions of temperature and humidity without any kind of treatment is one of the interesting finding of the study. Long term comparative study for *in-situ* in the field and *ex-situ*

germination in the nursery may be taken up to identify and understand limiting and promoting factors for germination and further ecological attributes. Further, seedling establishment of nursery plants in *in-situ* conditions is a crucial step in conservation of endangered species through introduction of species in suitable habitat.

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### REFERENCES

- Bhuvra DC, Gunaga RP, Thakur NS and Bhusara JB 2019. Seed and germination attributes in *Sterculia urens* Roxb. populations in South Gujarat. *Journal of Tree Sciences* **38**(1): 23-27.
- CEPF 2007. Ecosystem profile: Western Ghats and Sri Lanka Biodiversity Hotspot- Western Ghats Region. Critical Ecosystem Partnership Fund, 100pp. <https://www.cepf.net/sites/default/files/western-ghats-ecosystem-profile-english.pdf>
- Chauhan RS, Thakur NS, Gunaga RP, Bhuvra DC and Jadeja DB 2019. Assessment of germination attributes in Candidate Plus Trees (CPTs) of Malabar Neem (*Melia dubia* Cav.). *Indian Journal of Ecology* **46**(2): 335-339.
- Geo Distribution Map for *Syzygium caryophyllatum* (L.) ALSTON accessed <http://envis.friht.org/plantdetails/e6b8230259849d41e15569b6c654e7b3/aeb054959dc3136e9bc3a2a5b2da34c4> accessed on 18Dec 2020.
- Gunaga RP 2011. Influence of seed size on seed germination and seedling vigour in *Calophyllum inophyllum*: an important multipurpose tree of coastal region. *Journal of Indian Society of Coastal Agricultural Research* **29**(2): 35-38.
- Gunaga RP and Vasudeva R 2009. Seed traits and half-sib family variation for seed germination and early seedling vigour in Suragi (*Mammea suriga*), an important aromatic tree species of the Western Ghats. *Journal of Non-Timber Forest Products* **16**(4): 285-290.
- Gunaga RP, Manjunath AV, Gunaga SV and Vasudeva R 2015. Tree to tree variation in seed traits and germination in *Dysoxylum binectariferum* Hook. F. *The Indian Forester* **141** (5): 578-580.
- Gunaga RP, Wanage SS, Ganiger RV, Rane AD, Narkhede SS, Bhavne SG, Vasudeva R, Patwardhan A and Sai Prakash 2011. Stand dynamics and regeneration status of *Nothapodytes nimmoniana* Graham. in Open and Close forests of Western Ghats of Maharashtra. In: Proceedings of national seminar on Forest resources: Diversity, Utilization and Conservation held

- at UAS Bangalore, Pp. 44-47.
- Hegde HT, Gunaga RP, Thakur NS, Jha SK and Dobriyal MJ 2018. Population structure and regeneration of Mahua (*Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev.) in disturbed and undisturbed sites. *Indian Journal of Ecology* **45**(4): 724-727.
- Joglekar A, Tadwalkar M, Mhaskar M, Chavan B, Ganeshaiyah KN and Patwardhan A 2015. Tree species composition in Koyna Wildlife Sanctuary, Northern Western Ghats of India. *Current Science* **108**(9): 1688-1693.
- Jose PA, Mohanan N and Hussain A 2009. Occurrence of twin seedlings in *Humboldtia vahliana* Wight and *Syzygium mundagom* (Bourd.) Chithra - Two Endemic Trees of Southern Western Ghats. *Indian Forester* **135**: 290-292.
- Kanade R, Tadwalkar M, Kushalappa C and Patwardhan A 2008. Vegetation composition and woody species diversity at Chandoli National Park, Northern Western Ghats, India. *Current Science* **95**(5): 637-646.
- Mirgal AB, Rane AD, Gunaga RP, Narkhede SS and Bhawe SG 2013. A note on stand dynamics of *Antiaris toxicaria*, a rare plant of Konkan Region of Western Ghats. *The Indian Forester* **139**(12): 1161-1162.
- Osuri AM and Sankaran M 2016. Seed size predicts community composition and carbon storage potential of tree communities in rain forest fragments in India's Western Ghats. *Journal of Applied Ecology* **53**(3): 837-845.
- Parnell Jan, Craven LA and Biffin E 2007. Matters of scale: Dealing with one of the Largest Genera of Angiosperms, pp. 251-273. In: Hodkinson TR and Parnell JNL (eds). *Reconstructing the Tree of Life: Taxonomy and Systematics of Species Rich Taxa*. Edition: Systematics Association Special Volume Series 72. Taylor and Francis, CRC Press. Boca Raton.
- Patwardhan A, Pimputkar M, Mhaskar M, Agarwal P, Barve N, Gunaga R, Mirgal A, Salunkhe C and Vasudeva R 2016. Distribution and population status of threatened medicinal tree *Saraca asoca* (Roxb.) De Wilde from Sahyadri-Konkan ecological corridor. *Current Science* **111**(9): 1500-1506.
- Poschlod P, Abedi M, Bartelheimer M, Drobnik J, Rosbakh S and Saatkamp A 2013. Seed ecology and assembly rules in plant communities. *Vegetation ecology* **2**: 164-202.
- QGIS.org 2020. QGIS Geographic Information System. QGIS Association. <http://www.qgis.org>
- Ramasubbu R, Divya C and Anjana S 2016. A Note on the taxonomy, field status and threats to three endemic species of *Syzygium* (Myrtaceae) from the Southern Western Ghats, India. *Journal of Threatened Taxa* **8**(11): 9384-9390.
- Singh NP, Lakshminarsimha P, Karthikeyan S and Prasanna PV 2001. *Flora of Maharashtra State*. Botanical Survey of India, Vol. 1 and 2.
- Sivasubramaniam K and Selvarani K 2012. Viability and vigor of Jamun (*Syzygium cumini*) Seeds. *Brazilian Journal of Botany* **35**(4): 397-400.
- Stalin N and Swamy PS 2015. Prediction of suitable habitats for *Syzygium caryophyllatum*, an endangered medicinal tree by using species distribution modelling for conservation planning. *European Journal of Experimental Biology* **5**(11): 12-19.
- Tadwalkar M, Joglekar A, Mhaskar M and Patwardhan A 2020. Woody species diversity from proposed ecologically sensitive area of Northern Western Ghats: Implications for biodiversity management. *Journal of Threatened Taxa* **12**(9): 16048-16063.
- Wanage SS, Mirgal AB, Gunaga RP, Rane AD, Narkhede SS and Bhawe SG 2012. A report on double embryos in *Syzygium cumini*, an important tropical wild fruit tree. *Journal of Non-Timber Forest Products* **19**(2): 151-152.
- World Conservation Monitoring Centre 1998. *Syzygium caryophyllatum*. The IUCN Red List of Threatened Species 1998:e.T38036A10094391. <https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T38036A10094391.en>. Downloaded on 24 April 2021.