International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X, Impact Factor: RJIF 5.12
Received: 03-03-2021, Accepted: 04-04-2021, Published: 13-04-2021
Volume 6, Issue 2, 2021, Page No. 505-509

Pollination biology of *Syzygium myhendrae* (Bedd ex Brandis) Gamble: An endangered tree species of the Western Ghats

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Abstract

Syzygium myhendrae (family: Myrtaceae) is a semi evergreen, endangered tree growing in parts of Western Ghats. The present investigation was aimed at understanding its phenology, floral biology, and pollination biology. The pollination biology was assessed through observations on the frequency of pollinators visit and also from the floral characters. The flowering period of mature individuals was reported to be from June – November and fruit set in December. The tree usually flowers at the onset of south west monsoon and the peak bloom was noticed during September. Honey bees which include *A. cerana, A. dorsata* and *Trigona iridipennis* are the prime pollinators. Not only honeybees but also butterflies, moths, and flies are visiting the flowers during the peak period of flowering. Diurnal anthesis, numerous stamens soft and bright inflorescence are the major pollination syndromes for pollinators. The fruit is edible and very small with only 1-2mm thickness of fruit pulp. The single seeded fruit becomes edible after 18-34 days. The common frugivores include birds and bonnet monkey.

Keywords: endangered, honey bees, phenology, pollination, *Syzygium myhendrae*

Introduction

Syzygium myhendrae is a medium sized tree species belonging to the family Myrtaceae. *Syzygium* is the largest tree genus among flowering plants globally, comprising approximately 1200-1800 species [14]. The genus is generally restricted to the tropical evergreen forests and its native range extends from Africa through Madagascar, south and south East Asia to Australia and New Zealand [14]. The greatest diversity occurs in Australia and south East Asia. In India, the genus consists of 75 species, of which 52 reported from Western Ghats [16].

Of these, 26 species come under IUCN red data list. Five species are critically endangered and eight species are endangered [15, 16]. Some species of *Syzygium* yield valuable timber and fruits of some species are edible. The leaves of several species are used as green manure by farmers. A few species showed medicinal properties and some are used to extract natural dyes [12].

Syzygium myhendrae (Bedd ex. Brandis) Gamble is mainly distributed in Karnataka, Kerala and Tamil Nadu. Due to its restricted distribution *Syzygium myhendrae* is categorized as endangered in the IUCN red list 2015.The colour and ornamentation of young leaves are highly attractive and many taxonomists recommended that it can be introduced as wild ornamental. Fruits are edible, sweet and sour in taste with a tinge of mango flavor [19].

Flowers of *Syzygium* are of brush type showing a generalized pollination strategy. Studies conducted in Australia and New Zealand indicate that the flowers of *Syzygium* species are pollinated by many animals including insects and vertebrates. However, detailed studies on pollination biology of Indian species of *Syzygium* are limited. Some authors have studied and documented floral visitors, but with little information about pollination efficiency [23]. The present study aims to investigate the pollination biology of *S.myhendrae* an endangered tree species of the Western Ghats.

Materials and methods

Study area

The present investigation was undertaken on plants of *Syzygium myhendrae* growing in the shola forests of Ponmudi hills (Kerala), a part of Agasthyamala Biosphere Reserve. Ponmudi hills lie at an altitude of 1100 m above sea level but the study area is confined to only 800-1000 m a.s.l. and between 10^0 12'29.60" N latitude and $7^0$28'50.32" E longitude. This region prevails heavy south west monsoon during June- September. Annual temperature varies 23.7^0 C to 32.17^0C and annual rainfall between 20cm to 25cm. The study was undertaken during 2017-2020.

Phenology

Phenological events were noticed among 50 unopened flowers on 20 inflorescence in bud stage were randomly marked and observed through field visits. The initial appearance of leaf primordia, floral bud initiation, peak and end of flowering was recorded. Time of opening of flowers, flower development, anther dehiscence, fruit initiation and maturation were observed.

Floral biology

Floral morphology was studied in the field and later in the laboratory with the help of a stereo microscope. Twenty fresh flowers from 10 inflorescence were selected and floral morphometric measurements were taken by using a digital vernier calipers. Colour of the flower was analysed by using a colour chart (Royal horticultural society colour chart). Presence of odour was detected by keeping some flowers in glass vials for 2-3 hrs. Twenty mature buds were tagged for recording the anthesis time. Anther dehiscence was

observed by using a 10X hand lens. Number of pollen grains were calculated by suspension method [1]. Pollen ovule ratio was calculated by the method proposed by Cruden (1997).Acetocarmine test was used to asses the pollen fertility [5].

Pollination

Flower visitors and their visiting behavior were recorded by direct observation. Marked flowers (n=75) were observed during the peak flowering period (August-September). Observation during the rainy day (between 0600- 1900 h), indicated that there were no visit/foraging to flowers of species by insects. Thus, observations were made between 0600- 1900 h over 10 non-consecutive days with possible weather condition (i.e. Temperature above 20^0C, moderate wind (40Km/hr) and sunny days. The number of floral visitors, visiting time, foraging nature, foraging hours, time spent (flower handling time) in each flower was recorded by using a stop watch [6]. Insects foraging on flowers of *S.myhendrae* were also photographed. The frequency of insect visits was also recorded. The insects were captured using mesh net and captured insects were fixed in small vials with 70% ethyl alcohol and these pollinators were authentically identified by the experts in Agricultural college, Vellayani, (Dept, of Entomology) Thiruvananthapuram. These flower visitors/pollinators identification was carried at lowest taxonomic level (species, genus & family). Some insects could not be identified up to species level.

Results and Discussion

Phenology

S. myhendrae is a semi evergreen mass flowering tree species (Fig.1A). Leaf shedding takes place during April-May. Flower bud initiation occurs by the second week of June. Emergence of new leaves takes place simultaneously with the flower bud initiation. Development of flower took almost 28-34 days from bud initiation to full bloom. Flowering starts in the month of July and extends up to October. Peak flowering lasts for a fortnight during August and September. By the end of September flowering declines rapidly. Fruit initiation was observed in November. Fruit maturation was noticed during December- January. Unripe fruits are green and when matures colour changes to pink then to shining crimson red and finally to black purple. Fruit is predated by birds and common bonnet monkeys

Floral biology

The floral anthesis occurs between 0530-0730h. Anther dehiscence takes place 2 hours (i.e. by 0900h) after floral and anther dehisce by longitudinal slits. The number of pollen grains per flower is 26040±1032. There are 15±3 ovules/ flower and the pollen ovule ratio was calculated as 1736:1. The pollen grains (Fig. 1C) are triangular and tri colporate. The apertures appear as short furrows in a thickened portion of the wall. Pollen grains are powdery dry type and fertile. The average life span of each flower is 2-3 days.On the third day all the stamens are abscised.The fertilized ovary gradually developed in to fruit and calyx remain persistent for 40-45 days.

Table 1: Floral characters of *Syzygium myhendrae*.

No.	Floral characters	Observations
1	Flowering period	June-October
2	Flower opening time	≈5.30-7.30 am
3	Flower type	Actinomorphic
4	Odour	Odourless
5	Nectar	Present at the nectar cup
6	Inflorescence	Terminal corymbose cyme
7	Flower colour	White
8	No. of flowers/ Inflorescence	39±2.94
9	No.of flowers/branch	42,175±3986
10	No.of flowers /tree	3,19,523±4865
11	Anther dehiscence time	2 hrs after anthesis
12	Flower diam.(mm)	3-5 mm
13	Length of stamens(mm)	4.81-5.42mm
14	Pollen - ovule ratio	1736:1
15	Pollen grain	tricolporate
16	Pollen shape	triangular
17	Length of style(mm)	3.10-3.52mm
18	Stigma type	Wet and papillate

Pollination biology

Trees of *S.myhendrae* produce small, white odorless flowers. It shows diurnal anthesis. As a result of continuous observation eight different pollinators belonging to Hymenoptera, Diptera and Lepidoptera were trapped. Flowers provide both pollen and nectar as floral rewards to the pollinators. Honey bees made the highest number of visits to the flowers during the observation time, which includes *Apis cerana*(Fig.1D),*Apis dorsata* and stingless bee (*Trigona iridipennis).Apis dorsata* and starts *A.cerana* starts visiting the flowers from (0700hrs) and their peak is between 0700-1430 hrs (Figure 3). *Trigona iridipennis* also starts its foraging in the morning and spends 3-6 seconds in each flower. During hourly observation, it is found that honey bees were regularly visiting all the flowers in an inflorescence randomly and they were considered as effective and active pollinators. They visit the flowers and forage both pollen and nectar. Sequential visit of honeybees in each flower helps in successful pollination leading to fruit set. *Pachilopta pandiana* (Fig 1F) and *Danus genutia* (Fig. 1E) are the two butterflies foraging the plant, they visit the flower during the day time and starts its foraging on 08.30hrs. It spend 2-4 seconds on each flower but forage only for nectar. An unknown species of both moth and wasp (Fig. 1H) as well as fly species (Fig. 1G) also visiting the flower. The fly species visiting the flowers during 08.30-12.39h. Moth species starts its foraging activities in the early morning 07.00h (Fig.3).The number of butterfly species visiting the flower is much higher than fly species and moth species but comparatively lower than honey bees. All the pollinators (Table 2) were found to be very admissible to the plant. In general, all the pollinators are not sufficient to pollinate all the flowers in the individual plant/population. Due to heavy rainfall and heavy winds (47km/hr) affect the insect visitation rate in the population which adversely affect the reproductive success. This may be one of the reason for the endangerment of the candidate species in the natural habitat.

Table 2: Pollinator behaviour in *Syzygium myhendrae*.

Visitors	Common name	Family	Visiting time	Foraging nature	Foraging time	Visiting status
Apis cerana	Indian honeybee	Apidae	Day	Pollen + Nectar	0.700-14.30h	Regular
Apis dorsata	Rock bee	Apidae	Day	Pollen + Nectar	0.700-14.30h	Regular
Trigona Iridipennis	Stingless bee	Apidae	Day	Pollen + Nectar	08.00-12.00h	Regular
Hypolimnas misippus	Danaid egg fly	Nymphalidae	Day	Nectar	08.30-15.00h	Regular
Pachilopta pandiana	Malabar rose	Nymphalidae	Day	Nectar	08.30-15.30h	Regular
Danaus genutia	Common tiger	Nymphalidae	Day	Nectar	09.00-12.30h	Regular
Moth spp	Unknown	Unknown	Day	Nectar	07.00-10.30h	Regular
Fly spp.	Unknown	Unknown	Day	Nectar	08.30-12.39h	Regular

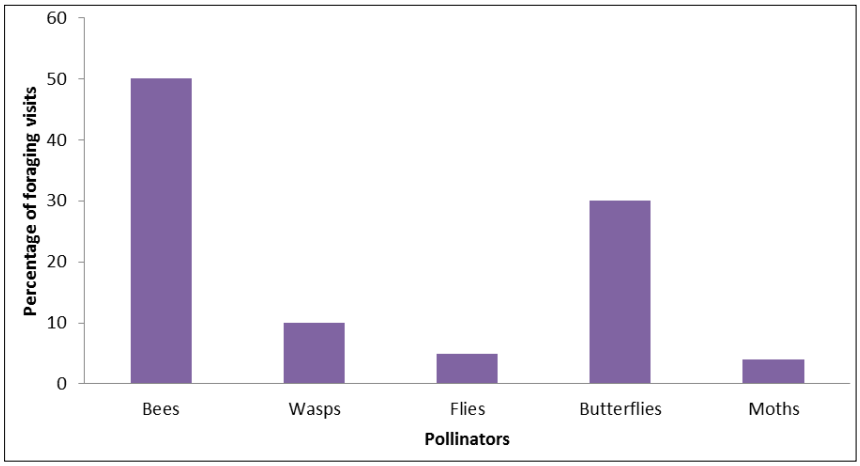

Fig 1: Percentage of foraging visits of different categories of insects on *Syzygium myhendrae*.

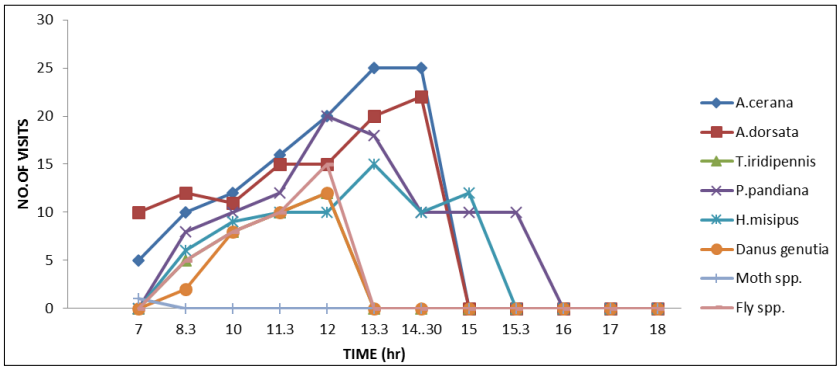

Fig 2: Hourly foraging activity of pollinators of *Syzygium myhendrae*

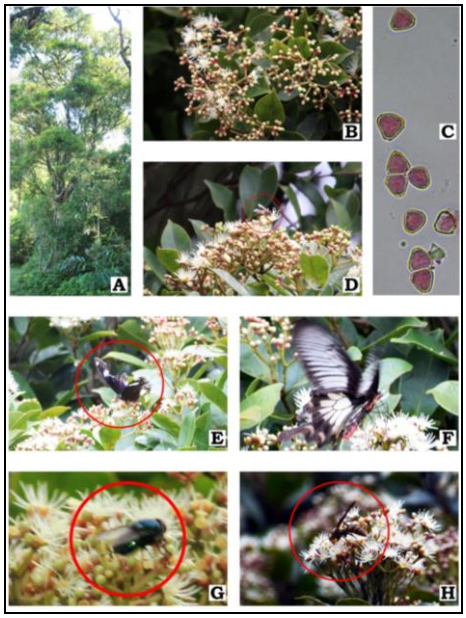

Fig 3: A-Habit, B-Inflorescene, C-Pollengrains, D-*A.cerana*, E-*Danus gen9utia*, F-*Pachilopta pandiana*, G-*Fly sp*., H-*Wasp sp*.

Phenology is the timing of physiological stages such as growth and reproduction; accordingly flowering phenology refers to the seasonal time of flowering. Temperature, moisture and photoperiod are the major factors that affect the phenology (Growth and reproduction) of both plants and their pollinators. Timing of flowering helps in maintaining reproductive isolation and in reducing competition for pollinators. Therefore, in any pollination biological studies it is very important to record observations on flowering phenology of the plant in question. In *Syzygium*, there are two types of flowering patterns; one is short time steady state flowering and mass flowering. Most of the species showed mass flowering such as *S.cuminii* [17] *S. sayeri* [25] and *S.aqeum* [21]. *Syzygium myhendrae* is also a mass flowering tree, produced flowers during June-October. Exploration trips at different flowering periods revealed that the tree regularly bloom at the onset of south west monsoon. Flowers usually emerged in the first two-three months did not develop in to fruits due to heavy rainfall and wind speed in the study area. Scarcity of pollinators in the monsoon season affect the fruit production in first two-three months. During the monsoon period heavy rainfall and heavy wind affect the insect visitation rate of plant which may leads to poor reproductive success. This finding does not agree with the observation of many authors in other species of *Syzygium*. In *S. alternifolium* [22] reported that the tree starts flowering in the month of March and continuous up to May and fruit initiation started in June-July. Some *Syzygium* species such as *S.cuminii, S. laeutm, S. mundagam, S. heyneanum* and *S. travencoricum* flowering was completed during summer itself before the initiation of south west monsoon but fruit maturation and dispersal takes place during the rainy season [12, 17]. Leaf flushing occurs after the flowering season in *S. myhendrae*. This observation is similar to many *Syzygium* species. In *S. myhendrae*, the mass flowering phenomenon is not a regular event: Flowering intensity varies, mass flowering was noticed during 2017 & 2019. But moderate flowering was observed in the second year. Several studies revealed that the influence of rainfall or water levels affect the flowering intensity in mass blooming *Syzygium* species [8, 13].

Floral traits of the flowers are important predictions of plant pollinator interactions [7]. Insects are the predominant visitors of cream coloured flowers [3]. This observation is similar to that of our candidate species. A total of 8 species (bees, flies, butterflies and moths) were attracted to the flowers of *S. myhendrae*. Honey bees (*A. cerana, A. dorsata)* are the prime pollinators during the morning time. They spend an average of 2-4 seconds in each flower and their interplant movement facilitates pollination. In general, Myrtaceae members have no specialized pollination system and attract a wide range of both vertebrates and invertebrate floral visitors [4, 10]. Williams and Adam 2010 studied and reported the pollination biology of several species of *Syzygium* [25]; In *S. tiernyanum,* reported 45 species of nectar feeding insects and hawk moths. The mass flowering species *S. floribundam* is pollinated by a guild of insects but bats and birds do not visit the flowers although they occur in that study site. In some *Syzygium* species such as *S. neurocalyx* and *S. mundagam* are pollinated by birds and bats [24]. During the peak period of flowering of these plants, secreted copious amount of nectar. Plants such as *S. alternifolium, S. occidentale* and *S. cuminii* exhibit both anemophilous and entomophilous pollination ie, ambophilous condition [9]. But in *Syzygium my hendrae* the foraging activities of pollinators was noticed in day time only. The plant flowers in the monsoon time, heavy rainfall and wind affect the visitation rate of pollinators. They are completely inactive in rainy season. Bees activities are also very poor in monsoon period.

Conclusion

Syzygium myhendrae is a semi evergreen mass blooming tree species. Habitat degradation, environmental factors and reproductive constrains such as scarcity of pollinators in the flowering season, low insect visitation rate, could be the reasons for the limited distribution of the plant in the natural habitat. Hence, the present study provides a base line data for studying the reproductive dynamics of the plant and strategies for conserving this endangered plant

Acknowledgement

The authors are thankful to the Director, JNTBGRI for providing necessary facilities. The author Divya S Pillai is greatful to the CSIR for financial assistance.

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