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Pollinating Agents of *Eucalyptus citriodora* Hook. –Insects or Wind?

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Abstract: *Eucalyptus citriodora* is a self-compatible, protandrous, monoclinous, mass-bloomer tree. Protandrous nature prevents intrafloral selfing. Geitonogamy becomes predominant. Eighteen different insect species were recorded at the flowers foraging for nectar and pollen. The inefficiency of the visitors made the plant into anemophilous nature. Fruit set was unaffected when the insects were excluded from visiting the flowers. Flower and pollen anthesis, pollen release took place during day time. Nocturnal pollen release was not observed. The shifting of pollination system might be viewed as one of the adaptive mechanisms for tropical conditions.

Key words: Pollination, pollinators, geitonogamy, anemophily

INTRODUCTION

The relationship between plants and insects is considered to be one of the longest partnerships in biological history. Relation between plants and insect pollinators has been subject of several studies in co-evolutionary interactions. Studies on the adaptive significance of floral traits for successful pollination are not new[1]. The modern view of evolution of floral traits started with Darwin[2] and it has been proved that flower shapes, colours and energy rich nectar and pollens have made certain animals to visit the flowers to take forage matter and act as pollen vectors[3]. However, rigorous explanations for relating floral traits to pollination success have come recently. Tropical ecology is plagued with generalised mode of pollination[4]. One such generalisation is about the type of pollinating agent which states that wind pollination is rare or absent in the tropics[5,6]. Under the influence of generalised mode, most of the pollination ecologists are now concentrating on recording and monitoring the activities of biotic pollen vectors with little enquiry into the pollen characteristics and functions.

To have a better knowledge in the pollination study of any plant, the details of pollen and pollinator dynamics in ecological perspective for several seasons are prerequisites, but studies in this line are few and experimental work is rare[7,8]. The present study, without being carried away by the above generalisation, was aimed at evaluating the mode of pollination of *Eucalyptus citridora*, a commercially important tree of the family Myrtaceae.

MATERIALS AND METHODS

Cultivated as avenue tree in road side, *Eucalyptus citridora* is available in Santiniketan and its adjoining areas (23°55′ N, 87°40′ E, 60 m above sea level), formed the study material. Ten trees were marked for present investigation. Visits were made periodically to record various phenological events of the inflorescences and flowers, and the behavioural patterns of insects at the flowers. The rate of anthesis was recorded using tagged inflorescences, which were free of open flowers. For pollen productivity, mature but undehisced anthers were collected, squashed, spread on a clean glass slide with a droplet of safro-glycerine (1:1) and the entire area was observed under a microscope (× 400 x magnification) for pollen counting[9]. Pollen dispersal rate as single grains or in aggregates was checked by gently touching the dehisced anthers and collecting the released pollen on microscope slides placed close to the anthers. The duration of pollen viability and stigma receptivity was based on the fruit set resulting from hand pollination of 200 flowers at periodic time intervals after flower opening. The rate of pollen release was determined by taking anthers from foraged flowers at periodic time intervals and counting of pollen left in the anthers was made. The difference between two successive counts gave the amount of pollen depleting during that interval. The hourly pollen incidence over canopy were determined by operating Rotorod Sampler[10]. Pollen spread downwind of the source, at the time of anther dehiscence were measured at a distance of 0, 10, 20, 40 and 50 m using

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Rotorod Sampler. The insects were collected and identified from reference materials and Zoological Survey of India, Kolkata. To determine apomixis, 10 emasculated flowers were bagged with butter paper. Another 10 emasculated flowers was pollinated with geitonogamous pollen and another 10 emasculated flowers with xenogamous pollen, then bagged with butter paper to avoid other pollen contamination. Then the flowers were observed until mature fruit development took place. The contribution of pollen vectors, insects and wind was assessed by keeping inflorescences for 10 days in nylon nets. The rates of fruit-set in the initial, peak and ending of the flowering period were recorded.

RESULTS

Phenology: *Eucalyptus citriodora* is a evergreen, avenue, mass bloomer tree cultivated for honey and wood[11], flowers from December to February. Flowers are small, whitish, in panicles with indefinite number of stamens which start to open in morning with peak flower anthesis at 10.00 h (Fig. 1).

Breeding systems: The tree is self-compatible, apomixis is absent, fruits are set through autogamy and allogamy. Autogamy is successful to 32%, geitonogamy to 47% and xenogamy to 61% in setting fruit.

Pollen grain characteristics and floral rewards: Each anther produces an average number of 1087 pollen grains. It becomes roughly to 108720 per flower. More than 75% of the grains dislodges as single grains. Most of the pollen grains enter into atmosphere showing three peak concentrations. (I) With 5974 pollen grains m^{-3} of air sampled in 10.00 h; (ii) 6760 grains m^{-3} in 12.00 h and (iii) 4852 grains m^{-3} in 15.00 h (Fig. 2). Approximately 11.4% of the pollen grains produced remained unreleased and adhered to anther walls. In pollen releasing periodicity, the pollen incidence varied between 2544 to 6760 m^{-3} of air sampled. With regard to distance, the atmospheric pollen incidences were 6760 at 0 m, 3265 at 10 m, 452 at 20 m, 128 at 40 m and 25 at 50 m. Nectar is considered to be the chief floral reward to visitors. Nectar volume, its regulation and sugar concentrations, were not measured during present study. It was observed that nectar was secreted in the calyx cup continuously for the period of 2 days, from the time of flower anthesis. Pollen was also the floral reward because bees, flies and beetles were found to collect pollen.

Flower visitors: A total of 18 different insects were recorded and monitored (Table 1). All the insect visitors were diurnal in nature. Their visiting time, mode of visit, forage nature, time spent on flower vary with each other.

Table 1: Flower visitors of *Eucalyptus citriodora*

Name of the visitors	Forage type
Hymenoptera	
Apis cerana indica	P + N
A. florea	P + N
A. dorsata	P + N
Trigona sp.	P + N
Ceratina viridissima	P + N
Wasps	N
Bombix borrei	N
Sphex sp.	N
Chalybion sp.	N
Ants (Formicidae) 2 species	N
Lepidoptera	
Hesperidae	N
Danaidae	N
Lycaenidae	N
Diptera	
Chrysomya megacephala	P + N
Sarcophaga sp.	N
Ligyra sphinx	N
Coleoptera	
Unidentified	P+N

P = Pollen; N = Nectar

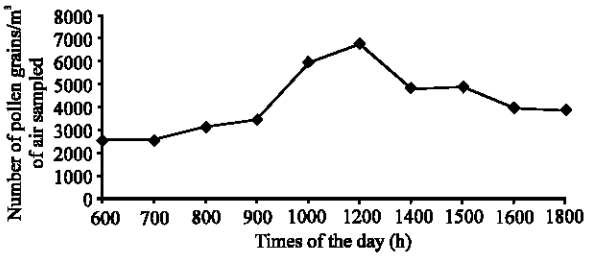

Fig. 1: Circadian periodicity of airborne pollen of *Eucalyptus citriodora*

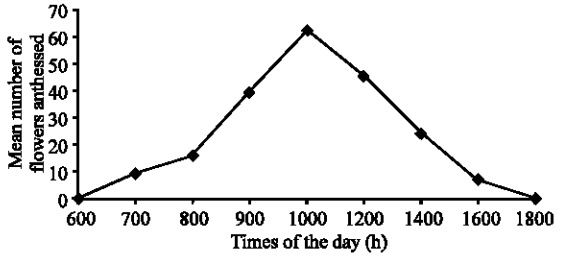

Fig. 2: The rate of anthesis (%) at different times of the day in *Eucalyptus citriodora*

Fruit-set: After bagging with nylon net to allow wind but to prevent large insects for several days, 23% fruit-set was observed. The open natural flowers showed similar amount of fruit-set, indicating that the plant is not insect dependent for fruiting. The percentages of fruit-set vary with different period of flowering (initial phase-41%; middle phase-48% and terminal phase-6%).

DISCUSSION

The spatial and temporal separation of the sex organs are in support of cross-pollination. But from the functional point of view the plant may be considered as self-pollinated. Although self-pollination is prevented by protandrous nature but the protandry does not prevent intra-plant selfing i.e. geitonogamous pollinations[5,12]. If the self-pollen falls on receptive stigma, then there is a possibility of intra-floral selfing, because the pollen is self-compatible. The chance of self-pollen falling on sticky receptive stigmas is much probable due to stickiness. In this plant lack of long distance pollinators may enable the difficulties in cross pollination. So, the plant may opt either apomixis[13] or geitonogamy[14]. *Eucalyptus citridora* may choice second option (selfing in form of geitonogamy). The mass flowering, self-compatibility, sticky receptive stigmas, high pollen incidence are feasible to facilitate increased geitonogamy. Although the flower structure and pollination syndrome match better for entomophily nature of this plant, but experimental data indicate anemophily and markedly deviate from entomophilous nature. However, a dynamic functional approach is required to rightly comment on plant's pollination system[8,15]. As the nature and diversity of pollinating agents and breeding system may vary with time, place and genetic lineages, it is often difficult to describe a species as purely wind pollinated or purely animal pollinated. Many entomophilous pollen grains are also transported by wind[5], entomophilous pollen are present in atmosphere also[16] and pollen of some anemophilous plants were often collected by insects and do some pollination[17]. However, the plant species are flexible enough to alter the pollination mechanisms to be fit to the changing environment. According to Frankel and Galun[12], the jackfruit growing at the vicinity of tropical region in monsoon countries became anemophilous in the absence of biotic pollinators. So, there is a chance of having wind as a pollinating agent of entomophilous plants. People are of the belief that anemophily is derived from entomophily[3,5] for which *Eucalyptus citriodora* also stands as an example.

But the question is, what selection pressure made *Eucalyptus citriodora* to resort to anemophily. This tree attracted 18 different insects offering nectar and pollen as floral rewards. The unprotected floral resources were utilised by floral visitors. But the plant became failure to establish perfect adaptive features with insect species. The diurnal insect visitors were more frequent in numbers and consistent in their visitation but their body dimensions and foraging behaviour made them ineffective pollinators. They failed to be touched with stigmas because the stigmas remain intermingled with the filaments of anthers. The visitors touched the stamens and style while collecting nectar from the calyx cups. So, the insects failed to play the role of pollinators. Even, the flowers set fruits normally in absence of visitors. Probably, the inefficiency of insect visitors and the unreliability of the biotic resources made the plant resort to anemophily. So, the insects appear to be dependent on *Eucalyptus citriodora* than the tree. From ecosystem point of view this type of relationship is of immense significance because the insects that were nourished and supported by the tree might be useful in the pollination of some other plant species in community[18]. The emission of pollen grains in atmosphere maintains the appreciable pollen quantity surrounding the canopies and ensure guaranteed pollinations in this self-compatible, mass bloomer tree species. Thus, the inefficiency of insects, unreliability of resource base of entomophily and the gamete wastage of anemophily appear to be the positive sites of *Eucaplytus citriodora* in its pollination system by resorting to the anemophily, which could be considered as an adaptive feature of tropical country.

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