International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
Coden: IJARQG(USA)

Research Article

SOI: http://s-o-i.org/1.15/ijarbs-2016-3-2-12

Flower-visitor diversity with reference to pollen dispersal and pollination of *Carica papaya* L.

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Abstract

The present paper deals with the diversity of flower-visitors and their interactions of *Carica papaya* Linn. (Caricaceae) with reference to pollen dispersal and pollination. It flowers throughout the year and produces huge amount of fruits. Flowers are whitish, unisexual; males are in lax panicle while females are fascicled. Flowers generally open in the evening (19:30 hrs-22:30 hrs.). Anther dehiscence takes place before flower opening. In average each male flower produces 47580 pollen grains. Different visitors like the members of Hymenoptera, Lepidoptera, Thysanoptera, sunbird (Nectarinia sp.) etc. were found to visit the flower for their forage. During their visit their body parts get dusted with pollen grains and subsequently transferred to the con-specific plants resulting in successful pollination. This mutualism is a good example of diversity and dynamics of plant- animal interaction.

Keywords: Flower-visitors, pollen production, pollen dispersal, *Carica papaya.*

Introduction

Biological diversity refers to the variety and variability among the living organisms and the ecological complexes in which they occur. Biodiversity can be defined as the structural and functional variety of life forms at genetic, population, species, and community and ecosystem levels. The flower-visitor interaction is the most important phase in pollination and pollen dispersal . Pollination is a major constraint for plant propagation. Over all 80% of flowering plants are pollinated by animals, mainly by insects among these honey bees and butterflies are the most important and dominant. In the present study, birds also play an important role in plant breeding system.
The flower is the main characteristic structure concerned with sexual reproduction in flowering plants (angiosperms) and plays a critical role in plant reproductive system by forming a co-relation with pollinating agents. Thus it is an important part of biological system of a plant. There is a close relationship between floral organization and pollinators. Availability of pollen and nectar, odour, colour, etc of principal attractants are responsible for establishing flower-visitors relationships (Faegri and van der Pijl, 1980). Plants produce huge numbers of pollen grains. Pollen grains are non-motile reduced male gametophytes which, upon pollination, produce pollen tubes that grow through the pistil for effective fertilization and seed sets. The production and the dispersal of pollen grains have both biological and genetic implications for the quality and genetic value of the seed produced. Hence pollination biology is of immense significance in plant improvement programmes as it determines gene flow and heterozygosity of the population and these in turn determine genetic variability.

In order to set fruits and seeds the male and female reproductive unit must come together and that's why

pollination is a prerequisite for the formation of fruit and seed. Pollination biology is a recently developed branch in biological sciences and has attracted the attention of the scientists throughout the world because of its importance in understanding plant breeding system, floral evolution, foraging theory and animal behaviour.

In the present investigation an attempt has been made to study the floral morphology, pollen productivity, flower visitor diversity and their foraging behaviour in relation to pollination mechanism of *Carica papaya* L. (Melon tree, papaya, papita) belonging to the family Caricaceae. It is popular all over India and is commercially the fifth most important fruit of the country (Singh and Saxena 2012).

Materials and Methods

This study was conducted by following the process of Mathur and Mohan Ram (1986), Reddi et al. (1989) and Mondal et al. (1992) to observe different phonological events with ten individuals plants of same species grown in an around our University campus at Santiniketan, Birbhum, West Bengal (87 degree 41”- 87 degree 42” east latitude and 23 degree 40” and 23 degree 42 north longitude). Pollen grains per anther and per flower were quantified following the procedure of Mandal and Chanda (1981).

Results and Discussion

Table: 1Floral characters of Carica papaya L.

Floral Characters	Observations
Flowering period	Throughout year
Flower type	Regular
Flower colour	Creamy white
Odour /nectar	Present
Flower opening time	19:00 hrs. – 22:30 hrs
Mode of anther dehiscence	Longitudinal
Number of anthers	10
Pollen/Anther	4758
Pollen production/Flower	47,580

Table: 2Flower visitors of Carica papaya L.

Visitors	Time of visiting	Forage materials
Hymenoptera *Apis* sp. *Trigona* sp. *Camponotus compresssus*	Day	Nectar and pollen
Thysanoptera *Thrips*	Day and Night	Nectar and pollen
Lepidoptera *Papilio polytes,* *Cephonodes hylas,* *Borbo* sp.	Day	Nectar
Sunbird (*Nectarinia* sp.)	Day	Nectar and pollen

The Melon tree, a papaya, or papita (*Carica papaya*) belonging to the family Caricaceae is become popular all over India and is commercially the fifth most important fruit of the country (Singh and Saxena,2012). The plant is generally dioecious trees of quick grown, 5-10 meters tall, with succulent trunk and milky sap. Trunk straight and palm like, rarely branched, covered with prominent leaf-scars. Leaves very large nearly orbicular in outline, palmately and deeply 7-lobed, each pinnately lobed, pale beneath, dark green above; petioles hallow, 60 cm or more long. The unisexual small, sweet scented, creamy

white male flowers are in long drooping lax panicles while the females are in short clusters. It flowers throughout the year with a peak during March-June. Anther dehisces about six hours prior to flower opening (Sharma and Bajpai, 1969).Each anther contains a maximum 14,000 pollen grains and number of pollen grain is not correlated with the size of anther (Allan, 1963).

The stigma surface of the genus *Carica papaya* at the receptive stage has been described by Heslop-Harrison and Shivanna (1977) as dry meaning little or no surface secretion as well as possessing a papilla. Stigmas of similar age were described by Sharma and Bajpai (1969) as moist and shiny when observed under a hand held lens. Using fluorescence microscopy Rodriguez et al. (1990) reported that the papilla is coated with a layer of cutin. They also reported about the evolution of Carica papaya autogamy mode of pollination syndrome. Various functions of stigmatic exudates have been postulated including being a part of a pollinators diet (Baker, 1976) and/or to assist in pollen germination (Baker, 1976; Bawa, 1980). The stigma is receptive for one day prior to and three days after opening. Stigma receptivity is assumed to be associated with secretion of stigmatic fluid promoting the germination of pollen grains (Baker1976, Bawa,1980).Receptivity is highest on the actual day of flower opening (Sharma and Bajpai,1969; Subramanyam and Iyer,(1986). Tissue discolouration (Brown) indicates the onset of senescence.

After flower opening different flower visitors like *Apis* sp., *Trigona* sp., *Camponotus* sp., *Papilio* sp., *Borbo* sp., *Cephonodes* sp.,*Thrips,* and Bird (*Nectarinia* sp.) visit the flower for colleting their food materials. During their forage large quantity of pollen grains are released and dispersed in the ambient air. From the extensive data obtained on floral dynamics coupled with activity of insect's visits to flowers *of Carica papaya* are geared for pollination exclusively by wind (Anemophily) and insects (Entomophily). There are several features in this taxa adopted for wind pollination are the increase in pollen production, adequate expression in the number of pollen grains produced per ovule. Stigma of *Carica papaya* is sticky for catching pollen grains. Further, large female flowers are with the flattened and forked stigma with a great reduction in stylar tissue. It is necessary to increase the area of receptive stigmatic surface to ensure efficient capture of pollen grains. So the air flow, large vegetation and population of *Carica papaya* influenced the large productivity of fruit. On the other hand netting and bagging experiment showed that both cases produced fruits and seeds which indicated anemophilios as well as apomixis modes of reproduction in *Carica papaya*. From foraging behaviour and floral dynamics in Carica papaya showed that this taxa is well adapted for wind pollination (anemophily) and insects (Entomophily). In India and abroad different workers demonstrated that wind also plays natural role for pollination of different pants such as *Madhuca indica* (Reddi, 1976), *Mimusops elengi* (Reddi and Janaki Bai, 1981), *Cicca acida* and *Emblica officinalis* (Reddi and Reddi, 1984). 46% fruits wear observed in natural open condition and 37% fruits formation were found in netted condition. But in bagged condition 18% fruits formation was observed in this plant. Fruits formations were always better in natural open condition than netted and bagged condition. From the results of netting and bagging experiment it can be predicted that plants some external agents, indicating their cross-pollination nature). Allan et al. (1987) also observed that environmental factors are related to fruits production of *Carica papaya.* According to Garrett (1995) pollination of *Carica papaya* is carried out by hawk-moth(Lepidopter: sphingidae) and seven pollinator species and four suspected pollinator species have been identified for the central Queensland region and all species belonging to the same sub-family the Macroglossinae. Contrary to anecdotes from grower, neither native or European bees, nor wind was of significance in the pollination of dioecious papaya cultivars and incidences of apomictic and parthenocarpic fruit set occurred though were rare. Seasonally occurring fruit set and period of low seed set of papaya, under the subtropical central Queensland climate were due to three key factors- the availability and viability of pollen and the absence of sphingid pollinators. Thus the pollination biology of carica papaya projected with regards to anemophily, entomophily and agamospermy. Parthenocarpic fruits set in *Carica papaya* has been reported from various geographical locations of tropical and sub-tropical countries (Hofmeyr, 1938).

The pollination mechanism by which nectarless pistillate flower attract pollinator visitation has been identified and involves a multitude at stimuli, including those of olfaction, gustation, tactility and vision. Earlier studies on the pollination biology of *Carica papaya* have suggested that it is wind (anemophilic) Agrew (1968) or insect (entomophilic) mediated (Storey 1969; Free 1970,1975; Baker 1976). According to Baker (1976) the pollinating agents of *Carica papaya* in Central America were probably sphingid moths but the exact genus was not clear. The involvement of honey bees (*Apis mellifera*) in pollen

Fig. 1 *Carica papaya* with huge fruits

Fig. 2 *Apis* sp visiting flower

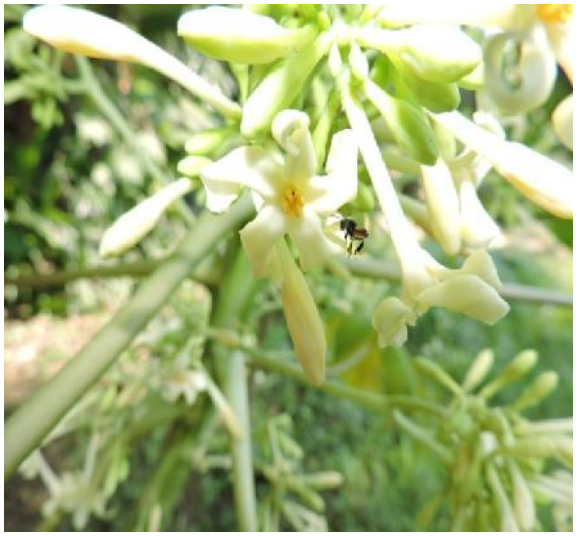

Fig.3 *Trigona* sp. visiting flower

Fig. 4. *Thrips* on flower

Fig. 5 *Borbo* sp. on flower

Fig. 6. Butterfly visiting flower

Fig.7: Ant on anther

Fig. 8:*Nectarinia* sp. visiting flower

Fig.9: Hawk moth visiting flower

transfer in papaya was suggested from a study conducted in South Africa (Allan, 1963). Storey (1969) reported that pollination in the papaya is apparently widely carried out by wind, but the author believes that insects also play some role. Frankel and Galun (1977) reported that the main pollinating agents of the papaya are wind and insects. In bisexual flower, the release of pollen and receptivity of the stigma may be simultaneous, distinct or overlapping (Pacini, 1992). In species with separate male and female flower on the same plant, the flower may appear in or out of phase with each other; where they are present together, their receptivity often differs, female receptivity lasting longer than that of the male flower. The minimum number of male plants is necessary to secure seed setting in diocious species of *Carica papaya* and the number of pollen plants and their distance from seed plants vary with the activity level of the pollinator(Faegri and van der pijl, 1980).

After flower opening different visitors like *Apis* sp, *Trigona* sp, *Cephonodes* sp, *Thrips*, members of Lepidoptera, ants and Sun Birds (*Nectarinia* sp.) were found to visit flowers for collecting their food materials. During their forage they carry a considerable amount of pollen grains through their body parts and help in pollen transfer and pollination. *Apis* sp. plays a major and vital role in pollination of this plant through regular and frequent visitation. Hawk moths are active at dusk or at night Hawk moth can also be recognized in darkness because the colour of flower is white. Hawk moths have the longest proboscises among the insects and the corresponding flower has the longest tubes spours. These flowers have a strong, sweet fragrance which is often stronger at night than during the day. This indicates the rhythmic diurnal change in the production of volatiles .Long distance attraction by the fragrance and short distance visual orientation is very important and vital for the pollination of this plant by the Hawk moth. As flying animals with a rough surface, birds possess good external prerequisites for becoming pollinators. Sunbirds constitute one of the most important groups of bird pollinators, forages from the legitimate position and brings about effective pollination. Whereas everybody apparently takes for granted the fact that various insects find their food in blossoms, the corresponding habit of birds seems to have caused a great deal of astonishment and speculation about how birds got the idea of utilizing the nectar of blossoms. Elongated, gently decurved beaks seem to facilitate sunbirds to harvest the deep-seated nectar from flowers in a large number of plant species. Thus the sunbird (*Nectarinia* sp.) also helps in pollination of this plant.

Among the visitors *Trigona* sp. visit most frequently and also play a major role in pollen dispersal and pollination. In *Lantana camara*, flower opening and anther deshiscence occurs simultaneously. The petal colour changes from yellow shades to shades of red, scarlet and mauve. Pollination occurs only at the yellow colour stage when the stigma is receptive and exudes a nutritious fluid. The pollinators are thrips (*Thirps hawaiiensis* and *Haplothrips tenuipennis*) which enter only the yellow flowers looking for food. Pollination is brought about by the fluttering of the feathery wings and jerky moments of the abdomen. Changes of petal colour guide the thrips to the yellow flowers (Mathur and Mohan Ram 1978). The plant can also be pollinated by two butterflies, *Precis almona* and *Catopsilia pyranthe-pyranthe,* in their visits to yellow flowers for nectar. The compositae members, *Tridax procumbens, Wedelia chinensis, Ageratum conyzoides, Syndrella nodiflora* and *Cosmos bipinnatus* are thrip-pollinated. The population build up of thrips seems to regulate the synchronization of flowering periodicity and phenology of the pollinating thrips. Such a continuous build up leads to thrip migration ultimately promoting cross-pollination (Ananthakrisnan et al. 1981, Ananthakrisnan 1982, Gopinatahan et al. 1981).These results corroborate with present findings regarding pollination of *Carica papaya.*

Thus the different types of visitors visit flowers regularly for their food materials and subsequently help in pollen dispersal and pollination which has great significance in biological diversity and dynamics. For the sustainable development such type of plants and animals interaction indicates a good biological and ecological balance. So, pollination biology is a dynamic field of scientific research constantly adopting novel methods and making progress in understanding the interaction between plants and their pollinators. The recent study generated the main scientific steps of pollination biology focusing on the environmental, ecological and biological systems. Thus these works will present a simple framework integrating environmental, ecological, societal, socio-ecological, socio-economical, and biological issues relevant to pollinators and pollination.

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How to cite this article:

Krishnendu Dey, Subrata Mondal and Sudhendu Mandal. (2016). Flower-visitor diversity with reference to pollen dispersal and pollination of *Carica papaya* L.. Int. J. Adv. Res. Biol. Sci. 3(2): 65-71.