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## Review on insect pollinators of fruit crops

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**Abstract**

Pollinator play a very significant role in pollination of angiosperms. Many fruit crops require an insect pollinators for the pollination so that the yield of crops is increased. Fruit crop having a large group of pollinators, increases its quality and quantity of fruit production. These pollinators belong to different insect order like Diptera, Coleoptera, Hymenoptera, Lepidoptera etc which plays significant role in both the process of pollination. It is essential know the importance of pollinator species, their abundance in their natural habitat, and their involvement in crop improvement.

**Keywords:** Pollination, insects, fruit -crop, pollinators

**Introduction**

Pollination is considered as the first step in sexual reproduction in plants. Pollination is the act of moving of pollen from male anther to female stigma and it basically allows the flower to develop seeds for the process of reproduction. (Muhammad Faheem *et al.* 2004)<sup>[10]</sup> Pollination is a mutualistic interaction, in the ecological domain that plays a critical role in the timing of its occurrence. (Rajesh Tandon *et al.* 2010)<sup>[39]</sup>. Specific relationship between plant-pollinator have been built during the co-evolution of angiosperms and insects (Meena Thakur 2012)<sup>[40]</sup>. There are different types of vectors which plays the main role in the process of pollination i.e., wind, water, insect etc. The most common pollinators are insects (Shuvadeep Halder *et al.* 2019)<sup>[18]</sup>. Pollination is referred as a complex phenomenon, and its effect on plant is the reproductive success mediated by several pre-and post-pollination events (Willcox, Aizen, Cunningham, Mayfield, and Rader (2017)<sup>[46]</sup>, Pollination is a complicated phenomenon whose impact on plant reproductive success is mediated by a number of pre- (e.g., pollinator visitation rate) and post-pollination (e.g., pollen load quality, pollen- stigma interactions) events. In the process of pollination floral sent is the important character which are responsible to attract specific pollinator (Muhammad Faheem *et al.* 2004)<sup>[10]</sup>. The insects that visit flower which are Hymenopterans and Dipterans because of these reasons. There are variety of bees, 19% of flies, 6.5% of bats, 5% of wasps, 5% of beetles, 5% of beetles, 4% of birds, and 4% of butterflies and moths pollinate over 73% of the world's cultivated crops. (Bashir, M.A. *et al.* 2015)<sup>[5]</sup>. Pollination is one of the most crucial methods which helps in maintaining and conserving biodiversity, as well as for the survival of all species on Earth. (Meena Thakur 2012)<sup>[40]</sup>. Insects play an important part in maintaining the nitrogen cycle, soil regeneration and protection, pollination of phanerogamic plants, and natural pest control. (Sanjay Kumar *et al.* 2016)<sup>[26]</sup> Around 90% of flowering plants fully depend on pollinators for successful pollination. (Nurul Alia Omar *et al.* 2021)<sup>[26]</sup>. A well pollinated flower contains a greater number of seeds. It improves the process of pollination it can also reduce the time period between flower and fruit set and also reduce the risk of exposure fruit to pest. Around 73% of the world's crops are dependent on bee pollination, whereas 19% come from flies, 6.5% from bats, 5% from beetles, 5% from wasps, 4% from moths and butterflies, and 4% from birds. (Bashir, M.A., *et al.*, 2015)<sup>[5]</sup>. Species richness and abundance of pollinator insects increase the yield of some angiosperms (Garibaldi *et al.* 2011)<sup>[14]</sup>. As it describes that pollination ecology involves intricate animal-plant interactions by highly mobile pollinators; this must be examined in a broader context that includes the pollinators' specialized requirements. (Ricketts, 2004)<sup>[37]</sup>. The value of pollinators to the ecosystem and ecology is large and immeasurable. The pollinators have different adaptation for the access for the collection of pollen and nectar (Victoria Wojcik 2021)<sup>[47]</sup>.

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It is found that the four major orders of insect pollinators includes insect orders like Hymenoptera (bees, ants, and wasps), Diptera (flies), Coleoptera (beetles), and Lepidoptera (butterflies and moths). (Frankie, G. W., & Thorp, R. W. 2009) [11]. Effective pollination is the most complex phenomenon which is determined by both species-level and community-level. Pollinators are critical players in the crop production process since plants rely entirely on vectors to

transmit pollen during cross-pollination. Hymenoptera were the most prolific and extensively spread pollinators, followed by Lepidoptera and Diptera.

Fruit crop output increases considerably after insect cross-pollination (Wei *et al.*, 2019) [45], for example, bee cross-pollination raised production rates by 2 to 4.5 times. This analysis will highlight the importance of pollinators in plant pollination and their economic impact.

**Table 1:** Pollinator insects of fruit crops

Common name	Scientific name	Pollinators	Commercial product of pollination	Timing of pollination	Period of flowering
Papaya	<i>Carica papa</i>	Honeybee, trips, moth midges, butterflies	Fruit	Morning	Throughout the year
Mango	<i>Mangifera indica</i>	Honeybees, stingless bees, flies, ants, wasps	Fruit	Morning	December - February
Lemon	<i>Gossypium spp.</i>	Honeybee, black ants	Fruit	Morning- evening	January -February
Guava	<i>Psidium guajava</i>	Honey bee	Fruit	Morning-evening	February & June
Custard apple	<i>Annona squamosa</i>	Nitidulid, beetle	Fruit	Morning-Evening	April -May
Fig	<i>Ficus carica</i>	Fig wasps	Fruit	Morning	February-June
Dragon fruit	<i>Hylocereus spp.</i>	Moths, bees, ants	Fruit	Evening	May -October
Pomegranate	<i>Punica granatum</i>	Honey bees, black ants	Fruit	Morning	March -April & July-August
Sapota (Chickoo)	<i>Manilkara zapota</i>	Thrips	Fruit	Morning-Evening	February -March & October- November

### Pollination of custard-apple

Custard apple (*Annona squamosa* L.) is the most frequently cultivated species in India and throughout the world. It belongs to the family Annonaceae. Custard apple is mostly used as a dessert fruit, but the pulp and seeds are also used medicinally (Pinto *et al.*, 2005) [35]. The process pollination is done in morning hours before 9.00 am (Janvi Singhania and D.K. Varun 2022) [38]. Mc Gregor (1976) [26] conducted the study in Australia and Israel they found that the main insect pollen-carrying vectors are Nitidulid beetles. The population of Nitidulid beetle is influence by the food source, rainfall and temperature. Shmuel Gazit *et al.* (1982) [16] reported that there are mainly four species of beetle which belong to family Nitidulidae are the most common arthropods which are the visitor of Annona. The arthropod which pollinates custard-Apple is known as sap beetle. (A.P. George *et al.* 1989) [17] During anther dehiscence, these beetles can transmit pollen from the stamens to the stigmas on the same flower or to other flowers.

### Pollination of pomegranate

Pomegranate (*Punica granatum*) is an ancient beloved plant and fruit. Flowering occurs approximately one month following bud break on freshly produced branches of the same year, most commonly on spurs or short branches. (Jaime A 2013) [7]. The principal pollinators of pomegranate are considered as honeybee. Pomegranate is self and cross-pollinating plant. When compared to self-pollination, bee pollination considerably improved the setting rate and weight of pomegranate fruit (Derin and Eti 2001) [8]. Pomegranate varieties typically flower between March and April and July and August. It can last 10-12 weeks or longer, depending on the type and geographical location. Several studies have demonstrated that cross-pollination resulted in a 20% increase in fruit set as well as an increase in overall fruit quality (Derin and Eti 2001) [8]. The honey bee is the primary pollinator of pomegranate. Insect which pollinates pomegranate are as follows black ants, honey bees, beetles and lemon butterfly.

### Pollination of fig

Figs (*Ficus carica* L) is believed to be the oldest cultivated

plants. The female fig wasp's involvement in pollinating certain edible figs, particularly the Smyrna fig (*Ficus carica*), is crucial for fig growers because most economically valuable figs require fertilization to ripen (Kjellberg *et al.*, 1987; Noort, 2004; Moe *et al.*, 2011) [24, 42, 30]. It is mention that the galligenous, short styled, female flower. The remaining, lower two-thirds of the syconium is occupied by the pollination agent, the little agaonid wasp *Blastophaga psenes* L. (Chalcidoidea, Hymenoptera). Female wasps leave their native galls and push between the open, pollen-laden anthers, becoming coated with pollen grain. They transport pollen. On the surface of their body. When the insect enters the receptive female syconia they pollinate the ripe stigma of the long-styled female flowers by touching them with their pollen and dust their bodies on the stigma (J. Galil and G. Neeman 1977) [13]. Figs and their pollinator wasps completely depend on each other for the long-term for pollination of the eggs and complete the life cycle of a fig wasps. (Herre and West 1997) [20].

### Pollination of papaya

*Carica papaya* L. (C. Papaya) is considered as the most important plant for tropic and sub-tropic region (Barker *et al* 2018) [3]. The flowering period of papaya is throughout the year. The basic time of opening of flower is 19.00hrs to 22.30 hrs (Krishendu Dey *et al* 2016) [9]. Some believe wind is the primary pollinator, while others believe a combination of wind and insect pollination is required for optimal pollination, and still others credit several other insects, including the humming bird moth (*Macroglossum Stellatarum*) and various Trigona and Xylocopa species (Mc Gregor 1976) [26]. According to Garrett (1995) [15], the hawk moth is the major pollinator in Queensland orchards It is also confirmed Apis sp. performs a significant and crucial part in pollinating this plant through regular and frequent visits. Trigona sp. is the most common visitor on papaya and also plays an important role in pollen distribution and pollination. (Krishendu Dey *et al.* 2016) [15]. Hawkmoths in the tropics and subtropics are one group of pollinating insects that have multiple requirements for survival and persistence. The importance of the hawk moth in papaya pollination and the role of natural habitat

adjacent to farms as a source of wild pollinators are being researched. (Dino J. Martins 2009) [28]. Nocturnal moths have also been shown to pollinate papaya fruit, with hawkmoths making up more than 95% of all visits to the bloom. Pollinators are often regarded as an important component of biodiversity (Klein *et al.*, 2007) [25]. They are components of ecosystem services that directly 2009 from pollination by wild insects.

#### Pollination of mango

Mango (*Mangifera indica* L), popularly known as India's national fruit, is one of the most significant tropical fruits in the Anacardiaceae family (Mehta, Indu). Mango (*Mangifera indica*) flowers are pollinated by wasps, ants, flies, butterflies, beetles, and bees, as well as wind (Aliakbarpour and Chelamah 2010) [2]. It is observed that flies and ants displayed different visitation behaviour on mango flowers (Nurul Huda *et al.* 2015) [21]. Pollinators efficiency or effectiveness measure the amount of pollen deposited by insects on stigma of the flower. (Nurul Huda *et al.* 2015) [21] The pollination of fruit trees, such as mango trees, is dependent on insects. The principal pollinators of mango were recorded from the order Diptera, such as *Melipona* sp. and *Syrphus* sp., *Musca domestica* (Linn), and it was noted that the house fly was not a very common pollinator (Singh 1989) [12]. A study on mango tree pollination was conducted, and it was discovered that Dipterans and Hymenopterans are the primary pollinators. Pollinator insects of mango trees in India (Singh G. 1989) [12]. A study on tropical mango orchards discovered that insect pollinator services provided around 53% of total mango fruit yield. (Nurul Huda A *et al.* 2015) [21].

#### Pollination of guava

Guava (*Psidium guajava*) is a popular tropical fruit grown in many tropical and subtropical areas. Honey bees are the best pollinators, and increases in fruit set and fruit quality were achieved. (Rajagopal and Eswarappa, 2005) [36]. (Katrine Hansen *et al.* 2020) [10] There are around 26 pollination species and 498 individuals seen visiting guava flower (combining visitation and richness phases). Honey bees are the most important pollinators, accounting for 92.86 percent of all dipterans and coleopterans. (Abrol D.P 2015) [11] *Apis mellifera*, *Trigona spinipes*, *Xylocopa frontalis*, *Melipona subnitida*, and *Partamona cupira* are the most important floral visitors on guava. Honeybees, bumble bees, and wild bees pollinate guava blooms in a fairly reliant manner, according to the findings. (Madhurima Vinod and HN Sattagi 2018) [43] Explains that the activity of bees on guava pollination are *A. Dorsata*, *A. Florea*, *A. Cerana*, *T. Iridipennis* and other hymenopteran pollinators was noticed on guava tree. (Vinod, M. and Sattagi, H.N 2018) [43]. It was also discovered that three different insect species, including Hymenoptera, Diptera, and Lepidoptera species, visited the organic and conventional guava ecosystems, with Hymenoptera species being the most dominant pollinator group, accounting for 95.85% of the maximum relative abundance in the organic guava ecosystem and 94.42% in the conventional guava ecosystem. The amount of cross-pollination ranges from 25.7 to 41.3% (Vinod, M. and Sattagi, H.N 2018) [44]. According to research study 20 to 40 percent of pollination of guava was due to honeybees. Around 73% of global crops are pollinated by different types of bees, 19% by flies, 6.5% by bats, 5% by beetles, 5% by wasps, 4% by moths and butterflies, and 4% by birds. The guava plant has

long been used as a medicinal plant in many nations to treat a variety of disorders, as all portions of the tree are thought to be beneficial. (Barbalho, S.M 2012) [4].

#### Pollination of Dragon-fruit

Dragon fruit (*Selenicereus undatus*) is an exotic fruit that is produced all over the world. It was once employed as a decorative plant, but due to its health benefits and market worth, it has now developed as a new fruit crop (Chandni V Mori *et al.* 2023) [31]. Due to its low water requirement and adaptability to high temperatures, dragon fruit has significant potential as a new crop for Mediterranean growers (Trivellini *et al.*, 2020) [41] This fruit have lack of genetic diversity and in some cases, there is absence of pollinating agents in various production area is represented. Dragon-fruit is also known as pitaya it generally belongs to the family of cactus The normal flowering period is in summer mostly from June to October. The flower of dragon fruit flower blooms between 10.00 pm to 2.00 am. Season of flowering is from May to November and last up to December (Vijay Singh *et al.* 2020) [22]. Moths, flies, and bees pollinate dragon fruit in the evening, and manual pollination can improve fruit set and size.

#### Pollination of citrus-lemon

Citrus lemon belong to family Rutaceous and scientific name of citrus lemon is *Gossypium* spp. Honeybee (*Apis mellifera*) is the primary pollinating agent of Citrus. The literature contains conflicting reports on the need for bees in some citrus varieties (V. V. Pashte and s. R. Kulkarni 2015) [34]. The most important period for pollination was in the morning (Malerbo-Souza D. T *et al.* 2004) [26]. When beekeepers and citrus growers (who blame the bees for causing otherwise seedless mandarins and oranges to develop pips) work in close proximity, conflict can arise. Lemon is a citrus fruit with an oval shape and smooth porous skin. The colour range of lemon is greenish yellow to bright yellow (Mc Gregor 1976) [26]. Lemon is also pollinated by black ants during day as well as evening also. Lemon is an important medicinal plant. Citrus flavonoids exhibit a wide range of biological actions, including antibacterial, antifungal, anticancer, and antiviral properties (Burt, 2004; Ortuno *et al.* 2006) [6, 33]. Bees collect nectar and will knock the pollen off of the flower anthers onto the stem.

#### Pollination of sapota

Chikoo (*Manilkara zapota* (L) P. Royan (Sapotaceous) is an important tropical fruit which is cultivated in India which is commonly known as sapota or Chiku. Which is grown under tropical climatic condition. The flowering period is mostly through the year but there is specific period for flowering i.e., June to July, September to October and march to April. (Kishore. K. *et al.* 2017) [23]. In Chiku the pollination is done by Thrips sp. and *Sylvanopsis* sp. usually take shelter in the floral chamber of Chiku and live primarily on the pollen grains (Pollinivorous) (Kishore. *et al.* 2017) [23].

#### Summary

Pollination results in seed production, which is essential for the breeding process in many plants. Review on the research on different fruit crops concludes that insect pollinators increases the yield of crops. The orders of insects which play important role as pollinators include Hymenoptera (bees, ants, and wasps), Diptera (flies), coleoptera (beetles), and Lepidoptera (butterflies and moths). There are some

comprehensive benefits to the farmer about crops which are still unknown. Insects are most effective pollinators in fruit crops. In some of the cases honeybees are most effective pollinators. There is urgent need of further research and experiment which can clearly give the estimate the economic value of pollinators to the fruit crop. It is also very necessary to understand the importance of different pollinators species and their natural habitat.

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