POLLINATORS DIVERSITY AND THIER IMPACT IN ENHANCEMENT OF YEILD IN VARIOUS CROPS

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ABSTRACT

About 120 million years ago, the honey bee eveloped its morphologies specifically to collect pollen and nectar such as increased fuzziness, pollen baskets, longer tongues, and colonies to store supplies. Beekeeping became commercially viable during the 19th century with four inventions: the moveable-frame hive, the smoker, the comb foundation maker, and the honey extractor. These inventions still support commercial apiculture. A fifth invention, a queen grafting tool, allows beekeepers to control genetic lines. Many pulse and oilseed crops are good sources of bee forage. Among the plantation commercial crops, coffee, orange and other citrus fruit, apple and other pomaceous fruit species, cardamom and rubber tree are important from the beekeeping point of view Rubber plantations are found in southwestern and northeastern parts of India, where tropical humid climate prevails. This chapter covers all measure for mitigation of insect vector control in detail.

Keywords: *pollinators, insects, crops, yield*

1. INTRODUCTION

The flowers do not tend to have any common characteristics because many different types of insects have very different ways of pollinating flowers. In insect pollinated plants, mostly pollen is dry while stigma is viscid. When any pollinator touches the latter some mucous is transferred to its body. When this pollinator visits next flower, the pollen gets adhered to its body and will be carried to next stigma where it will be shed off e.g. in orchids, *Montrapa* etc. The various insect pollinators are ants, bees (honey bees and other colonial bees, gregarious and solitary bees), beetles, butterflies, flies, moths and wasps. The bees are by far the most important among insects. Some of the characteristic features of insect pollinated flowers are

- The flowers are large, conspicuous and brightly coloured.
- When flowers are small, they aggregate in the form of inflorescence.
- The flowers have a pleasant fragrance and sweet nectar.
- Pollen grains are usually rough and sticky and often show spinous outgrowths.

1. 1 Bee pollination (Melittophily)

Bees are the most versatile, the most active, and consequently, the best-known pollinators of several plants and are best adapted for various blossoms and floral structures. remarked that bees with about 17,000 known species are the world's dominant pollinators; whereas (Buchmann and Ascher 2005) affirm that bee species collectively pollinate the 250,000 known angiosperm species.

1.2 Wasp pollination (Sphecophily)

They are unsteady pollinators. In general, wasps are of little significance as pollinator. Their pollination ecology includes: no brood management, primitive mouth parts, tongue usually small (1-3 mm), flat and can be used for lapping nectar only (with some exceptions). Their body is sparsely covered with coarse spines, not adapted to the transfer of pollen as are the hairs of bees.

1.3 Butterfly pollination (Psychophily)

Butterflies are diurnal and have good vision (can see red) but a weak sense of smell. They are perching feeders. Highly perched on their long thin legs, they do not pick up much pollen on their bodies and lack specialized structures for collecting it. Butterflies walk around on flower clusters probing the blossoms with their tongues. Possession of a long proboscis in butterflies allows them to access nectar from narrow tubular corollas, in addition to those with more exposed nectar.

1.4 Moth pollination (Phalaenophily)

Moths are nocturnal, have a strong sense of olfaction, and are active fliers, hover in front of flowers but not land on them. Moth-pollinated flowers tend to be white, night opening, large and showy with tubular corollas and a strong, sweet scent produced in the evening, night or early morning. The petals are flat or bent back (recurved) so the moth can get in. Ample nectar is produced by them, with nectaries deeply hidden, such as morning glory, tobacco, yucca, and gardenia. The yucca plant is dependent upon the tiny yucca moth for cross pollination.

Hawk moths (Sphingidae) have especially long tongues and can pollinate tropical flowers with the corolla tube up to ten inches long. Hawk Moths hover in front of flowers with rapid wing beats and a lot of nectar is produced to fuel the high metabolic rates needed to power their flight.

1.5 Fly pollination (Myophily)

Flies are considered to be less important, ineffective and unreliable pollinators but their sheer numbers and the presence of some flies throughout the year make them important pollinators of some temperate and many tropical flowering plants. Flies are also important pollinators in high-altitude and high-latitude systems, where they are numerous and other insect groups are lacking. Flies generally visit flowers that smell foul, often with scents of decaying meat or feces. Some flies feed on nectar and pollen as adults e.g. bee flies (Bombyliidae), hoverflies (Syrphidae), etc. These regularly visit flowers. On the other hand, male fruit flies (Tephritidae) are attracted to and feed on specific floral attractant (which acts as fly's sex pheromone precursor or booster) of some wild orchids (*Bulbophyllum* species) that do not produce nectar. Myophilous plants are purple, violet, blue, and white coloured: open dishes or tubes and includes nectar guides but have no scent.

1.6 Carrion and dung fly pollination (Sapromyophily)

Sapromyophiles, normally visit dead animals or dung but sometimes adult females seeking for a site to lay her eggs get attracted to flowers that mimic these odoriferous items and lay eggs inside so that after hatching larvae can feed on animal-originated material. However this "resource", in fact, does not exist in the flower and pollination occurs by allurement and deception. After the hatching of the eggs the larvae starve to death. It is mainly performed by carrion flies and occurs in flowers which are brown or orange in color and have a strong, unpleasant odor. This group includes the Araceae family, which produces highly modified flowers.

1.7 Beetle pollination (Cantharophily)

Beetles were among the first insects to visit flowers and they remain essential pollinators today. They comprise the largest set of pollinating animals, due to sheer numbers.

They are responsible for pollinating 88 per cent of the 240,000 flowering plants globally. Cantharophily, is somewhat rare in temperate areas, but is quite common in the tropical zone. Some beetles have evolved the pollen eating habit. Beetle-pollinated flowers are usually large, greenish or off-white in color and heavily scented as beetles rely on their sense of smell for feeding and finding a place to lay their eggs. Scents associated with beetle pollination are often spicy (Crab apples), sweet (*Chimonananthus*), or fermented (*Calycanthus)*.

1.8 Ant Pollination (Myrmecophily)

Myrmecophiles form a great group of social insects that are often observed visiting flowers to collect energy rich nectar. Ants are gregarious and visit extra-floral nectarines in groups. They are wingless and must crawl into each flower to reach their reward. They mostly take nectar without effectively cross-pollinating flowers. Ants visit inconspicuous, low-growing flowers positioned close to the stem. Many tropical plants have floral

structures that make it difficult for bees and other pollinators to access internal nectar. Thus, it is tempting for such insects to simply pierce the flowers from the outside. But ants feeding on the nectar secreted outside of the flower prevent these insects from robbing nectar and thus forcing them to enter the flower in a way that is more conducive to pollination.

1.9 Thrip pollination (Thripsophily)

Thrips are mainly considered as phytophagous insect pests. While demonstrating the significance of change in the colour of an inflorescence of a particular variety of *Lantana camera*, established the role of thrips in pollination. Several instances of thrip pollination has been reported from the members of Asteraceae, Solanaceae and Fabaceae reaching to the conclusion that thripophily is a common phenomenon in nectar producing flowers.

1.10 Slug pollination (Malacophily)

The cross pollination that is favoured by slugs is called malacophily. Snails and slugs are herbivores that feed on soft vegetation and are most unlikely to be considered as pollinators. Some flowers, however, would not attract flying pollinators because they are so close to the ground and are covered by leaf litter. It is believed that slugs or snails may pollinate these flowers e.g. wild ginger.

2. VERTEBRATES AS POLLINATORS

Although vertebrate pollinators are not as common as insect pollinators, they do exist, and include birds and mammals. Compared with most insects, flower-visiting birds and bats are much larger, have greater energy requirements, can carry larger pollen loads and are longer-lived. Despite the potentially greater costs to plants to attract and reward these larger pollinators, the benefits of vertebrate pollination can be substantial, especially in habitats where insect activity is limited by harsh climatic conditions compared with many insects, birds and bats are excellent in promoting out crossing and as a result, most vertebrate-pollinated plants have hermaphroditic breeding systems; very few are dioecious. Besides birds and bats, some squirrels, tree-shrews and lower primates also help to accomplish pollination of flowers.

2.1 Bird pollination (Ornithophily)

It is a mode of pollination performed by birds. The most common bird pollinators are sun bird, humming bird, crow, bulbul, parrot, mynah, etc. They visit flowers for the sake of nectar or insects. Pollinating birds are diurnal in their activity, and have long tongue and bill. They have visual sensitivity for red colour but not for ultra violet reflectance. In general, they lack sense of smell. Still they can efficiently locate the path to nectar which they consume in bulks. The flowers that are visited by birds and hummingbirds are both tubular and disc shaped and has petals that are recurved to be out of the way. The flowers pollinated by birds are brightly coloured (red, yellow, or orange), odourless, secrete copius amount of concealed nectar and are modest pollen producers that are designed to dust on the head or beak of the bird, as it probes the flower for nectar.

2.2 Bat pollination (Chiropterophily)

Bat pollination is an integral process in tropical communities with 500 tropical plant species completely, or partially, dependent on bats for pollination. They provide two important benefits to plants: i) they deposit large amounts of pollen ii) disperse pollen to long-distances. Bats are nocturnal with a good sense of smell, good vision and a long, bristly tongue.

3. BEE FLORA OF INDIA

Large number of plants such as coconut, areca nut, red oil palm, date palm, cacao, mango, custard apple, jujube, cinnamon, clove, cashew, fodder legumes, coriander, cumin, dill seed, fennel, fenugreek, garlic, turmeric, ginger and other spice and condiment crops, road side plantations that contribute to honey production like eucalyptus, karanj, tamarind, gulmohr, peltaphorum and soap nut. Hedges and fence plants like mehndi, duranta, mulberry, justicia and jatropha, do also add to the bee forage value of farms and orchards.

Cereals in general are not very useful as sources of bee forage. However, jowar, bajra and maize are valued for their pollen, particularly during the Kharif and Rabi crop seasons, when natural sources are scarce. In the case of jowar, some varieties produce sugary exudation on the nodes. Leaves also secrete a thick sweet liquid when infected by rust fungi. In both cases bees collect the sweet substances.

Many pulse and oilseed crops are good sources of bee forage. Among the plantation commercial crops, coffee, orange and other citrus fruit, apple and other pomaceous fruit species, cardamom and rubber tree are

important from the beekeeping point of view Rubber plantations are found in southwestern and northeastern parts of India, where tropical humid climate prevails. Next importance plant is litchi tree. The entire North India from West Bengal to Jammu has large areas under litchi orchards that constitute an excellent source of nectar during March to May. Some garden species like railway creeper, ocimums, salvias, coleus, poinsettia, petunia, zinnia, phlox, and daisy contribute to the bee forage in the otherwise useless areas under gardens and parks.

Andhra Pradesh and Telangana : The major bee floras are coconut, citrus, mango, cashew, drum stick, imli, jamun, palmrah, sesamum, sunflower, soapnut,banana, rubber and cotton. Beekeeping is successful with migration. Good bee flora do exist in Cotton growing districts. Indiscriminate use of insecticides is the main constraint

4. HONEY BEES : MANAGEMENT AS POLLINATORS

Two species of honey bees are effectively managed and utilized for pollination purpose. These are *Apis mellifera* L. and *A. cerana* F. Honey bee species can effectively be utilized for pollination of crops because :

- Honey bees are dependent on flowers for pollen and nectar as their food.
- The bees possess some morphological adaptations favourable for pollen carry over and transfer.
- The honey bees can be kept in the hives and are very easy to be managed.
- Due to their polylectic nature, honey bees visit large number of plants, therefore, they can pollinate a wide variety of crops.
- There abundance on the crop can easily be manipulated.
- Honey bees have better communication system for food searching and gathering.
- When a honey bee forager begin foraging on a plant species, it continues to do so until the resource gets exhausted. This behaviour of individual foragers has been termed as floral fidelity or constancy. This is very important for the plant species they visit for the effectivity of pollination.
- Behaviour of honey bees can be manipulated by modifying the reward system of the plant/or nectar and pollen storage in the hive or colony's unsealed brood.
- Colonies of honey bees can be moved to a place of short pollinators supply.

4. 1 Management of honey bee colonies for crop pollination

Honey bees can increase the quality and quantity of most crops. Weak colonies are of little use in pollination, so one must manage the honey bee colonies to produce large populations of foraging bees just as for honey production. For effective pollination of crops, following points are taken into consideration.

Time of placement of honey bee colonies

When 5-10 per cent of the flowering has initiated, honey bee colonies are placed on the crop.

Colony strength

Strong colony should be placed after flowering of the crop starts to attract more foragers. Brood area and number of combs occupied by bees is a good index of the strength of bee colony. The colonies should meet the following requirements.

(i) Bee strength = 8-10 frames
(ii) Unsealed brood = 3 frames
(iii) Sealed brood = 2 frame
(iv) Honey = 2 frames

The colonies should have a new mated queen and these should be free from any diseases and pests. Other general and specific management practices required for honey bee colonies are also to be observed.

Concentration of colonies/ha

It depends upon the following factors:

a) No. of honey bees
b) Other pollinators
c) Size of crop
d) Competitive plants of the same and different species.

Site of placement of honey bee colonies

The colonies are placed near the target crops so that they can actively move and bring about cross pollination and less energy is utilized in traveling. Honey bees can visit upto 11.3 km but 0.4 km is the excellent distance. Nearer

the source of forage greater the economy. Less time is taken to collect pollen load than nectar load and thus shift to pollen collection if the crop is near the hive.

Method of placement of honey bee colonies

The colonies are placed either in groups or are scattered, and further, either around the target crop or scattered in between as per the convenience of the beekeeper.

Conditioning colonies to a particular crop

Shift colonies to crop only after flowering. If insect pests appear, crop should be sprayed before the initiation of flowers. Use only insecticides safe to honey bees and close the entry of boxes on the proceeding night of spraying. However, the colonies should not suffer of want of sufficient ventilation.

Feeding the scent of target crop to honey bee colonies :

Immerse flowers of the crop in sugar syrup for some hours. Remove the flower and feed the syrup to the colonies kept for pollination service. Feeder containing scented sugar syrup & moving it to the site of crop directs the bees to the crops.

Number of colonies needed

On an average, five colonies per hectare are needed for fruit orchards, but the need vary with place to place and crop to crop.

Increasing the attractiveness of crops

- Breeding of varieties of crops that produce more nectar and pollen of good quality.
- Optimum doses of fertilizers should be applied so that physiology of the crop is not disturbed.
- Wide spacing encourages bee visits.
- Excessive irrigation dilutes the nectar and make it unattractive to honey bees.
- Foraging areas of colonies depends upon quantity of pollen and nectar weather conditions, physical features etc.

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4.2 Facts about bee pollination

- 50% of the existing species of plants propagated by seeds are dependent on insects for adequate pollination.
- Only 15% of the 100 or so crops that fed the world are pollinated by domestic honey bees while 80% are pollinated by wild bees and other wild life.
- Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of all the hive products put together.
- In India 50 million hectares of land is under bee dependent.
- Being a mega diversity country there are about 1000 species of bee forage plants offering rich food to all the four important species of honey bees
- Losses in India due to complete absence of bee pollination has been measured to be somewhere between Rs.10,000 to Rs.55,000 per hectare in some crops

Increase in yield due to bee pollination It has been established through research that, installation of 3-5 bee colonies of *Apis cerana indica* / acre of crop increased the seed yield in sunflower by 79%, mustard by 55%, niger by 33%, sesamum by 15%, safflower by 64%, cotton by 18%, litchi by 20%, coconut by 40%, and gourd crops by 20%.

5. ROLE OF INSECT POLLINATORS IN DIFFERENT CROPS

Sesame

- ✓ In India, many flowers have aborted anthers , so visits by insects are necessary for cross-pollination
- ✓ Plants exposed to insect visits had a 25% greater yield than plants from which insects were excluded .
- ✓ On sesame, honeybees are the most abundant insects comprising 32% of the foraging population
- ✓ *A. cerana* (the most abundant) and *A. florea* visited all the cultivars in India. *A. dorsata* was much less numerous than the other two species..

5.1 TRENDS IN INSECT POLLINATION OF CROPS

Insect pollination is a natural process and continues uninterrupted unless there is disturbance in its environment. It is the greatest gift of nature. It is known to many that insects and other animals are involved in pollination but still it is not considered important. Loss of natural service can have a long-term impact on the farming sector which accounts for about a fifth of the nation's gdp. Both the main components of biodiversity (plants and animals) are involved in bringing about pollination. The farmers and general public still do not give much importance to it. They depend mainly on other agricultural practices for enhancing the crop yield. They are

happy when the yield is good but if the yield is poor, agricultural scientists are blamed. They will never consider the pollination failure as the cause. The declining agricultural productivity can be attributed to a number of factors but pollination plays a crucial role. If you have any trouble with your vegetable and fruit plants failing to reproduce, chances are that what your plants are lacking are pollinators. One can use all good agricultural practices but without pollination no seed or fruit would be produced. There is close relationship between pollenizers (plants giving nectar and pollen), insects and crop production. The importance of insect pollination to agriculture is unequivocal. This process is many times adversely affected due to natural calamities and human activities. Due to ever rising human population, there is tremendous pressure on earth for more food and shelter. Both these requirements are directly connected with changes inland use resulting in fragmentation of habitats. The extensive and indiscriminate use of pesticides and chemical fertilizers further complicates this problem. This results in degradation of our environment. The population of insect pollinators declines adversely affecting pollination. Thus, there is great need to educate our farmers and general public about the utility of insect pollinators in pollination on which our survival depends. At places where there is dearth of natural pollinators, the pollination can be made effective by bringing domestic bees to the crop when it is in bloom. This practice is very much in use in developed countries for enhancing the quality and quantity of various agricultural crops. Here, too, this can be encouraged by bringing both the farmers and bee keepers in close contact for mutual benefit

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