Fertilization in Flowering Plants

1. Bringing the Male and Female Partners Together is Outsourced

K R Shivanna

Fertilization in flowering plants appears simple when compared to that in higher animals. In reality all pre-fertilization events involved in screening and selection of the partners, so familiar in animals, take place in a subtle way in flowering plants also. As plants lack mobility, they cannot perform, on their own, the most important and primary requirement of bringing the male (pollen grain) and the female (pistil) partners together. This process, termed pollination, is effectively outsourced largely to animal agents. Both plants and animals have evolved fascinating adaptations to do this, which is vital not only for their sustenance but also for crop productivity.

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Introduction

Fertilization is one of the essential features of most organisms irrespective of their size, shape and the level of organization. Although fertilization essentially involves fusion of the male and female gametes, it also covers a number of pre-fertilization events associated with the selection of suitable partners. These pre-fertilization events are obvious in higher animals but not in plants. Transformation of flowers into fruits and seeds is almost taken for granted by a layman. In reality, flowering plants also perform all essential pre-fertilization events to screen and select suitable male partners. These events are very subtle and refined. This article (Part 1) briefly elaborates a range of adaptations that flowering plants have evolved to achieve the first step in pre-fertilization events – bringing the male and female partners together – termed pollination. Subsequent events involving selection and screening of the male partner are described in Part 2.

Key words
Crop productivity, floral advertisements, plant diversity, pollination, pollinators, pollination by deceit, stigma, anther, nectar, sexual deception.

The Venue of Fertilization

In flowering plants, the flower is the venue of fertilization

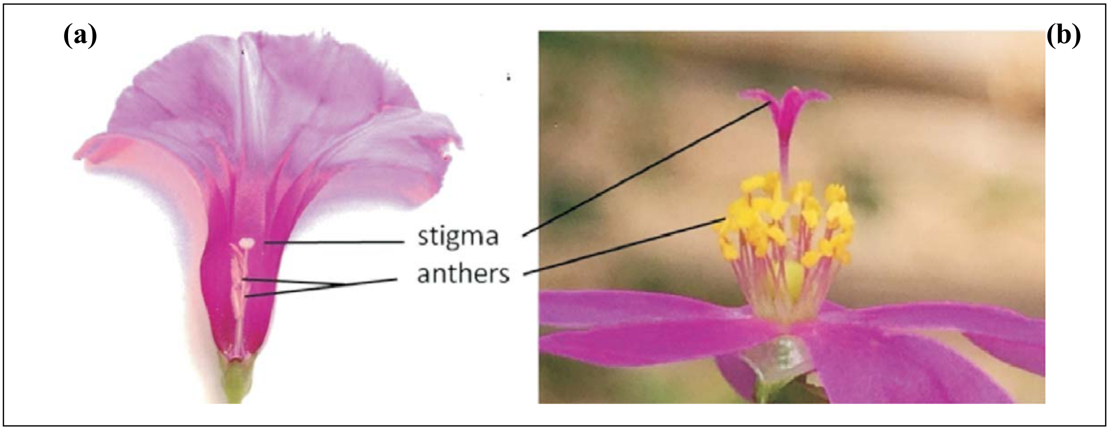

Figure 1. The venue of pollination. Flowers of two species showing male and female sexual parts. In (**a**) a part of the corolla tube is removed to expose the anthers and the stigma.

(*Figures* 1a, b). In spite of enormous diversity in morphological features of flowers, they are essentially made up of four whorls: the calyx made up of sepals, the corolla made up of petals, the androecium made up of the stamens and the gynoecium made up of carpels. All the carpels of the flower together are referred to as the pistil. The calyx and corolla are not differentiated into separate whorls in some species; in such species the common whorl is referred to as the perianth. The calyx and corolla do not take part in the fertilization process directly, although they facilitate the event. The stamens are the male sexual organs and their job is limited to the production of the male partners, the pollen grains. Each stamen is made up of a filament terminating in an anther. Pollen grains develop in the anther and are exposed to the atmosphere following anther dehiscence. The pistil is the female sexual organ. It is made up of the basal ovary, elongated style and terminal stigma, which is the recipient of the pollen grains. The ovary bears ovules, the female partners. Inside the ovule is the embryo sac which contains, in addition to the egg, several other cells which are needed for effective fertilization and subsequent growth of the embryo.

The First and Essential Step: Bringing Together the Male and Female Partners

One of the most important and critical pre-fertilization events is pollination – the process of transfer of the pollen grains from the anther to the stigma. Unlike animals, plants lack mobility and bringing male and female partners together is an issue. However, plants have overcome this hurdle by outsourcing this task to other agencies (*Box* 1). This has imposed evolution of a number of adaptations in the structural and functional features of the flower, the venue of fertilization. In majority of plants (about 90%), the outsourced agents are animals (biotic pollination) and in the remaining plants, it is an abiotic agent (abiotic pollination), largely air and in a few cases water. Gymnosperms[1], which evolved much earlier than angiosperms[2], also outsource this job, and air is their dominant pollinating agent. Biotic pollination is limited to a few gymnosperms, but it is not refined and thus the efficacy is low. In angiosperms, biotic pollination is highly refined, largely due to the evolution of the flower. Animals are more efficient in carrying out pollination as the transport of pollen is generally directed onto the stigma of the same species; thus, there is very little wastage of pollen. Pollination by abiotic agents is not very efficient as pollen movement is not directed to the stigma. Pollen grains are released into the air or water passively; if they happen to come in contact with the stigma during their movement, pollination is brought about. Thus, there is a lot of wastage of pollen. To compensate such a wastage, wind and water pollinated plants produce enormous amount of pollen for which the plant has to spend much more resources when compared to animal pollinated plants.

[1] Plants with exposed seeds such as *Cycas* and *Pinus*.

[2] Plants that produce flowers (flowering plants).

Box 1. Types of Pollination

Anemophily: Pollination by wind. Cereals such as maize, wheat and sorghum are wind pollinated.

Entomophily: Pollination by insects. Insects are the major pollinators of flowering plants.

Hydrophily: Pollination by water. Only a few species such as sea grasses and a few fresh water plants are water pollinated.

Ornithophily: Pollination by birds. Humming birds and sunbirds are the major bird pollinators.

Zoophily: Pollination by animals. Major animal pollinators are insects, birds and bats.

Insects are the major biotic pollinators. Amongst insects, bees, beetles, flies, butterflies, wasps, moths and thrips are the major groups involved in this courier function.

Essentials of Animal-Mediated Pollen Transport

Use of animals to transport pollen grains is an elaborate and meticulous process. Insects are the major biotic pollinators. Amongst insects, bees, beetles, flies, butterflies, wasps, moths and thrips are the major groups involved in this courier function. Apart from insects, bats and birds are the other important agents of pollen transport. Moths and bats perform this function during the night (nocturnal) while all other animals are day-pollinators (diurnal). Cockroaches, reptiles, squirrels and even snails are known to be pollinators in a few plant species.

The most essential requirement for outsourcing animals for pollination services is that the animals visit the flowers repeatedly in a sustainable way. For this the flowers have to offer some rewards to the visiting animals and also they have to advertise the presence of these rewards. Animals visit the flowers repeatedly only to harvest these rewards and not to bring about pollination. Pollination is only incidental but not intentional as far as the animals are concerned. Plants have to make use of their visits to achieve pollination. For this, the flowers have to position the stamens and stigma in such a way that they have to come in contact with the body of the animals during their visit (*Figures* 2a, b). Only then the dehisced anthers can deposit pollen grains on the animals. When the animal visits another flower, the stigma comes in

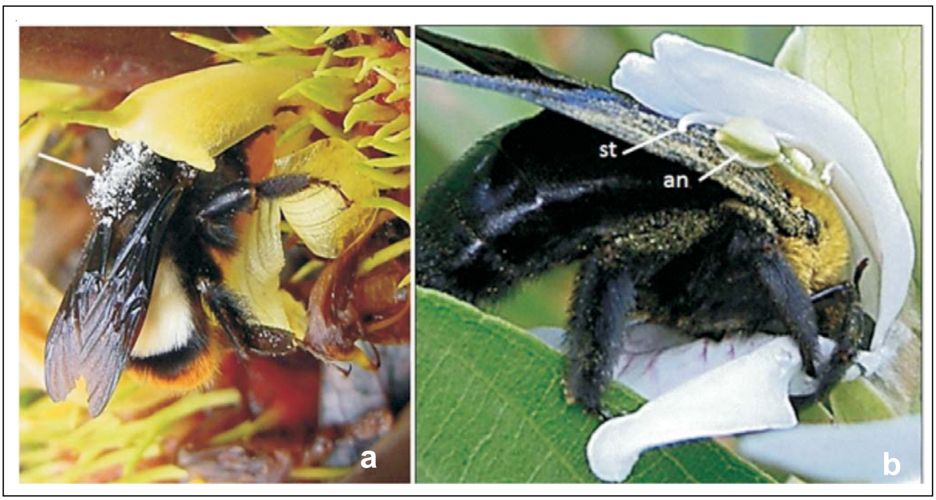

Figure 2. (**a**) A bumble bee coated with white powdery pollen grains (arrow) after visiting a flower of large cardamom entering another flower. (**b**) Flower of *Adhatoda* with a carpenter bee harvesting the nectar. Contact of the stigma (st) and the anther (an) with the upper body surface of the bee are clearly seen.

contact with the part of the animal on which pollen grains are deposited; thus, some of the pollen grains get transferred from the body of the animal to the stigma to bring about pollination. Thus, biotic pollination is largely mutualistic. This mutualism is referred to as 'biological barter' involving the exchange of resources of the flower for the services of the pollinator.

Evolution of biotic pollination, in which insects form a major group of pollinators, has acted as an important catalyst for reciprocal diversification of insects as well as flowering plants.

Flowering plants are the most successful and diverse amongst all plant groups. Similarly insects are the most successful and diverse group amongst animals. The possible reasons for this diversification have been under discussion amongst evolutionary biologists since long. The present consensus is that evolution of biotic pollination, in which insects form a major group of pollinators, has acted as an important catalyst for reciprocal diversification of insects as well as flowering plants. Although insects originated much earlier than flowering plants, their diversification was slow until the origin of flowering plants and evolution of pollination mutualism.

Advertisements and Rewards

Enormous diversity in the size, shape, colour and patterns of the flowers act as visual advertisements to the pollinators. Many of the pollinating insects, particularly bees, have the ability to see objects in the UV range. The perception of flower colours by the insects is different from that of us. Apart from these visual cues, flowers of most of the species produce species-specific fragrance as olfactory cues for pollinators. The fragrance is in the form of complex mixtures of a large number of volatile compounds. Pollinators can perceive specific fragrances and respond. In general, the fragrance acts as a long-distance attractant, and at closer range, both colour and fragrance act synergistically to guide the visitor to the flower. For nocturnal pollinators, the fragrance acts as the main advertiserment as they cannot see the colour clearly in the night. Birds are poor in perceiving fragrance; they depend largely on colour. That is why most of the bird-pollinated flowers are large and brightly coloured.

The major rewards for the pollinators are the pollen grains and the nectar.

The major rewards for the pollinators are the pollen grains and the nectar. Pollen grains are highly nutritious and are a rich source of proteins, vitamins, amino acids and minerals. The nectar is an aqueous solution made up of sugars (largely sucrose, fructose and glucose) generally ranging from 5 to 45% in different species, and small amounts of amino acids and a few secondary metabolites. The pollinators harvest the nectar using their proboscis/tongue. In some species, the rewards are in the form of oils and resins which the insects use to build nests. In some orchids, fragrant compounds act as advertisers as well as rewards. There are evidences to indicate that insects make use of these fragrant compounds to produce sex pheromones which they release to attract females. Some species reward pollinators with nutrients for their larvae in the form of seeds (nursery pollination). Fig and fig wasps (described later), and *Yucca* and *Yucca* moths are classic examples of providing seeds as rewards for pollinators.

Generalized and Specialized Pollination Systems

The flowers of some species such as mustard, apple and rose are simple and expose both the anthers and the pistil (*Figures* 3a, b). The rewards are readily available to any floral visitor. Such flowers tend to attract larger number of pollinator species. Flowers of many other species are complex to varying degrees; the rewards are hidden at the bottom of the corolla tube or in long

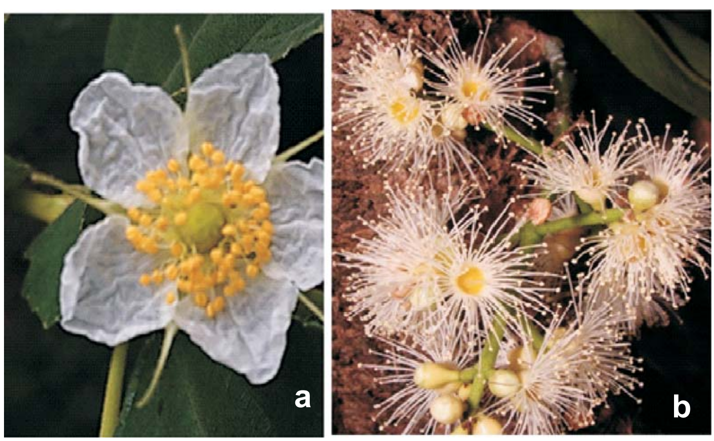

Figure 3. 'Open' flowers of Singapore cherry (*Muntingia,* (**a**)) and Jamun (*Syzygium*, (**b**)). The rewards (pollen grains and nectar) are exposed and any visitor can harvest the rewards.

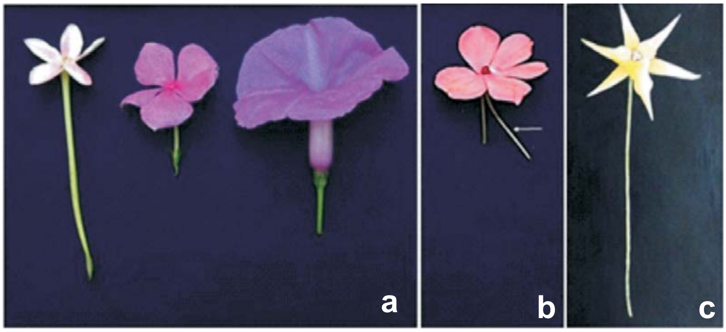

Figure 4. Specialized flowers in which the rewards are hidden. (**a**) Some examples of flowers in which the nectar is at the bottom of the corolla tube of various lengths. (**b**) A flower of balsam with a spur of about 3 cm, (arrow). (**c**) Painting of a flower of *Angraecum* orchid with a long (about 25 cm) spur.

tube-like structures called spurs of various lengths (*Figures* 4a–c). The spur is present in many orchids and its length ranges from a few mm to several cm (see *Box* 2). For successful harvesting of the nectar, the length of the proboscis/tongue of the pollinator should be long enough to reach the reward. Bees which have a short proboscis cannot harvest the nectar in flowers with longer corolla tube or spur; they do not visit such flowers. Only moths and butterflies can harvest the rewards in such flowers and visit the flowers regularly. Thus, in specialized flowers, the rewards can be harvested only by specialized pollinators. Generally, there is a match between the length of the proboscis of the pollinator and the length of the corolla tube or the spur where the nectar is located.

Flowers with hidden nectar generally have contrasting patterns on the petals, termed 'nectar guides' to help the pollinator locate the nectar readily. The size and shape of nectar guides vary greatly. Often they are in the form of radiating lines pointing toward the source of the nectar (*Figure* 5a) or contrasting colours

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Box 2: Darwin and Orchid Pollination

One of the classic examples of long-spurred orchid is *Angraecum sesquipedale* also known as Darwin's orchid, endemic to Madagascar. In this species the nectar is located at the base of a long spur of about 25cm. Charles Darwin, as early as 1862 predicted that the pollinator should be the one which has long proboscis matching the spur length of the orchid. It was only in 1903 (over 40 years after Darwin's prediction), that a hawk moth (*Xanthopan morgani)* with a proboscis length of about 25 cm was shown to be the pollinator of this orchid.

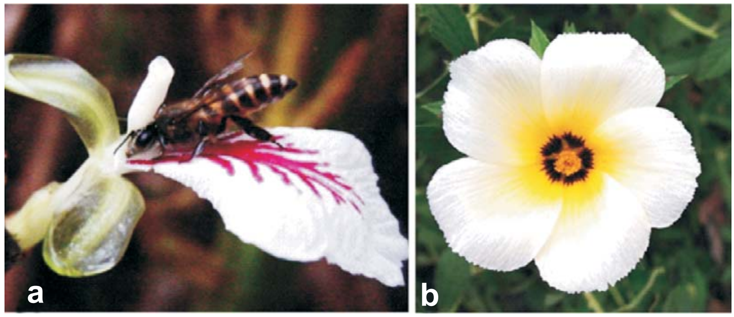

Figure 5. (**a**) Flower of cardamom showing bright nectar guides which guides the bee to the source of nectar. (**b**) A flower of Malvaceae with conspicuous nectar guide at the entry of corolla tube.

around the mouth of the corolla tube (*Figure* 5b). Many experimental studies have shown that nectar guides do help the visitors locate the source of nectar.

The concept of generalist and specialist applies to pollinator species also. Those animals that visit flowers of several plant species are generalists. Specialization leads to a reduction in the number of plant species that the pollinators visit.

Super-Specialization

In highly specialized pollination systems, one pollinator visits the flowers of just one plant species (super-specialization). Pollination in species of *Ficus* (fig) and *Yucca* and a number of orchids are examples of super-specialization. These species-specific pollination systems have evolved as a result of coevolution of the flower and the pollinator. Super-specialization represents obligate relationships, as neither the plant nor the pollinator is able to sustain without the other. Figs represent one of the most intriguing pollination system. There are about 700 species of figs; each species is pollinated by a specific species of fig wasp. Figs produce flowers in special urn-like inflorescences called syconia with a small opening at the tip called ostiole (*Figure* 6a). The flowers are arranged compactly on the inner surface of the syconium. Most of the fig species are monoecious (produce male and female flowers on the same plant). The female flowers are present towards the base of the syconium while the male flowers are produced at the tip. Female flowers are the first to mature; when they become receptive, the syconium emits species-specific

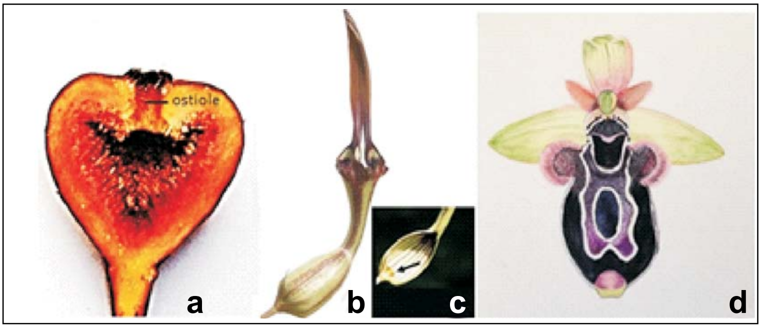

Figure 6. Specialized pollination systems. (**a**) A longitudinally cut fig fruit to show the arrangement of the flowers inside the syconium and the ostiole. (**b**–**d**) Pollination by deceit. Flower of *Ceropegia* (**b**) which shows brood-site deception to achieve pollination. The mouth of the flower is elongated into a strap-like coloured structure. (**c**) Lower part of the flower chamber of *Ceropegia* cut open to show the position of the stamens and the pistil at the base (arrow). (**d**) Painting of a flower of Cyprus bee orchid resembling the female of its pollinator. (**b**) and (**c**).
Courtesy: Professor S R Yadav, Shivaji University, Kolhapur.

fragrance and attracts specific female fig wasps. The wasp enters through the ostiole and pollinates female flowers as it carries the pollen from its visit to the previous syconium. Apart from pollinating female flowers, the wasp lays its eggs in the ovaries (oviposit[3]) of some of the female flowers and dies. After a few weeks, the eggs hatch and the larvae consume the galls that develop from the ovules of oviposited flowers and grow into adults (males and females). Non-oviposited but pollinated flowers develop into fertile seeds. The males are wingless and their life is very short. As the ostiole through which the female had entered the syconium is closed by this time, the males bore a hole in the wall of the syconium for the escape of females and die. As the males do not develop wings, they cannot survive outside the syconium. By this time the syconium reaches the male phase and the pollen grains get deposited on female wasps inside the syconium. The female loaded with pollen comes out of the syconium through the hole (made by the males) and enters another receptive syconium which is in the female phase. It pollinates the stigmas of the new syconium and oviposits in some of the female flowers. Pollinated syconium that develop into fruits, therefore, invariably contain some dead insects. Luckily, commercially cultivated fig species are mostly parthenocarpic[4] and do not require pollinators to produce fruits. Thus, fig eaters are saved from consuming insects! There are a number of other examples of super-specialization, particularly amongst orchids (see *Boxes* 3 and 4).

[3] Deposition of eggs by insects through a specialized appendage (ovipositor) at the end of the abdomen.

[4] Development of fruit without fertilization. Cultivated banana is naturally parthenocarpic.

In figs and fig-wasps mutualism, the survival of both the partners depends on the realization of an optimal benefit to both the partners. If the pollinators are too greedy and lay their eggs in too

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Box 3. Hazards of Super-Specialization

Super-specialization in pollination has many advantages, particularly when the number of pollinators are adequate in the habitat. It increases pollination efficiency since the pollinator and the plant species have evolved to optimize pollen transfer. There is very little pollen wastage as the pollinator does not visit flowers of any other species. Also, there is no chance for hetero-specific pollen deposition. However, super-specialization is a major handicap when the number of pollinators in the habitat becomes limited. The chances of flowers being pollinated reduce and frequently results in pollination limitation or even failure. Since the survival of the plant as well as pollinator species are dependent on each other, extinction of any one of the partners leads to the extinction of the other. Also, the spread of plant or pollinator species to new habitats is dependent on the spread of both the species, which becomes more difficult. Because of the problems associated with over-specialization, many such species including some figs and several orchids have opted out of species-specific pollination and are being pollinated by more than one species of insects.

Box 4. Evolution of Inbreeding Under Pollination Constraints

Evolution occurs under conflicting demands. Although cross-pollination is a desirable option to maintain heterozygosity of the population needed for evolution, outcrossing* often becomes a constraint threatening the survival of the population in their natural habitats. Under such pollination constraints, several species have evolved autogamy (self-pollination with the pollen of the same flower which does not require pollinating agent) as a means of reproductive assurance. Although the selfed progeny suffers to some extent because of inbreeding depression, at least it results in the development of some seeds to sustain the progeny.

Orchids have developed the most elaborate pollination systems and a large number of them require species-specific pollinators. They experience pollination hazards more frequently. To overcome this hazard, they have evolved many alternative strategies. 1) Unlike many other species, in which stigma receptivity lasts only for one or a few days, flowers of orchids remain receptive to pollinators for a much longer period, for several weeks in some species, to increase the chances of pollination. 2) All the pollen grains of a flower are packed into a single mass called ‘pollinarium’. As pollinarium is the unit of transport and not individual pollen grains, one visit by the pollinator is enough to transfer the whole mass of pollen which is sufficient to fertilize all available ovules. 3) Many of the orchids are able to self-pollinate as a last resort when there is no cross-pollination.

* Pollination of stigma with pollen grains coming from a flower of another plant of the same species. Often used to distinguish cross pollen coming from another flower of the same plant.

many female flowers to increase their progeny, fig is the loser as very few seeds or no seeds develop in such syconia. However, such fruits will abscise as sufficient number of seeds are required to sustain fruit growth. Thus, an optimum balance between the number of flowers used for egg laying and the number of pollinated flowers that develop into seeds is maintained. If this balance is upset, both the partners will suffer.

Cheaters and Robbers

Although pollination is generally a mutual interaction in a majority of species imparting benefits to both the partners, there are many examples in which only one of the partners will benefit. A number of plant species cheat pollinators; they manage to achieve pollination without providing any reward to the pollinator. Such plants advertise the presence of rewards without offering the reward and achieve pollination through deceit (deceptive pollination). Non-mutualistic interactions have evolved in all major groups of flowering plants. However, orchids are the most successful group of cheaters; about one third of the orchids (over 10,000 species) are estimated to get pollination services by deceit. Such species have developed a range of enticements to attract pollinators.   Most of the species producing rewardless flowers are pollinated by insects.

Food Deception

One group of orchids deceives insects by advertising the presence of food rewards, pollen and/or nectar (food deception). Flowers of the deceptive plant morphologically resemble (mimic) another species which offers rewards (model) and grow along with the rewarding species. Floral visitors cannot discriminate between rewarding and non-rewarding flowers; they visit the flowers of both the species and harvest the reward from the rewarding species. For example, a South African orchid, *Disa ferruginea* imitates nectar-producing flowers of *Tritoniopsis triticea* (Iridaceae). The butterfly (*Aeropetes tulbaghia*) pollinates both nectar-less orchid flower and the nectar-producing model flower in sympatric populations.

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Brood-Site Deception

Flowers of several plants emit the odour of mammalian faeces, carrion and decomposing plant materials on which their pollinators, mainly flies, oviposit (brood site). In the species of *Aristolochia* and *Ceropegia* (*Figure* 6b), the flowers are roughly flask-shaped with an expanded mouth leading to a long narrow neck and swollen floral chamber at the base where the anthers and the pistil are located (*Figure* 6c). Receptive flowers emit a strong fetid odour, mimicking the natural oviposition substrate of their pollinators. The pollinators (mostly Dipterean flies), attracted by the colour and odour of the flower, enter the floral chamber through the narrow tube and bring about pollination. The emission of odour ceases from the flowers after pollination so that it does not attract any more pollinators.

Several brood-sites mimicking species such as *Aristolochia* and *Ceropegia* are protogynous (the stigma becomes receptive 1 or 2 days before the pollen grains are dispersed). They have developed effective trap mechanism to hold the insects inside the floral chamber until the pollen grains are shed. The inner surface of the floral tube in such species is lined with downward-pointed stiff hairs which allows the insects into the floral chamber but prevents their exit for 24–48 h. By this time, the anthers dehisce and as the insects move inside the floral chamber, they get coated with the pollen. The hairs in the tube become flaccid and start senescing allowing the flies to escape. The flies, coated with pollen, enter freshly opened flowers with receptive stigmas and bring about pollination.

Flowers resemble the females of the pollinator species. They emit odour similar to the sex pheromones of receptive females and excite the male when it comes near the flower.

Sexual Deception

A large number of orchids achieve pollination by sexual deception. In several species such as Cyprus bee orchid (*Ophrys* sp.), and *Chiloglottis*, pollination through sexual deception is highly specific and attracts a particular species of pollinator. Emittance of odour from the flower plays a dominant role in sexual mimicry. Flowers resemble the females of the pollinator species

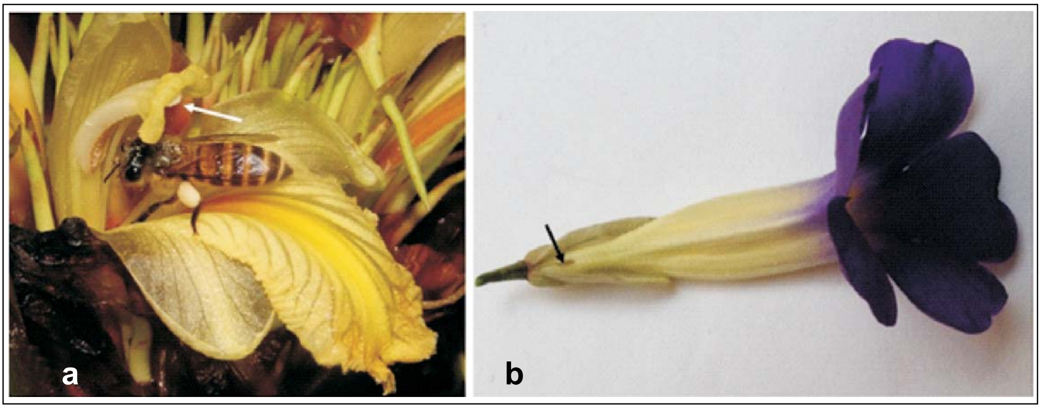

Figure 7. Pollen and nectar robbers. (**a**) Flower of large cardamom in which honey bee is harvesting the pollen without touching the stigma (arrow). (**b**) A flower in which the nectar is located at the base of the corolla tube. Carpenter bee cannot access nectar by entering the flower; it has harvested nectar by making an incision (arrow) at the base of the corolla tube.

(*Figure* 6d). They emit odour similar to the sex pheromones of receptive females and excite the male when it comes near the flower. The visitor lands on the deceptive flowers and tries to copulate, thinking that the flower is the female partner (pseudocopulation). It cannot succeed in copulation but brings about pollination during this process.

Similar to plants, many animal visitors rob floral rewards; they harvest the rewards without effecting pollination, similar to pick pocketers. Such visitors are referred to as pollen or nectar robbers. Pollen robbers harvest the pollen without coming in contact with the stigma (*Figure* 7a). Nectar robbers harvest the nectar form the sides of the flowers by piercing the corolla tube without coming in contact with the anthers or the stigma (*Figure* 7b). Nectar robbers are also common in bird-pollinated flowers.

Pollination Services in Sustaining Plant Diversity

In recent years sustenance of our biodiversity has become a major concern as a result of degradation of the habitat, overexploitation and climate change. A large number of species have been pushed into the endangered category and many of them have already become extinct. If this trend continues, it may lead to the sixth major extinction[5] of biodiversity on our planet. One of the primary causes for erosion of plant biodiversity is reproductive failure. This results in an increased number of deaths in the population when compared to the number of births. When this

[5] See Prasanna Venkhatesh V, The Age of Extinction, *Resonance*, Vol. 20, No.8, pp.748–750, 2015.

For effective management of our biodiversity, it is important to sustain pollination services.

trend continues, the species becomes endangered and eventually becomes extinct. The main cause for reproductive failure is pollination limitation/failure as a result of a decrease in the density and diversity of insect pollinators. For effective management of our biodiversity, therefore, it is important to sustain pollination services. This is a major challenge we have to face in the coming decades. It requires concerted efforts by biologists as well as others to make the habitats eco-friendly for the pollinators.

Pollination and Crop Productivity

Pollination services are equally important to sustain/improve productivity of our crops. In most of the crop plants, fruits and seeds are the economic products. Pollination is a pre-requisite for their development. Except cereals, which are wind pollinated, a large number of other crops, particularly legumes, oil crops and fruit crops are pollinated by insects. In recent decades, adequate pollination has become a major limitation for crop productivity because of a marked reduction in the density and diversity of natural pollinators. The major culprits responsible for this situation are: a) habitat fragmentation, b) extensive use of unfriendly agrochemicals particularly herbicides and pesticides, c) high levels of pollution, d) monoculture cropping system, particularly in Western countries, in which the same crop is spread over hundreds of hectares, and e) climate change. In the absence of adequate pollination, application of any amount of fertilizers or advanced agronomic practices will have no effect on the crop yield. To overcome pollination problem, managed pollinators, especially honey bees and bumble bees, are being used routinely in Western countries. Almond (see *Box* 5), apple, tomato, water melon, mustard and sunflower are some of the major crops that depend on managed pollinators. The farmers rent bee colonies from the beekeepers and keep them in their farm/orchard during the flowering period of the crop for pollination services. This has developed into a well-organized industry. The annual monetary value of honey bees as commercial pollinators in the United States is estimated to be about $ 20 billion. The major income for

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Box 5. The Largest Managed Pollination Show on Earth

The largest managed pollination show on earth occurs in the almond orchards in California, USA. Almond is the most important crop of California. California has 82% of the world's almond production. Over 800,000 acres of almond orchards require 1,600,000 beehives, which amounts to nearly 60% of the available hives (2–2.5 million) in USA, for pollination services. Only about 400,000 hives (25%) are available locally and the rest have to be trucked from other places as far away as Florida and Texas. Their transportation needs 3,000–6,000 trucks, depending on their capacity. After completing pollination services of almond, some of the hives are moved to other crops locally and the rest are moved to other states such as Washington for apple and cherry orchards, Texas for vegetable crops, Florida for citrus orchards and Wisconsin for cranberries. The number of bee colonies available for pollination services in USA in recent decades has come down by 50% (from 5 million during the 1950s to 2.5 million) due to various diseases. But the acreage of almond has increased, resulting in a marked increase in the rental value of bee colonies. The average rental value for each hive for almond pollination has jumped from about USD 54 in 2004 to USD 140 in 2006.

the beekeepers is from renting the colonies for pollination services. The income from honey and wax has become minor.

In India, pollination is still taken for granted by most of our farmers. So far, apple is the only crop in which this technology is being used to some extent in our country. Although pollination limitation has been reported in several other crops also, the technology is yet to be used effectively. This is largely because of a) lack of baseline data on pollination scenario of crop plants and their pollinators, b) lack of awareness amongst the farmers and the public on the importance of pollination services in productivity of crop species, and c) lack of strong research backup on the management and use of domesticated pollinators for pollination services. As in Western countries, the focus of beekeepers has to be shifted from honey production to pollination services. Unless serious efforts are made to safeguard the pollination services of crop plants in the country, crop productivity, so vital to feed the growing millions, is going to become worse in the coming decades.

The focus of beekeepers has to be shifted from honey production to pollination services.

Conclusions

The crucial event of pollen transport from the anthers to the stigma has been evolving since the origin of flowering plants over 100 million years ago to make it more diverse and refined through adaptations by both the partners. This eco-service is essential not only for the sustenance of our plant diversity which has been seriously threatened by human activities but also to ensure food security. It is high time that serious efforts are made both at national and international levels to sustain this vital eco-service in the coming decades.

Suggested Reading

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