Pollination

Pollinators. Source: USFS; Credit: Paul Mirocha.

Carpenter bee with pollen collected fromNight-blooming cereus

Pollination in angiosperms and gymnosperms is the process that transfers pollen grains, which contain the male gametes (sperm) to where the female gamete(s) are contained within the carpel;[1] in gymnosperms the pollen is directly applied to the ovule itself. The receptive part of the carpel is called a **stigma** in the flowers of angiosperms. The receptive part of the gymnosperm ovule is called the **micropyle**.

The study of pollination brings together many disciplines, such as botany, horticulture, entomology, and ecology. The pollination process as an interaction between flower and vector was first addressed in the 18th century by Christian Konrad Sprengel.

Pollination is a necessary step in the sexual reproduction of flowering plants, resulting in the production of offspring that are genetically diverse. It is important in horticulture and agriculture, because fruiting is dependent on fertilisation, which is the end result of pollination. Pollinators are responsible for assisting over 80% of the world's flowering plants. Without them, humans and wildlife would not have much to eat or look at. Animals that assist plants in their reproduction as pollinators include species of ants, bats, bees, beetles, birds, butterflies, flies, moths, wasps, as well as otherunusual animals. Wind and water also play a role in the pollination of many plants.

Types

Abiotic pollination refers to situations where pollination is mediated without the involvement of other organisms; these abiotic factors that achieve pollination include wind and gravity. Only 10% of flowering plants are pollinated without animal assistance.[2] The most common form, anemophily, is pollination bywind. This form of pollination is predominant in grasses, most conifers, and many

deciduous trees. Hydrophily is pollination by water and occurs in aquatic plants which release their pollen directly into the surrounding water. About 80% of all plant pollination is biotic. Of the 20% of abiotically pollinated species, 98% is by wind and 2% by water.

A hummingbird feeding.

Biotic pollination is the more common process of pollination which requires biotic pollinators: organisms that carry or move the pollen grains from the anther to the receptive part of the carpel or pistil. This is '"biotic pollination"'. The various flower traits (and combinations thereof) that differentially attract one type of pollinator or another are known as pollination syndromes.

There are roughly 200,000 varieties of animal pollinators in the wild, most of which are insects.[2] '"Entomophily"', pollination by insects, often occurs on plants that have developed colored petals and a strong scent to attract insects such as, bees, wasps and occasionally ants (Hymenoptera), beetles (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). In '"Zoophily"', pollination is conducted by vertebrates such as birds and bats, particularly, hummingbirds, sunbirds, spiderhunters, honeyeaters, and fruit Bats. Plants adapted to using bats or moths as pollinators typically have white petals and a strong scent, while plants that use birds as pollinators tend to develop red petals and rarely develop a scent (few birds have a sense of smell).

Mechanics

Pollination also requires consideration of pollenizers. The terms "pollinator" and "pollenizer" are often confused: a ***pollinator*** is the agent that moves the pollen, whether it be bees, flies, bats, moths, or birds; a***pollenizer*** is the plant that serves as the pollen source for other plants. Some plants are **self-fertile** or**self-compatible** and can pollinate themselves (e.g., they act as their own pollenizer). Other plants have chemical or physical barriers to self-pollination and need to be cross-pollinated: with these self-infertile plants, not only pollinators must be considered but pollenizers as well. In pollination management, an efficient pollenizer is a plant that provides compatible, viable and plentiful pollen and blooms at the same time as the plant that is to be pollinated.

A European honey bee collects nectar, while pollen collects on its body.

- Pollination can be **cross-pollination** with a pollinator and an external pollenizer, **self-pollenization** with a pollinator, or **self-pollination** without any pollinator:

  Cross-pollination (***syngamy***): pollen is delivered to a flower of a different plant. Plants adapted to outcross or cross-pollinise have taller stamens than carpels to better spread pollen to other flowers.

- Self-pollenization (***autogamy***): pollen moves to the female part of the same flower, or to another flower on the same individual plant. This is sometimes referred to as self-pollination, but this is not synonymous with autogamy. Clarity requires that the term "self-pollination" be restricted to those plants that accomplish pollination without an external pollinator (example: the stamens actually grow into contact with the pistil to transfer the pollen). Most peach varieties are autogamous, but not truly self-pollinated, as it is generally an insect pollinator that moves the pollen from anther to stigma. Plants adapted to self-fertilize have similar stamen and carpel length.
- ***Cleistogamy***:. is self-pollination that occurs before the flower opens. The pollen is released from the anther within the flower or the pollen on the anther grows a tube down the style to the ovules. It is a type of sexual breeding, in contrast to asexual systems such as apomixis. Some *cleistogamous* flowers never open, in contrast to ***chasmogamous*** flowers that open and are then pollinated. Cleistogamous flowers by necessity are self-compatible or self-fertile plants.[3] Many plants are self-incompatible, and these two conditions are end points on a continuum.

Hybridization is effective pollination between flowers of different species of the same genus, or even between flowers of different genera (as in the case of several orchids).

Peaches are considered self-fertile because a commercial crop can be produced without cross-pollination, though cross-pollination usually gives a better crop. Apples are considered self-incompatible, because a commercial crop must be cross-pollinated. Remember that most fruits are grafted clones, genetically identical. An orchard block of apples of one variety is in effect all one plant. Growers now consider this a mistake. One means of correcting this mistake is to graft a limb of an appropriate pollenizer (generally a variety of crabapple) every six trees or so.

Evolution of Plant/Pollinator Interactions

Pollination syndromes are flower traits that attract pollinators, and can be highly specialized. Plants and their pollinators are often in coevolutionary mutualisms.

The first fossil record for abiotic pollination is from fern-like plants in the late Carboniferous period. Gymnosperms show evidence for biotic pollination as early as the Triassic period. Many fossilized pollen grains show characteristics similar to the biotically-dispersed pollen today. Furthermore, the gut contents, wing structures, and mouthpart morphologies of fossilized beetles and flies suggest that they acted as early pollinators. The assosciation between beetles and angiosperms during the early Cretaceous period led to parallel radiations of angiosperms and insects into the late Cretaceous. The evolution of nectaries in late Cretaceous flowers signals the beginning of the mutualism between hymenopterans and angiosperms.

In Agriculture

Pollination management is a branch of agriculture that seeks to protect and enhance present pollinators and often involves the culture and addition of pollinators in monoculture situations, such as commercial fruit orchards. The largest managed pollination event in the world is in California almond orchards, where nearly half (about one million hives) of the USA honey bees are trucked to the almond orchards each spring. New York's apple crop requires about 30,000 hives; Maine's blueberry crop uses about 50,000 hives each year.

An "Andrena" bee collects pollen among the stamens of a rose. The female carpel structure appears rough and globular to the left. The bee's stash of pollen is on its hind leg.

Bees are also brought to commercial plantings of cucumbers, squash, melons, strawberries, and many other crops. Honey bees are not the only managed pollinators: a few other species of bees are also raised as pollinators. The alfalfa leafcutter bee is an important pollinator for alfalfa seed in western United States and Canada. Bumblebees are increasingly raised and used extensively for greenhouse tomatoes and other crops.

Well-pollinated blackberry blossom begins to develop fruit. Each incipient drupelet has its ownstigma and good pollination requires the delivery of many grains of pollen to the flower so that all drupelets develop.

Blueberries being pollinated bybumblebees.

Bumblebee hives need to be bought each year as the queens must hibernate (unlike honey bees). They are used nonetheless as they offer advantages with certain fruits as blueberries (such as the fact that they are active even at colder outdoor ambient temperature).

Theecological and financial importance of natural pollination by insects to agricultural crops, improving their quality and quantity, becomes more and more appreciated and has given rise to new financial opportunities. The vicinity of a forest or wild grasslands with native pollinators near agricultural crops, such as apples, almonds or coffee can improve their yield by about 20%. The benefits of native pollinators may result in forest owners demanding payment for their contribution in the improved crop results: a simple example of the economic value of ecological services.

The American Institute of Biological Sciences reports that native insect pollination saves the United Statesagricultural economy nearly an estimated $3.1 billion annually through natural crop production;[4]pollination produces some $40 billion worth of products annually in the United States alone.[2]

Pollination of food crops has become an environmental issue, due to two trends. The trend to monoculture means that greater concentrations of pollinators are needed at bloom time than ever before, yet the area is forage poor or even deadly to bees for the rest of the season. The other trend is the decline of pollinator populations, due to pesticide misuse and overuse, new diseases and parasites of bees, clearcut logging, decline of beekeeping, suburban development, removal of hedges and other habitat from farms, and public paranoia about bees. Widespread aerial spraying for mosquitoes due to West Nile fears is causing an acceleration of the loss of pollinators.

The US solution to the pollinator shortage, so far, has been for commercial beekeepers to become pollination contractors and to migrate. Just as the combine harvesters follow the wheat harvest from Texas to Manitoba, beekeepers follow the bloom from south to north, to provide pollination for many different crops.

Environmental Impacts

Loss of pollinators, also known as Pollinator decline (of which colony collapse disorder is perhaps the most well known) has been noticed in recent years[5]. Observed losses would have significant economic impacts. Possible explanations for pollinator decline include habitat destruction, excessive use of chemical herbicideor pesticides, parasitism/diseases, air pollution and other causes.

References

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Further Reading

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- New "Pollinator Garden Wheel" from the National Academies provides information on pollination and tips on building a pollinator-friendly garden.
- Insect Pollination Of Cultivated Crop Plants by S. E. McGregor USDA 1972 (needs updating but still valuable)
- The Pollination Home page
- Pulse of the Planet description of buzz pollination
- Pollination syndromes images at bioimages.vanderbilt.edu
- TheKidsGarden - Teach Kids About Pollination

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