# Background to Pollination and Pollinators[1]

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## What is pollination?

Flowering plants (Angiosperms) of the world are able to reproduce sexually (i.e. combining the genes of two parent plants) through the transfer of pollen from the male part of the flower (or male flower) to the female part of the flower (or female flower)[2]. This process is known as **pollination** and leads to the fertilisation of the flower and the production of seed, enclosed in a fruit (forms of fruit vary and include berries and nuts).[3] The Gymnosperms, which include the conifers, cycads and the gingko, also produce pollen, but not from animal-visited flowers. "Lower" plants, like mosses and ferns reproduce sexually, but with a complex "alternation of generations" involving spores and swimming sperm instead of pollen.

## Types of pollination

Two main forms of pollination[4] can be found in UK gardens; wind pollination and insect pollination. In many flowering plants the pollen is simply released into the air and carried on the wind to other plants. Typical wind pollinated plants include sweetcorn, hazelnut, ornamental grasses and cereal crops. However, the majority of flowering plants rely on insects to carry the pollen from one flower to the next. These insects (often unwittingly) pick up pollen grains on hairs on their bodies as they move around the flower seeking nectar, and then carry the pollen from one flower to the next they visit. If the next flower is of the same species, the receiving flower will be fertilised and set seed. Examples of insect pollinated plants include apples, strawberries, tomatoes and most ornamental flowers such as dahlias and lavenders.

Outside Europe, birds (and to a small extent specialised mammals such as bats) are also significant pollinators. The Crown Imperial *Fritillaria imperialis*, which is pollinated by blue tits in its native Turkey, is the only bird-pollinated species of wild flower in Europe[5]. British gardeners are generally unaware that in other continents, including North America, pollination by birds such as humming-birds is not uncommon. This matters to UK gardeners simply because bird-pollinated flowers have often evolved very specific floral structures to attract birds that make them difficult for insects to access.

Bird-pollinated flowers tend to share a set of typical features[6] – they are often red or orange, colours that attract birds but which cannot be seen by bees; they are often pendant and tubular in shape, like the hanging flowers of *Fuchsia* , so that hummingbirds can hover underneath and push their long bills up into the flower. Other kinds have robust inflorescences that birds can perch upon, for example *Kniphophia*, *Phormium*, and *F. imperialis*.

**Why pollination is important**

Without insects to transfer pollen, insect-pollinated plants would fail to set seed and/or fruit. This is vital to the success of many of our vegetable and fruit crops so it is no surprise that the value of 'pollination service' performed by pollinating insects in the UK has been estimated at around £430 million a year[7]. Human pollinators (armed with fine brushes) would have to fill the gap if insect pollination failed. In certain regions of China human pollination for apple production is already practised.[8] The relationship between pollinating insects and gardeners is particularly close. The activity of insects such as bees ensures reliable seed set in the flower garden and is vital for success in the fruit and vegetable garden.

Outside cultivation, pollinating insects also provide an essential service for most species of wild flowers[9]. In the long term, without adequate pollination, some populations of wild flowers are likely to decline.

**What are insects are pollinators?**

Although honey bees play a major role in pollination, they are not the only insect pollinators[10,11]. Essentially, *any* insect that visits flowers can facilitate pollination. A fuller list of pollinating insects should include the following, all of which are at the adult stage when they forage on flowers;

Domesticated or farmed pollinators

- Honeybee (*Apis mellifera*) (1 species)

Wild pollinators

- Bumblebees (Hymenoptera: Apidae: *Bombus* species) with around 24 species in Britain. Some are farmed for glasshouse crop pollination
- Solitary bees (Aculeate Hymenoptera: many families) Around 260 species in Britain
- Social wasps (Aculeate Hymenoptera: Vespidae)
- Solitary wasps (Aculeate Hymenoptera: many families)
- Hoverflies (Diptera: Syrphidae: many species)
- Other flies (Diptera)
- Many butterflies and moths (Lepidoptera)
- Some beetles (Coleoptera)

**Pollinating insects and plants**

Adult insects that visit flowers do so for a nutritional reward. This is either in the form of the pollen itself, a valuable source of protein (though the amount of pollen consumed rarely impacts on the success of pollination), or a sugar-rich liquid called nectar, produced in nectaries located usually at the base of the flower.

Foraging insects show preferences for certain plants. These preferences are not fully understood but factors that are known to be involved include flower shape, flower colour, fragrance and the quality and quantity of pollen and nectar.

Other environmental factors can play a part in plant/insect interactions, such as temperature and wind conditions, and in the case of bees how far a plant is from the nest. Honeybees, for example, can range easily 6 km or more to forage on flowers[12], whereas most bumblebees will forage less than 1 km from the nest[13]. Gardeners that position their flowering plants in a sunny, sheltered spot are likely to see them visited by more insects than identical plantings in the shade or an exposed site.

Some pollinating insects, especially honeybees, will feed on honeydew which is a sugary excretion produced by sap-sucking insects such as aphids. Some trees like maples will also leak sugary sap from wounds. Honeydew and sap can be a significant part of the diet of insects in some northern countries.

**Flower Accessibility**

While much is still unclear about why insects favour certain flowers, the importance of flower shape and accessibility has been well known for many years and understanding this goes a long way to helping the gardener choose insect-friendly flowers. It is a fascinating area of study and can give you a new perspective on the flowers in your garden.

The various groups of insects have complex and quite different mouthparts. Ancestral insect mouthparts were designed for biting and chewing[14], as with the grasshoppers, dragonflies and beetles. Many pollinators have specialised mouthparts. Adult butterflies and moths take only nectar from flowers, sucking it up through a long thin proboscis. Bees drink nectar using shorter tongues. At the same time as they delve into the flower to find the nectar, bees accumulate pollen that rubs off onto their bodies from the male parts of the flower (stamens). Stiff hairs on the bee's legs are used to comb the pollen into a pollen basket or corbicula to help transport the pollen back to the hive. Adult hoverflies, depending on species, may take either pollen or nectar but have shorter mouthparts and tend to prefer flat, open flowers.

During millennia of evolution, species of flowers have co-evolved with their pollinators to meet these different shapes and requirements. Some types of flowers have gone down the "open access" route. They have flat or bowl-shaped flowers that attract insects from many families. Other species of flowers have become specialised. They may have bell-shaped flowers that accommodate whole bumblebees, or 'lips' that act as landing platforms for bees at the front of the flowers; some flowers consist of bunches of very thin tube-like florets that can accommodate the hair-like proboscis of a butterfly or moth.

**State of health of pollinating insect populations**

In the UK and globally there are concerns over falling numbers in pollinating insects[15]. In Britain between 1968 and 2007, the total number of larger moths recorded in a national network of moth traps fell by 28%[16]. A report on British butterflies in 2011 found 72% of species decreased in abundance over 10 years and 54% decreased in distribution at the UK level.[17] Since the 1950s there has been a general trend in Britain, the Netherlands and Belgium of declining bumblebee, solitary bee and hoverfly species.[18]

Precise reasons for the decline in pollinating insects are complex and opinion on the causes remains divided, particularly over issues such as the impact of pesticides. Where agreement exists it is in the loss of habitat (including nesting sites), the loss of forage (including wildflowers) from the countryside, the fragmentation of habitat and impact of pests and diseases. The role of the varroa mite and the viruses it transmits is particularly devastating in apiculture. In some areas honeybee decline[19] has been so severe that entire colonies fail, now called "colony collapse", but again there are thought to be multiple drivers rather than one specific cause[20].

**The role of gardens in helping pollinators**

The evidence for the role of gardens in sustaining pollinators is very strong, and reviewed in detail in our page on Gardens: Native or Non Native species? The National Bumblebee Survey found higher densities of nests in gardens than in short grassland, long grassland and woodland, and most linear habitats of woodland edge, hedgerows and fence lines[21]. Margaret Couvillon and her team at the Sussex University Laboratory of Apiculture and Social Insects have used clever decoding of honeybee dances to show the use of garden flower resources within a mixed landscape.[22]

There is evidence from Swedish studies that gardens provide an important landscape-wide resource for pollinators and that without gardens to boost pollinators, there is inadequate pollination of wild plants in modern agricultural landscapes[23]. A German study[24] has shown that the presence of nearby gardens is a benefit for pollination in adjacent crops.

Good plant choice and use is one of the best ways to maximise our gardens for pollinating insects, but we need more information on what sorts (especially cultivars) of garden plants are most valuable. There are many published lists, but they show alarming inconsistencies and omissions[25,26]. Fortunately simple survey protocols suitable for citizen science studies are now available and providing useful results.[27]

**UK Government promotion of pollinators**

In the UK, government agencies are developing national pollinator strategies and other plans;

- Insect Pollinator Initiative (IPI): sustainable pollination services for UK crops.[28] Led by Dr Koos

Biesmeijer, University of Leeds

- Insect Pollinator Initiative (IPI) AgriLand project[29]
- Insect Pollinator Initiative (IPI) Urban pollinators project[30]  STEP (Status & Trends in European Pollinators)[31]
- Defra Bees and other pollinators: their value and health in England[32] (Review of policy and evidence) July 2013
- Parliamentary Office of Science and Technology Postnote Number 348 January 2010
- "Insect Pollination"[33] and Postnote 442 September 2013 "Reversing insect pollinator Decline"[34] Reference list for these[35]
- Healthy Bees Plan[36] – published by Defra and the Welsh Government in 2009
- Welsh Government Action Plan for Pollinators[37].
- And if you're interested in the bigger picture, see the projects, research and strategies section below.

**Finding out more**

Books for bees:

- Plants for Bees: A Guide to the Plants That Benefit the Bees of the British Isles. W. D. J. Kirk & F. N. Howes, International Bee Research Association 2012, ISBN 9780860982715
- Plants and Planting Plans for a Bee Garden: How to Design Beautiful Borders That Will Attract Bees. M. Little, Spring Hill 2012, ISBN 9781905862801

Books for butterflies and other insects:

- The Butterfly Gardener. Miriam Rothschild & Clive Farrell, Michael Joseph / Rainbird 1983, ISBN 0718122585
- How to attract butterflies to your garden. John & Maureen Tampion, Guild of Master Craftsman Publications 2003, ISBN 1861082975
- Gardening for Butterflies, Bees and Other Beneficial Insects: A How-to Guide Jan Miller-Klein 2010, ISBN 9780955528804

General books:

- Plant-pollinator Interactions: From Specialization to Generalization , edited by N M Waser & J Ollerton, University of Chicago Press 2006, ISBN 9780226874005
- Evolution of Plant-Pollinator Relationships. Sébastien Patiny ed. Systematics Association Special Volume Series 81, Cambridge University Press 2011, ISBN 9780521198929
- Pollinator identification book
- Lewington, R. & K. Thompson Guide to Garden Wildlife. British Wildlife Publishing 2008, ISBN 9780953139972

Field Studies Council guides :

- Bees: http://www.field-studies-council.org/publications/pubs/guide-to-bees-ofbritain.aspx

- Butterflies: http://www.field-studies-council.org/publications/pubs/butterflies-of-britain-british-butterfly-identification-guide.aspx  Day-flying moths: http://www.field-studies-council.org/publications/pubs/day-flyingmoths.aspx

Online wildlife identification sites

- iSpot http://www.ispotnature.org/
- bees and wasps http://www.bwars.com/index.php?q=content/beginners-bees-wasps and-ants
  - bumblebees http://www.nhm.ac.uk/researchcuration/research/projects/bombus/bumblebeeid.html
  - hoverflies http://www.microscopy-uk.org.uk/mag/artmay07/cd-hoverflies.html

[1] Reviewed by Steve Head

[2] Flower structure, pollination and fertilisation: http://www.bbc.co.uk/bitesize/standard/biology/world_of_plants/growing_plants/revision/3/

[3] For more general information on plant reproduction and pollination see *RHS Botany for Gardeners* Octopus Publishing 2013, ISBN 9781845338336

[4] Differences between insect and wind pollinated flowers: http://www.bbc.co.uk/bitesize/standard/biology/world_of_plants/growing_plants/revision/4/

[5] Duthie, D. 1989. Bluetits pollinate the plants that other creatures cannot reach. New Scientist (1681). 9 September 1989.

[6] Proctor, M. Yeo, P. and Lack, A. 1996 The Natural History of Pollination. Harper Collins

[7] Smith, P., Ashmore, M., Black, H., Burgess, P., Evans, C., Hails, R., Potts, S.G., Quine, T., Thomson, A., 2011. UK National Ecosystem Assessment. In: Regulating Services. UNEP-WCMC, Cambridge (Chapter 14)

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[14] http://en.wikipedia.org/wiki/Insect_mouthparts

[15] Potts S G, *et al* 2010. Global pollinator declines: trends, impacts and drivers. Trends in Ecology & Evolution **25**:345 -353

[16] http://butterfly-conservation.org/1776/the-state-of-britains-moths.html

[17] http://butterfly-conservation.org/1643/the-state-of-britains-butterflies.html

[18] http://www.parliament.uk/briefing-papers/POST-PN-442.pdf

[19] RHS advice page Bees: decline in numbers http://apps.rhs.org.uk/advicesearch/Profile.aspx?pid=528

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[21] Osborne, J. L. *et al* 2008 Quantifying and comparing bumblebee nest densities in gardens and countryside habitats Journal of Applied Ecology **45:**784–792

[22] http://www.sussex.ac.uk/lasi/sussexplan/dances

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[27] Garbuzov M, Ratnieks F.L.W. 2014 Quantifying variation among garden plants in attractiveness to bees and other flower-visiting insects. Functional Ecology **28:**364– 374

[28] https://wiki.ceh.ac.uk/display/ukipi/Home

[29] http://www.agriland.leeds.ac.uk/

[30] http://www.bristol.ac.uk/biology/research/ecological/community/pollinators

[31] http://www.step-project.net/

[32] http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210926/pb13981-bees-pollinators-review.pdf

[33] http://www.parliament.uk/documents/post/postpn348.pdf

[34] http://www.parliament.uk/briefing-papers/POST-PN-442.pdf

[35] http://www.parliament.uk/documents/POST/postpn442_Reversing-Insect-Pollinator-Decline.pdf)

[36] https://secure.fera.defra.gov.uk/beebase/index.cfm?sectionid=41

[37] http://wales.gov.uk/topics/environmentcountryside/consmanagement/conservationbiodiversity/action-plan-for-pollinators/?lang=en