Environmental Studies
FACT SHEET
www.curriculum-press.co.uk
Number 112

Why biodiversity matters: pollination

Bees and other insects provide e**cosystem services** - benefits to humans as a result of their interaction with other organisms.

One of the most important ecosystem service performed by wild animals is pollination. Animal pollination is important to the sexual reproduction of many crops and most wild plants.

Most pollinators are insects - bees, flies, beetles, wasps, butterflies, moths and thrips - but birds, bats, marsupials, slugs and rodents also contribute.

Fig.1 shows the relative importance of animals in crop and commodity pollination in 2004. The data covers those crops and commodities for which annual production exceeded 4Mt.

Animal pollination is irrelevant to 18 of the leading single crops (equal to 60% or 39108 Mt of the world production) and 10 of the leading commodity crops. These are wind - or passively self-pollinated grasses (cereals and sugarcane).

However, production of 39 of the leading 57 single crops increases with pollinating animals (in this case, they are all insects) which account for 35% (23.1Mt) of global food production. In these crops the presence of insect pollinators may increase the yield of edible seeds, fruit or vegetables or they may increase seed yield which is intended for breeding.

There is growing evidence that pollinators are under threat from a variety of direct and indirect human activities

Not only does the decline of pollinators result in less food production, there is also evidence that their decline can lead to a parallel decline of plant species.

The importance of bees

Honeybees, mainly *Apis mellifera*, are the most economically valuable pollinators of crop monocultures worldwide. Yield of coffee in Panama) and yields of some fruit, seed and nut crops decrease by more than 90% without pollination by bees.

If wild bees do not visit the crops, farmers have to use managed honeybee hives. Although managing honeybees is relatively easy and cheap, for some crops honeybees are not as effective pollinators as wild bees.

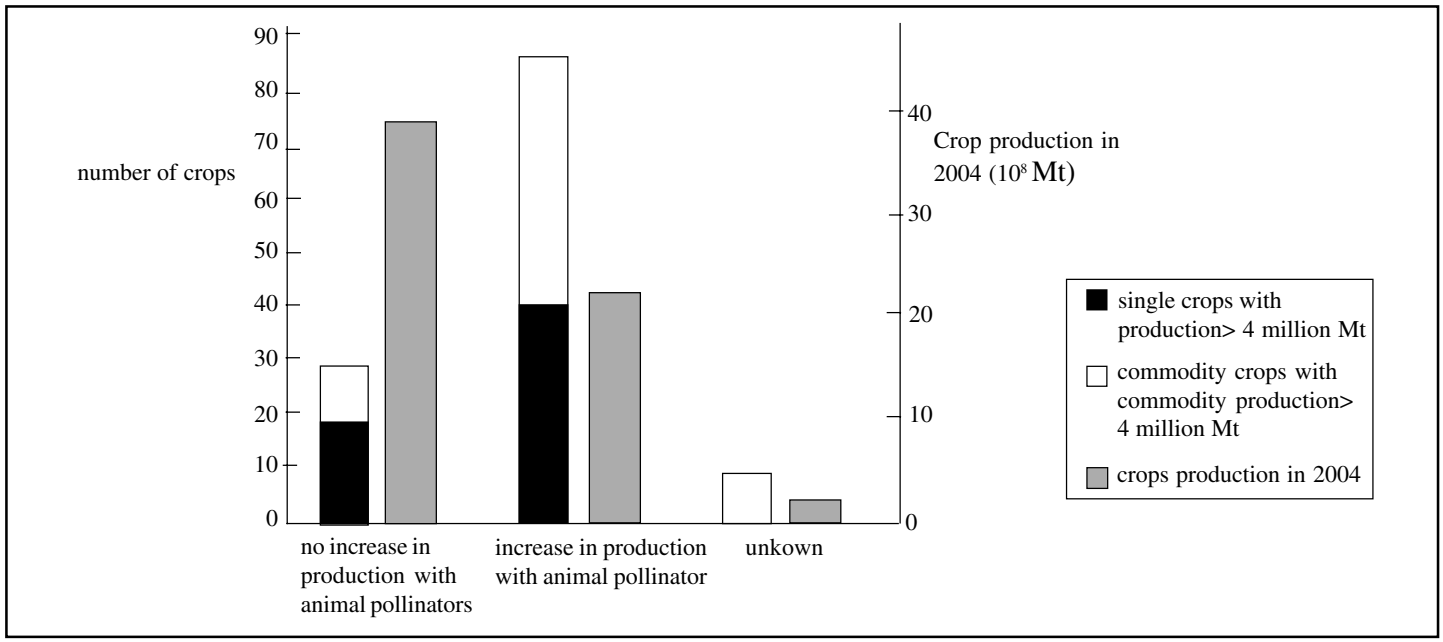
But both honeybees and wild bees are under threat.

Threats to managed honeybee colonies:

(i) the spread of pests like parasitic mites (*Varroa jacobsoni* & *V. destructor*)
(ii) spread of the hive beetle *Acarapis woodi*
(iii) improper pesticide and herbicide use
(iv) ageing of the beekeeper population in Europe and North America
(v) Wet summers which prevent foraging
(vi) threats from Africanized honey bees
(vii) lower market prices for their products and services

The major threat to wild bees is fragmentation and degradation of habitats which separates bee nests from their food sources.

Fig.1 Importance of animals in crop and commodity pollination

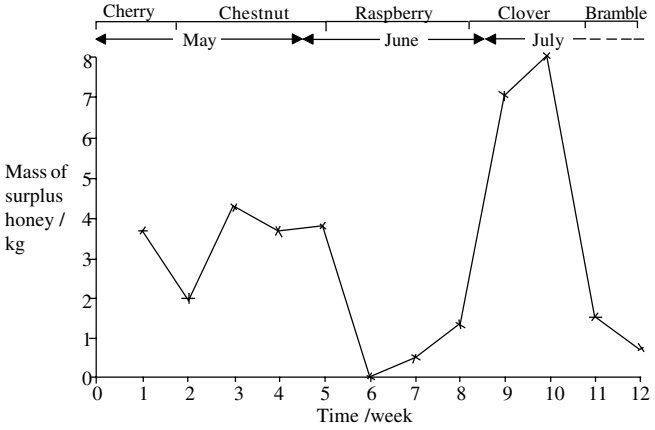


Typical Exam Question

Bee-friendly gardens

Householders are being encouraged to keep bees in order to help falling bee populations, maintain important pollinators and produce honey! The amount of surplus honey in a hive depends on several factors, one of which is the species in flower growing locally.

The graph shows the mass of surplus honey in a hive over the period May to July. The main species in flower growing locally during these months are shown at the top of the graph.

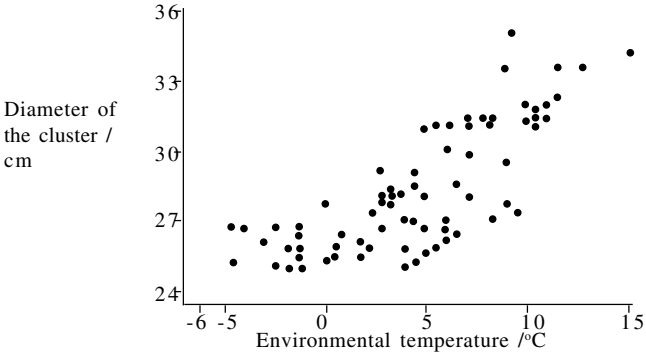


(a) Which flowers appear to enable the bees to produce most surplus honey? (1)

(b) Suggest one other factor, which is under the control of the household beekeeper, that might increase the production of surplus honey (1)

(c) Honeybees cluster together in the centre of the hive to try to keep the temperature of this area at a constant 34 to 35 'C. This enables the bees to survive external temperatures.

In an investigation, the diameter of the cluster formed by one colony of bees was measured at various environmental temperatures. None of the bees died during the investigation. The results of the investigation are shown below.



Suggest an explanation for the trend shown (1)

(d) It was also discovered that the lower the temperature in the centre of the cluster of bees, the more sugar they consumed and the less honey they produced. Suggest why (1).

Markscheme

(a) Clover;

(b) Diversity of flowering plants/trees around the hive; artificial food supply e.g. sugar solutions;

(c) As environmental temperature drops the bees cluster together tighter and tighter to try to conserve heat;

(d) The lower the temperature, the more energy the bees need to generate to release energy to keep warm/ ref to rate of respiration increases;

What is pollination?

Pollination is the transfer of pollen from the anther (the male part of the flower) to the stigma (the female part of the flower).
An estimated 80 percent of flowering plants depend more or less on insect pollination to be able to reproduce, and it is estimated that half of the pollinators of tropical plants are bees.

Bees and the plants upon which they feed have evolved together. The bees enter flowers to find food – pollen or nectar (a sugary solution). Bee - pollinated flowers have evolved so that a visiting bee ends up covered in pollen. Bees are extremely hairy and the hairs are effective at catching pollen. Bees only forage on one plant species at a time so the chance of the pollen landing on the stigma of a flower of the same species is maximized. This is pollination.

To create a seed, the pollen grain grows a small tube inside the stigma to the ovary of the flower. A male gamete then travels through the tube and fertilizes the egg cell. This starts the development of the fertile seed. Some plants need several successful visits from bees to ensure that all the flower's eggs are fertilized. For example, an apple flower may need four or five bee visits to receive enough pollen grains for complete fertilization. If fertilization is inadequate not all the seeds will develop and the shape of the fruit will be poor and small.

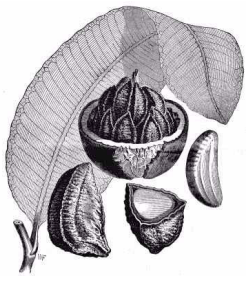
Specialized pollination

Some species of plants and bees have become very closely interdependent.

The pollinating bees of the Brazil nut tree *Bertholletia excelsa* are a good example

The Brazil nut tree grows wild in the Amazon forest and > 50 000 tonnes of the nuts are exported from Brazil annually.

The tree needs to be pollinated by one special bee species, the *Euglossa* bee.



This bee is dependent on an orchid species that is found only in the rain forest, hence attempts to grow the Brazil nut trees in plantations failed.

Euglossa also pollinates several other orchids and flowers in the forest. Studies in the Amazon forest have shown that many *Euglossa* bees do not cross open areas Thus, forest fragmentation leads to the loss of pollinators.

Wild bees

Improving habitats for wild bees

(i) increase nesting opportunities for particular species e.g. gaps in surface vegetation or modify cultivation practices
(ii) retain neighbouring forest nesting sites for ground nesting bees or leave dead wood providing holes for cavity-nesting bees
(iii) increase forage by providing diverse flowering resources in the local area
(iv) Use crop rotation using these flowering plants
(v) Connect habitats with flowering strips and hedgerows around arable fields, small forest patches or even single trees as 'stepping stones'
(vi) Ban the use of broad-spectrum insecticides during bloom, especially systemic ones that can contaminate nectar and pollen

Conservation monitoring

Sadly, we simply don't know enough about the behaviour of many pollinators to implement effective conservation strategies.

Population monitoring techniques e.g. studies of roosting behavior of bats, foraging strategies, identifying home ranges, and the importance of "nectar corridors" in migration have only just really begun.

Plants

The IUCN predicts that 20,000 flowering plant species will become extinct within the next few decades. This will almost certainly lead to the decline of their co-dependent pollinators.

The pollinators at greatest risk are those that specialize on particular plant taxa, such as orchids. Again, the major threats are habitat fragmentation, degradation and loss.

Studying community level interdependence

If keystone plant species such as figs lose their pollinators, for example, the entire structure of ecosystems will change dramatically. In the case of tropical communities dominated by figs, 80% of the vertebrate species depend on figs as the basis of their diet. Scientists just do not know what the outcomes will be if the figs pollinators die out.

The first step is to try to work out which whether the key species are pollinated by wind or animals, and if the latter, which species.

The basic approach is as follows:
The importance of self-pollination is achieved by isolating all the flowers of a plant at the bud stage in permeable plastic bags which have little effect on the physical environment of the flower but insulate it from other pollen and the insects which visit the flowers.

To measure the contribution of wind, all flowers of a plant are isolated from visiting by insects from the bud stage using polyamide net bags which allow 75% of air-borne pollen to pass and do not affect its composition.

The contribution of insects is then determined from the production of plants under free pollination, after the contributions of the wind and passive self-pollination have been deducted.

When this method was tested in the seed-bearing onion it was discovered that pollination by bees makes a 70% contribution to seed production. Further, the seeds from flowers visited by bees were 10% more likely to germinate than those produced by flowers pollinated solely by the wind.

Typical Exam Question

Bees play a minor role as pollinators in the rainforest compared to their role in temperate, monsoon and savannah woodland. In tropical rain forests, there is often little wind between the trees and the distance between trees of the same species is great. In tropical forest, there may be rather few flowering plants on the ground because of the trees' shade but in European deciduous forests, the forest floor can be totally covered by flowering plants in springtime, before the trees produce their leaves.

Suggest why, in tropical rainforests birds, bats and insects other than bees are the most important pollinators (2)

Markscheme

Great distance between trees of the same species;
Little wind;
Relatively few ground flowers;

Practice Question

At least half of the known species of plants and animals in the world are found in tropical rainforests.
There may be 50-200 different tree species per hectare, each of which supports over 400 unique insect species. However, an individual of a particular plant species may be very widely separated from another individual of the same species.

The high species diversity is partly due to the large variety of ecological niches available within the forests, as these allow more separate species to evolve and reduce interspecific competition

(a) Define the terms:
  (i) ecosystem (2)
  (ii) niche (2)

(b) Explain why a large variety of ecological niches reduces interspecific competition (2).

(c) Explain why forest fragmentation can lead to serious ecological damage in tropical rainforests (4)

Markscheme

(a) (i) community of organisms;
interacting with each other and their non-living environment;

(ii) the role of a species /how a species lives within an ecosystem;
position in food chain/ nesting position/food sources/ nocturnality etc;

(b) no 2 species may occupy the same niche;
different resources are used in different niches;
so the more niches, the less competition there is;

(c) fragmentation may separate individual trees etc by distances too far for pollinators to travel;
pollination therefore declines;
seed/fruit production declines;
populations decline;
animals dependent on the foliage/fruit etc of the trees decline;
effects pass along food chain;

Acknowledgments: This Factsheet was researched and written by Kevin Byrne. *Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU*
 ISSN 1351-5136