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Finding future models for agricultural systems

The Importance of Insect Pollinators for Agriculture

As the human population increases rapidly, our demand for food grows with it. To cope with this, in the future, our agricultural systems will need to produce more food in a sustainable way. Pollinators are, and will continue to be, crucial to these systems. Both wild and managed pollinators offer essential ***pollination services*** *– either provided by nature or arranged for by people.*

Some global statistics illustrate the scale of pollinator contribution to agriculture and food security:

// Of the 115 leading global crops consumed by humans, **87 rely on animal pollination**, to some degree.[1]

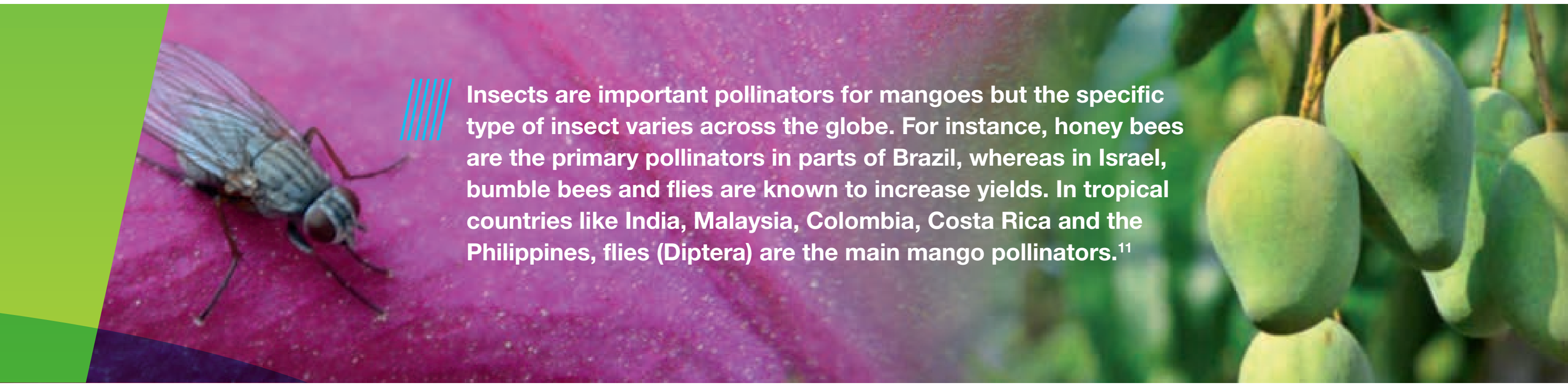
// **35 percent of the crops we eat**, in terms of the volume produced globally, depend on animal pollination, to some extent.[2]

// It is estimated that **five to eight percent of global crop production**, with an annual market value of **235 billion - 577 billion US dollars**[3], is directly attributable to animal pollination.

The figures indicate the extent to which animal pollination enhances the quantity and quality of many crops, increasing their value to farmers. And for the millions of people across the world who rely on pollinator-dependent agricultural crops for their livelihoods, this is important.

The importance of pollinators to the agricultural sector demands that we increase our knowledge about which crops need which pollinators and establish how best to protect and enhance both wild and managed species.


Pollinators perform a crucial service that supports most of the world's plant diversity – and a significant portion of global agriculture.[4]



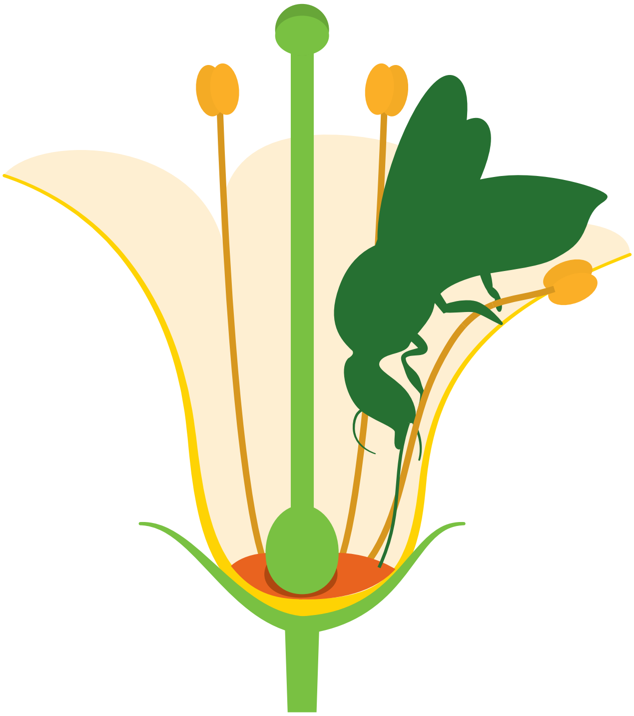
Insects are important pollinators for mangoes but the specific type of insect varies across the globe. For instance, honey bees are the primary pollinators in parts of Brazil, whereas in Israel, bumble bees and flies are known to increase yields. In tropical countries like India, Malaysia, Colombia, Costa Rica and the Philippines, flies (Diptera) are the main mango pollinators.[11]

Insects: The leading Group of Pollinators

Plants are static organisms: That means they cannot move around. To reproduce, they must either self-pollinate or use external vectors to carry their male gametes (transported as pollen) from one flower to another, fertilizing the female parts in each flower.[5] While wind and water carry some pollen, animals help to pollinate an estimated 87.5 percent of flowering plant species.[6] These animals come in many shapes, sizes and numbers, as figure one demonstrates.

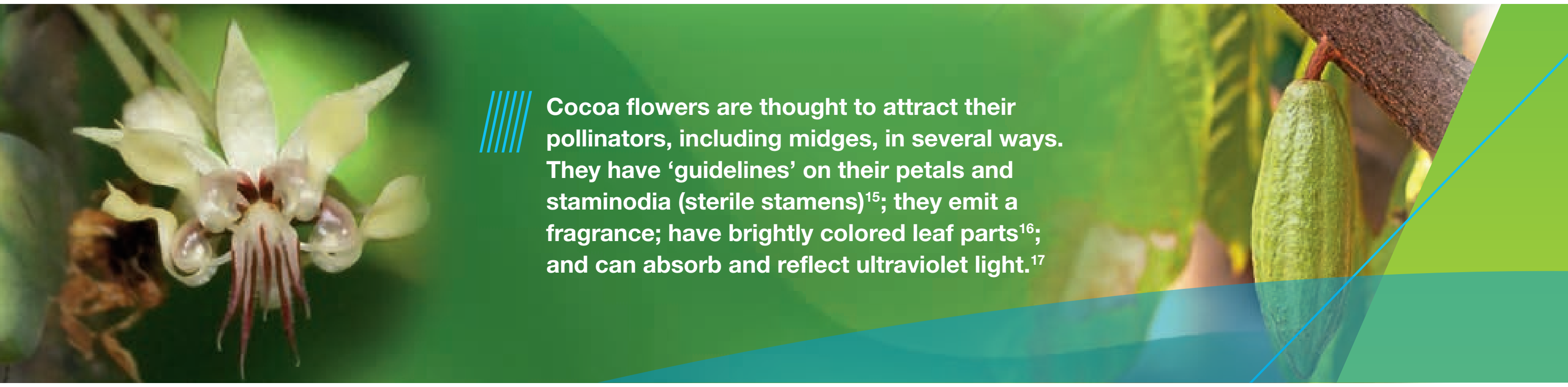
As many as 200,000 different animal species are thought to act as pollinators[7], though some estimates put this figure as high as 350,000.[8] Around 1,000 are vertebrates, including small mammals (such as bats or some marsupials like the Small Pygmy Possum from Oceania) and birds. Insects are by far the largest group and bees are the most important group of pollinating insects.

The relationships between pollinators and plants range from generalist – pollinators (such as honey bees) that visit many different plants, and plants that have many pollinators – to highly specialized, one-to-one relationships. These relationships are not fixed: A plant species may be visited by different pollinators in different regions and relationships can also vary during the year depending on changing pollinator abundance.[9]



To reproduce, plants must either self-pollinate or use external vectors to carry their pollen from one flower to another, fertilizing the female parts in each flower.

A few plants that grow in the vicinity of cashew plantations produce oil, which is attractive for some oil-collecting bees. These bees are also good pollinators of cashew. Oil-collecting bees gather floral oil on hairs on their legs or abdomen and use it as food for their larvae, to build nests or to feed themselves.[10]



Cocoa flowers are thought to attract their pollinators, including midges, in several ways. They have 'guidelines' on their petals and staminodia (sterile stamens)[15]; they emit a fragrance; have brightly colored leaf parts[16]; and can absorb and reflect ultraviolet light.[17]

Figure 1

Pollinators in Agriculture

The variety of pollinator groups and species

Lepidoptera – which includes butterflies and moths – are the most diverse group of pollinators, with more than 140,000 species believed to visit flowers.[12]

As many as **200,000 animal species** are thought to act as pollinators[13]; some estimates put this figure as high as 350,000.[14]

Around 1,000 are vertebrates, including small mammals, such as bats and birds. Even so, **insects are by far the largest group**.

Insect pollinators include bees, flies, butterflies, beetles, wasps, moths, midges and ants, among others. Of these, **bees are the most important group**, with both wild and managed species acting as pollinators.

Bees: Agriculture's Helpers

Insects are the dominant pollinators in agricultural systems – and bees top this list, providing pollination services for many of our crops. Bees are a highly diverse group. Over 20,000 species have been described globally.[18]

Around 50 of these species are managed by humans for different purposes, for instance honey production, with twelve specifically managed for crop pollination.[19] Some managed species have a widespread usage, notably the Western Honey Bee (*Apis mellifera*).

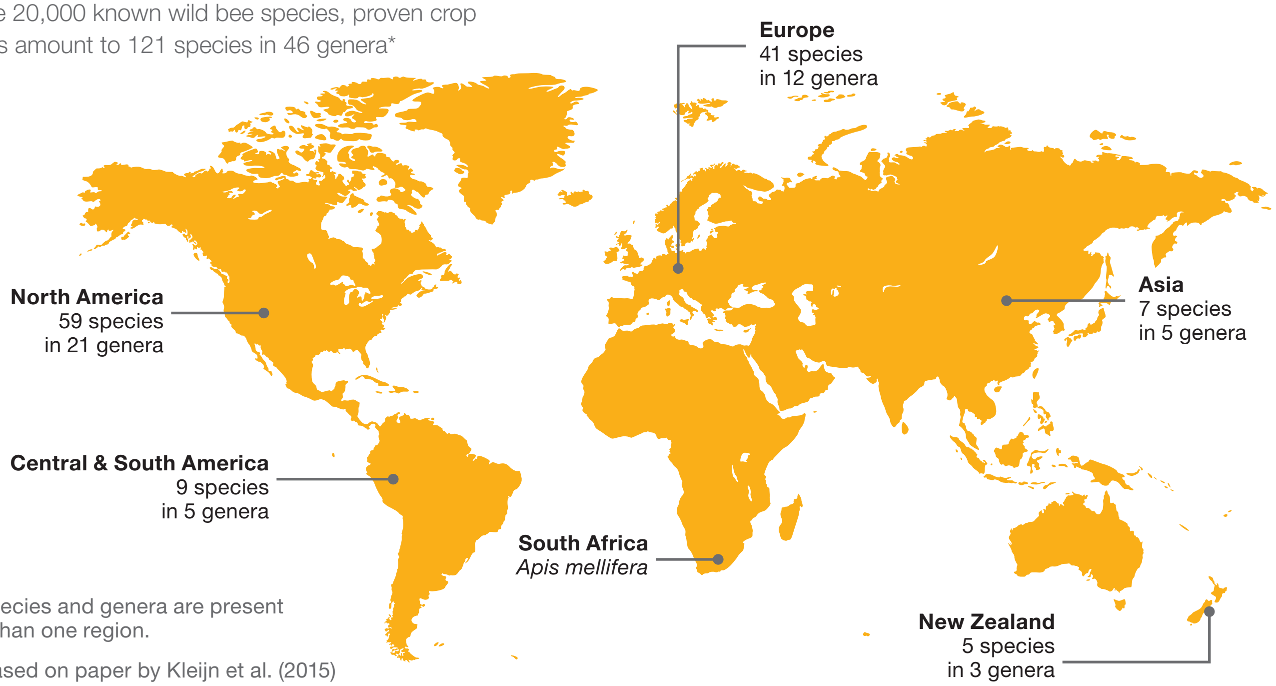
By contrast, the composition of wild bee species varies greatly around the world, with the highest number found in warmer temperate areas such as the Mediterranean basin, the Californian region and certain semi-desert areas.[20] Among them are bumble bees, stingless bees, carpenter bees and orchid bees.

Not all bee species are important for agriculture. When we look across crops, years and regions, a small number of common species dominate (see figure two): this means that 80 percent of crop pollination is provided by only two percent of bee species and threatened or rare species are rarely observed in crop fields.[21]

Figure 2[22]

The Bee Species identified as dominant Crop Pollinators in 90 Studies

Out of the 20,000 known wild bee species, proven crop pollinators amount to 121 species in 46 genera*



* Some species and genera are present in more than one region.

Figures based on paper by Kleijn et al. (2015)

On average, wild bees contribute 3,251 US dollars per hectare to the production of crops worldwide – about the same as managed honey bees.[26]

Despite this, there are several reasons for conserving pollinator diversity beyond these key pollinator species in the agricultural landscape. One is to provide insurance over time and space, as species that are rarely observed on crops now may, in future, become important.[23] Protecting pollinator diversity also helps to counter the risks associated with relying on a small number of species for pollination and may make agricultural systems more resilient in the long term. More immediately, pollinator diversity needs protecting because there are specific relationships between certain crops and certain pollinators. If a pollinator disappears from a landscape, it is not guaranteed that another will take its place and provide the same crop pollination service.

This diversity needs protection by integrating **conservation** measures with sustainable agricultural practices, which may raise crop yields and protect bees (both wild and managed species) and other pollinators. But, while we know quite a lot about the biology and ecology of managed pollinators and their importance to different agricultural systems, our understanding and knowledge of most wild pollinators are less developed.[24] Increasing this will support conservation efforts and help to maintain pollinator diversity and effectiveness.[25]

Bumble bee buzz-pollinating a tomato flower.

Creating a Buzz: How Bees access 'hidden' Pollen

Around 15,000 flowering plants, including important crops such as tomatoes and peppers, hide their pollen in pouches on their anthers that can only be reached via very small openings.[27] To access this, the females of certain bee species, such as bumble bees with tomato plants, have evolved to use a technique known as sonication or 'buzz pollination'.

These specially adapted anthers prevent some insects from accessing the pollen (such as pollen-eating beetles, flies and non-buzzing bees), so that pollen is not lost to inefficient pollinators and 'pollen thieves' (visitors that remove pollen but make little or no contribution to pollination).[28] The anthers may also increase the efficiency of pollen transfer by ejecting it onto specific areas of the pollinator's body which are more likely to come into contact with the stigma of other flowers.[29]

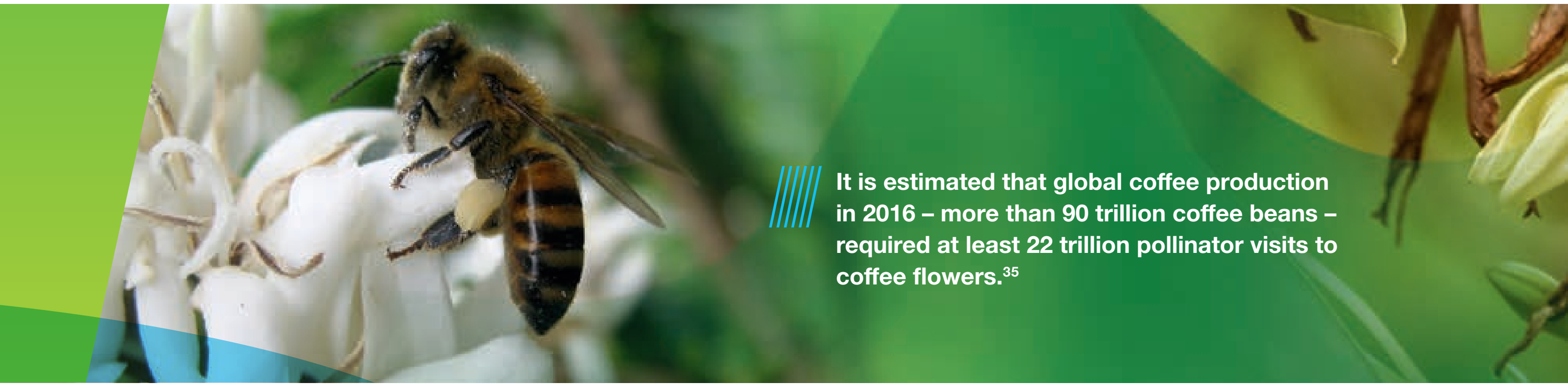
How it works:

// A bee lands on the flower and curls its body around the anthers.

// It starts to 'buzz' with its body, causing the pollen to fall.

// The pollen lands on its body and is carried to the hive or another flower.

The buzzes that bees emit vary widely in length, lasting from 0.1 seconds to a few seconds.[30]



How Pollinators enhance Crop Yield and Quality

There are many examples of the major significance of pollinators to farmers, especially in terms of increasing the volume and quality of crops produced. One example is a project ran by CropLife India, which aimed to raise farmers' awareness of the importance of honey bees to their crop yields.[31] The project used a number of approaches, such as providing subsidized honey bee hives and training farmers how to use them for managed crop pollination, as well as training in Integrated Pest Management, the responsible use of pesticides[32] and practical beekeeping. Overall, the project helped 230 farmers in Maharashtra district to increase their onion seed and pomegranate yields by 17 percent and almost 35 percent, respectively.

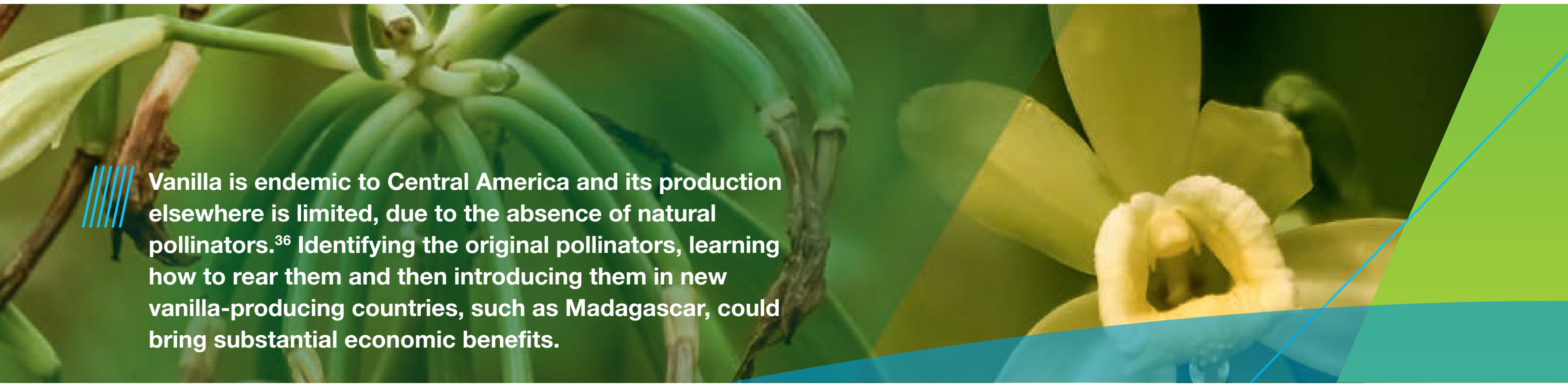
Importantly, the farmers also saw their incomes increase, by 19 percent on average for onion farmers and a staggering 42 percent for those growing pomegranates. These increased profits were not only due to higher yields but also improved quality: For example, the color and shape of the pomegranates were more attractive to consumers. Moreover, spending on pesticides was reduced as farmers were taught to use them selectively and in a more targeted way.

It is not just managed bees that influence crop quality. High pollinator diversity can improve several commercially-important crops.[33] For example, strawberries that have not been pollinated by a diverse group of insects like flies, solitary bees and honey bees can be smaller and irregular in shape, whereas those which are pollinated by these diverse insects are larger and have fewer deformations[34], enabling farmers to charge a higher price. Coffee is another globally-important crop where it seems that a high diversity of pollinators can improve the quality.

A four-year Bayer Bee Care Center project in Colombia aims to establish the extent of this relationship.

Sushil Desai, Stewardship Manager at Bayer India (left): "It was great to see how farmers began to view the bees as valuable farm companions, as part of their business."

Scientists from Cenicafe and Juliana Jaramillo, a scientist in the Bayer Bee Care Team (right), select coffee plots where pollination diversity assessments will be carried out.



Vanilla is endemic to Central America and its production elsewhere is limited, due to the absence of natural pollinators.[36] Identifying the original pollinators, learning how to rear them and then introducing them in new vanilla-producing countries, such as Madagascar, could bring substantial economic benefits.

Different crops have different dependencies
The extent to which different plants rely on animal pollinators varies considerably, from being an essential service to unimportant. Many fruits, vegetables and stimulant crops (e.g. coffee) are highly dependent on animal pollinators, specifically insects. In contrast, some important staple crops like cereals, maize or potatoes do not require insect pollination at all.[37] Figure three illustrates the range of dependencies for leading, global crops.[38]

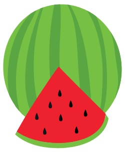
Many of the fruits and vegetables we like to eat are highly dependent on animal pollinators, specifically, insects.

Figure 3[39]

The Dependence of leading Crops on Animal Pollinators

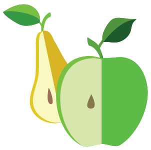
The crops fall under the following categories:

ESSENTIAL



atemoya, brazil nut, cantaloupe, cocoa, kiwi, macadamia, passion fruit, pawpaw, rowanberry, sapodilla, squash/pumpkin, vanilla, watermelon

HIGHLY DEPENDENT

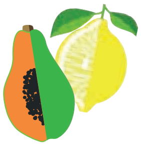


almond, apple, apricot, avocado, blueberry, buckwheat, cardamom, cashew, cola nut, coriander, cranberry, cucumber, cumin, durian, feijoa, fennel seed, loquat, mango, naranjillo, nutmeg, peach, pear, pimento, plum, raspberry, rose hip, sour cherry, starfruit, strawberry (cross-pollinated varieties), sweet cherry, tomato (greenhouse)

MODERATELY DEPENDENT

blackcurrant, broad bean, caraway, chestnut, coconut, coffee, eggplant/aubergine, elderberry, fig, guava, hyacinth bean, jack bean, jujube, mammee, mustard seed, okra, pepper (vegetable), pomegranate, prickly pear, rapeseed, seedcotton, sesame, shea nut, soybean, sunflower seeds, tree strawberry

SLIGHTLY DEPENDENT



azarole, bambara bean, citrus (most varieties), cowpea, guar bean, hog plum, kidney bean, linseed, longan, lychee, oil palm, oilseed rape, papaya, peanut, persimmon, pigeon pea, rambutan, safflower, star apple, strawberry (wind-pollinated varieties), tamarind, tomato (field)

UNIMPORTANT

chickpea, garden pea, grape, lentil, olive, pepper (spice), quinoa, cereals, rice, potatoes

UNKNOWN SIGNIFICANCE

?

anise, breadfruit, grains of paradise, jackfruit, medlar, sapote, star anise, winged bean, velvet bean

Data adapted from Klein et al. 2006'

The Need for Nests: Enhancing Passion Fruit Production in Brazil

Pollinators are essential for yellow passion fruits as the plants cannot self-fertilize and require cross-pollination.[40] They are an important export crop in Brazil, yet production often fails to meet demand.[41] In many passion fruit-growing areas, the density of effective pollinators for this crop is low, so that in some places, crops need to be hand-pollinated, which raises production costs.

Encouragingly, research shows that introducing occupied carpenter bee nests can increase pollination.[42] Carpenter bees are the crop's most important pollinator: They are the right size for passion fruit flowers and have the appropriate foraging behavior.[43] These bees nest in materials such as deadwood (e.g. fallen trees and logs), hollow stems and trap-nests made from bamboo.[44]

Research found that introducing nests to orchards was a successful management approach. More than 50 percent of introduced females continued using their original nests and others established new nests after introduction (if materials were available). This measure may have potential benefits for farmers. It increased the bees' visitation rates to the crop – which may have an impact on pollination, although this has yet to be proven.

Carpenter bee making a nest in the branch of an acacia tree.

The effectiveness of pollinators varies according to factors, such as their abundance; whether they reach individual plants of the same species and their ability to pick pollen up from, transfer and deposit it to the appropriate plant organs.[56] For example, pollen collected on the specialized soft down on a mining bee's body is more easily transferred to stigma than from the small brush-like tufts of hair on the hind legs of honey bees.[57]

Wild Bees or managed Bees: Which are best for Crop Production?

Both wild and managed bees contribute to crop pollination in their own ways, across crop types and regions.[45] In many places, they complement each other and enhance pollination overall, yet in others there may be negative ecological effects due to competition for food and habitat.

Diverse and free: wild bees
There are over 20,000 different bee species in the world, most of them wild. Most species of wild bee are solitary, thus not living in colonies and, as such, they are less prone to the problems, such as pests and diseases, that can afflict managed bee populations. They are also freely-available if crop and landscape factors provide suitable habitat for them, although farmers may need to invest in conservation measures to protect nearby populations.

There are limits to their usefulness, however. Farmers may find that local, wild pollinators do not provide the level of pollination service they need. For example, wild bees are frequently too sparse in intensively-farmed landscapes to pollinate crops adequately.[46]

Bayer supported a study with local researchers and growers in Brazil to investigate if and how pollination of melons could be improved.

Deployable and dependable: managed bees
Given these limitations, many farmers opt for the convenience of buying or renting managed pollinators. These can provide pollination services in a more reliable way and are easier to 'steer' than wild populations. Honey bees are the most common managed species – the Western Honey Bee is the most frequent visitor to flowers of crops worldwide[47] – and often the most economically valuable.

Managed bees offer several benefits. Their presence can be controlled by growers or beekeepers; some have generalist foraging behavior; and they are relatively competent pollinators.[48] Many live in hives or colonies that can be attracted to the target crop or positioned as needed.[49] In many cases, they are more versatile than other pollinators[50] and essential in places where wild pollinators do not visit agricultural crops in sufficient numbers, all the time.[51]

Managed bees also have limitations, though. For example, the honey bee does not visit all crop species: It is a frequent visitor to a small number of insect-pollinated crops.[52] Nor are managed bees always the most effective pollinators. Their effectiveness can be reduced by factors such as a mismatch between body size and flower size, low nectar production of the crop and the specialized pollen-release mechanisms in some plants.[53] In such situations, other bee species are a better fit.

There is also increasing evidence that high densities of managed honey bees can contribute to declines in wild pollinators[54], particularly where the honey bees are invasive species (as in the Americas). For example, they may move from their target agricultural lands to surrounding natural habitats[55] and out-compete wild pollinators for food. These interactions need careful consideration when introducing managed bees to an ecosystem.

When wild and managed bees meet
Wild bees and managed bees sometimes visit the same flowers, which can be advantageous for certain crops – their interactions improve the pollination service provided.[58] It is not simply a question of numbers (i.e. more visitors lead to more pollination); distinct behavioral interactions between the two groups can increase pollination efficiency.

For example, in California, USA, researchers found that the presence of wild pollinator species changed the foraging behavior of honey bees on almond trees.[59] Trees in almond orchards are often planted in rows with two or more alternating varieties because almonds need to cross-fertilize and pollen needs to be moved across rows. In the absence of wild bees, honey bees tended to move along rows, limiting their effectiveness as pollinators. In contrast, in orchards with diverse wild species, honey bees moved between rows more often, increasing their effectiveness. It may be that the wild bees competed for resources, forcing the honey bees (who tended to visit flowers later in the day) to travel further afield. Another theory is that wild bees left a scent on the flowers they visited, causing the honey bees to avoid these.[60] The net effect was that the increased pollinator diversity improved the pollination services provided by honey bees – meaning a higher fruit set and greater benefits for farmers.

However, introducing managed species to a new ecosystem can also lead to negative ecological effects. This has implications for agriculture, as newly-introduced managed bees may reduce the number of wild pollinators. Research in Sweden found that placing honey bee hives adjacent to oilseed rape fields reduced the overall density of bumble bees, solitary bees and other insects in the crop, most likely due to these species being displaced due to competition and interference.[61]

To answer the question as to whether wild or managed bees are better for crop production: **It's all about getting the balance right. Having the right number of managed and wild pollinators in an agricultural region is key, as for many crops a mix of both is the ideal scenario.**

Sunflowers are the second-most important oilseed crop worldwide, after soybeans, and global demand for sunflower oil is rising every year.[65]

A good Match: How Wild Bees improve Honey Bees' Pollination of Sunflowers

Research in California into hybrid sunflowers found that behavioral interactions between wild bees and honey bees increased pollination efficiency by up to five times.[62] When wild bee numbers were low, honey bee pollination produced three seeds per visit on average; when wild bees were abundant, this increased to 15 seeds.

The critical factor is what the honey bees did after visiting a flower. When they interacted with a wild bee on a male flower, 20 percent moved to a female flower (the transfer of pollen between these is essential for pollination); when they interacted with another honey bee, however, only seven percent did so.[63]

The presence of wild bees could be influencing the behavior of honey bees in several ways. For example, male wild bees in search of a mate might land on honey bees, forcing them to fly off and increasing the likelihood of moving to a different flower.[64]

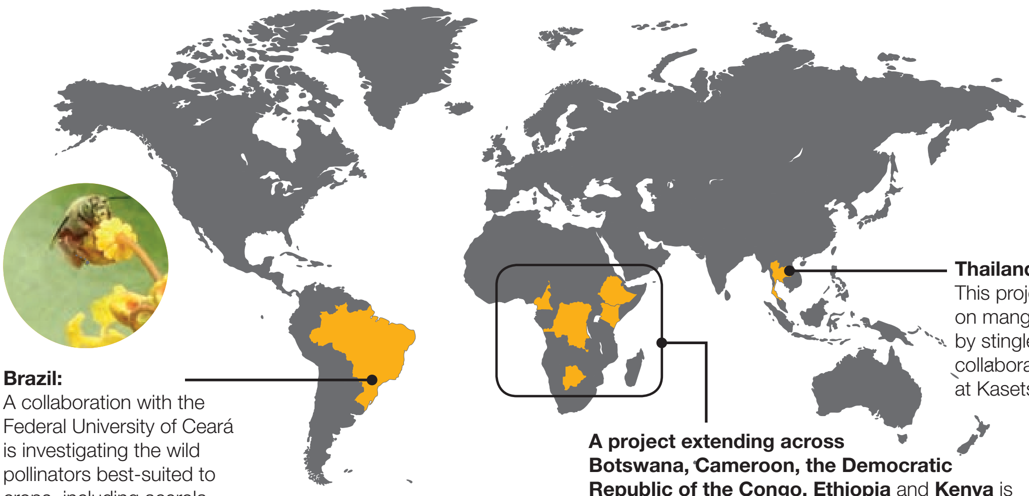
Meet the Pollinators of the Future

Identifying new species among wild pollinators that could serve as managed pollinators is a growing – and important – field of research. This includes identifying which wild species could be managed (in similar ways to honey bees) or discovering the best ways to protect wild populations and enhance their contribution to crop pollination. Some non-honey bee pollination services are already commercially available and successful, such as the use of bumble bees to pollinate tomatoes in greenhouses.[66] Another promising group is stingless bees, which have the potential to pollinate many tropical crops (see below).

Figure 4

Looking for the next Generation of Pollinators

Research is underway to better-understand wild bees' biology and potential contribution to crop pollination. This includes projects established by the Bayer Bee Care Center, to identify whether some wild bee species could become managed pollinators for different crops.



Brazil:
A collaboration with the Federal University of Ceará is investigating the wild pollinators best-suited to crops, including acerola, tomato, cashew, melon and watermelon.

Thailand:
This project is focusing on mango pollination by stingless bees, collaborating with experts at Kasetsart University.

A project extending across Botswana, Cameroon, the Democratic Republic of the Congo, Ethiopia and **Kenya** is exploring the efficiency of ten species of stingless bee in pollinating crops including macadamia and several types of vegetable.

Stingless bees have been managed for honey and wax production for centuries, for example, the Maya in Latin America used their wax in the production of gold ornaments.

Born to be wild or managed: stingless bees

There are around 500 species of stingless bee which comprise the tribe Meliponini within the Apidae family of bees. These are found in most tropical and subtropical regions but the vast majority of species are found in the Americas. As a group, they have great potential as pollinators, being common visitors to wild, flowering plants. Stingless bees also have several characteristics that make them suitable for managed crop pollination: They collect pollen from a variety of unrelated plants[67]; these bees can adapt to visit new plants[68] and it is possible to rear them in large quantities, i.e. colonies can also be placed in hives and artificially re-queened.[69] Furthermore, they vary greatly in colony size, body size and foraging strategy. This diversity allows for the selection of the most appropriate species for particular crops.[70]

Stingless bees even have some advantages over honey bees. They are generally less aggressive towards humans and domestic animals – although still being able to defend themselves by biting – and may be more resistant to the diseases and parasites that afflict honey bees.[71] This latter quality may be reduced if they are reared intensively, however.

Their potential to boost agriculture is also considerable and these bees are known to visit more than 90 crops[72], including coffee, guava, rattan, cardamom and watermelon.[73] They have already been identified as important pollinators for 18 tropical crops[74], including macadamia nuts, coconut and mango.

At present, however, there are limitations to their widespread use in agriculture. They cannot survive cold winters, which limits their geographical range[75], and there is currently a lack of technology needed to rear them, leading to a limited availability of hives.

Stingless bees have a considerable potential to boost agriculture. They have been identified as important pollinators for 18 tropical crops.[74]

The Need to protect all Pollinators

The right balance of wild and managed pollinators is instrumental in achieving the necessary pollination services for a good crop harvest. Yet, land use changes like urbanization, the intensification of agriculture and other factors have negatively affected local pollinator populations in different parts of the world.

A range of conservation measures in intensively-farmed regions can help to maintain diversity, by preserving the resources that pollinators need (figure five). These measures protect the dominant crop pollinators in agro-ecosystems and contribute to maintaining the biodiversity of the ecosystem, including the less agriculturally-important pollinators.

Figure 5[76, 77]

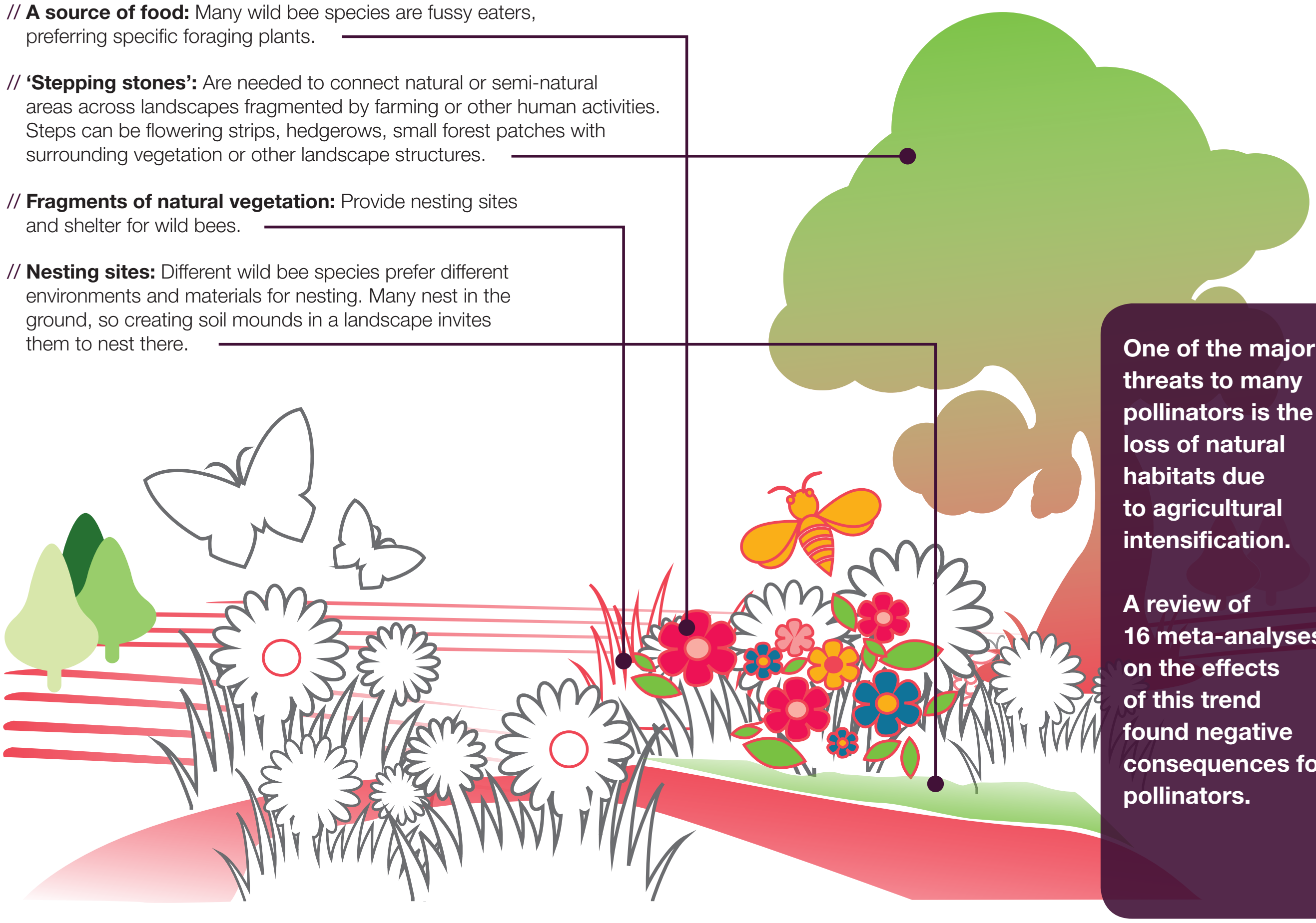
What do Pollinators need?

// **A source of food:** Many wild bee species are fussy eaters, preferring specific foraging plants.

// **'Stepping stones':** Are needed to connect natural or semi-natural areas across landscapes fragmented by farming or other human activities. Steps can be flowering strips, hedgerows, small forest patches with surrounding vegetation or other landscape structures.

// **Fragments of natural vegetation:** Provide nesting sites and shelter for wild bees.

// **Nesting sites:** Different wild bee species prefer different environments and materials for nesting. Many nest in the ground, so creating soil mounds in a landscape invites them to nest there.



One of the major threats to many pollinators is the loss of natural habitats due to agricultural intensification.

A review of 16 meta-analyses on the effects of this trend found negative consequences for pollinators.

There are several different measures to mention. Some of these are at farm-level, such as planting flower strips among crops, (re)introducing hedges and planting trees. These are already proving to be effective: Planting wildflowers and establishing margin strips have been shown to enhance dominant crop-visiting bees in arable landscapes.[78] In contrast, research has found that restricting the use of chemicals and delaying the annual onset of agricultural activities does not increase the densities of dominant crop pollinators.[79]

Different measures to maintain diversity at farm-level can be introduced. One example is the planting of flower strips among crops, such as here in the Eifel region of Germany.

Other approaches are implemented at landscape-level, such as the conservation of natural and semi-natural habitats in agricultural landscapes.

There is no 'one size fits all' approach to conserving all species, given their varying preferences for different food sources and nesting sites. Furthermore, there is no guarantee that a certain conservation approach will work for all agricultural systems. The goal is to identify the right solution for each region, each crop and each pollinator – and this requires research. The good news is that in many places, scientists are already discovering effective measures which are relatively simple and cost-effective to implement.[80]

Wildflowers for Wild Insects: Helping Bees and Butterflies in Germany

The Bayer Bee Care Center is collaborating with partners across the globe to identify which conservation measures work best for pollinators in different regions. For instance, in Baden-Württemberg, Germany, work is ongoing, to identify which ecological enhancement measures are most effective for the conservation of wild bees and butterflies in an area dominated by maize and cereal crops.

The project, run in partnership with the German IFAB (Institute for Agro-Ecology and Biodiversity) and the ILN (Institute for Landscape Ecology and Nature Conservation), introduced two ecological enhancement measures for wild bees:

// Wildflower strips and areas, created in different sizes and interconnectivity, were sown with various flower mixes.
// 10-20 m earth 'bee banks' constructed to provide nest sites for ground-nesting wild bees.

The results to date[81] show that creating wildflower areas on ten percent of arable land[82], using a combination of annual, winter-hardy and perennial wildflowers, makes a valuable contribution to supporting pollinators. At one of the study sites, the number of wild bee species increased from an average of eight in 2010 (at the start of the project before enhancement measures were introduced) to a peak of 31, six years later (following the introduction of enhancement measures).

This approach seems to also benefit endangered species. For instance, the Violet-winged Mining Bee (*Andrena agilissima*), an **endangered** species on the German Red List, and the **critically endangered** furrow bee species, *Lasioglossum lineare*, were both identified at the testing sites.

More flowers, more bees – and more apples?
A project, established by the Bayer Bee Care Center, the Freiburg University and the Kompetenzzentrum Bodensee, is studying the most suitable ecosystem-level approaches to support pollination in apple orchards in south-west Germany. Apples are the most widely cultivated fruits in Europe[83], often grown intensively in orchards which provide low-quality habitats for bees and other pollinators. As apples largely depend on insect pollination, especially bees[84], preserving these pollinator species is essential.

One approach being tested is the creation of hedges. Apple trees only bloom for around two weeks in spring. By contrast, hedges can provide floral resources all season long and could be a valuable source of food for pollinators, such as bumble bees, which have long activity periods during the year. Hedges can also provide nesting sites for cavity-nesting and ground-nesting bees.

The project will determine whether hedges help to improve pollination services and whether certain types of 'attractive' hedge can support pollinators more effectively than wildflower strips. The researchers will also monitor the effects on other beneficial insects, such as biological control agents like predatory wasps. This should identify holistic ecosystem-level measures which enhance pollinators and support Integrated Pest Management.[32]

Conclusions

There is no doubt that bees and other pollinators play an important role in agricultural systems around the world. The value of their contribution to people is significant, both economically and in terms of ensuring food security and nutrition, supporting livelihoods, enabling agricultural diversification and maintaining natural ecosystems.[85]

As research into crop-pollinator relationships continues apace, as well as experiments to identify the most effective conservation and enhancement measures, our understanding of these creatures will continue to grow. Management measures, whether to increase pollination or to conserve pollinators, will become more refined and targeted, providing farmers with the information and tools they need to achieve the right balance between agriculture and nature conservation on their farms.

Achieving this understanding will ensure that the pollination provided by bees and other animals will continue, and indeed increase further, benefitting farmers, consumers and nature.

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Endnotes

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31 Further details are available in BEENOW (2018)
32 Integrated Pest Management (IPM) means the careful consideration of all available pest control techniques (biological, cultural, mechanical etc.) and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. Source: FAO (2018).
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L. Constantino, p 6 upper banner left coffee

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