B book

Bees – small insects, big impact

bee care

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As busy as a bee

“In omen been! For ay as bisy as bees.”
Geoffrey Chaucer, Canterbury Tales (1387-1400)

This phrase likely originates from something that bees are known for: being hard workers. Bees are indeed busy insects and can always be seen buzzing around, collecting pollen and nectar and pollinating plants. It is clear that this observation was made early on and that people were later compared to these diligent creatures.

Did you know that bees play an important role in producing the fruits, vegetables and nuts we enjoy as part of our daily diet? These agricultural crops rely, at least in part, on bees and other insects to pollinate them. So, bees can be seen as ‘farm workers’ – actively participating in agricultural activities.

With this book, we would like to introduce you to the fascinating world of bees: their diversity, their role in pollination, the challenges they face and what we all can do to support them. We would also like to zoom into the life of the bee most kept by beekeepers around the world: the Western Honey Bee.

We have no doubt that by the end of the book you will agree with us: bees may be small, but their impact is big.

Enjoy!

The Bayer Bee Care Center

Bees may be small, but they are immensely important.

Insects, which also include bees, play a key role in the pollination of many plants.

Numerous crops depend on pollination by bees and other insects.

1 One big and *very diverse family*

Probably the most popular and most common species of bee is the Western Honey Bee *(Apis mellifera)*, even in regions where it is not native. This is partly because these bees are easy to breed and are used by beekeepers around the world to produce honey and pollinate crops.

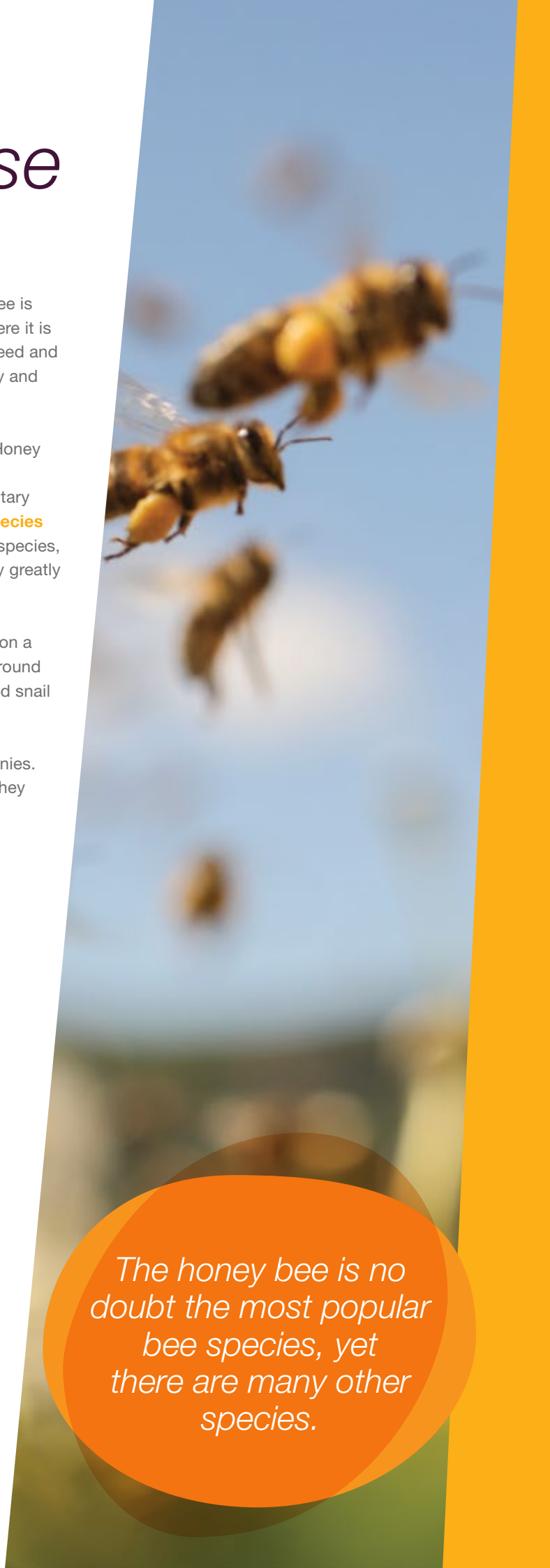
While it may be the best-known bee species, the Western Honey Bee is only one of more than **20,000 different bee species worldwide** – including other honey bees, bumble bees, solitary bees and stingless bees. Germany is home to some **550 species of wild bee,** including bumble bees and many solitary bee species, like furry bees, sand bees and silk bees. These species vary greatly in appearance and size.

While managed honey bees live in beehives, wild bees rely on a variety of nesting habitats. Some species burrow into the ground or in wood, some nest in ready-made homes like abandoned snail shells, while others look for holes in stone walls.

Most species of wild bee are solitary and do not live in colonies. Stingless bees and many bumble bees are an exception – they form a colony, including a queen, drones and worker bees.

Did you know?

// 80 percent of wild bee species nest in the ground. For instance, mining bees burrow out nests in which to lay their eggs.
// Managed honey bees live in man-made hives, with up to 60,000 bees in a colony.
// Bumble bees live in colonies and prefer dry, dark nesting sites.
// Stingless bees typically nest in plant or soil cavities.



The honey bee is no doubt the most popular bee species, yet there are many other species.

Meet some of the many bee species ...

SOCIAL ORGANIZATION

HONEY PRODUCTION

STRIKING FEATURE

Honey bee *(Apis* genus)

These bees are eusocial, meaning that they live in colonies with a high level of social organization. They divide the tasks; all females except the queen have given up reproduction, taking care of the young of the colony.

Yes, though the production varies according to hive management type, forage plant, region or the weather. German honey bee colonies produce an average of about 30 kilograms per year, while Spanish colonies produce around 13 kilograms.

Western Honey Bees (*Apis mellifera*) are not doorstep foragers. Their range may extend up to five kilometers from the beehive, or even further in extreme cases – that's the same as humans traveling 2,500 kilometers for food.

Mason bee *(Osmia* genus)

Solitary bee.

No.

Some mason bee species of the *Osmia* genus are characterized by their metallic blue, black and green colors; others are furry with red, brown or black hairs. Unlike the honey bee, mason bees have a relatively small foraging area and seldom travel more than 250 meters.

Stingless bee *(Meliponini* tribe)

Stingless bees live in colonies of a few hundred to some ten thousand bees.

Yes; a colony can produce anything from a few milliliters to several liters of honey annually, depending on beekeeping practices, foraging sources and particular species.

While stingless, these bees sometimes bite to defend their nests.

Sweat bee *(Lasioglossum* genus)

Sweat bee species can be solitary or social bees. Two species exhibit a high level of social organization known as eusociality.

No.

As their name may imply, sweat bees are attracted to perspiration, as it provides them with moisture and salts.

Leafcutter bee *(Megachile* genus)

Solitary bee.

No.

These bees live up to their name by cutting circular sections from leaves (between six and twelve millimeters wide) and using the cuttings to build nests in which they place their eggs.

Bumble bee *(Bombus* genus)

These bees are mostly eusocial. They usually live in colonies of around 50 to 500 bees, which is considerably smaller than a honey bee colony, and the colony lasts one season only.

Yes, though they do not produce as much as honey bees.

South America is said to be home to the largest bumble bee species in the world: *Bombus dahlbomii*. The queens of this particular species can measure up to four centimeters in length – locals even call them 'flying mice'.

2 In the *beehive*

Honey bee colonies function as a collective (a **superorganism**): there is a high level of social organization, with division of reproduction and labor among its members. A colony normally contains a female queen, male drones (only at certain times of the year) and female worker bees. **In places with temperate climates, a beehive doesn't contain the same number of bees throughout the year.** The largest numbers of honey bees are present in the summertime, with only one queen, between 30,000 and 60,000 workers, and approximately 300 to 3,000 drones. In the wintertime, the beehive contains the queen and about 5,000 to 10,000 winter worker bees.

Get to know your honey bees

There are nine honey bee species in the world. The most widespread honey bee, the **Western Honey Bee**, was originally feral (wild). Yet, it has long been kept by humans to facilitate honey collection and is now predominantly kept as a honey producer and crop pollinator in some regions like Europe and North America. Originally common across Europe, Western Asia and Africa, it is today found across the globe.

The **Eastern Honey Bee** *(Apis cerana)*, in contrast, only lives in Asia and is somewhat smaller than its western relative. The smallest of these, at a typical length of seven to ten mm, is the Black Dwarf Honey Bee *(Apis andreniformis)*, which lives in South and Southeast Asia. The largest is the Himalayan Giant Honey Bee *(Apis laboriosa)*, which can be up to three centimeters long and nests on cliff walls. This species has only been seen in the Himalaya regions of Bhutan, China, India and Nepal.

Queen

The queen is the largest bee in the honey bee colony at almost two centimeters long. Her main task is producing offspring. A queen may live for up to five years but will typically be replaced by the beekeeper after two, to ensure the queen in the colony is healthy and strong.

All the offspring in a beehive descend from the queen. Honey bee queens lay up to 2,000 eggs per day during the active season.

Worker bees

The colony consists mainly of worker bees. They help keep life in the beehive going. During the active season, they live for only a few weeks and have many duties during their short lives: cleaning, taking care of the brood, building honeycombs and guarding the entrance. After that, they fly out and gather pollen and nectar.

All the worker bees in the beehive are female.

Drones

The male honey bees are called drones. In places with temperate conditions, they are only part of the colony during spring and summer. Their only role is to mate with young queens, preferably from other colonies.

At the end of the summer, the worker bees drive the males out of the hive. This is also referred to as drone eviction.

Spring

Bee season starts in the spring, when the insects become active. The bees end their overwintering phase and swarm out in search of food for themselves, the queen and her new developing brood. **The queen will begin laying eggs and progressively lay more and more, reaching a maximum of around 2,000 eggs per day** sometime around May.

Summer

At this time of year, **Western Honey Bees begin to stock up for the upcoming winter.** They preserve the nectar they collect from flowers by turning it into honey, which provides food during the cold season when flowers are no longer available. Worker bees will drive the males out of the hive as the mating season comes to an end.

A year in the life of the Western Honey Bee

For a honey bee colony, things are not the same all year round. In a beehive, the animals adapt to the weather and the time of year. Moreover, the lifecycle depends on the climate zone. Let's take a look at the cycle of bees living in the Northern hemisphere, in places with temperate conditions.

From late summer until fall, beekeepers need to help their bee colonies stay healthy to survive during winter, by controlling the parasitic *Varroa* mite and providing food for nutrition after honey harvest and at a time when flowers become less abundant.

Winter

To survive the cold winter months, around 10,000 longer-lived winter worker bees huddle together around the queen in the hive, forming a large ball called a winter cluster. **They keep each other warm by shivering their flight muscles to maintain a stable temperature of around 20-23 °C.** In a ball, they lose much less heat than they would in other configurations.

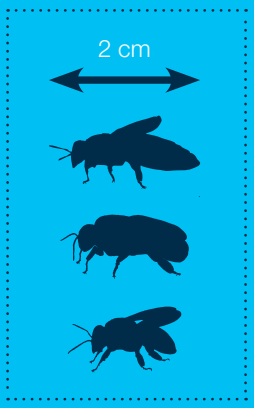
Fall

From late summer to fall, as food sources become scarce, honey bees may start to steal the winter food stocks of neighboring weaker colonies. During this period, **the longer-lived winter worker bees will hatch and begin to replace the summer worker bees in the hive.** These bees can live for up to seven months.

Did you know?

To produce one jar of honey (500 grams), worker bees between them need to cover a distance of up to 120,000 kilometers while foraging – that's almost three times around the globe! A bee colony needs about 20 kilograms of honey for the winter – so imagine the distance bees cover to collect this.

Life and structure in a honey bee colony



QUEEN | **DRONE** | **WORKER BEE**

SUMMER

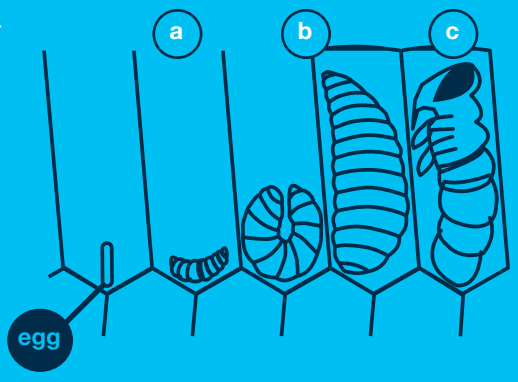
1	300-3,000	30,000-60,000
♀	♂	♀
Fertilized egg	Unfertilized egg	Fertilized egg

Development rates in days

Queen:	**16**
Worker bee:	**21**
Drone:	**24**

As a result of a different diet with royal jelly, the queen develops into a sexually mature female, unlike the worker bees.

A new young queen flies out for her mating flight (nuptial flight) to drone congregation areas. The queen bee will mate with up to 20 drones high in the air, continuing until her sac used to store sperm (spermatheca) is full. This supply will last throughout her entire life to fertilize her eggs.



a Larva hatches from egg.
b Larva develops from being coiled to stretched. Worker bees cap and seal the honey comb cell.
c Larva pupates and emerges as an adult bee.

Honey

Honey bees collect the nectar produced by blossoming flowers and plants with their tube-like tongues and carry it to the beehive in their honey stomachs. While inside the bee's honey stomach, the proteins and enzymes present convert the nectar to a sugary juice. **Back in the hive, the sugary juice is passed on to the other worker bees, and will eventually be stored in the honey comb** – hexagonal cells made of wax produced by the bees. There, water will evaporate from the honey mixture. When the water content is low enough, the comb cells are sealed off with a thin layer of wax and the honey is ready.

How honey is obtained

To obtain the honey, **beekeepers open and centrifuge the honey combs** (the honey can be found under the thin layer of wax) and pass the honey through a sieve. **The honey is then stirred until it reaches the desired consistency.** The quality of honey is assessed through several characteristics, including the origin, color, consistency, smell and taste of the honey.

Bee products

When thinking about honey bee products, the first thing that comes to our mind is honey of course. But this is far from all that these insects provide. Find out more!

Propolis

WHAT IS IT?

Propolis or bee glue is produced by honey bees when they mix saliva and beeswax with a fluid gathered from the leaf buds and bark of trees. Propolis acts as a natural disinfectant that is effective against numerous fungi, viruses and bacteria. Bees also use it as a resin to seal cracks and fissures in their hives.

PURPOSE FOR US?

The use of propolis is still being explored; it has been used in traditional medicine or as a varnish ingredient by some string instrument makers.

Pollen

WHAT IS IT?

Pollen grains are the male germ cells of flowering plants. Bees collect up to four million grains of pollen per flight in so-called pollen baskets on their hind legs. In this way, they carry the pollen back to the beehive and deposit it into honey comb cells.

PURPOSE FOR US?

We humans use pollen as a supplement when we feel run-down and for allergy desensitization.

Wax

WHAT IS IT?

Beeswax is produced by the worker bees from glands on their abdomens. Bees use it to construct the honey combs for the brood. For every ten pounds (4.5 kg) of honey in the hive, there is a pound (0.45 kg) of wax, which makes it a rarer material than honey.

PURPOSE FOR US?

In Egypt, beeswax was used for the mummification of bodies. Today it is used for food conservation, in ointments, to manufacture candles, for wax sculptures and as a skincare product.

Bee venom (not just painful!)

WHAT IS IT?

Bee venom is produced in the venom glands of female bees. When worker bees sting a human (or other mammals), they secrete the venom to defend the colony. Bee stings hurt and can produce significant swelling. The stinger gets stuck in the skin, which causes the bee to lose her rear end and ultimately die.

PURPOSE FOR US?

In medicine, bee venom is used for the treatment of rheumatism, among other things. It is obtained using mechanical or electric irritation of the bees, which stimulates them to release venom.

Do you know your honey?

Depending on the origin of the nectar, honey can vary in color and flavor. If the honey is fully or primarily produced from nectar of specific blossoms or plants, it can be marketed as a mono-flower honey type.

Below you can find a few examples of common honey types in Germany[1]:

Honey type	Flavor	Color
Oilseed rape honey	Mild	White to light beige
Dandelion honey	Intense flowery aroma	Golden yellow
Linden (or lime blossom) honey	Intense aroma, mentholated	Light to dark beige
Forest honey[2]	Spicy, malty	Brown, red-brown

[1] LAVES – Institut für Bienenkunde Celle: „Was ist ein Sortenhonig?“ Informationsblatt Nr. 44, August 2016
[2] Type of honey made from honeydew excreted by plant-sucking insects
[3] Production quantity of honey (natural) in 2016 across world regions. United Nations, Food and Agriculture Organization, Statistics Division (FAOSTAT). Retrieved on 6 June 2018

Did you know?

// For bees, honey is the stockpile of food for the winter, when there are no blossoms outside and it is too cold to fly out.
// Bees are among the few insects that produce food that is fit for human consumption.
// Beekeepers around the world harvested 1.78 million tons of honey in 2016. Almost half of this was produced in Asia.[3]

3 *Pollination* and its significance

Around one-third of all crops eaten by humans benefit, to some extent, from pollination by bees or other insects. Of the 100 crops providing 90 percent of the world's food, 70 benefit from pollination by bees and other insects.

All around the world, insect pollinators help ensure that high-quality crops such as strawberries, kiwis and almonds grow in the fields. Apple trees produce significantly higher yields when insects transfer the pollen and farmers do not need to rely on the wind. Melon plants would produce little fruit without insect pollination, and those would be of lower quality.

However, not all crops are dependent on pollination through bees or other insects but rely on, for instance, self-pollination or pollination through the wind. In fact, many of the main staple crops such as wheat, rice or maize do not require insect pollination. Up to eight percent of global agricultural food production relies on pollinating insects.

PLANTS CAN BE POLLINATED BY:

WIND

WATER

SELF-POLLINATION

ANIMALS

As many as **200,000 animal species** are thought to act as pollinators; some estimates put this figure as high as 350,000. Around 1,000 are vertebrates, including small mammals, bats and birds ...

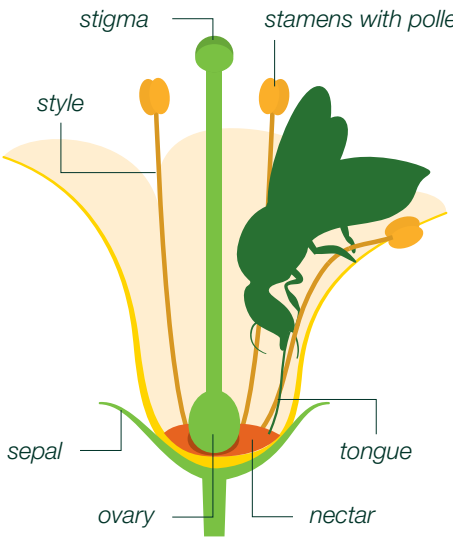
... but insects are by far the largest group.

Insect pollinators include bees, flies, butterflies, beetles, wasps, moths, midges and ants, among others.

Of these, **bees are the dominant group,** with both wild and managed species acting as pollinators.

Did you know?

The worldwide economic value of insect pollination has been estimated at US $ 235-577 billion annually (IPBES Report 2016).



Pollination – how does it work?

Pollination involves the transfer of pollen from a plant's male organ (stamen, where the pollen is produced) to the female organ (stigma) – a vital part of the reproductive process. To get to the nectar, a bee has to brush past the stamens. Doing so, its hairs collect pollen. It then carries that pollen with it as it flies from blossom to blossom. When it visits the next plant, the pollen gets caught on the sticky stigma – and the blossom is pollinated. A single honey bee can visit 200 to 300 blossoms per flight.

Creating a buzz

Some flowering plants, such as blueberries, have their pollen tucked away in a tubular pouch that only has a very small opening at the bottom end. That makes it hard for the bees to collect the pollen. Some bees, like bumble bees, have adapted: they grip the blossom, hold on tight and begin to tremble. This creates vibrations that shake the pollen out of its cover. Bumble bees use this approach on flowering plants, such as tomatoes, peppers, eggplants and cranberries. Experts call the technique buzz pollination.

Did you know?

A very special adaptation has developed between some plants and bees so that the bees do not look for nectar in blossoms that have already been pollinated. It is invisible to the human eye, yet some plants provide a special guiding system for bees to detect which blossoms have already been pollinated. Blossoms that have not yet been pollinated smell and look more attractive to bees than others, so the pollinators are automatically guided to the right blossoms.

4 Factors affecting bees

We are often confronted with alarming headlines that bees are dying out. The truth is: they are not. But it's important to distinguish between honey bees – typically managed by beekeepers – and wild bees. **The number of managed honey bee colonies worldwide has increased by 65 percent since 1961** according to the United Nations Food and Agriculture Organization. The situation is looking more challenging for wild bees: there are over 20,000 different bee species, each with their own biologies and needs. This makes generalizations very difficult. Yet, there seems to be an overall decline – at least in many regions where investigations have been done. Generally, data is rather scarce.

So what are the factors affecting bees? And do they differ between honey bees and wild bees? Find out on these two pages!

Meet the honey bee's greatest enemy: the Varroa *mite*

Bee experts agree that the *Varroa destructor* mite is the greatest threat to Western Honey Bees:

// The mite is about 1.6 millimeters long.
// It sucks on the bee's hemolymph, a body fluid similar to blood, or on the fat body.
// The mite weakens the bee's immune system, causing diseases to become more virulent.
// It transmits viruses directly into the bee's hemolymph, making previously harmless viruses lethal. These viruses spread quickly across bee colonies.

Beekeepers can do many things to control this dangerous mite. It is especially important to get honey bee colonies in good shape for the winter by removing as many mites as possible in the late summer. This is crucial for ensuring that sufficient numbers of bees survive the cold months of the year, thus enabling a strong colony to develop again in the spring.

Beekeeping practices – honey bees

// Beekeepers directly influence the health of their bees by offering the colony food, shelter and a safe environment. Without their help, honey bees would hardly be able to survive in Europe today. Unattended colonies would die after two to three years, due to the *Varroa* mite.
// The struggle against this tiny parasite from Asia nowadays shapes much of a beekeeper's routine in Europe and North America. For more information, see page six, 'A year in the life of the Western Honey Bee'.

Nutrition and habitat

// A bee's food comes from flowers in the form of nectar and pollen. Honey bees forage on a broad range of plants and need good nutrition throughout the season. Managed honey bee colonies are usually housed in hives; feral colonies in nest cavities in deadwood. In comparison, many wild bee species forage specifically on certain plants and depend on particular habitat and nesting structures.
// A lack of nutrition for honey bees and the loss of habitat for wild bees are key threats for these pollinators.
// Today's landscapes often lack the all-season foraging supply for honey bees and the specific foraging plants and habitats that wild bees need for nesting.

Genetic factors – honey bees

// Honey bee breeding over the last decades and centuries, which includes long-term inbreeding, introduced favorable traits in bee colonies, such as reduced swarming, less aggression and increased honey production. On the other hand, this has probably led to the loss of genetic diversity and of certain traits and characteristics that made the bees more resistant to parasites and diseases.
// The reduced population-wide genetic diversity due to current breeding practices is also thought to have led to poor queen viability.

Agronomic practices

// Farming in many regions of the world has intensified. This has partly resulted in larger monocrop fields and fewer areas with flowering weeds and forage plants that are a habitat for wild bees.
// Crop protection products (pesticides) are frequently highlighted as a main factor affecting bee health, which is not supported by scientific evidence. In most cases where bees were harmed by pesticides, this was due to incorrect or irresponsible use.

Pests and diseases – honey bees

// The health and survival of honey bees are threatened by a range of pests, diseases and predators. These may weaken a honey bee colony, reducing its chances of survival.
// In addition to the *Varroa* mite, a honey bee colony may also be affected and weakened by other parasites (such as wax moths or the Small Hive Beetle), diseases (caused by fungi, bacteria or viruses) or predators such as the Asian Hornet.

Adverse weather conditions

// Unfavorable weather conditions, such as a very cold spring, can impact bee health by inhibiting the flight and foraging activity, hereby interrupting nectar and pollen collection to supply the colony. This will, in turn, negatively affect the brood development.

5 What can I do to *support bees?*

A lack of nutrition for honey bees and the loss of habitat for wild bees are key threats for these pollinators.

The good news is: every garden can be a paradise for insects. There are many design elements that will help to attract a wide variety of beneficial insects to your garden or balcony, among them numerous ornamental and crop plants, garden ponds or features that offer shelter, such as insect hotels, dead wood or natural stone walls.

Tips for a garden design that will help insects

// Whenever possible, plant native, pollen- and nectar-rich plants.
// Plan for a long flowering season.
// Create nesting habitats and refuge for beneficial insects.

Planting flower strips

Planting a strip of flowers in tubs, pots and flower beds in a home garden helps provide food for a wide variety of bees. Suitable seeds can be found in many garden supply stores. Wildflowers need little water to grow and only need to be cut back once or twice a year.

Building an insect hotel

A wooden insect hotel, made from a kit or from scratch, is easy to build and provides nesting and breeding space for wild bees. To make sure that bees are attracted to the hotel, it should be set up in a dry place and face south (in the northern hemisphere).

Did you know?

Orchid bees get their name from their perfume-seeking behavior; the beautiful orchid flower is one of their favorite places to visit when collecting scents to attract mates. As the bees crawl into the flowers to collect the perfumes, the orchids glue packets of pollen onto the bees in hard-to-reach places. With this, the orchid gets pollination help. A win-win situation!

Some more *facts about honey bees*

Incredible scent detection

Each honey bee colony identifies itself via a unique smell that honey bees, with their **170 scent receptors,** can easily distinguish from others. By way of comparison, fruit flies have only 62 and mosquitoes only 79 receptors.

How honey bees communicate: just dance

Biologist Karl von Frisch wondered how a honey bee that has found a food source informs the other bees about it. He 'decoded' **an important element of the language of bees, known as the round dance** (used to show that a food source is within about 100 meters of the beehive) and **the waggle dance** (showing that a food source is about 100 meters or further away). Our fundamental knowledge about honey bee communication is based on his discoveries.

THE ROUND DANCE

THE WAGGLE DANCE

A thousand eyes in one

Honey bees and other insects see through compound eyes. These consist of thousands of so-called ommatidia, each one acting like an individual simple eye. **Fast flying insects, such as the honey bee, see up to 300 pictures per second – while we humans can only manage up to 65. What's more, the honey bee also sees ultraviolet light,** which is invisible to humans. The plant has adapted to this characteristic via special pigments in flowers which can absorb or reflect UV light, revealing a 'landing strip' that guides the bee to a plant's store of nectar and pollen. The bee learns that dark dots in the middle of the blossom indicate where the nectar can be found. There is another difference between the human and honey bee sight: bees cannot perceive the color red.

Swarming: how a superorganism reproduces

We have all seen or heard of swarms of honey bees. But did you know that swarming is the natural method of reproduction for honey bee colonies? When a colony reaches a certain size, the old queen will lay a number of eggs, from which a new queen will emerge in 16 days. Shortly before the new queen hatches, the old queen and roughly half the worker bees will leave the hive to search for a new place in which to establish a new colony.

Not all blooming strips are equal, so... grow local plants!

There is no 'one-size-fits-all' solution to providing pollinators with the nutrition they need. Blooming strips should be tailored to local growing conditions and wild bee communities or provide season-round forage for generalists like honey bees and bumble bees.

The Bayer Bee Care Program
Bees and other pollinators are facing some key challenges in much of our modern world. Protecting them is a shared responsibility for us all.

This is why, in 2011, Bayer created the Bee Care Program.

Did you know?

// The Bayer Bee Care Center in Monheim was opened in 2012 to better connect with farmers, beekeepers, non-governmental organizations and other stakeholders, to seek opportunities to work together on promoting and protecting pollinator health.

// Bayer has an extensive global network of in-house experts, around 30 of whom work primarily with bees and other pollinators.

// Our Bee Care Science Program has over 30 collaborative scientific projects worldwide, addressing some of the main threats and opportunities facing pollinators and pollination, offering customized approaches for specific local and regional needs.

Find out more about the work we carry out at the Bayer Bee Care Center at http://beecare.bayer.com.

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