



# BEENOW

2015

The Bee Health Magazine



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## **A Choice Fruit Bowl**

Closing gaps in pollination knowledge

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## **Combating Varroa**

Efficient mite control for honey bees

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## **Blueberry Balance**

Canada investigates its pollinators

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# EDITORIAL

Healthy bees are necessary, not only as pollinators for sustainable food production but also for the unique role they play in many ecosystems round the world. With multifactorial issues contributing to poor bee health, finding solutions will not be easy. We see the health of bees as a shared responsibility amongst multiple stakeholders, and as something which must be collectively tackled.

Bayer takes its role in this work very seriously as it clearly fits with our mission of applying “Science for a Better Life”.

For nearly 30 years, Bayer HealthCare’s Animal Health division has been, and continues to be, actively involved in finding solutions to improve honey bee health. We have been working hard on the development of new and innovative technologies to combat the *Varroa* mite, believed to be the main factor affecting bee health.

For Bayer CropScience, pollination is important, not just for the success of our customers’ businesses but for our own canola or vegetables seeds businesses, too. For decades, we have invested heavily in research and development and in extensive stewardship measures, to minimize the impact of crop protection products on bee health. Honey bee safety has long been well-integrated in the development process for new active ingredients and products we bring to market. In 2011, Bayer took a strategic decision to establish its Bee Care Program. As a

result, two Bee Care Centers have been opened so far, one in Germany in 2012 and the other, serving North America, in April 2014. Combining the resources and bee health expertise from our Animal Health and CropScience businesses, the centers enable us to proactively reach out to and better connect with a broad range of stakeholders, addressing their questions and concerns and seeking opportunities to work together on bee health issues.

Bayer will continue to play an active and visible role in bee health. In collaboration with external partners, we will further develop and provide agricultural and animal health solutions. Bringing together key stakeholders such as farmers and beekeepers is a critical part of this process, as we have a common interest which is bee health.



**Bernd Naaf**

Member of the Board of  
Management of Bayer  
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**Dr Dirk Ehle**

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# CONTENT

We are all aware of how much “Pollination Matters”, and not only for the supply of high-quality, affordable food across the planet. As a result, we are partnering with research institutes and universities, beekeepers and industry partners around the world on some exciting research projects and partnerships. This magazine will present you the results of some of the inspiring initiatives we have been involved with.

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Toxicogenomics

## Honey bee self-defense mechanisms



Honey bees have natural metabolic self-defense mechanisms against certain insecticides.

When developing new selective insecticides, researchers have to seek ways to fight pests while simultaneously protecting beneficial organisms. If a product is shown to be harmful to honey bees, for example, it will not be

approved without substantial use restrictions. Scientists may soon receive support in developing even more specific active substances. “Honey bees have very effective metabolic mechanisms to deal with certain insecticides,” explains

Dr Ralf Nauen, insect toxicologist and Bayer CropScience Research Fellow. He and his team are, therefore, investigating the processes that play a role in honey and wild bee metabolism – and what genes underlie each of these mechanisms. For example, the scientists hope to find out why honey bees have ways of handling the insecticide thiacloprid, but not other active substances that take effect in the same place in the insects’ bodies. For this, Bayer is also working closely with the renowned British institute Rothamsted Research.

The goal of the project is to develop novel screening technologies. The plan is then to test active substances in a targeted way to see whether bees can better tolerate them.

International council for biological diversity

## Global policy advice

Making science and policy work together more effectively – that is the mission of IPBES, short for Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. This international United Nations (UN) committee disseminates information about the status of and developments in biological diversity as well as the current state of science. This service is intended to support politicians, environmental organizations and UN institutions in their decision-making. The committee consists of selected well-known researchers from around the world.

Dr Christian Maus, Global Pollinator Safety Manager at the Bayer Bee Care Center, has now been appointed to the council as a Lead Author for the assessment on pollination and pollinators associated with food production. He will be involved in the assessment of, for example, the role of native and managed pollinators. He will also be charged with evaluating legislation in various countries on a global level that is related to pollination and pollinators. “I am very pleased to be able to contribute, along with other researchers, to the goal of making sustainable pollination services a higher priority in policymaking,” says Dr Maus.



Dr Christian Maus has been appointed to the IPBES as a Lead Author for the assessment of pollination and pollinators.



## Software helps protect bees Collaboration via smartphone



Farmers and beekeepers in Canada can now easily get in touch with the “DriftWatch” software.

A beekeeper checks his cell phone to see whether he can place his beehives next to the field of crops. An online software tells him when the farmer is planning to apply plant protection. The beekeeper can thus minimize the risk to his bees, which can safely collect pollen and nectar from the field. Then the hives can either be removed or closed up during plant protection application.

This is made possible by the software “DriftWatch”. Beekeepers and farmers can register and access it using a smartphone. Beekeepers also can supply information on the location of their hives. That way, the farmers know whether beehives are present and when the fields can be sprayed without harming the bees. The software is now available in the province of Saskatchewan, Canada, and some US states. Bayer CropScience collaborated with the Saskatchewan Ministry of Agriculture to adopt DriftWatch and promote the communication tool.

In the future, the software’s creators, Fieldwatch, plan that barcodes will be placed on beehives. This feature should further ensure the accuracy of the information.

## Honey Bee Health Coalition All for the bees

Honey bees are important pollinators of wild and cultivated plants around the world – from apples to zucchini. In the USA alone, they pollinate crops valued at \$15 billion per year. However, many factors make life difficult for the insects, including diseases, lack of food sources, and overbreeding. Beekeepers, researchers, governments, farmers and agricultural industry must work together to tackle these problems. To this end, Bayer is a member of the Honey Bee Health Coalition, which brings together all the parties involved.

The shared goal is to strengthen the health of commercial honey bees. The coalition was founded by the American Keystone Center.

## Pollinators and neonicotinoids Realistic conditions in the field

Do neonicotinoids actually affect pollinating insects? Many studies that have classified these plant protection products as dangerous, exhibit significant scientific shortcomings. Nevertheless, the use of these insecticides has been heavily restricted in Europe. Bayer is, therefore, supporting a study to investigate the effects of neonicotinoids on honey bees in rapeseed fields. This oil-producing plant is cultivated extensively, for example, in Europe and America, meaning its yellow blossoms are an important nutrient source for honey and wild bees. The project includes large-scale field testing in the UK, Germany and Hungary. The British Center of Ecology and Hydrology is conducting the study, while Bayer and Syngenta are funding it and supporting it with their expertise.

## Nicaragua: honey as source of income Help for small-holders



Beekeeping can help farmers supplement income in developing countries.

Small-scale farmers account for 50 percent of global food production. However, in developing countries such as Nicaragua, they struggle to survive. To help the situation, Bayer is supporting a project by the organization Chinantlan, which offers farmers additional sources of income: with honey bees. With the financial help of Bayer, Chinantlan provides honey bee hives and equipment for beekeeping for selected farmers. The fledgling beekeepers can then sell the honey, which generates additional income for them. What is more, they can also use the honey for themselves.

# FACTS & FIGURES

*Remarkable facts about bees, food and pollination*



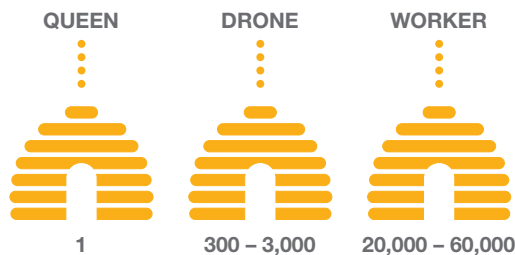
A queen may live for up to 4 years but will typically be replaced by the beekeeper after 2.



Three types of honey bee make up a colony, each has a characteristic size.



A colony normally contains only one queen, a few hundred drones and up to 60,000 worker bees.



Worker bees are sterile, so breeding is left to the queen and the drones.



The worker bee progresses through several work stages, from brood and hive maintenance through to foraging duties.

A queen can lay as many as 2,000 eggs per day during the height of egg-laying season.



**Development stages:**  
egg, larva, pupa

After mating with drones, the queen bee lays eggs in brood cells prepared by worker bees. If the cells are small the queen releases sperm from her spermatheca and fertilizes the egg shortly before laying. From these eggs worker bees will develop. In larger cells the queen lays unfertilized eggs from which male drones develop.



# 150 Billion

The total economic value worldwide of insect pollination is estimated to be at least 150 billion EUR annually.

## POLLEN of Flowers

Bee pollen is richer in proteins than any other animal source. It contains more amino acids than beef, eggs or cheese of equal weight.

# 90 %



## of the World's Food

Of the 100 crops providing 90% of the world's food, 70 benefit from pollination by bees and other insects.

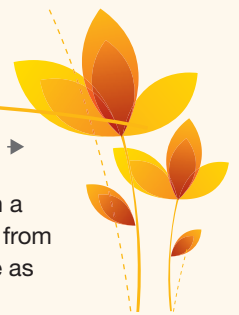
# 2,000,000 Flowers

Bees need to visit some 2,000,000 flowers in order to produce 0.5 kg honey.



## Long Journey

Honey bees will forage in a radius of up to 3 to 4 km from the hive. That's the same as humans traveling around 2,500 km for food.



# 15 Million

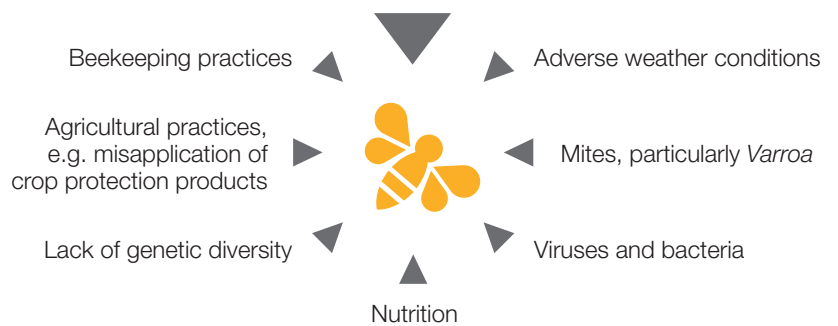
The total number of bee colonies in Europe remained stable over the last 10 years at approx. 15 to 16 million colonies.



# 1/3 Benefit from Bees

One third of all plants consumed by humans are dependent, to some extent, on insect pollination.

### IMPORTANT FACTORS AFFECTING BEE HEALTH



Bee health is a complex issue, affected by many different factors.



# A CHOICE **FRUIT** BOWL

*Papaya, guava, mango: For us humans, these kinds of fruits bring a welcome change to ordinary mealtimes. But of what interest are these fruits for bees and other pollinators? In many cases we know relatively little about which insects pollinate which crops or how or when. But now, a collaborative study between Bayer and the University of Freiburg is working on filling the gaps in our knowledge – providing information that could be used to develop bee-friendly application methods for insecticides in the future.*



Mango flowers (above) rely on pollinating insects to develop the juicy fruit (below).

With some 75 percent of the world's crops depending, to some extent, on insects to pollinate them, the smallest farmworkers of all have a very big role to play. If bees, bumble bees and flies didn't lend a helping hand, fewer fruits and seeds would grow in fields or on trees and bushes. However, the insects actually do more: Their involvement can affect the size of crop yields and the levels of nutrients they contain. In many cases researchers have yet to reach a consensus on the role that bees play in pollination of crops. Even for conventional classics like apples, almonds and rapeseed some open-ended questions remain, never mind more "exotic" crops like guava, mango and cocoa.

The insects' involvement can affect crop yields and the levels of nutrients they contain.

"For many crops there's thin data on the ground. And even if information on pollinators is available, the findings are often ambiguous, which makes it harder to assess," says Dr Christian Maus, Global Pollinator Safety Manager at the Bayer Bee Care Center. Yet crop protection researchers are very keen to get hold of any existing information, especially on the pollination of exotic crops, as it will help them in developing bee-friendly insecticide application schemes and usage guidelines. "For them to be able to do that, we need to know things like which crops honey bees and other pollinators actually visit regularly, and during which part of the year and at what time of day they do it," says Dr Maus. This is why Bayer is supporting a new study that will go through and summarize all the currently available scientific literature on crops worldwide.

The study is being run by the working group of Prof. Alexandra-Maria Klein's

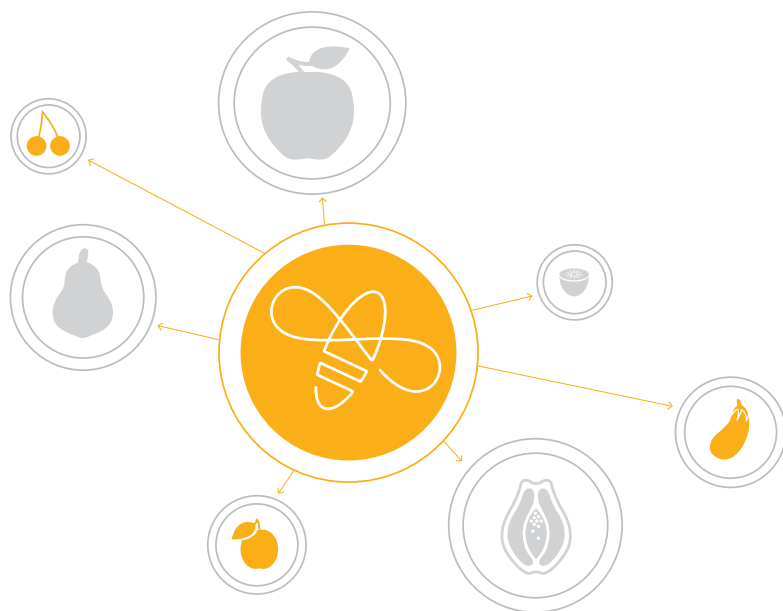
## AT A GLANCE

- // Many crops depend on insect pollination.
- // However, the exact role of bees and other pollinators is often unclear.
- // Closing gaps in knowledge: Bayer supports a literature study on crops worldwide.
- // More knowledge could facilitate the development of bee-friendly insecticide application methods by others in the future.



**Dr Christian Maus**  
Global Pollinator Safety  
Manager, Bayer Bee  
Care Center

*“For many crops there’s thin data on the ground. And even if information on pollinators is available, the findings are often ambiguous, which makes it harder to assess.”*



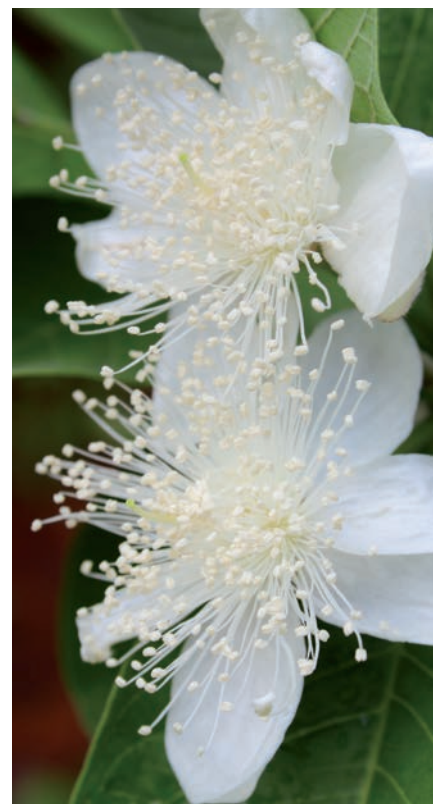
Most papaya plants can self-pollinate their blossoms.

Honey bees pollinate many important fruits, nuts and vegetables that contribute to a healthy diet.

Nature Conservation and Landscape Ecology working group at the University of Freiburg. One of the team members, Dr Virginie Boreux, spent two years trawling through archives and online databases – and the work has paid off: “From about 1,500 publications, I found information on more than 130 crops,” she says. The oldest find dates back to 1881. Dr Boreux identified the most important findings in each of the studies and created a table that summarizes them by crop. Mangos, for instance, were the subject of less than a dozen studies published in English, conducted in various regions.



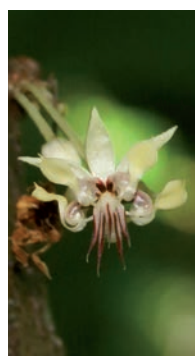
Guava fruit



Insect pollination of guava flowers (above), can provide higher fruit yields.



Papaya fruit



The cocoa flower (left) is pollinated by small flies to produce fruits (right).





“Although some studies indicate that mangos are pollinated by honey bees and wild bees, in others it seems that flies play an important role,” says Dr Boreux. Investigating which pollinators are important for fruit harvests was not the only focus of her work: She was also interested in finding out whether the insects preferred nectar or pollen, when exactly they visited the plants, and what conditions will promote pollination. It is a laborious task, as not every study contains information on all the key issues and not every finding is scientifically sound.

### Some studies even arrive at contradictory findings.

This is why Dr Boreux is now concentrating on evaluating the masses of data. The work involves filtering out the most important and most reliable data, weighting them and then making them available in an easy-to-use system. But even once that’s done, Dr Boreux still won’t be able to rest. “I’m sure the data pool will keep on growing,” she says.

“There are still significant gaps in our knowledge, so research into the pollination of agricultural crops will continue for a long time to come.”



Papaya is one of the most popular tropical fruits worldwide. It has become an important export product for developing countries.



## INTERVIEW

### Filling gaps in the knowledge

**Professor Alexandra-Maria Klein runs the Nature Conservation and Landscape Ecology Group at the University of Freiburg, Germany. Her research focuses on the ecology and biodiversity of plant-insect interactions in cultural landscapes.**

## THE RESULTS

The study shows, for example, that wild bees contribute greatly to the pollination of tomatoes, lettuce (for seed production) and melons among other crops. The situation is quite different with, for instance, field beans or citrus species, which are mostly visited by honey bees in the interpreted studies.

In addition to this, the pollinator composition can vary from country to country for some crops. For example, onions are pollinated (for seed production) mainly by wild bees in the USA, flies in Pakistan, and honey bees in Poland.



## How much of an effect do pollinators have on crop yields?

*“It can vary widely. Some varieties of rapeseed can deliver high yields with no help from insect pollination at all. With other crops, though, yields can go up by as much as 25 percent when the winged helpers get involved. And some apple and cherry varieties wouldn’t produce any fruit at all without help from pollinating insects.”*

## Do honey bees and wild bees differ in terms of how well they pollinate?

*“Honey bees are highly social and form large colonies, which means they are very efficient pollinators. But they don’t fly in cooler temperatures, wind or light rain. When that happens, bumble bees take over*

*pollination duties. Also, a lot of wild bees fly between blossoms more than the honey bees do. That can be an advantage if pollen from a different plant individual or variety has to be transferred.”*

## What gaps in knowledge still need to be filled?

*“For a start, our knowledge about the effects of a stop in pollination extends to just a few crops. We also don’t know much about which species of insect act as pollinators, or when and how exactly they do it. Another grey area is what and how much food and nesting sources are important, especially for wild bees. The only way we can work out how to protect specific groups or species of bee is if we know which ones rely on which plants and vice versa and to understand their nesting requirements.”*

## CONCLUSION

The effect of pollinators on crops can vary widely. But researchers are working on filling the gaps in knowledge. With that, it will be possible to work out how to conserve specific pollinating insects and the important services they provide for nature and humans.





## AT A GLANCE

- // The *Varroa* mites can do serious damage if they get into a beehive.
- // Bayer has developed a strategy that it hopes will effectively combat the parasites at the entrance to the hive.
- // The Varroa Gate should be on the market in selected countries by 2017.



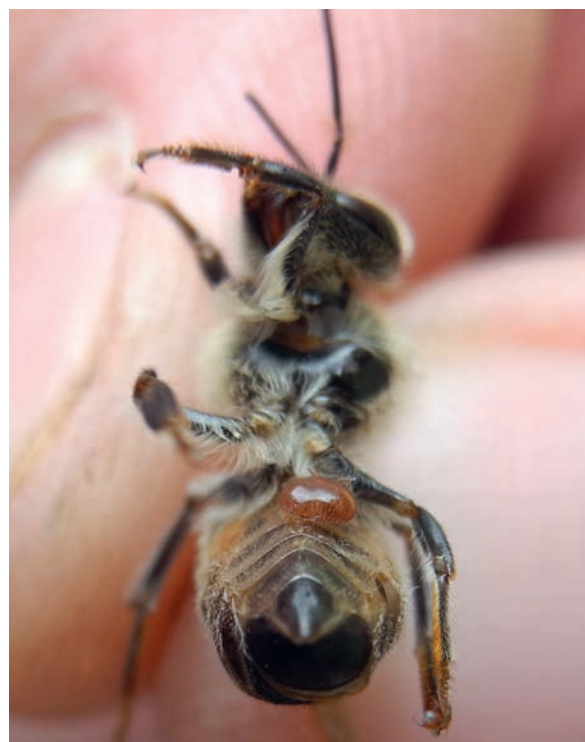
# SECURITY AT THE BEEHIVE DOOR

*It may only be tiny, but the Varroa mite can do major damage: The parasite has the power to destroy whole colonies of bees worldwide. Researchers at Bayer are looking to solve the problem by developing a special gate that already tackles the uninvited guests at the doorway.*

Honey bees are the embodiment of assiduous workers, but that does not mean they always behave impeccably. They are willing to engage in some sneaky activity when flower stocks start to dwindle in late summer to fall. Then they start creeping into neighboring hives to steal honey. But supplies might not be all they take back home. Sometimes they have a dangerous passenger on their coat-tails: the mite *Varroa destructor*. After laying their eggs on bee larvae in the honeycomb cells, the mites multiply fast. It takes a maximum of two weeks for their offspring to spread throughout the whole hive along with the newly hatched bees. The parasites transmit pathogens that weaken the honey bees.

Many colonies of the Western honey bee have fallen victim to the *Varroa* mite in Europe and the USA over recent years. The bees therefore desperately need human help: “The mite originally comes from Asia, where it is a natural parasite of the Eastern honey bee. It came to Europe in the 1970s, and began spreading across the USA in the 1980s,” explains Dr Klemens Krieger, who is responsible for, among other things, bee health in the Animal Health Division at Bayer HealthCare. “Australia is the only place they haven’t reached yet.”

Unlike its Asian cousin, the Western honey bee cannot defend itself against the parasite. Acaricides are one of the weapons to combat the mites. These kill off the mites without endangering the health of the bees. The challenge is how to distribute the acaricides in the hive without contaminating the honey. Bayer researchers and bee experts at Frankfurt University are working together on a solution: the Varroa Gate – a perforated strip of plastic that contains an active acaricidal substance. The strip is fitted over the hive’s entrance. When



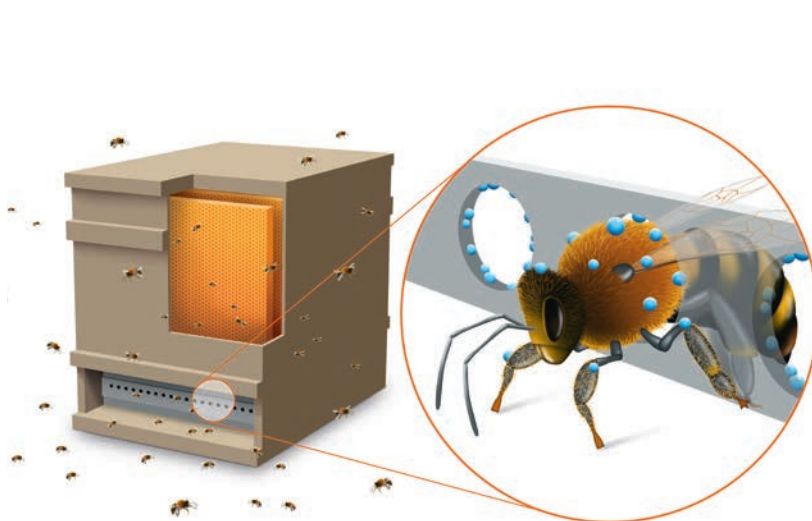
Like a tick, the *Varroa* mite latches onto a bee with its jaws, sucking on it’s blood, the so-called hemolymph.

the bees slip through one of the holes in the strip, the active substance sticks on their legs or hair. “The strip automatically replenishes the substance – but only as much as is necessary. That means it keeps working for several weeks,” says Dr Krieger.

Left page:

Dr Klemens Krieger watches the bees flying back to the hive. He has been working with scientific partners all over Europe to develop an innovative hive gate. It is to protect the honey bees from the deadly *Varroa* mite.





When a bee enters the hive, the active acaricidal substance around the edge of the hole rubs off on its body and the bee transports it inside. The plastic strip immediately replenishes the lost substance.

## The *Varroa* mite is the most serious pest

**Dr Tjeerd Blacquière is a Senior Scientist at Plant Research International of Wageningen University in The Netherlands. His lab is testing the efficacy of the Varroa Gate at beekeepers' apiaries and carrying out dose confirmation studies.**

### What are the main factors influencing honey bee mortality?

*"The loss of colonies during winter is a big issue. Only very healthy winter bees will ensure colony survival until spring. Many environmental stressors in late summer can impair the development of vital winter bees: Bee diseases and parasites such as the gut parasite Nosema, lack of forage or adverse effects in summer may reduce the quantity and quality of the winter bee populations. However, by far the most serious pest is the Varroa mite together with the viruses it spreads.*

*The role of the beekeeper in preventing winter losses of colonies is pivotal. This is not easy, and the tools currently available are limited."*

### How are you involved in the development of the Varroa Gate?

*"Our role is to do part of the efficacy testing in the field, at beekeepers' apiaries, as well as a dose confirmation study at our apiary to determine the efficacy and safety. We included also a group of colonies that were not treated against Varroa. This might actually be lethal for some. However, the results are part of the file needed for registration of the Varroa Gate and its active ingredient as a veterinary medicine for honey bees against varroosis."*

### Which development do you expect?

*"Knowing that colony losses vary greatly between beekeepers, I hope and expect they will learn from each other, improving their hive and apiary management and Varroa control. They will need more options than now available, since very few effective Varroa control measures are currently available in America or Europe. In the longer term, the development of Varroa-resistant honey bees will be the ultimate solution."*



The gate will help beekeepers to protect their colonies against the *Varroa* in late summer, before the bees become dormant for the winter.

His team is working on developing different gates with diverse active substances. This will allow beekeepers to vary the acaricides they use.

“The only way we can stop the mites from becoming resistant is by using different modes of action,”

says Dr Krieger. Because even if beekeepers manage to successfully treat their colonies for *Varroa* mites, lone parasites might still survive. Unless these robust specimens are tackled with another substance, they will be free to multiply in the hive and among the bee population. Another problem is that bees carrying the mites can end up spreading them when they buzz into other hives.

Dr Krieger and his colleagues are equipping their plastic strips with three tried-and-tested active acaricidal substances: flumethrin, coumaphos and amitraz. “Right now, our biggest challenge is identifying the right concentration for the substances,” says the bee expert. To do that, the researchers are conducting large-scale field trials with different *Varroa* Gates in over 400 hives across Europe. This enables them to investigate different substance concentrations, as well as plastic formulations.

The researchers have made the most progress with their work on developing the flumethrin strips, and have already come up with the optimal dosage. Trials are now underway in Germany, Hungary, The Netherlands and Spain to see how the strips perform under different climatic conditions and temperatures. The participating laboratories are also testing honey samples for residues. “Clearly, the active substance must not contaminate the honey,” says Dr Krieger. So far, the tests for flumethrin have had positive outcomes, with no detectable residues. That means a flumethrin gate will not affect the quality of the honey.



Honey bees need to be in excellent health to ensure the survival of the colony from late summer to spring.

Dr Krieger believes the other two substances also have a promising future: “We’re already testing coumaphos at different concentrations in field trials in Germany and Sicily,” he says. He also expects to be able to take amitraz into the next test phase soon. “If everything goes well, we’ll be launching the flumethrin gate as early as 2017,” he says. The gates with the other two substances should then follow. Each gate will come in a different color to make it easier for beekeepers to alternate the treatments.

“That means beekeepers will be able to protect their bees in the hive and also prevent new infestations,”

says Dr Krieger. The gate is thus part of an integrated concept for tackling the mites and keeping them out of beehives.

## CONCLUSION

Once a honey bee colony has been controlled for *Varroa* mite in late summer, mite numbers should be kept low.

The *Varroa* Gate should therefore prevent renewed infestations or stop the mites spreading from the outset.

# ENEMIES ON THE WING

*They are both unwelcome guests in the beehive: the hornet species *Vespa velutina* and the Small Hive Beetle (*Aethina tumida*). They have traveled west and north from Asia and Africa and are now threatening honey bees in Europe and America. Researchers at Bayer are looking for effective solutions against these dangerous insects.*

So far, the sticky cage has kept the predatory hive beetle in check. The invader is held in a sturdy prison that African honey bees build out of propolis, a resinous mixture that they gather themselves. They even posted a guard to watch over the enemy. That is how these honey bees defend themselves against the voracious beetles, which are originally from Sub-Saharan Africa. However, since 1998 they have unfortunately spread to the USA, Canada, Mexico, Jamaica, Australia and Cuba, where they have proved to be a very serious pest of Western honey bees. In 2004, the beetle was intercepted and eradicated in Portugal in a consignment of queen bees from Texas. Now the Small Hive Beetle has also reached Italy.



The Small Hive Beetle mingles with the honey bees. The larvae of this African pest eats honey, wax and pollen and destroys the structure of the comb.

African honey bees know how to deal with this beetle: “Compared to their European relatives, they discover infested brood cells more quickly and clean their hive more thoroughly before they swarm,” explains Peter Trodtfeld, beekeeper and Bee Health Expert in the Bayer Bee Care Center. But the beetles have also become smarter: They imitate the behavior of begging bees to obtain food stealthily and can survive for up to two months in their prison. “Fortunately, under these conditions they cannot reproduce or mate,” explains Trodtfeld. “African honey bees can therefore better control the risk to the colony posed by the hive beetle, which measures just five millimeters,” says the bee expert.

Once a beetle has made its way into the hive, it lays its eggs in protected hiding places that the bees cannot reach.

After the larvae hatch, they eat honey, wax and pollen – and destroy the structure of the comb. The honey spoils and is no longer usable for human consumption. Some bee colonies even leave the infested hive in an emergency swarm.

## AT A GLANCE

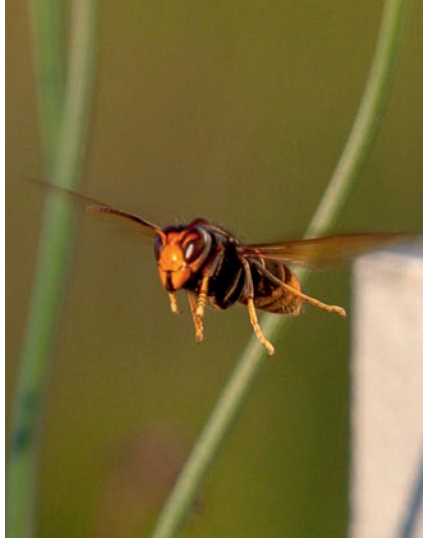
- // Invasive insect species can disrupt the ecological balance and threaten honey bee colonies.
- // Examples include the arrival of the Asian hornet, *Vespa velutina* to Europe and the spread of the Small Hive Beetle from Africa to North America and Europe.



## Efficacious bee resin

Propolis is a sticky mass that bees use to seal off tears and cracks in their home. It consists of about half resin, one third wax and ten percent essential oils and proteins, trace elements and vitamins. Propolis is effective against many bacteria, viruses and fungi. Bees use it to protect their hives, but propolis' properties are also useful in human health, for example for treating infections of the skin and mucosa or for strengthening the immune system.

Bees gather propolis from leaf buds and bark. Its color depends on the source trees and can range from yellow (alders) to brown (poplars) to black (birches).



Asian honey bees have already found a way to defend themselves from *Vespa velutina* (left): The bees gather round the hornet (right) and heat it to almost 50°C, killing it.

## Another winged enemy is also threatening the Western honey bee: the *Vespa velutina* hornet, which comes from Asia.

You recognize the mostly black hornet by its broad orange stripe on the abdomen and the fine yellow band on the first segment. Experts fear a lasting disruption of the ecological balance if this insect, which measures about two centimeters, continues to multiply. "These hornets aren't any more aggressive than their European relatives, and they are not particularly dangerous to humans. However, honey bees and wild bees can suffer because of them," explains Trodtfeld. As the hornets usually create their new colonies quite close to each other, there is a very high concentration of nests in the area – and the pressure on food sources increases. And honey bees are already on the hornets' menu.

The hornet arrived in Europe in 2004, at the Atlantic coast of France. From there it started to invade the European mainland. In 2010, it was found in Spain and a year later in Portugal, before arriving in Germany in 2014. In their place of origin, Asian honey bee colonies have already developed a tactic for ridding their hives of this enemy. They attack the hornets as a group, forming a ball around their enemies and heating them to almost 50°C. "The bees can endure the high temperatures for a while, but the hornet perishes," explains Trodtfeld.

However, in Europe the bees do not know how to fight against *Vespa velutina* and therefore need support. To this end, the hornets' lifestyle is about to be studied closely and solutions to control the Asian hornet are to be evaluated. Bayer is supporting a Ph.D. thesis that is taking on this task, in collaboration with the National Institute of Agronomic Research (INRA). The 3-year project has started in November 2014 and its methods will include equipping the insects with electronic transmitters in order to collect information about the location of the colonies and the animals' hunting behavior. "Because the hornets usually build their nests high up in the trees, they are covered with foliage most of the year, and are thus difficult to find," explains Dr Benedicte Laborie, Ecotox Engineer at Bayer CropScience, France.

The experts at Bayer hope that the results of the Ph.D. study will provide effective tools to control this hornet – using baits, for example, could be an option. Dr Laborie: "If the hornets bring the active substance into the nest and feed it to their larvae, that would be an effective measure for better controlling this bee enemy." Until then, beekeepers can mainly protect their bees when they take refuge in the hive, by placing mesh across the entry hole through which the hornets cannot pass.

There is another thing that makes these quickly multiplying beetles dangerous for bee colonies: They can fly very well, covering distances of up to 20 kilometers and thus spread rapidly. Currently, there are hardly any methods available for combating the beetle. "In the USA and Canada, the Bayer product CheckMite+®, with active ingredient coumaphos, has been approved," explains Trodtfeld. "Also in Canada, Permanone®, with active ingredient permethrin, applied as a light soil drench against the larvae living in the ground, is registered." These treatments have to go along with improved bee husbandry and changes in honey handling. Once well established, the beetle cannot be eradicated.

Strict import regulations for honey bees have been established as the main defense against the introduction of the beetle as well as other serious bee pests and diseases from overseas. In Europe, however, there is currently only one solution: If a beekeeper has detected the vermin, he has to report it, as the Small Hive Beetle is a statutory notifiable pest in the EU. Hence, beekeepers must observe their hives extremely closely. In case of a beetle infestation, the only chance for eradication is the early interception of the beetle.

# A WARNING SYSTEM FOR BEEKEEPERS

*The condition of a honey bee colony depends on many circumstances. Using high-tech methods, researchers in Canada and the USA are investigating just how agricultural practices, disease and weather conditions can influence the insects.*

## AT A GLANCE

- // Honey bees are affected by diverse factors such as diseases, weather or agricultural practices.
- // Canadian and US researchers and beekeepers now gather more data to investigate especially the influence of agriculture.
- // They want to show that beekeeping and agriculture can co-exist happily.



Many factors influence the health of a honey bee colony, such as diseases or the weather.

If the honey bees aren't doing well, beekeepers suffer, too. Then they have to begin searching for the source of the problem – which is no easy task. Many factors influence honey bee health such as diseases, parasites, agricultural and apicultural practices and the weather.

**“It is important to us to show that modern agriculture and beekeeping can co-exist without impacting negatively on each other.”**

Beekeepers and scientists in Canada and the United States are, therefore, pursuing an answer to the question: What exactly influences honey bees when they live in an agricultural setting? They closely observed beehives over a two-year period: The researchers installed modern measuring systems in the beehives of beekeepers in Ontario and Quebec, Canada and in Indiana and Utah, USA. “They are all located near corn-growing areas. That means we can also investigate agriculture’s influence,” explains entomologist Dick Rogers, speaking about the “Sentinel Hive” research project. He is the Manager of Bee Health Research at the Bayer Bee Care Center in North Carolina and oversees work in Canada and the USA. He and his colleagues

play a primarily advisory role in the study and coordinate the team of researchers who collect and analyze samples. The study’s goal: “We want to develop a kind of early warning system that is triggered as soon as bee health risk factors are detected,” says Rogers. And: “It is important to us to show that modern agriculture and beekeeping can co-exist without impacting negatively on each other,” adds his Canadian colleague Paul Thiel, Vice President of Innovation & Public Affairs.

The studies are in the second year of running – and there are differences between the Canadian and US studies. “The conditions differ a little. But we are very interested in each other’s results,” explains Thiel. For example, the American beekeepers are more involved in the sampling of bees and pollen than their Canadian counterparts. And while the researchers in the USA are not measuring the weather directly, weather stations have been set up next to the Canadian beehives. They automatically measure air humidity, temperature, wind direction and precipitation every 15 minutes. The data reveals the extent to which the weather, especially cool, rainy periods, can affect the bees’ life.

The climate inside the beehive is also monitored. And the honey bees’ homes are placed on scales that keep a constant record of the entire hive’s weight. In this way, it is possible to tell



# INTERVIEW

## Research in bee-keepers atmosphere

David Shenefield

**Beekeeper participating in the US Sentinel Hive project**

how many workers are out and about at any given time – a single worker bee weighs about 100 milligrams, as much as three peppercorns. And longer-term weight changes can reveal when the insects begin collecting nectar – an important indicator of the hive’s overall health.

The researchers also periodically obtain samples of honey, nectar and wax from the hive and test them for pesticide residues. In addition, they regularly collect live and dead bees and send them to the specialized laboratories of cooperating partners to check for diseases and infestations by parasites.

In the USA, samples are submitted to the bee lab at the North American Bayer Bee Care Center in North Carolina. One big challenge for the project in Canada is transporting the live bees through the mail for virus analysis. The bees are now sent by express courier in jars, with insect nets in the lid.

### How many of your hives are involved in the project?

*“We have four hives in four different apiaries. Each apiary consists of around 20 hives. They are located in Huntington and Wells Counties in Northeast Indiana.”*

### What is your experience with the study so far?

*“It has been a very productive experience so far and we have collected some good data. What is special about this project is that the information and samples that are collected are being done in apiaries that are managed in a beekeeper’s atmosphere. This is not being done in a research facility. And this type of research is important since that’s how most hives are being managed. I feel we will get the best information for help in resolving honey bee health.”*

Overwintering losses in the USA in 2013/2014 declined by 24 percent from the previous year. Also most Canadian provinces had significantly lower losses than in 2013.

Sources: “The Bee Informed Partnership” and Canadian Association of Professional Apiculturists (CAPA)



**Researchers assessing hives** in a 50,000 colony holding yard in Lost Hills, California.



One year into the project, the partners are satisfied with the progress so far. All the colonies survived the first winter well. In Canada, viral infections were detected in most living and dead bees from various hives but the viral load appeared to be low enough that the bees remained healthy. The conditions under which viruses actually lead to bee death will be investigated more closely in the coming years.

The researchers are also investigating the influence of crop protection products. In the first tests from Canada, residues of two active substances were found in honey, nectar or pollen – but the amounts were so small that they are significantly below the acceptable threshold values. The laboratories also found small amounts of residues in some of the dead and live bees. In the coming months, the project partners will continue to investigate the extent to which crop protection products and bee medicines can influence the health of a colony. The results from the USA are still pending.

*“It can be seen that *Varroa* mites, nutrition and viral diseases, as well as the beekeepers’ work have a great influence on honey bee health,”*

summarizes Thiel. In any case, the researchers are eager to see what the following project years will reveal, as are the beekeepers. “The participating beekeepers really appreciate the work we are doing on this project because it allows them to gain important new insights into the relationships between environment and pathogens,” says Rogers. “That’s the foundation for better management of honey bee colonies.” And the more data the scientists compile, the closer they get to their goal of developing an early warning system to enable better protection of beehives.



**Dick Rogers**  
Entomologist and Manager of  
Bee Health Research at the Bayer  
Bee Care Center in North Carolina,  
USA

*“The participating beekeepers really appreciate the work we are doing on this project because it allows them to gain important new insights into the relationships between environment and pathogens.”*





## CONCLUSION

The Sentinel Hive study may help to develop a kind of early warning system for beekeepers, taking into account all the influences the researchers monitored. The system will trigger further investigations as soon as bee health risk factors are detected.



# JOINING HANDS IN ASIA

*A Bayer-supported study has investigated the situation of honey and wild bees and the impact of agriculture in China and India. The findings show that beekeepers and farmers in both countries have to learn to work together better.*

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China is the world champion when it comes to honey. Its bees make roughly 450,000 tons of the sweet substance every year, which equates to a quarter of total global production. These days, China exports around 100,000 tons of honey – but that was not always the case. Apiculture in Asia has changed rapidly over the past few decades. This topic was the focus of a joint study by experts from CropLife Asia and the Chinese Academy of Agricultural Sciences (CAAS), and supported by Bayer.

One of the study's findings was that beekeeping in China has multiplied – from half a million honey bee colonies in 1949 to nearly nine million in 2011.

This change could have a positive impact on the country's agriculture.

Many of China's crops, such as apple and buckwheat, benefit enormously from insect pollination: It results in bigger, better-quality harvests.

"However, in Asia the beneficial effects of pollinators are still vastly underestimated. This explains why China has spent so long focusing almost exclusively on honey production," says Dr. Jing Quan Guo, Asia Pacific Product Stewardship and Sustainability Manager at Bayer CropScience in Singapore. So over the years, a gulf has opened up between beekeepers and farmers. "But they could support each other and benefit from the collaboration," says Dr Guo.

One topic particularly drives beekeepers and farmers apart: the potential incorrect use of plant protection products. Smallholders, who grow the majority of China's food, are especially likely to use insecticides wrongly – and therefore putting beneficial insects at risk. Beekeepers, in turn, refuse to put their colonies anywhere near the fields, for fear that their bees will suffer. This leads to some absurd situations: "Some apple farmers in Shandong and Sichuan provinces, north and southwest China, pollinate their plants by hand because wild bees alone can't ensure big enough harvests," explains Dr Guo.

## AT A GLANCE

- // A new study sheds light on the life of bees in China and India.
- // One problem in both countries is the disconnect between beekeepers and farmers.
- // Training programs can bring both parties together – and make agriculture more compatible with pollinating insects, for the benefit of both.





When Asian beekeepers let their honey bees (above) fly over fields, farmers also profit such as Indian harvest workers (below). Thanks to diligent bumblebees, the tomato harvest in the South of China is also good (right).



As well as identifying the problems, the CropLife and CAAS study also proposes solutions. One of them is to hold farmer training sessions, run by the researchers in collaboration with the Chinese agricultural authorities. The farmers receive advice on how to use plant protection products correctly. They could, for instance, apply many of the insecticides at dusk, when the bees are no longer active. Another solution involves collaborating with the regulatory authorities to further improve the labelling of insecticides – to explain as clearly and detailed as possible how the products are used without harming beneficial insects.

This should help to bring some beekeepers and farmers closer together. The crop protection industry supports the approach: “It is our job to make both sides aware of how they can benefit one another,” says Dr Guo. When bees pollinate crops, farmers can look forward to bigger harvests. In turn, beekeepers will benefit from the increased honey supply that their well-nourished bee colonies produce. “Awareness of the interdependence between agriculture and apiculture is emerging only very slowly,” explains Dr Guo.



**Dr Jing Quan Guo**

Asia Pacific Product Stewardship and Sustainability Manager at Bayer CropScience in Singapore.

*“Beekeepers and farmers in Asia could support each other and benefit from the collaboration.”*



## INTERVIEW

# Agriculture has a big influence

Professor Wenjun Peng

**He is a bee pollination researcher, working at the Apiculture Research Institute of the Chinese Academy of Agricultural Sciences (CAAS) based in Beijing, China.**

### Which factors influence the pollinators in Asia?

*“There are many things such as the extensive use of plant protection products, changes of plant biodiversity, inter-species transfer of pathogens and parasites, and also loss of habitats due to the development of the intensive agriculture in Asia. In China, especially, agriculture has a big influence, as it is the foundation of the country’s economy.”*

### How can beekeepers and farmers better work together?

*“A business model of mutual benefit for farmers and beekeepers was suggested: It is to strengthen the technical training for both fruit growers and beekeepers. They need to understand each other’s needs so that they both profit from increasing bee pollination. This also can change fruit culture areas and promote ecological tourism.”*

The situation in India – also a focus of the study – is very similar. People there also rely on the beneficial insects for help, with half of all Indians earning their living from agriculture. The farmland is divided up into millions of small parcels of land that have to grow ever-increasing amounts of food to supply the growing population. To achieve this, smallholders use every last centimeter of their land. Unfortunately, this practice can impact on the habitats of natural pollinators like flies and wild bees. And inappropriate use of insecticides can be harmful to both honey and wild bees. In view of this, the researchers involved in the study want to make India’s agriculture more compatible with pollinating insects. If more insects disperse the pollen from mango and sesame plantations, the harvests will increase naturally.

CropLife Asia is committed to work with the national authorities and launch a training program similar to the one envisaged for China. The focus will be on teaching farmers to use insecticides in line with the instructions on the label. This will protect beneficial insects – and will be an important step towards beekeepers and farmers joining hands to work together.

### Subtle differences

Not all bees are alike: there are nine different species of honey bee, for example. The Western honey bee (*Apis mellifera*) has become the most widespread. It used to just buzz around Europe, Western Asia, and Africa.

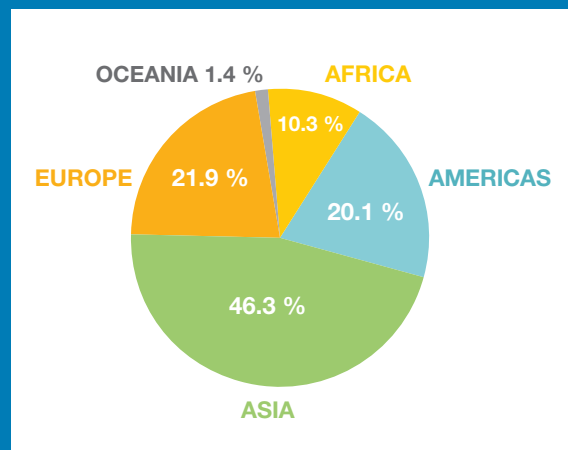
But having moved with traveling humans, it is now present in almost every country of the world. The Eastern honey bee (*Apis cerana*), by contrast, lives only in Asia and is somewhat smaller than its western cousin. The smallest honey bee is the Black dwarf honey bee (*Apis adreniformis*). The largest is the Himalayan cliff honey bee (*Apis laboriosa*), which can be up to three centimeters long.



Honey for the world

# 1.6 million tons of honey

Beekeepers around the world harvested 1.6 million tons of honey in 2012. Almost half of this total was produced by honey bees in Asia.



Source: FAOSTAT

## CONCLUSION

The awareness of the interdependence between agriculture and apiculture is only emerging slowly in China and India.

Training programs by CropLife Asia, supported by Bayer, will inform farmers and beekeepers about how they can benefit from each other, thus promoting healthy populations of pollinating insects and increasing harvests naturally.





## AT A GLANCE

- // Agricultural land often offers little shelter for beneficial insects.
- // Simple helping measures are nesting aids or blooming strips.
- // A German field experiment shows the positive impact of such measures.

# PUTTING NATURE BACK INTO THE FIELDS

*Offering little long-term shelter or food, agricultural land is not a hospitable place for wild bees, bumble bees and butterflies. But just a few simple changes can make field life a lot easier for these insects. A multi-year field experiment in Germany is showing how small measures can make a big difference. What's more, farmers also stand to benefit from thriving insect populations.*

Insects and plants have a pact: Hungry bees, butterflies and bumble bees can help themselves to a plant's sweet nectar in return for spreading its pollen. And pollination has advantages, especially for humans: Many plants we eat either benefit from it or, like almonds, pumpkins and melons, are largely dependent on it. A lot of flowering plants also need insects to pollinate them, such as many types of meadow flowers and the wild flowers that grow near farmers' fields. And plants like these supply other animals with seeds and fruit to eat.

But, often, agricultural land is not a very nice place for the hard-working insects. This is because agriculture has intensified over the years. While this has the advantage of being able to feed a growing world population, monocultures with no natural field boundaries make it impossible for insects to find enough food and shelter. "Germany is one of many countries where huge swathes of agricultural landscape are effectively an ecological no-man's land," says Dr Rainer Oppermann. "We're all just used to it now," he adds. The engineer and agricultural environment expert heads the Institute for Agroecology and Biodiversity (IFAB) in Mannheim, Germany. His team is working on renewing the ties between agriculture and nature.

Even very simple measures can bring about big changes. Allowing wildflowers to grow in areas next to fields is one way of ensuring that pollinators have a good supply of pollen and nectar. Nesting aids that provide bees with shelter are another good option. "At the moment, though, we don't have many quantitative, comparative long-term studies on how these kinds of targeted measures affect insect diversity," says Dr Christian Maus, Global Pollinator Safety Manager at the Bayer Bee Care Center. He is now aiming to close that knowledge gap with researchers from the IFAB and the Institute of Landscape Ecology and Nature Protection in Bühl. They have sown flowering plants and created a home for wild bees on two farms in the Upper Rhine Valley of Southwestern Germany.

The researchers return every year to observe how the insect world has changed. Over the four years of the project, the number of pollinator species has increased. In addition, the ecologists have also seen a rise in the number of insects of each species.

**But often, agricultural land is not a very nice place for the hard-working insects. This is because agriculture has intensified over the years.**

Things looked very different in 2010 when the project began. That year, the researchers set up one area employing the new measures and one control area on each farm – a total of four areas, each spanning 50 hectares. The project areas were designed to be insect-friendly, while the control areas remained unchanged. Before the experiment began, the team made an inventory of the wild bees and butterfly species present on each farm. They then started sowing wildflowers in between the maize and cereal fields. Ten percent of the agricultural land was turned into "insect restaurants", where pollinators can now fill up on nutrients from field poppies, sunflowers and cornflowers.

The project has also tested bee shelters, such as soil banks where wild bees can breed. Conventional fields don't give the bees much shelter. "The ground is too densely vegetated, too shady and too cold. The eggs need to be kept warm if they are to develop properly," says Dr Oppermann. Beneficial insects like wild bees can also nest in chunks of wood with holes drilled in them, which the research team also distributed in the





**Belinda Giesen-Druse**  
Product Stewardship Manager  
Bayer CropScience, Germany

*“We want to work with farmers to investigate how to best set up flowered areas and other measures in order to achieve the most promising results.”*

study areas for experimental reasons. The insects appreciate the offerings: “The situation has improved immensely over the past four years. At first it went quite slowly, but now the difference is very clear,” says Dr Maus. In the first year, very few species of bumble bee were seen above the stretches of wildflowers. But that changed over the next few years. The number of wild bee species on one farm grew from 31 to 58, while on the other it more than doubled, rising from 34 to 74.

“We’ve also seen more endangered species take up residence here,” adds Dr Oppermann. Meanwhile, in the unaltered control areas the number of species stagnated. The researchers observed the same thing with butterflies.

“The entire ecological food web benefits when there are more species,” says Dr Oppermann. “Birds, for instance, will have more insects to eat.” And even farmers stand to benefit from the measures, as areas of wildflowers also attract predatory insects that can kill off agricultural pests, like aphids.

The project is now being extended: “We want to examine if we can transfer this model to large-scale farms in Eastern Germany. We’ll soon be sowing flowering plants on two farms there,” says Belinda Giesen-Druse, who will be coordinating the project at Bayer CropScience. The measures will be combined with ecological focus areas – sections of fields that are not treated with fertilizers or crop protection products, for instance. These will be obligatory for all EU farmers starting in 2015. “We want to work with farmers to investigate how to best set up flowered areas and, possibly, other measures in order to achieve the most promising results,” says Giesen-Druse. Dr Oppermann is especially happy about this:

*“It’s an important step, and the right one. After all, for the measures to be implemented, they must be convincing and produce results.”*



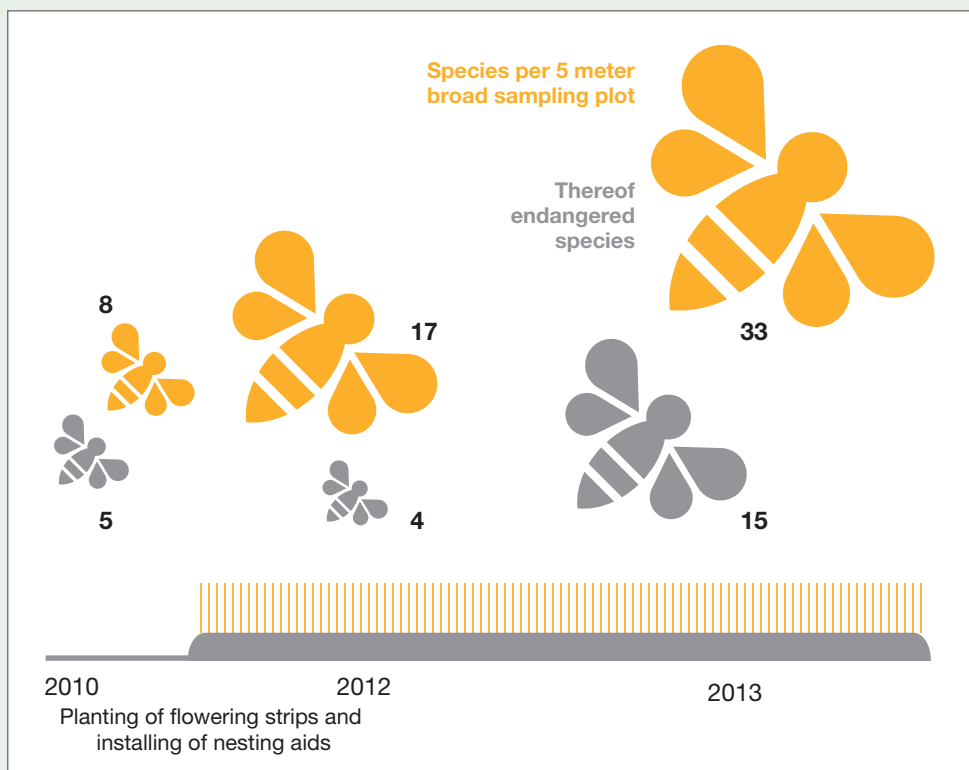
## More space for nature

Europe’s Common Agricultural Policy aims to narrow the gap between agriculture and nature. Ecological focus areas are among the measures designed to do this. These will apply starting in 2015. One example will require farmers to keep sections of land between fields free from crop protection products and fertilizers. The areas could take any number of forms. They might be strips of land where flowers are allowed to grow, fallow land, or wooded sections planted with trees and bushes. Farmers who own over 15 hectares of agricultural land will have to dedicate five percent of it to ecological focus areas.



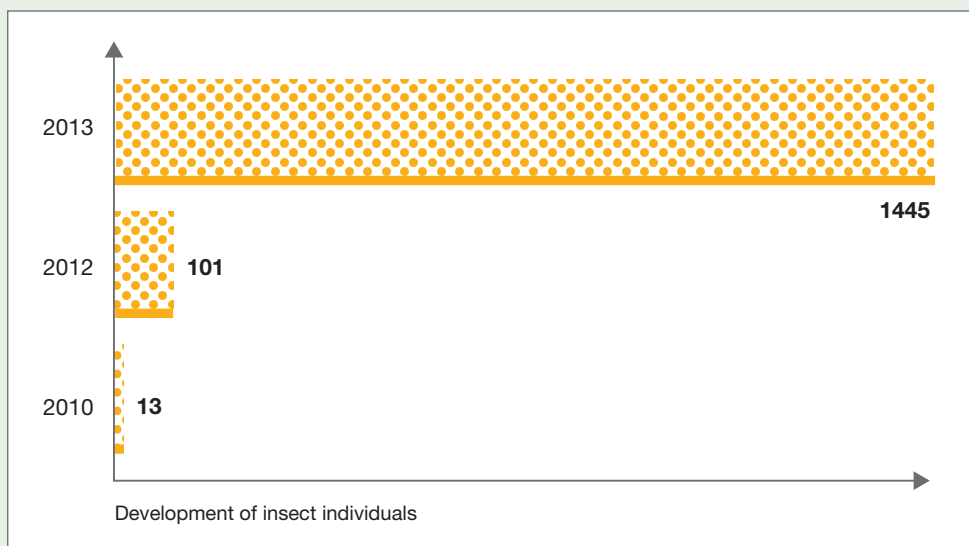
## Increase in wild bee species

Flowering plants and nesting aids already made an impact: More and more wild bee species buzz around in the redesigned areas, among them endangered species.




## More and more wild bee individuals

The wild bees appreciated the measures: They were increasingly found in the redesigned fields in the course of the project. The most abundant insects in the area were bumble bees, especially the red-tailed and the buff-tailed bumble bee.



## CONCLUSION

As the field experiment shows, simple measures can bring about big changes. In a next step, the researchers want to examine if they can transfer their model to larger-scale farms.



## Insect sleuths

Some honey bees recognize when *Varroa* mites are threatening the offspring in a closed brood cell.

Researchers do not yet know just how they do that. The worker bees might smell the damaged larva or the mite itself.



# GETTING RID OF MITES

*The Varroa mite is public enemy number one for bees. However, some Western honey bee colonies are starting to fight the parasites themselves. A European-American network of researchers and volunteers intends to reinforce this behavior via breeding, thereby creating Varroa-resistant bee colonies.*

Sometimes, honey bees become cannibals: A worker bee will bite off the cover of a brood comb, pull out a pupa, and, together with her fellow workers, devour it. By means of this seemingly gruesome act, the bees have protected their colony, since the pupa was infested by a breeding *Varroa* mite. The parasite can now no longer reproduce, meaning it will have no offspring that can attack the colony.

Bee experts describe this behavior, which was originally only known to occur among Asian honey bees, as Varroa Sensitive Hygiene (VSH) behavior. For centuries, Asian honey bees have adapted their behavior to the parasite and now live with it. However, the *Varroa* mite has now spread across most of the world, infesting hives and infecting Western honey bees who are not ready to cope with it. If beekeepers do not intervene, these mites can destroy a colony within two years. As BartJan Fernhout, former Head of R&D Boxmeer at MSD Animal Health, explains, “Some honey bees in Europe and America are removing infested offspring. This shows that VSH already exists in our colonies. And we can help to get that behavior more broadly established.” To this end, Fernhout founded the non-profit Arista Bee Research Foundation in 2013.

The goal is to breed *Varroa*-resistant honey bees.

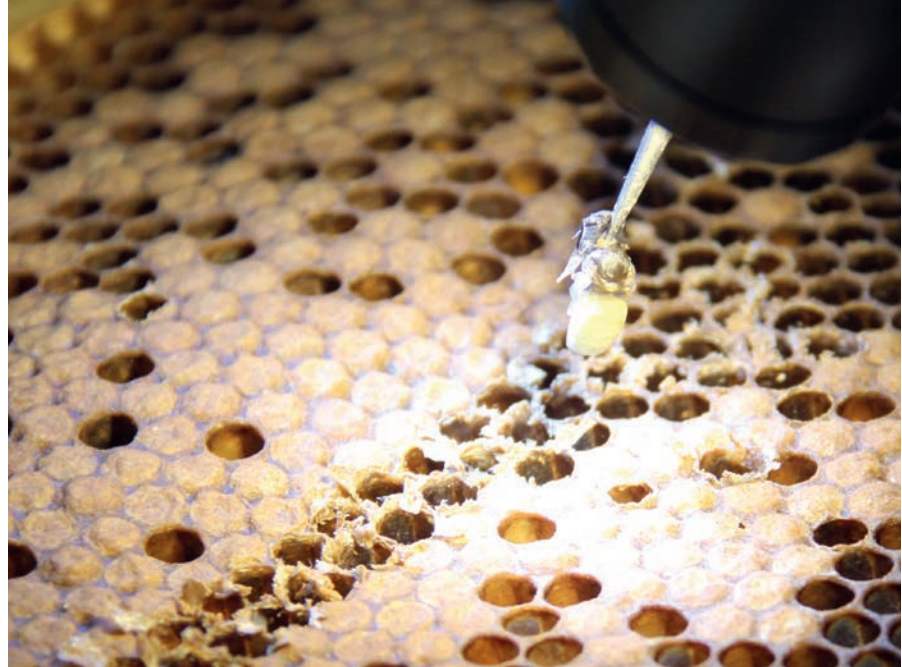


The midget danger: If beekeepers do not intervene, the *Varroa* mite can destroy a colony within two years.

## AT A GLANCE

- // The *Varroa* mite is the key threat to the Western honey bee.
- // However, some bee colonies developed the capability to remove the parasite from their hive.
- // The Arista Bee Research Foundation hopes to strengthen and establish this behavior through breeding.





Together with many volunteer beekeepers, BartJan Fernhout aims to breed *Varroa*-resistant honey bees in Europe. For this, they open the capped brood cells and count the mites inside in painstaking manual work.

This is also a personal matter for Fernhout, a Dutch medical biologist. “With a few interruptions, I have kept bees since I was a boy. But I had my share of problems fighting the *Varroa* mite. When I lost my two best queens using a well-intended treatment, I made my decision: stop beekeeping or come up with a better solution.” In his search for a solution, Fernhout came across VSH. American researchers from the US Department of Agriculture, USDA for short, have already bred honey bees with this trait and have established a research population. So Fernhout wanted to try it with the European breeding stock as well.

Starting a year ago, the newly created project team of beekeepers selected the most promising parent bees in advance from beehives with a relatively low level of mite infestation. In addition, the general hygienic behavior was studied by freezing a small portion of the brood in the beehive using liquid nitrogen and observing how quickly the worker bees removed the dead offspring. If they do this quickly and the same colony also has a lower *Varroa* count after treatment, then the more likely they are to carry the genes involved in the desired VSH trait. A queen and a drone from promising colonies are crossed. The project team,

composed of experienced beekeepers from Belgium, Germany, France, The Netherlands and Luxembourg, have already done this more than 100 times. They then subjected the resulting colonies to a real endurance test: They ensured the bee colonies had a lot of *Varroa* mites and left them to their own devices. After three months, the researchers and volunteer workers patiently counted the adult and juvenile mites in the brood of the colony. The effort was worth it: “More than 20 colonies with the European background clearly showed a VSH behavior,” explains Fernhout. “That’s a very good result.”

## The trick is to cross a queen with only one drone.

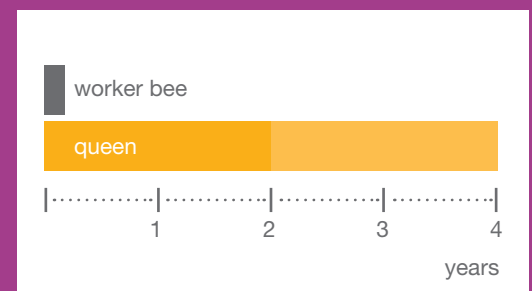
Normally, up to 15 drones mate with a queen on her nuptial flight. “However, if only two of her mates pass on VSH, not enough worker bees will engage in the clean-up behavior. This means that it is very difficult to find and select for VSH,” explains Fernhout. “However, if we select a promising drone as the sole father, we get a homogeneous bee colony.” All the worker bees are then siblings and behave in a similar fashion.

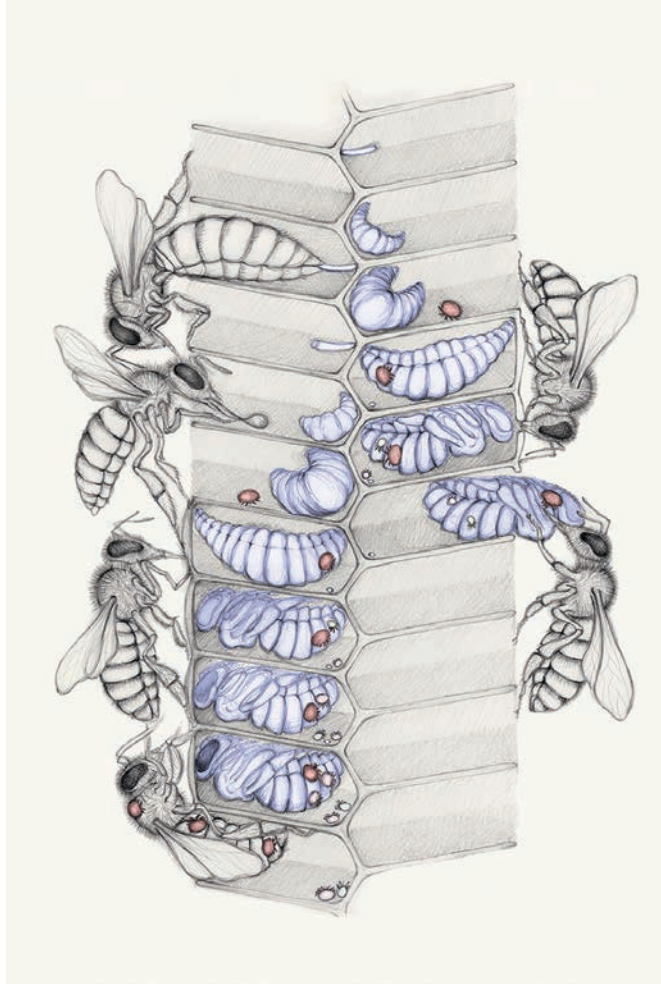
## Royal wedding

A queen bee takes up her royal duties early on. She begins her nuptial flight at the age of one week. Ten meters up in the air, she mates with up to 15 drones from different colonies. Having multiple fathers means that the resulting bee colony is genetically more diverse and thus more robust. However, natural mating cannot be controlled well enough to allow for targeted bee breeding. Therefore, the queen is generally artificially inseminated or mated on isolated places.

## Royal Age

The lifespan of a typical worker bee is 3 to 6 weeks, whereas the queen can live for 2 to 4 years.

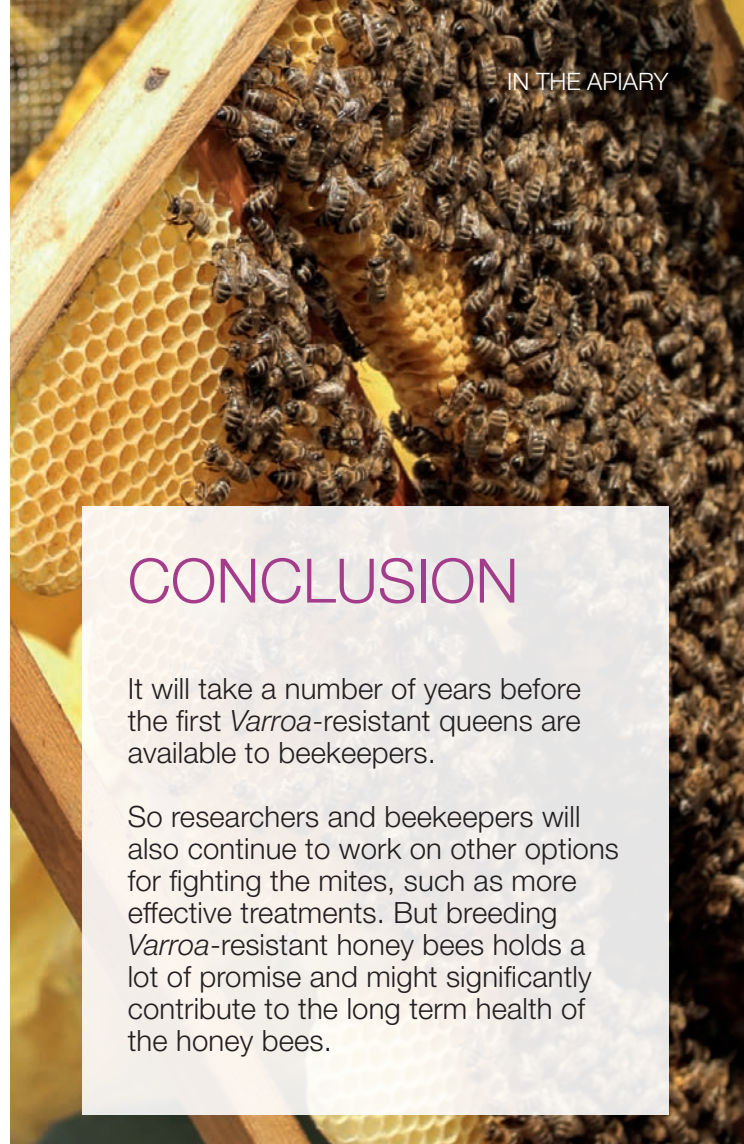




On the left side the illustration shows the normal development of honey bee brood infested with *Varroa*. The right side shows what happens if the bees have inherited the VSH trait: Worker bees detect the *Varroa* in the closed cell, open it and remove the pupae, hence preventing the mite from reproducing.

But the bees can do even better: Five American colonies were able to remove almost all the mites from their hive, bringing the *Varroa* infestation level from 20 - 40 to only 1 - 2 percent. The colonies were created with imported USDA-VSH sperm from the research population. In addition, the bee researchers and volunteers want to continue the breeding with subsequent European queens and bring this high-quality breeding stock also to 100 percent VSH – and a complete removal of the mites.

However, one problem had to be resolved: Queens that are paired with just one drone only lay eggs for up to six months instead of the normal three to four years. But the beekeepers cannot continue breeding the offspring until the following spring. The winters are too cold in northern Europe for the bees to mate and lay eggs. In order to speed up the project and to safeguard the high level of VSH, Fernhout and his colleagues therefore traveled to warmer, southern regions. “We transported the twelve most promising colonies to Spain. There we can breed a new generation up to the end of November. In addition, the warmer winter will support the survival of the newly-created queens and colonies,” explains Fernhout.



## CONCLUSION

It will take a number of years before the first *Varroa*-resistant queens are available to beekeepers.

So researchers and beekeepers will also continue to work on other options for fighting the mites, such as more effective treatments. But breeding *Varroa*-resistant honey bees holds a lot of promise and might significantly contribute to the long term health of the honey bees.

He is optimistic that the project will be successful. The ultimate goal is now significantly closer. “We want to establish the VSH trait in as many honey bee lines as possible,” says Fernhout. Until then, however, many queens still need to be bred. For this purpose, the young foundation is building up a solid collaborative network among universities, institutions and beekeeping groups.

More resources are needed to build out the technologies and create a breeding program of sufficient size.

For that the non-profit Arista Bee Research Foundation is also dependent on funding. The support of governments, private sponsors and corporations is needed to fund the breeding program. As well as financial support, Bayer will also help to make the breeding more efficient. The scientists hope to develop a genetic marker test that could locate the VSH genes in the bees’ DNA. “Then we could significantly speed up the selection of the queens,” says Fernhout. For the researchers and volunteers, that would be another big step on the way to *Varroa*-resistant honey bees.

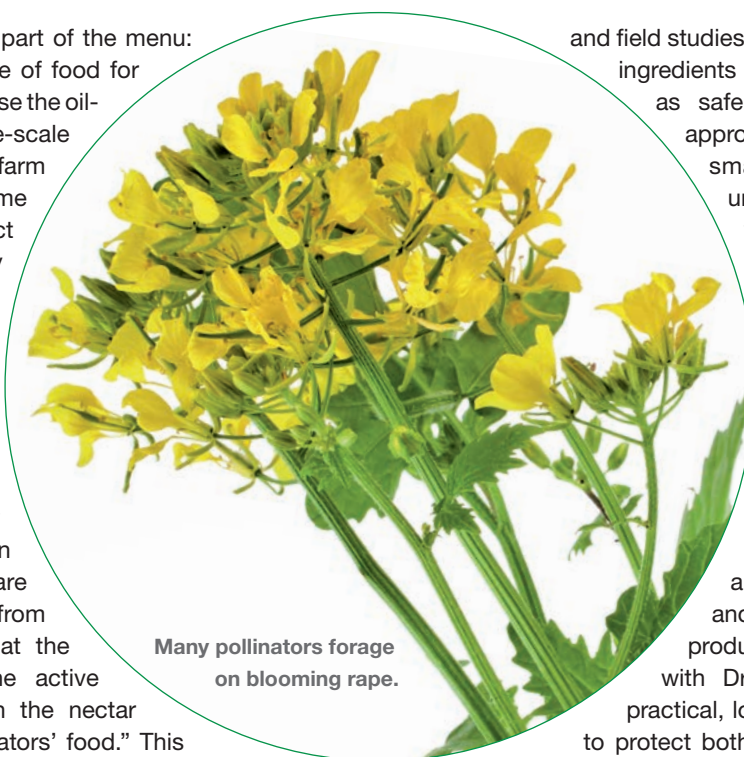


# LOWER APPLICATION FOR HIGHER PROTECTION

*There is some potential for tension between farmers and beekeepers. The one must keep pests in check, while the others fear for the health of their bees. But bee and crop protection can work in harmony – as a collaborative project in Germany shows.*

The yellow blooms are a major part of the menu: rapeseed is an important source of food for honey bees. This is largely because the oil-rich plant is a very important large-scale crop, flowering in spring in the farm fields of Europe. However, in some cases, honey bees may collect not only pollen and nectar. They might also inadvertently pick up crop protection products – used by farmers to protect their flowering rapeseed crops from fungal diseases and harmful pests.

“Open blooms are inevitably treated with pesticides when conventional spray methods are used,” says Dr Klaus Wallner from the Apicultural State Institute at the University of Hohenheim. “The active ingredient then accumulates in the nectar and pollen, that is, in the pollinators’ food.” This normally should not be a problem for the insects, because before crop protection products are approved for agricultural use, their impact on pollinating insects is rigorously and extensively tested in laboratory



and field studies. Only those active ingredients that are classified as safe for use receive approval. However, very small amounts of unwanted residues, which are still below the acceptable threshold levels, can find their way into honey.

Bee researchers and representatives of the manufacturers of application devices and crop protection products are working with Dr Wallner to find practical, long-term solutions to protect both bees and crops.

They are trying out a new approach for pesticide application that works in favor of both beekeepers and farmers: They have developed a spray technology that applies the active ingredient to crops, such as rapeseed, in

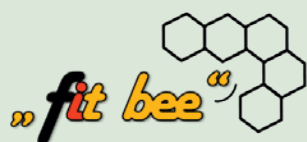
## AT A GLANCE

- // Rapeseed is a large-scale crop in Europe.
- // The yellow blossoms are also an important food source for pollinators, such as honey bees.
- // A new application technology for crop protection products can benefit the pollinators, as it reduces residues in pollen and nectar.



### Droplegs

The researchers developed hook extensions that hang from the spray machine. They apply crop protection products below the flowering level.



The “Dropleg project” is part of the Germany-wide collaborative project, FITBEE, supported by the Federal Ministry for Food, Agriculture and Consumer Protection in Germany. Its aim is to gain a better understanding of the interactions between bees and their environment, in order to protect bee colonies from diseases and other threats.

a way that prevents bees from coming into contact with it. Individual measures are limited in the help they can offer – a more comprehensive approach is required. That is why fourteen research institutions and companies, including Bayer CropScience, are participating in FITBEE to examine the various influences that can affect honey bees. The Dropleg project focuses on answering the question, “How can we reduce the chance of bees coming into contact with crop protection products?” The researchers’ idea was to lower the spray nozzles on the machines applying the products. “Instead of spraying above the crops and onto the rapeseed blooms, the active ingredient is applied from below onto the green parts of the plant,” explains Dr Wallner, who heads up the research project.

The Metzingen-based partner company Lechler, a spray equipment manufacturer, modified a conventional crop sprayer: Hook extensions – so-called droplegs – were mounted onto the several-meter-long spray boom. The nozzles hang from the spray machine like the teeth of a large comb and are pulled through the rapeseed field. Researchers at the University of Hohenheim compared crops that were sprayed from



**Dr Klaus Wallner**

Apicultural State Institute,  
University of Hohenheim, Germany

*“Instead of spraying above the crops and onto the rapeseed blooms, the active ingredient is applied from below onto the green parts of the plant.”*



above, as is normally done, with those treated from below with the new dropleg spray technology. They collected and analyzed honey samples from beehives that were placed next to the rapeseed fields. The researchers also caught bees as they were flying back to the hive and took samples from the pollen pellets on their legs and from their honey stomachs. The result:

The pesticide residues in the pollen fell to just under a quarter of the normal amount with the new technique – compared with the conventional method they had used.

The projects partners Bayer CropScience and Syngenta Agro conducted so-called tent experiments, constructing large flight tents over the rapeseed plants. “This simulated the worst-case scenario, which is that the insects collect pollen just from the treated rapeseed field and not from any other plants,” says Dr Christian Maus, Global Pollinator Safety Manager at the Bayer Bee Care Center. Yet the suspended spray nozzles also performed very well in these tests: Residues found in bee colonies, which have been foraging on oilseed rape treated with dropleg spray equipment were substantially lower than in colonies from conventionally treated rapeseed crops.

The new technique benefits not only pollinators but also farmers because the crop protection products are applied between the plants, reducing the impact of wind and thus lowering drift losses significantly.

There is also no compromise in efficacy of the product. And even pests on the blooms are caught out: When the droplegs comb through the rapeseed, they shake the blooms, causing pests like the cabbage seed weevil to fall off onto lower leaves. There they then get sprayed with the crop protection products. This process does not damage the crop plants because of their considerable ability to bend and straighten again afterwards.

Dr Wallner: “The project is a win-win situation for all parties involved.”

Oilseed rape is used now as a model culture for the development of the technology, which may also be used in other crops in the future. After the first promising results in rapeseed fields, the partners are already planning the next steps. “We are investigating how effective the application technique works against fungal diseases and weevils, independent of its impact on bees,” explains Dr Wallner. If it proves to be as effective as conventional methods, everyone stands to benefit. Beekeepers could let their bee colonies visit rapeseed fields without any worries of unwanted residues in the honey, farmers would have more effective crop protection with less drift and machine manufacturers could also further develop their products.

The dropleg technology is developed in oilseed rape as a model culture. But the machinery may also be used in other crops in the future.



## CONCLUSION

With the dropleg technology, crop protection products are applied below the blossoms. This benefits farmers and the environment as it reduces drift losses dramatically with no compromise to the product efficacy. The concept has proven useful in rapeseed but may also be used in other crops in the future.



# BLUEBERRY BALANCE

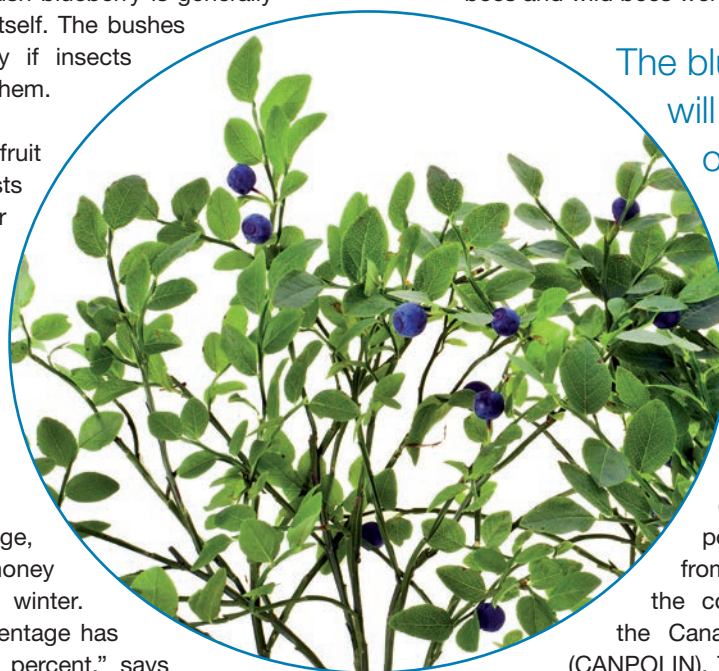
*Canada's honey bee and wild bee populations are facing challenges - due to many different factors. This could become a problem for the food chain and for agriculture, since many crops rely heavily on insect pollination. Experts from several universities came together in a nationwide 5-year research project to try and work out what is going on.*

The North American lowbush blueberry is one of Canada's top exports. The berries owe part of this success to honey bees, bumble bees and wild bees. This is because the lowbush blueberry is generally not capable of fertilizing itself. The bushes will produce berries only if insects handle the pollination for them.

But now the famous fruit may be in crisis. Harvests are shrinking because, for years now, the number of wild bees bustling around the blueberry bushes has been falling and honey bees have been in short supply. The downward trend is visible throughout the country.

"In the past, on average, about 10 to 15 percent of honey bees colonies died each winter. In recent years, that percentage has spiked to as high as 35 percent," says David Drexler, who is a plant physiologist, the

president of Researchman Consulting Inc., and a former Bayer employee. "For a long time we could only speculate about why this was happening and about what state the bumble bees and wild bees were in."



The blueberry bushes will produce berries only if insects handle the pollination for them.

This led Canada to take stock of the situation. In a nationwide research project to assess the current status of the pollinators, 44 scientists from 26 universities across the country joined together in the Canadian Pollination Initiative (CANPOLIN). They spent more than five years investigating Canada's bustling buzzers.

## AT A GLANCE

- // Blueberries are one of Canada's top exports.
- // Insects pollinating the blossoms enable development of the fruit – as they do with other cultivated plants.
- // However, Canada's pollinator populations face challenges.
- // A nationwide research project that has investigated the multifactorial causes, finished this year.

Source: 2014 "Pollination in Lowbush Blueberry: A Summary of Research Findings from the Canadian Pollination Initiative" 42 pp. ISBN 978-0-9680123-8-3 available online at [uoguelph.ca/canpolin](http://uoguelph.ca/canpolin).

The experts came from the fields of entomology, plant protection, plant population genetics, ecology and genomics. Their tasks included working out how many pollinator species the country has and why the numbers of some species are declining. They also analyzed how land management, adverse weather effects and crop protection products are affecting the insects.

Bayer supported parts of the project, that finished earlier this year, funding and provided researchers with advice from an industrial perspective. Drexler, who worked at Bayer during that time, was one consultant in question: “CANPOLIN created a basis from which we can better follow, and have a positive influence on, the future lives of our managed and wild bee populations.”



CANPOLIN researchers counted some 800 different bee species – and that’s just in Canada. Estimates put the global figure at around 25,000. However, the multitude of species has nothing to do with the challenges bees are facing in Canada. There are many reasons for this: “The challenges to pollinator populations is a multifactorial problem,” says Dr Peter Kevan, Professor Emeritus at the University of Guelph, Canada and the Scientific Director of the Canadian Pollination Initiative.

For instance, the CANPOLIN experts managed to identify the chief culprit in the decline of the honey bee: It is the *Varroa* mite, a bee parasite dreaded the world over. “Combating the problem will probably be a huge challenge because the mite is already resistant to many varroacides,” Drexler says. To find out which mites are resistant to which varroacides, Bayer is currently collaborating with Rothamsted Research in the United Kingdom, who have specialized in tackling resistance issues. Weather conditions are another big problem for Canadian pollinators, as it varies the duration of the seasons. So the bees’ favorite blossoms might

*“CANPOLIN has created a basis from which we can better follow, and have a positive influence on, the future lives of our managed and wild bee populations.”*



**David Drexler**  
President of Researchman  
Consulting Inc.

Blueberry flower (left), fruit (middle) and ready to eat (right).



bloom earlier or later than usual. It’s impossible for the insects to re-adapt every year, which means they struggle to find enough food. And agriculture doesn’t help much. Blueberry bushes, which cannot flourish without bees, are part of the recent problem. “That’s because they’re grown in large areas and in monocultures,” explains Dr Kevan. This means farmers do their best to keep their fields free of any other kinds of competing flowering plant.

Unfortunately, managed and wild bees need exactly these types of plants to survive. Especially wild bees love the nectar and pollen they find in the blueberry blossom, but if this is the only food on the menu, they won’t be getting any of the other important nutrients they need. We humans would have the same problem if we did not eat a balanced diet and ate the same thing every day – even if it was something as healthy as tomatoes. What’s more, blueberry bushes are only in bloom for a few weeks of the year. When the fruit forms in summer, the bees lose their source of nourishment.

*“The challenges to pollinator populations is a multifactorial problem,” says Dr Peter Kevan, Professor Emeritus at the University of Guelph and the project’s scientific director.*





**Dr Peter Kevan**

Professor Emeritus at the University of Guelph and the Scientific Director of the Canadian Pollination Initiative

*“We need to come up with some unconventional ideas – and collaborate with growers in the process even more than we do now. The CANPOLIN project has achieved a lot and produced good ideas for further research. But there is still a long way to go before all the bees are completely healthy and harvests across the country start to improve.”*

CANPOLIN researchers counted some 800 different bee species – and that’s just in Canada. Estimates put the global figure at around 25,000.

“Unfortunately, there’s no simple solution for our pollinator problems,” says Dr Kevan, summing up the findings of the CANPOLIN study. “We need to come up with some unconventional ideas – and collaborate with growers in the process even more than we do now.” By that he means organizing joint research projects, such as CANPOLIN has done with blueberry producers, and other collaboration projects that aim to develop new ways of combating pests like the *Varroa* mite. This will also help researchers better understand the basic links between the various stress factors. Dr Kevan also sees a need for better, closer collaboration between beekeepers and blueberry growers. Both sides stand to benefit from drawing up joint land management plans.

A farm on Prince Edward Island in eastern Canada is already proving that this can work, with bee researchers, beekeepers and blueberry growers all working hand in hand. Wild roses and other wildflowers grow in between the blueberry fields to help provide a healthier diet for the pollinators. The result: more insects and better harvests. “Production levels are now almost as good as they were a decade ago,” says Dr Kevan. He concludes: “The CANPOLIN project has achieved a lot and produced good ideas for further research. But there is still a long way to go before all the bees are completely healthy and harvests across the country start to improve.”



A farm on Prince Edward Island in eastern Canada is already proving that finding new ways of combating pests can work, with bee researchers, beekeepers and blueberry growers all working hand in hand.

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## Trembling flowers

The blueberry blossom doesn't make life easy for pollinators. Any bee that wants to collect its protein-rich pollen needs to work hard to get to it. This is because the pollen is tucked away in a tubular pouch, with only a small opening at the bottom end. Fortunately, bees like bumble bees are very resourceful creatures. They grip the blossom, hold on tight and begin to tremble. This creates vibrations that shake the pollen out of its cover.

The bees use this approach on about eight percent of all flowering plants, such as tomatoes, peppers, eggplants, and cranberries. Experts call the technique buzz pollination.

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## CONCLUSION

There is no simple solution for the pollinator issue in Canada. However, the CANPOLIN initiative has cleared the way for further collaboration projects to better understand the combination of stress factors and to develop solutions.



# COMBATING VARROA

*If young bees have deformed wings and larval bees die in the cells before hatching, one thing is certain: The honey bee colony is in great danger. Varroa mites and Varroa-transmitted viruses are usually the cause of this disaster. A study in the German Main-Kinzig district, carried out by the Frankfurt University Bee Research Institute, shows how this parasite can be efficiently kept in check.*

## AT A GLANCE

- // The *Varroa* mite is one of the biggest challenges beekeepers face in Europe and North America.
- // Beekeepers participating in a five-year-long field study, only had overwintering losses of less than 10 percent
- // To prevent resistance mechanisms, beekeepers need to alternate active components.

The Western honey bee's biggest enemy is not much larger than a millimeter in length. And the name of this parasite says it all: *Varroa destructor*. The tiny arachnid kills off entire honey bee colonies – and brings despair to beekeepers, particularly in Europe and North America. This is because *Varroa* mites are a huge threat to the health of these important pollinators. The parasitic pests transmit – much like ticks – dangerous viruses that can be fatal to bees and their brood. Over the past few years there have been massive die-offs of honey bees in many different countries.

“In 2011 and 2012 *Varroa* mites decimated a third of the bee population in Germany alone, that is some 300,000 of the country's one million colonies,”

says Professor Bernd Grünewald, Director of the Bee Research Institute in Oberursel. “In August and September beekeepers do little else besides fighting the *Varroa* mites,” says Dr Klemens Krieger, Head of Global Development Special Projects/Bee Health at Bayer HealthCare Animal Health. This is because a beekeeper's most important task is to get the bee colony ready for overwintering.

“It is important to attack the mites on different fronts. Employing various mechanisms of action helps to prevent resistance.”

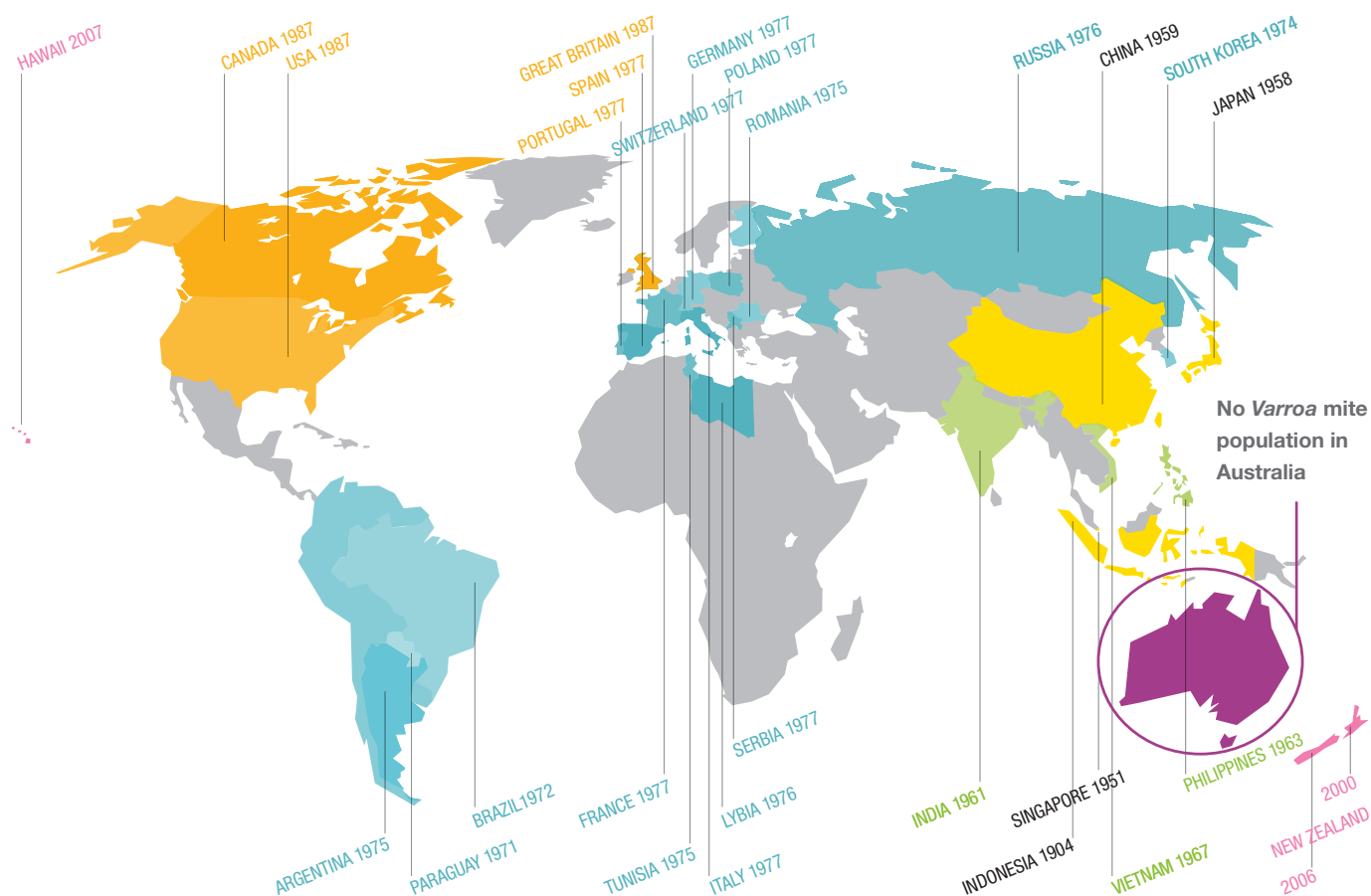


The *Varroa* mite, seen on the bee's leg, is a dangerous parasite to honey bees.



The eight-legged *Varroa* mite is only 1.6 mm in size but looks threatening under the electron microscope.

## World map showing the expansion of the *Varroa* mite



Bee experts around the world agree that *Varroa destructor* poses the greatest threat to Western honey bees. During a five-year-long field experiment in the Main-Kinzig district in central Germany, researchers at the Bee Research Institute worked with beekeepers to investigate how the deadly foe might be efficiently combated. The experts focused their efforts on an alternating treatment regimen that used two types of compounds. “It is important to attack the mites on different fronts. Employing various mechanisms of action helps to prevent resistance building up,” explains Dr Krieger. More than 2,000 honey bee colonies were involved in the study, which concluded at the beginning of 2014. The core part of the study targeted 150 representative colonies from 18 different beekeepers. A particularly positive aspect was that two thirds of the beehives in the region took part in the study. “This enabled us to comprehensively monitor how the colonies responded to being treated with alternating anti-mite compounds, which are called varroacides,” explains Dr Krieger.

The beekeepers began administering the highly effective varroacides after the honey harvest. All bee colonies participating in the trial in both rural and urban areas were treated over the same period of time. The medications were alternated every year to prevent the *Varroa* mites from developing resistance to the varroacides.



## DID YOU KNOW?

*Varroa* mites are 1.6 mm in size. On a human scale, this would be equivalent to a person being attacked by a parasite the size of a rabbit.



“Plastic strips containing one of the active ingredients are applied in the space between the combs of the brood chamber,” says Dr Krieger. The bees pick up the active ingredient when they crawl on the strips and then, as they rub up against each other in the hive, they pass the compound on to other bees – and also the mites. The varroacides kill the mites on contact and they then drop to the floor of the hive. Researchers working on the field experiment in the Main-Kinzig district kept weekly records of the number of dead parasites they found on the hive base.

The experts at the Bee Research Institute analyzed the data from the five-year field experiment at the beginning of this year. Professor Grünewald: “We collected reliable data over a large geographical area and over many years. These show that a comprehensive treatment regimen not only controls the mites infesting the colonies but also mites being introduced into to hives from other infested colonies which are not being treated simultaneously.” The results also demonstrate that beekeepers participating in the trial were very successful in overwintering their colonies. “This figure was considerably higher than 90 percent in every year except one,” reveals Professor Grünewald. The experts also had success on another front: They did not observe any kind of resistance being established.

But the bee experts were in for an unpleasant surprise: In spite of successful treatment, the colonies in the study showed differing levels of mite infestation again the following year. As long as there were untreated or unsuccessfully treated colonies around, they could re-infest one another over and over again, as honey bees from stronger colonies robbed weaker ones nearby of their winter reserves as external food resources began to dwindle in autumn. Unfortunately the bees didn’t bring back just food – but new *Varroa* mites as well.

“We were especially amazed at the extent to which the colonies became re-infested,” says Associate Professor Dr Stefan Fuchs, a staff member of the Bee Research Institute in Oberursel. “In some cases, more new mites were brought into the colonies than were originally present,” he explains.

The researchers also investigated whether there were traces of varroacides in the beeswax and honey. The Apicultural State Institute in Hohenheim analyzed both representative honey and wax samples, every year. The result: When the combs located next to the strips containing the active ingredient were removed before the honey harvest, no residues were found. Dr Krieger: “Good beekeeping practices include a well-thought-out beeswax management and a separation of brood and honey chambers. If this is carried out rigorously by beekeepers, varroacides cannot end up in bee products.”

The study in the Main-Kinzig district shows that it is only possible to bring the *Varroa* problem under control with a joint strategy – and that beekeepers carry a large responsibility for honey bee health. “It is therefore all the more important that beekeepers talk openly about their successes and failures and discuss ways to work together wherever possible,” concludes Professor Grünewald.



#### Potent plastic

The varroacides are embedded in plastic strips that are applied between the combs.



#### Professor Bernd Grünewald

Director of the Bee Research Institute, Oberursel, Germany

*“Our data shows that a comprehensive treatment regimen not only controls the mites infesting the colonies but also mites being introduced into to hives from other infested colonies which are not being treated simultaneously.”*

## The mite profile

*Varroa destructor* mites infest honey bees living in hives. Outside of the breeding period, female mites live as ectoparasites on adult worker bees. They find their way to the soft intersegmental membranes. There they pierce a hole and feed on the bees' hemolymph, a circulatory fluid similar to blood. This enables the mites to transmit pathogens such as the Deformed Wing Virus (DWV). Infected bees have such poorly developed wings that they are unable to visit flowers and collect pollen. DWV is transmitted solely by the *Varroa* mites.

The mites reproduce in the sealed brood cells of bee colonies. Shortly before the cells are capped with wax, the female mites move into these brood cells and slip under the young bee larva, feeding on their hemolymph. On the bottom of the brood cells they then lay their eggs. Acute DWV infections often cause bees to die in the cells before hatching – thus threatening the survival of the entire colony.

## CONCLUSION

Beekeepers carry a large responsibility for their honey bees' health. But they can bring the *Varroa* mite under control – with good beekeeping practices and a harmonized control strategy.



# A NUTRITIOUS BOUNTY OF BLOSSOMS



*In many places today, bees are hard-pressed to find enough nectar, particularly in the late summer. They are now getting a helping hand from the Areas in Bloom project started by Bayer.*

Honey bees act like squirrels: They gather stocks of food in the summer so as not to go hungry in the winter. They turn the nectar they collect from flowers into honey, which enables them to feed themselves and their brood during the cold months. A bee colony needs about 20 to 25 kg of honey as food, to get through the winter. And to produce one pound of honey the colony's 20,000 to 60,000 female worker bees have to fly up to 88,500 kilometers – more than twice around the globe.

However, even the busiest of bees will not be able to make their quota if there is a lack of diverse forage. On the fields of Europe and North America, most of which are intensively worked, the busy insects do not find enough food or, more importantly, a sufficient variety of nourishment. Wild bees and other pollinators such as butterflies are also suffering from the inadequate supply of food, because, unlike honey bees, they do not have beekeepers offering them sugar syrup when nectar and pollen are not available.

Field poppies and cornflowers are popular food sources for pollinators.

“Our aim is to improve forage diversity for bees and other pollinators in rural areas while also increasing the number of flowered areas and linking up existing structures,”

says Fred Klockgether, a beekeeper and bee health consultant for Bayer. “To contribute to that we have provided flower seeds to some 30 municipalities in Germany and Austria that have created nutritious blooming strips and fields that are beautiful at the same time.” Large stretches of nourishing blooms are also popping up at Bayer’s plants and offices throughout Europe and North America – and plans are underway to make the rooftop of the Bayer Information Center (BayKomm) in Leverkusen more attractive for bees and

## AT A GLANCE

- // Honey bees, wild bees and other insects do not find enough food on intensely worked fields of Europe and North America.
- // Cities also often lack forage diversity for pollinators.
- // Flower seed mixtures from Bayer help restocking food sources for insects in rural and urban areas.



# INTERVIEW

Dr Sophie Denise-Lecat

In charge of sustainable development at Bayer CropScience in France

visitors alike. So far, the Bayer initiative has led to the planting of almost 1,000,000 m<sup>2</sup> of wildflowers, an area that is twice the size of the Vatican City, the world's smallest country.

The first results show that strips of flowers in both town and country are doing the pollinators a world of good. This became evident in Bayer's cooperative study "Pollinator Diversity in Southwestern Germany," where test plots, ecologically enhanced with an abundant supply of wild flowers, showed a steep increase in both species diversity and the number of wild bees and butterflies (see pages 26 to 29). This effect has also not gone unnoticed by amateur gardeners, as the bags of mixed seeds have been on sale in many gardening and home-improvement stores in Germany and Austria. It takes about six weeks for a monochromatic stretch of green grass to be transformed into a colorful sea of blossoms. And nature lovers can enjoy this splendor without having to do a whole lot of work: The wildflowers need little water to grow and only have to be mowed or scythed once or twice a year – which makes them the perfect solution for urban areas, for example along bike paths or on traffic islands.

The flowered areas even indirectly help protect plants in the city and on the farm. This is because they provide food and habitat for insects that hunt down harmful plant pests. Ladybirds,

for example, feed on plant-sucking aphids. This will benefit those farmers who plant strips of flowers alongside their fields. And important pollinator insects, like bees, will be abuzz with excitement about the abundance of nourishing forage, which will enhance their diet.

## What response has the Bayer initiative "Areas in Bloom" had in France?

*"It has proven very successful so far. Dozens of employees have already sown the flowering plants in both their own gardens and those of their friends. What's more, lush stretches of blooming wildflowers have sprouted up at three Bayer locations in France, and we maintain test plots where we are studying the effects of this forage diversity in detail."*

## How are you getting the word out about the idea?

*"Along with our own promotional activities, we are relying on word-of-mouth publicity. And it's working. For example, Merville, a small town outside of Paris, recently contacted us to ask if we could also supply wildflower seeds there. Today, cornflowers and other wildflower varieties cover a total of nearly 5,000 square meters of the land in Merville."*



## DID YOU KNOW?



Bees need to visit some 2,000,000 flowers in order to produce 0.5 kg honey.



# THE SWEET LIFE FOR BEES

*Sugarcane is an important crop. Insects may also be attracted to the remaining stumps of this sweet grass once it has been harvested. If they really do has long been unclear. Now, a study funded by Bayer has filled in this gap in knowledge, making it easier to protect bees and Co.*

The sweet stalks are big business in Brazil: The South American country is the world's largest sugarcane producer. In 2013, this crop covered 9.8 million hectares – an area larger than Ireland. And the sweet grass is quite versatile: In addition to sugar, it can be made into ethanol fuel and the famous Brazilian liqueur Cachaça. The left-over fibrous matter, the so-called bagasse, is used to obtain energy and heat.

**Insects may also be drawn to sugarcane, though not to collect nectar and pollen.**

In fact, the plant is normally harvested before it even flowers. The stalks are then cut off close to the ground leaving short stumps. "The residual sweet sugar juice that comes out after the cane is cut may attract insects," explains Dr Christian Maus, Global Pollinator Safety Manager at the Bayer Bee Care Center. To protect the sugarcane from ground-dwelling pests, the remaining stubs are sprayed with insecticides. In this context, it also has to be ensured that harm to beneficial insects like wild bees, which still have further important pollination work to do for other crops, such as coffee, is avoided. Until now, scientists did not know for sure if honey and wild bees hang out in the sugarcane or at what time of day they may seek it out. "However, if we know whether bees can be found there and maybe even at what times, farmers can introduce insecticides at the optimal moment to avoid the bees. This makes it possible to both fight the pests and protect the beneficial insects," Dr Maus explains. The gap in knowledge is now being filled: In a study funded by Bayer, scientists from a partner laboratory investigated which, if any, bee species are attracted to the Brazilian sugarcane fields after the harvest.

## AT A GLANCE

- // After the sugarcane harvest, residual sweet juice runs out of the stalks and may attract insects to the fields.
- // Pests are controlled using insecticides, but to avoid harm to beneficial insects it needs to be ensured that they are applied at the right time.
- // A study funded by Bayer investigated which bee species are found at what time in Brazilian fields after the sugarcane harvest.







After harvesting, only stumps (left) remain on the sugarcane field. These are sprayed with insecticides to protect them from ground-dwelling pests. But the residual sugar juice leaking from the cuts may attract beneficial insects such as stingless bees (right), so it has to be ensured that harm to them is avoided.





## SWEET ENERGY

Biofuel from sugarcane is a hot topic in Brazil. These perennial grasses, which grow as tall as a man, can be used to produce many things besides sugar and ethanol fuel for vehicles. The fibrous material that is left over after the sugar juice is pressed out also supplies energy for electricity and heat.

# 740 million tons

have been harvested in Brazil in 2013.

Source: FAO

Brazil is the world's largest sugarcane producer. The sugar juice of the harvested sweet stalks also attract bees, as a study funded by Bayer found out. It was conducted in two of Brazil's large farming regions: Paraná and São Paulo.

The study was conducted in two of Brazil's large farming regions in the south of the country, Paraná and São Paulo, where more than half of the country's sugarcane is produced. On a total of 16 fields, the researchers investigated which species come to feast on the sweet cane juice after the harvest. To do this, they identified and counted bee species in the field on different days and at different times of day between October and December. When taking inventory, scientists made sure to collect data in the middle of the field as well as at the edge and about five to ten meters outside the cultivated area.

The result: "On both study sites, small numbers of bees were found after the sugarcane harvest,"

explains Dr Maus. The count of species and individuals depended on the exact location of assessment: When the researchers performed counts in the field themselves, they found markedly fewer bees in the fields than outside them. Most of the bees buzzing around the researchers' heads were honey bees or bees of the *Trigona* genus. The researchers also observed other species of stingless bees, identifying a total of 13 species. "Originally we considered it possible that we might not find any bees at all and there would be no chance of them potentially getting harmed by insecticides," Dr Maus says. "However, eventually just a few bee species were found. Also the number of specimens was quite low, especially compared to other crops that attract bees, like rapeseed or sunflowers."

The results help contribute to the basic understanding of the pollinator situation in Brazil. For example, the study clearly shows regional differences, with the scientists documenting significantly fewer species in Paraná than in São Paulo. It is these regional deviations which are precisely why the field studies are so important. However, the composition of the species does not just vary geographically. "In crops other than sugarcane, we may see very different kinds of bees," explains Dr Maus.

For this investigation, Bayer is collaborating with other companies within the industry and is also conducting studies on rice and maize, for example. Its partners Syngenta and BASF are also researching crops like coffee, cotton and citrus fruits. "We share our reports and results with one another," says Dr Maus.

"The more we all know about the habits of important beneficial insects, the better we will be able to protect them."



## CONCLUSION

The study shows one thing above all: Even within the same country and the same crop, the bee community can vary greatly. For this reason, Bayer, along with partners within the industry, is supporting additional studies on other crops, such as maize, citrus, and coffee.





PROPER APPLICATION OF FORMIC ACID  
FOR *VARROA* MITE CONTROL

# ACID VAPOR BATHS IN THE BEEHIVE

*It's an irritating affair for the Varroa mites: Formic acid is popular among beekeepers to protect their honey bees from these dangerous parasites. But if it's applied incorrectly, the acid can also harm the bees. A new study sheds light on the process.*

## AT A GLANCE

- // Formic acid is an important tool for beekeepers to fight the *Varroa* mite.
- // Bayer researchers investigated how the acid can be applied in an optimal way.



In diffusion studies the researchers tested how much formic acid finds its way through the brood cell caps.

When late summer comes around, it's time for beekeepers to undertake the painstaking task of getting their beehives ready for overwintering. This is crucial to ensure that sufficient numbers of honey bees survive the cold months of the year, thus enabling a strong colony to develop again in the spring. An extremely important part of this process is ridding the colony of deadly *Varroa* mites. The tiny parasites and the battle waged against them dictate the daily activities of nearly all beekeepers around the world. In this fight, a large number of European apiarists prefer to use formic acid. This liquid control substance offers many advantages, as it evaporates in the beehive. "Formic acid begins to act in the gas phase. That's how it's capable of penetrating into the sealed brood cells and killing off the mites feeding there," says Dr Ralf Nauen, an insect toxicologist and Bayer CropScience Research Fellow.

What's more, the mites are unlikely to develop resistance against the highly volatile organic acid after repeated treatment. This is because formic acid is not affected by metabolic enzymes conferring insecticide resistance. Compared to other acaricides it also bears a low risk of being accumulated, so residues are unlikely. Formic acid also controls *Varroa* mite populations which are known to be resistant to synthetic acaricides, such as pyrethroids.

However, formic acid can also have harmful side effects on honey bees, if the acid concentration during the treatment exceeds a certain level. On the other hand, if not enough formic acid evaporates, the mites are not affected. "The therapeutic window, in other words the concentration range between killing mites and damaging bees is very narrow," Dr Nauen explains. "It is therefore important that beekeepers know what concentration of formic acid to apply." But how the formic acid vapors are released also depends on the type of evaporator used and on the temperature. This prompted Dr Nauen together with Manuel Tritschler, at that time working as a bee expert and beekeeper at the Bayer Bee Care Center, to accurately test two different kinds of Nassenheider evaporators. Both devices are filled with 65 percent liquid formic acid that drops onto a mat, where it evaporates. However, the so-called vertical evaporator and the horizontal device differ in the rate the acid drops.

In collaboration with a master beekeeper, the researchers treated four honey bee colonies in August – two of each with one of the evaporators and at different temperatures. They then measured the dispersal of the formic acid vapor in the hive, while also regularly monitoring the concentration of the chemical in the air and how this changed over time. "We discovered some differences," says Dr Nauen,



To find out how formic acid distributes in the beehive, the researchers drilled holes into the chest and measured the acid concentration at different locations inside.

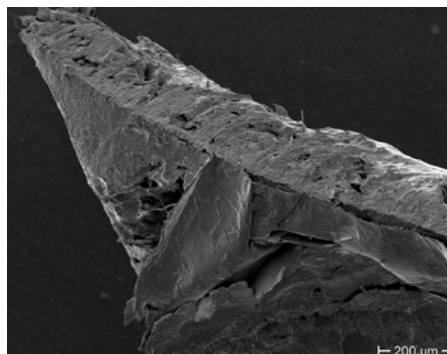
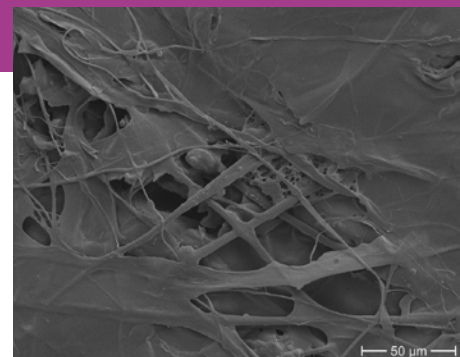
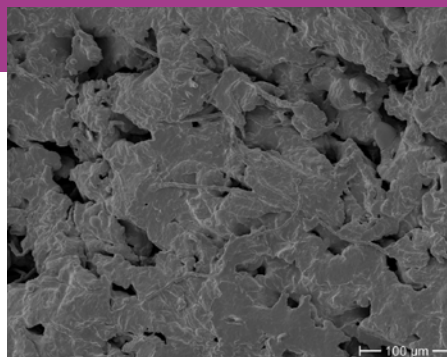
summing up the findings of the study. “Over a period of three days, the horizontal evaporator provided not only a fairly consistent concentration of formic acid but, most importantly, a sufficiently high level.” Also the vertical device managed to achieve this concentration, but in a less consistent manner, which means it was a bit slower in effectively protecting the bees from the *Varroa* mites.

Another finding: The higher the temperature, the better the chemical can vaporize and disperse throughout the hive.

“Beekeepers should avoid using these evaporators at low morning temperatures such as 15°C. Under laboratory conditions, temperatures of 25 to 30°C resulted in an ideal evaporation pattern,” says Dr Nauen. The findings of the study give beekeepers important data that can help them treat their hives more effectively – while also ensuring that they are well-prepared to combat the *Varroa* mites in the late summer to fall.

## Nature’s weapon

Formic acid not only protects against mites; the chemical, which was first extracted by scientists from some ants species, is produced naturally and used by the ants as a defense spray to ward off their enemies. The larvae of the puss moth can also squirt formic acid up to 30 centimeters when it feels threatened. Other creatures such as jellyfish, scorpions and beetles employ the substance to defend themselves, too. Even plants exploit the power of the chemical: The urticating hairs of stinging nettles also contain formic acid.



The close inspection under the electron microscope reveals: The sealed brood cells of a honeycomb are not air-tight. Formic acid can still diffuse through the caps, killing off *Varroa* mites inside.



## AT A GLANCE

- // Seed treatment is crucial for agriculture.
- // Unwanted dust can accompany treated seeds.
- // Bayer researchers are working on ways to prevent this dust.
- // Less dust means less potential risk for pollinators.



Field operation of Bayer SweepAir technology – one new way to make seed treatment even safer for pollinating insects.



# THE DUST TRAP

*Seed treatment products protect crops like rapeseed or corn from fungal diseases and insect pests. However, if particles of the protective layer which contain an insecticidal active substance are rubbed off the seed, they have the potential to harm honey bees, wild bees and other beneficials. Bayer researchers are working on making the entire seed treatment process even safer for beneficial insects and the environment.*

A thin, protective, multi-layer covering surrounds the seeds: Rapeseed, corn kernels, cereals, soybeans, and other crops are often coated with seed treatment products for crop protection. As the seeds germinate and grow, the active ingredient of systemic substances is later translocated in the roots or young plant shoots, protecting them from fungi and voracious insects. For many crops, seed treatment is essential – because if vulnerable seedlings are attacked by pests, the crops' growth and subsequent yield could be seriously reduced. By protecting plants early in this way, less crop protection products will need to be sprayed later, reducing the potential risk for beneficial pollinating insects. However, this is only true if the protective treatment stays where it is intended to exert its effect – on the seeds in the field.

To achieve this, seed treatment products need to be correctly applied to the seed by qualified professionals in the first place and carefully handled, stored and used by the farmer, as directed. Otherwise, they can be rubbed off the treated seed when being sown, making it difficult to totally avoid that the resultant dust may be emitted to the environment. This happened, for example, when corn was planted in certain regions of Slovenia and Germany in 2008.

Such accidents, though very infrequent, have strengthened objections to the use of neonicotinoid seed treatment products, which have fallen out of favor with the EU public in recent years. As a result, the European Commission restricted the use of such products. However, neonicotinoids are essential to farmers because they protect for instance rapeseed from the flea beetle, which is particularly causing damage to the young plants. These substances also kill wireworms, which feast on corn roots. Unfortunately, the reasons for negative incidents involving pollinators have often been simple: "Usually, the products were simply not used correctly or were of poorer quality," explains Dr Reinhard Frießleben, Head of Application Technology,

Bayer CropScience. "Significantly less dust is generated with higher-quality seed treatment products." Nevertheless, Bayer wants to make seed treatment products even safer to protect beneficial insects and their environment. Experts from Bayer CropScience and Bayer Technology Services are creating solutions together in the 'Zero' Dust project in order to further reduce the generation and emission of abraded dust during sowing of treated seed. 'Zero' in this context does not denote a "scientific 0.000..." for dust. It refers to all measures, which can help to reduce dust emergence and emission. Targets for mitigation levels depend on various factors such as crops, markets, treatment and sowing machinery types. The experts are taking a close look at the entire process, from the composition of the active substances and additives in the treatment coating to the planting of seeds in the field.

**For many crops, seed treatment is essential – because if vulnerable seedlings are attacked by pests, the crops' growth and subsequent yield could be seriously reduced.**

One sub-project is the development of SweepAir, a kind of vacuum cleaner for the seed sowing machine. Dr Lubos Urbka from Bayer CropScience who co-developed the technology explains its principle: "The abraded seed treatment dust, generated when sowing treated seed, is removed from the air, transported to the ground and buried just as the seed is." The core of this technology is a so-called cyclone separator used for cleaning the exhaust air generated by the sowing equipment's vacuum fan. The mixture of air and any rubbed-off seed treatment particles spins around in the



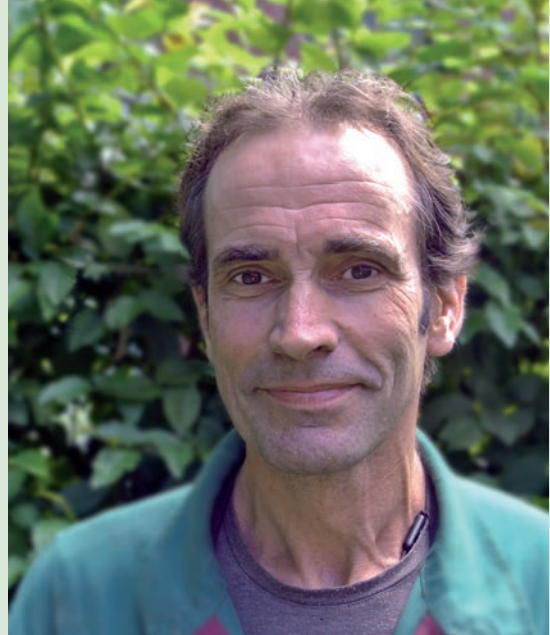
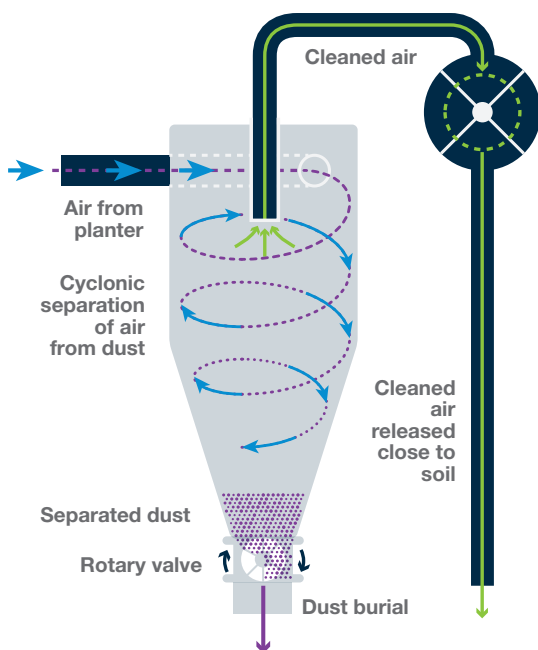
cyclone. The centrifugal force flings the dust particles onto the container's interior wall. From there, they trickle into a collecting tank and are then buried in the ground. The cleaned air is vented outside and let out close to the ground surface.

The renowned Julius Kühn-Institut in Germany has already tested the SweepAir system. In a standardized test, the experts assess the dust emission from sowing equipment systems in comparison to a reference machine that releases air and dust upward. Using the same test with the SweepAir cyclone system, 99 percent less dust was emitted into the air. "That is an enormous improvement," says Dr Björn Schwenninger, 'Zero' Dust project leader at Bayer CropScience, "even compared with the modified machines currently available, which release the air near to the ground. The so-called deflectors achieve dust reduction of approximately 90 percent in the standardized test. With SweepAir, the difference seen is an order of magnitude in dust reduction."

The new technology has proved convincing under controlled conditions. And the prototype that was developed has also been carefully tested in the field. "We can improve some aspects of the machine before the technology, hopefully, is taken up by an equipment manufacturer," says Dr Schwenninger. Farmers and mechanical engineers have already shown an interest – in part, for the sake of bees and their fellow pollinators.

## This is how SweepAir works

The planter exhaust air that may contain abraded seed treatment dust is guided into the cyclone. There the air spins around, flinging the dust particles onto the interior wall. They trickle down in a collecting tank from where they are buried into the ground.



## INTERVIEW

### The right approach

**Karl-Hans Wellen is a sub-contractor providing agricultural services. He tested the SweepAir prototype on his clients' fields.**

#### How did SweepAir perform in practice?

*"Sowing conditions were very dusty and dry here in 2014 – really hard on the equipment. It should be clear that we were testing a prototype. It still has a few glitches; for example, the equipment occasionally clogged. However, these things will be taken care of as the equipment is improved."*

#### How did your customers respond to the prototype?

*"Farmers are very environmentally conscious, and the SweepAir technology is a good approach to making agriculture more ecologically sound. Our customers with whom we tested the system were, therefore, very interested."*

## From the lab to the field

In the 'Zero' Dust project, experts from Bayer CropScience and Bayer Technology Services are working to further reduce the generation and emission of seed treatment dust and, thereby, make sowing treated seed even safer for pollinators and the environment. For example, they are investigating how to formulate seed treatments and film coatings so they stick better – by means of stabilizing additives or by varying particle size. They also want to improve the seed treatment application process itself. And since a little bit of dust always rubs off, they are also working on solutions to reduce the spread of dust in the field, for example with SweepAir.

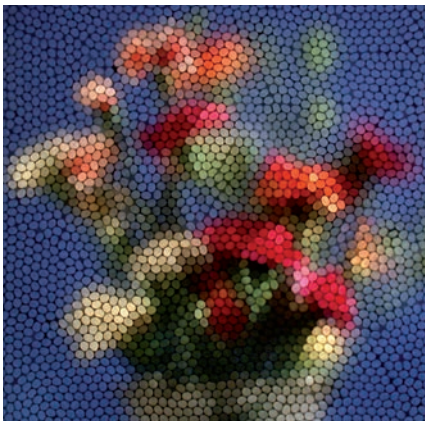
## CONCLUSION

The dust reducing Bayer technology SweepAir has proved convincing under controlled conditions and in a first practice test. We aim at collaborating with machinery manufacturers to make it available and at gaining acceptance by regulatory authorities.



# THROUGH INSECT EYES

*Seeing like a bee is not only an entomologist's dream. Understanding how their vision works and the relevant processes in the insect brain may even help greenhouse pollination and the evolution of camera technology.*



This is how a vase of flowers might appear to a bee considering **bee visual acuity**.



- A | Shows how we humans might see a flower
- B | Is the same flower photographed through a UV filter, as honey bees can see UV light
- C | Is the flower captured through an array of straws to simulate insect compound vision
- D | Shows a merge of the pictures processed on the computer and gives an idea of how a bee might see a flower

Having a thousand eyes instead of just two makes the world look a lot different: Honey bees and many other insects see through compound eyes. These consist of thousands of so-called ommatidia, each one acting like an individual simple eye. As they are located on an almost hemispherical surface on the head, they point in slightly different directions, offering a wide angle of sight.

The image the insects see is a combination of the input of all their ommatidia: The world through compound eyes doesn't look as sharp as through mammalian eyes, however, the insects can still easily detect very fast movements: 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 (UV) light which is not normally visible to humans. This comes in handy when searching for food: Special pigments in flowers 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 the dark area in the middle of the flower or dots indicate where the nectar is stored.

Yet honey bees also have a weak point in their vision as they cannot see the color red.

The liverwort (*Hepatica nobilis*) for example looks pink to us but blue to bumble bees.

Understanding the vision of bees and the processing of images in their brain can also boost other research fields. The Australian researcher Associate Professor Adrian Dyer of the RMIT University in Melbourne analyzes how bees learn and how they can even recognize human faces. Associate Professor Dyer has developed the

## AT A GLANCE

- // Honey bees and other insects see through compound eyes.
- // Perceiving UV light helps them to find nectar- and pollen-rich flowers.
- // Research on how bees process visual images might help the future development of cameras and even aerial vehicles.

## INTERVIEW



**Associate Professor  
Adrian Dyer**

is a vision scientist at the RMIT University in Melbourne, Australia. As a researcher he is interested in understanding how visual systems learn perceptually difficult tasks.

## Inside a bee's brain

### What fascinates you about bees?

*"These insects can solve amazingly complex problems with rather tiny brains. Some of the research done over the last twelve years even suggests that bees are able to solve problems at a level, which approaches what we see in mammalian systems."*

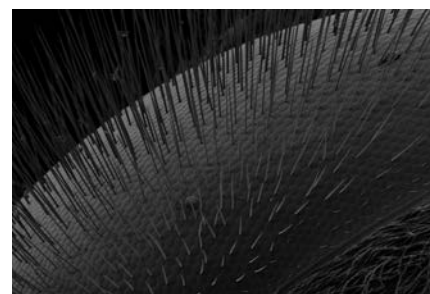
### How can technology benefit from your work?

*"One of the things we're working on is flying in a complex environment without crashing against things. The issue here is speed: If you have sensors on the front of an aerial vehicle, the data needs to be processed by a computer, which then has to drive a different system to avoid a collision. By the time this happens you have already crashed. For insects this is not a problem. So we try to analyze how the bee's brain is able to do this. The goal is for example to maybe improve the ability of unmanned aerial vehicles."*

"Bee Eye Camera" to see the world through the eyes of an insect. For this, he photographs e.g. a yellow flower through three special color filters and then overlays the pictures. This converts the light spectrum visible to humans into the UV-vision of honey bees, changes the contrast and transforms it into a colored version as a bee would perceive it; that is the yellow flower now appears pink. To simulate the compound eyes, the researcher uses a simple but effective method: He photographs the picture of the pink flower again through a wooden frame filled with thousands of straws. The result is a mosaic picture. With the aid of a computer, the bee researcher combines the different mosaic pieces into a normal picture, which appears slightly blurred.

Associate Professor Dyer is not only able to see like a bee. He also examines the way bees' process visual information in their brains. This might help the evolution of facial recognition in cameras: "There have been a lot of difficulties in producing algorithms that can reliably recognize people's faces when there is a change in viewpoint," he explains. So understanding how biological systems cope with these visual challenges could provide insights for software developers. Associate Professor Dyer: "The miniature insect brain may possibly provide some very efficient solutions that are easier to model than those we might derive from amazingly complex primate brains."

Fast flying insects, such as the honey bee, see up to 300 pictures per second – while we humans can only manage up to 65.



The picture above shows the eye of a honey bee in detail through an electron microscope.

Also bumble bees see their world through compound eyes (below).





# OUTLOOK

Thank you very much for your interest and for taking the time to read our new BEENOW magazine!

Our Bee Care Program and all related projects, some of them presented in this magazine, are a great example of what can be achieved if the relevant partners are willing to work together and look for opportunities to really make a difference to the health of bees and other pollinators. Whether it is the development of new technologies to further reduce potential risks of agricultural practices or research projects aimed at combating bee health issues due to malnutrition or diseases – each one can make a difference for bees and other pollinators.

We'd like to sincerely thank all project partners – externally and internally – for the insightful and inspiring collaborations and their great contributions and support for this magazine. We look forward very much to continuing our partnerships and jointly developing solutions to further improve the health of bees.

Throughout 2015, we'll present the results of additional projects on our website [www.beenow.bayer.com](http://www.beenow.bayer.com). Then, at the end of 2015, we'll publish the next edition of our BEENOW magazine. Stay tuned and register for our newsletter, if you'd like to be kept informed.



**Annette Schürmann**  
Head of Bayer Bee Care Center

We hope you now have a better understanding of some of the projects to promote better bee health which Bayer is involved in. If you would like to know more about any of the projects or want to share your feedback on this magazine, we would love to hear from you:

[beecare@bayer.com](mailto:beecare@bayer.com)



By working together,  
we can improve  
the health of bees.

**BEE PART.**

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