How banana plants kill root pests

By increasing local concentrations of plant toxins in infected root tissues, banana plants protect themselves from the parasitic nematode *Radopholus similis*. The toxins are stored in lipid droplets in the body of the nematode until the parasite finally dies. p. 4

How leaf beetle larvae fend off predators

Poplar leaf beetle *Chrysomela populi* larvae transport salicin, a substance from their leafy diet, from the midgut into the larvae’s defensive glands, where it is converted into the defensive compound salicyl aldehyde. p. 3

Why fruit flies prefer laying their eggs on oranges

A single odorant receptor controls the choice of citrus fruits as an egg-laying substrate in *Drosophila*. Laying eggs on oranges is advantageous, because parasitoid wasps feeding on *Drosophila* larvae avoid citrus fruits. The same smell that is attractive to the flies also repels the wasps. p. 5
Researchers of the future!

March 27, 2014 was the day of the 5th "science day for kids" (Forsche-Schüler-Tag): The Max Planck Institute for Chemical Ecology again invited school kids from the 8th grades of area schools to join scientists in the labs for hands-on experiments. Workshops focused on research questions in chemical ecology, for example, why does mustard have such a pungent flavor? what happens in insects’ brains when they perceive odors? what are symbiotic bacteria in our bodies or in those of insects good for? what roles do proteins play in a plant?

In the workshop "Natur vs. Douglas & Co. – a comparison of natural and purchasable scents – by means of GC/MS", students analyzed different odors, including those of their favorite perfume. Some of the substances they found were a real surprise, even for the scientists who supervised the experiment. Lena, Marie, Steffi and Georg had travelled to Jena from Ohrdruf and brought seeds of the horseradish tree *Moringa oleifera*. Using high-performance liquid chromatography techniques, they were able to determine the amount of glucosinolates in the seeds. Because of its high contents of essential amino acids, minerals, vitamins, and glucosinolates, the *Moringa* plant, which is also called the “miracle tree”, is thought to bring health. The four students will now continue to study the *Moringa* plant in more detail and are happy that scientist Michael Reichelt has offered to support their project.

In his concluding lecture “School is over – Now life really begins” for the 120 young people who had visited hands-on workshops in six campus institutes, Jan-Wolfhard Kellmann, research coordinator of our institute, provided some career guidance. In the context of a society which will be made up of fewer and fewer young people and more and more senior citizens, he encouraged the young participants to be optimistic about their professional futures, especially since their energy and creative ideas will be urgently needed.

The young students particularly liked the hands-on workshops which included them as active participants in the research labs and not just as spectators. 17-year-old Katrin summarized what many of the participants agreed on: “Organizing such a day for school kids is important and should continue in the future.”

Angela Overmeyer

Dear Readers!

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Leaf beetle larvae defense

Leaf beetle larvae are part of food chains. To protect themselves, some leaf beetle larvae emit a deterrent from their defensive glands in the form of little droplets on their back. The defensive substances in the secretion are synthesized by the larvae from chemical precursors, such as salicin, ingested when the larvae feed on leaves. Salicin is present in the leaf tissues of poplars and willows. A sophisticated transport network carries the precursors from the gut into the defensive glands.

Anja Strauß, who wrote her PhD thesis in the Department of Bioorganic Chemistry, unraveled the mystery of this transport mechanism. She studied gene transcripts in the secretory cells of the poplar leaf beetle *Chrysomela populi* and found a gene which is 7000 times more expressed in the glandular tissue than in the gut tissue. Gene sequence analysis revealed that the scientists had cloned the gene for a so-called ABC transport protein. Such transport proteins are widespread and also mediate multi-drug resistance, transporting substances potentially dangerous for the cell either away from the cell or into the tiniest cell organelles where they are rendered harmless.

Large amounts of *CpMRP* – as the scientists named the transporter – are located in the membranes of small bodies, the storage vesicles within glandular cells. As soon as the precursors of defensive compounds are ingested and reach the cells, they immediately accumulate in the cells’ abundant vesicles with the help of ATP, the molecular energy unit in the cell. This is where the name ABC transporter comes from: ATP-binding cassette transporter. The vesicles migrate within the glandular cells towards the reservoir, where they bind to the membrane of the large reservoir and distribute their contents. The defensive compound salicyl aldehyde is then produced from the salicin precursor. In case of danger, the repellent is secreted from the tips of the glandular tubercles as the larvae assume a threatening posture.

*CpMRP* functions as a pacemaker in this process: Thanks to its high carrying capacity, *CpMRP* lowers the concentration of salicin in the glandular tissue. As a consequence, there is a continuous and selective flow of salicin molecules via as-yet-unknown transport proteins from the larvae’s bodily fluid. Interestingly, ABC transporters form a huge network within the glandular cells of the leaf beetle larvae; this network efficiently absorbs the toxins and traps them in storage vesicles. In the insect, this is actually not a detoxification process, but rather a well-directed accumulation of toxin precursors ingested when the larvae feed on leaves and economically used to fend off predators. [JWK/AO]
Toxic substances in banana plants kill root pests

Bananas are among the world’s most important food crops. In addition to fungi and insects, the parasitic nematode *Radopholus similis* is also a major banana pest. It attacks the roots of banana plants, impeding growth and slowing development of the plant and fruit. In the final stage of the disease, plants topple over – often when already bearing an immature fruit bunch. Yield losses up to 75% can be the result of *R. similis* infestation.

In order to control such pests in banana plantations, high doses of synthetic pesticides are used which not only cause ecological damage but can also have severe negative effects on the health of people who are exposed to these chemicals.

Scientists have now taken a closer look at the plant-nematode interactions in the context of resistance versus susceptibility. They compared two banana varieties, a resistant and a susceptible one, and studied their defense responses to *Radopholus similis*. Using modern spectroscopic analysis and imaging techniques, the researchers were able to identify and localize defense substances in banana roots: The plants accumulated so-called phenylphenalenones only in infected regions of their roots, not in healthy tissues. This was the case in both the resistant and the susceptible banana variety. However, the concentration of the most active compound, anigorufone, was much higher in the immediate vicinity of lesions on the roots of resistant bananas than in the infected root tissues of the nematode-susceptible banana plants.

The toxic effect of anigorufone and other defensive substances was tested on living nematodes. Anigorufone turned out to be the most toxic to the pest. The researchers were able to visualize the plant toxin within the body of the roundworm. There the lipid-soluble anigorufone accumulated in lipid droplets which increased in size as they converged and finally killed the nematode. Why these complex lipid droplets are formed and why the nematodes cannot metabolize or excrete the toxin still needs to be clarified. The scientists assume that the growing lipid droplets displace the inner organs of the nematode causing an eventual metabolic dysfunction.

The researchers will now try to find out how resistant banana plants biosynthesize and translocate the defense compounds on the molecular level. Such insights will provide important clues for the development of banana varieties which are resistant to the nematodes. This could help to minimize the excessive use of highly toxic pesticides in banana plantations; these toxins jeopardize the environment and people’s lives.

For egg-laying insects, selecting the best site to lay eggs is crucial for the survival of the eggs and larvae. Once the eggs have been deposited, the maternal care of the female flies ends: eggs and larvae are henceforth at the mercy of their environment. Suitable food sources for the hungry larvae and protection against predators and parasites are important selection criteria for egg-laying substrates.

Researchers from the Department of Evolutionary Neuroethology wanted to know which oviposition substrates fruit flies preferred, so they let the insects select among different ripe fruits. An analysis of the behavioral assays showed that female flies preferred to lay their eggs on oranges. Further selection experiments helped to identify the odor that determined the flies’ choice: the terpene limonene. Although citrus is not an attractant for the flies, it elicits egg laying.

By performing electrophysiological measurements, the scientists were able to quantify the flies’ responses to limonene and to localize and identify the olfactory sensory neurons responsible for detecting citrus. Subsequently, they tested the flies’ responses to 450 different odors. Valencene, another component of citrus fruit, also triggered a strong response. Compounds that activated these particular sensory neurons induced oviposition. In vivo calcium imaging of the flies’ brains stimulated with citrus enabled the researchers to identify the corresponding odorant receptor.

In nature, a considerable proportion of Drosophila larvae are killed by enemies, mainly parasitoid wasps that lay their eggs inside the larvae. Astonishingly, these wasps are repelled by citrus odors, although citrus would guide them to their food source: Drosophila larvae. The parasitoid wasp Leptopilina boulardi, which specializes in Drosophila melanogaster, is repelled by valencene. Why wasps avoid citrus is not completely understood; however, female fruit flies have clearly learned to let their offspring grow on citrus fruits, because there the larvae are better protected against parasites.

These research results provide important information about the criteria that insects use to select an oviposition site that guarantees the best development of their offspring. There may be similar odor responses in other insects and ways to manipulate them. These insights may lead to new ways to control insects, especially those that destroy crops or transfer diseases. [AO]

Original Publication

Preparation for oranges protects flies from parasites
Captive breeding for thousands of years has impaired olfactory functions in silkmoths

Domesticated silkworms, *Bombyx mori*, have a much more limited perception of environmental odors compared to their wild relatives. A new study on silkworms revealed that the insects’ ability to perceive environmental odors has been significantly reduced after about 5000 years of domestication by humans. This is what scientists from the Department of Evolutionary Neuroethology and their colleagues from Japan found when they compared olfactory functions in *Bombyx mori* and in their wild ancestors. Nevertheless, the extremely sensitive olfactory detection of pheromones in domesticated males eager to mate remains unaltered. [AO]

Originalveröffentlichung:

Division of labor in the test tube: Bacteria grow faster if they feed each other

Humans know that divvying up the chores is more efficient than doing it alone, and this is also true for bacteria. Researchers from the Research Group Experimental Ecology and Evolution and their colleagues at the Friedrich Schiller University came to this conclusion when they performed experiments with microbes. The scientists worked with bacteria that were deficient in the production of a certain amino acid and therefore depended on a partner to provide the missing nutrient. Bacterial strains that complemented each other’s need by providing the required amino acid showed a fitness increase (faster growth) of about 20% relative to that of a non-deficient strain without a partner. These results help to explain why cooperation is such a widespread model of success in nature. [JWK/AO]

Original Publication:
The biological term “symbiosis” refers to what economists and politicians usually call a win-win situation: a relationship between two partners which is beneficial to both. The mutualistic association between acacia plants and the ants that live on them is an excellent example: The plants provide food and accommodation in the form of nutritious food bodies and nectar as well as hollow thorns which can be used as nests. The ants return this favor by protecting the plants against herbivores. Researchers have now found that ants also keep harmful leaf pathogens in check. The presence of ants greatly reduces bacterial abundance on the surfaces of leaves and has a visibly positive effect on plant health. The results indicate that symbiotic bacteria colonizing the ants inhibit pathogen growth on leaves. [AO]

**Original Publication:**

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**Ants protect acacia plants against pathogens**

Caterpillars use different strategies to protect themselves from their enemies; many are camouflaged, others use their bright colors as warning signals, have stinging hairs or secrete toxic substances, or assume threatening postures. Scientists from the Department of Molecular Ecology have now discovered a previously unknown protective mechanism: Tobacco hornworm larvae can exhale a small fraction of the nicotine they have ingested while feeding on tobacco leaves. To do so, they transfer some of the ingested nicotine into their hemolymph (insect blood) and from there into their respiratory system. The “bad breath” that results repels major predators. These insights were made possible by combining molecular techniques with a natural history approach in field experiments in the tobacco’s native habitat. [AO]

**Original Publication:**

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**The first insects could not smell so well**

An insect’s sense of smell is vital to its survival. Only if it can trace even tiny amounts of odor molecules is it able to find food sources, communicate with conspecifics, or avoid enemies. According to a new study, many proteins involved in the highly sensitive odor perception of insects emerged rather late in the evolutionary process. The very complex olfactory system of modern insects is therefore not an adaptation to a terrestrial environment that appeared when insects first migrated from water to land but, rather, an adaptation that appeared when insects developed the ability to fly. [AO]

**Original Publication:**
Flowering plants need sugar transporter SWEET9 for nectar production

To make sure that flying pollinators such as insects, birds and bats come to the flowers to pick up pollen, plants evolved special organs, the nectaries, to attract and reward them. Scientists from the Department of Molecular Ecology and their colleagues from Stanford and Duluth (USA) have identified the sugar transporter that plays a key role in plants’ nectar production. SWEET9 transports sugar into the extracellular areas of the nectaries where nectar is secreted. Thus, SWEET9 may have been crucial for the evolution of flowering plants, many of which attract and reward pollinators with nectar. [AO]

Original Publication:

Five new IMPRS PhD fellowships available in 2015

In April 2013, the International Max Planck Research School, the graduate program of the Max Planck Institute for Chemical Ecology, was evaluated positively by four internationally renowned scientists. Just before Christmas the institute received confirmation that the program will be extended for another six years, until 2021. Thanks to new funding, the IMPRS will be able to award new doctoral fellowships. Therefore, a new round for submission of fellowship applications will open in July. The application deadline will be at the end of August 2014.

At the end of November, selected candidates will be invited to Jena for interviews and give talks. Even more than five new PhD students may be hired, because the IMPRS will likely break its own record of successfully completed PhDs this year: Ten doctoral candidates have already successfully defended, ten more have submitted their theses.

http://imprs.ice.mpg.de/ext/