Leaf odor attracts Drosophila suzukii
Spotted-wing *Drosophila suzukii* lays its eggs in fresh and ripening fruits. Scientists have identified a leaf odor which is highly attractive to *Drosophila suzukii*. Beta-cyclocitral lures the spotted-wing drosophila but no other related drosophilids  ... p. 3

Fighting potato beetles with RNA interference
Potato plants can be protected from herbivory using RNA interference (RNAi). The plants were modified in such a way that their chloroplasts were able to accumulate double-stranded RNAs (dsRNAs) targeted against essential beetle genes ... p. 4

Bacteria network for food
It is well-known that bacteria can support each other’s growth and exchange nutrients. Scientists have now found how bacteria achieve this nutritional exchange: Some bacteria can form nanotubular structures between single cells that enable nutrients to be directly exchanged ... p. 5
Dear Readers!

In October 2014, we received a worried inquiry of a district office in Heilbronn. A television report on our institute, focusing on Drosophila olfaction, had drawn their attention to our research. The authorities expressed sincere hope that we could provide help. The major concern was the spotted-wing Drosophila suzukii, a drosophilid that had been noticed only recently in Germany.

In contrast to its harmless yet annoying relative Drosophila melanogaster, the common vinegar fly, which is one of the best-studied organisms worldwide, the suzukii fly is a dangerous pest: It specializes in red fruits and attacks as they ripen, before they are harvested. Cherries, raspberries, blackberries and even red grapes are affected. Wine growers are particularly alarmed: Last year, for the first time, insecticides had to be used to fight the new pest. The district office wanted to know which substances should be used as bait to catch Drosophila suzukii.

In February 2015, Ian Keesey and his colleagues from the Department of Evolutionary Neuroethology first reported a substance which Drosophila suzukii is especially attracted to (see Research Highlight, page 3). Our press release on the leaf odor beta-cyclocitrinal – a compound which attracts Drosophila suzukii – received a lot of public attention, especially among fruit and wine growers. They made no secret about how worried and desperate they were because of this dangerous new pest.

Some wine growers were provided with beta-cyclocitrinal in order to increase the number of Drosophila suzukii flies caught in the fly traps.

The immense public interest in the fight against this pest and the new bait substance should not disguise the fact that our scientists conduct basic research. Apart from identifying the attractant, our researchers were even more excited about the discovery that a certain receptor in Drosophila suzukii was changed in a way that enabled the fly to perceive the leaf odor beta-cyclocitrinal instead of the food odor ethyl hexanoate, which is so important for Drosophila melanogaster. Because this “fine-tuning” of the olfactory system to an odor of a different food source is of particular interest to the scientists in the Department of Evolutionary Neuroethology, they now plan similar studies with other related drosophilid species which are specialized to different food sources.

However, the research on the pest insect Drosophila suzukii will be continued, not least because of the increasing threat this new pest poses to fruit growers.

Angela Overmeyer

Solution-oriented basic research

Above: Grapes of the dark grape variety Dornfelder are also attacked by the spotted-wing Drosophila suzukii. Right: Male Drosophila suzukii fly with dark spots at the tips of their wings. Female flies lay their eggs into ripening red fruits including red grapes. The small fly has become a major threat in German viticulture. Photos: Wikipedia (above); Ian Keesey (right).
In 2014, more spotted-wing Drosophila suzukii than ever before were observed in Germany. This pest lays its eggs in fresh and ripening fruits before they are harvested. Infested fruits often become additionally infected with bacteria and fungi, and are then unsuitable for sale and further processing. Currently, the only way to effectively control this pest insect is through the use of insecticides.

Scientists from the Department of Evolutionary Neuroethology have now identified a leaf odor which is highly attractive to Drosophila suzukii: Beta-cyclocitral lures the spotted-wing drosophila but no other related drosophilids. The researchers were able to figure out the olfactory specialization of the insect to this leaf odor by measuring the response of a certain sensillum.

That D. suzukii is attracted by leaf tissue but nevertheless lays its eggs in ripening fruits is quite unusual. For oviposition, the females use their strikingly long and serrated ovipositor to pierce the skin of fruits and berries and to then deposit their eggs. “D. suzukii may act as an evolutionary bridge between fruit-centered and herbivorous species within the Drosophila family,” says Ian Keesey, first author on the study. Ripening fruits and berries are mostly surrounded by leaves. Attracted by leaf odors, D. suzukii flies are automatically guided to the vicinity of fruits; visual cues may then help to finally pinpoint the fruits.

By investigating D. suzukii’s olfactory specialization, the scientists want to better understand why and how this fly has specialized in ripening, healthy fruits and adapted its odor sensitivity accordingly. Their research results may help scientists to develop more efficient traps in order to simplify Drosophila suzukii monitoring and to better keep this pest in check. [AO]

Original Publication:

Above: Ian Keesey is injecting a headspace odor collection sample from plant tissue into the GC-MS for separation, analysis and identification. Photo: Anna Schroll

Right below: Male Drosophila suzukii. Males can be easily distinguished from many other closely related species by the dark spots at the tips of their wings. Foto: Ian Keesey, MPI-CE
RNA interference (RNAi) is a type of gene regulation that occurs naturally. During infection, many viral pathogens transfer their genetic information into the host cells as double-stranded RNA (dsRNA). Replication of viral RNA leads to high amounts of dsRNA, which is recognized by the host's RNAi system and chopped up into smaller RNA fragments, called siRNAs (small interfering RNAs). The cell then uses siRNAs to detect and destroy the foreign RNA.

The RNAi mechanism can also be exploited to knock down any desired gene by tailoring dsRNA to target the gene’s messenger RNA (mRNA). When the targeted mRNA is destroyed, less of the encoded protein can be synthesized. Because it can target an essential gene of a crop pest, dsRNA can be a precise and potent insecticide.

Fighting the potato beetles with RNA interference

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Ralph Bock of the Max Planck Institute of Molecular Plant Physiology and his colleagues decided to generate so-called transplastomic potato plants whose chloroplasts accumulated high amounts of dsRNA. The scientists chose the Colorado potato beetle to test this system on a real insect pest.

The efficacy of the dsRNAs as an insecticide was tested at the Max Planck Institute for Chemical Ecology in Jena. “Transplastomic leaves producing dsRNA against the actin gene caused a mortality rate of 100% after five days of feeding,” says Sher Afzal Khan from the Department of Entomology.

These recent results show that changing the target of transformation from the nuclear genome to the chloroplast genome makes it easier to exploit RNAi for crop protection. As many insect pests increasingly develop resistance to chemical pesticides and Bt toxins, RNAi represents a promising new strategy for pest control. This technology allows for targeted protective measures that do not involve chemicals or the production of foreign proteins in the plant.

Kathleen Dahncke, MPI-MP, Golm

Above: Colorado potato beetle (Leptinotarsa decemlineata): On average 40 to 50 cm² of leaf material are eaten by each of the beetles' larvae.

Right below: Feeding experiment with different potato leaves: Detached leaves of unmodified plants were compared to plants with an altered chloroplast genome. First instar larvae were fed on these leaves for three days in intervals of 24 hours.

Photos: Sher Afzal Khan, MPI-CE.

Original Publication:
It is well-known that bacteria can support each other’s growth and exchange nutrients. Scientists from the research group Experimental Ecology and Evolution, which is funded by the Volkswagen Foundation, have discovered a new way how bacteria accomplish this nutritional exchange. They have found that some bacteria form nanotubular structures between single cells, and that these structures enable a direct exchange of nutrients. Bacteria usually live in species-rich communities and frequently exchange nutrients and other metabolites.

Until now, it was unclear whether microorganisms exchange metabolites exclusively by releasing them into the surrounding environment or whether they also use direct connections between cells for this purpose. Christian Kost and his colleagues addressed this question using the soil bacterium *Acinetobacter baylyi* and the gut microbe *Escherichia coli*. By deleting bacterial genes from the genome of both species, the scientists generated mutants that were no longer able to produce certain amino acids, yet produced increased amounts of others. In co-culture, both bacterial strains were able to cross-feed each other, thereby compensating for the experimentally induced deficiencies. However, when the two bacterial strains were separated with a filter that allowed for the free passage of amino acids, yet prevented a direct contact between cells, neither strain was able to grow. “This experiment showed that direct contact between cells was required to occur,” explains Samay Pande, who recently obtained his PhD at the Max Planck Institute in Jena on this research project and has now started a postdoc at the ETH Zürich.

Under the electron microscope, a co-culture revealed nanotubes that formed between bacterial strains: these structures enabled a nutrient-exchange between cells. Remarkably, only the gut microbe *Escherichia coli* was capable of forming these structures and connecting to *Acinetobacter baylyi* cells. “To me, the most exciting question that remains to be answered is whether bacteria are in fact unicellular and relatively simply structured organisms or whether we are actually looking at some other type of multicellularity, in which bacteria increase their complexity by attaching to each other and combining their biochemical abilities,” Kost summarizes. His research focuses mainly on the question why organisms cooperate with each other. By using bacterial communities as experimentally tractable model systems, the scientists hope to learn why so many organisms have evolved cooperative lifestyles. [AO/CK]

**Original Publication:**


**Research Highlight**

Lisa Freund, Christian Kost, Shraddha Shitut, and (via Skype) Samay Pande. The Research Group Experimental Ecology and Evolution is funded by the Volkswagen Foundation. *Photo: Glen D’Souza, MPI-CE*
Thuringian Research Prize 2014 for basic research awarded to Martin Kaltenpoth

The State of Thuringia awarded the Thuringian Research Prize to Martin Kaltenpoth, the head of the Max Planck Research Group “Insect Symbiosis,” to honor his outstanding performance in the category “Basic Research.” The award ceremony, held in the Leibniz Institute of Photonic Technology on March 9, 2015, was hosted by the Thuringian Minister for Economics, Science and Digital Society, Wolfgang Tiefensee. Kaltenpoth studies symbioses between insects and bacteria. He discovered that antibiotic substances are produced by symbiotic bacteria in the antennae and on the cocoon of female beewolf. These digger wasps use the antibiotics to protect their offspring from harmful pathogens. “It is fascinating how two completely different organisms establish a symbiotic relationship and keep it up over such long periods of time. This is an amazing phenomenon,” says Kaltenpoth. His research contributes considerably to the understanding of the evolution of such “protective alliances” in nature. The discovery and identification of new antibiotic agents in nature and their effectiveness over long evolutionary periods is also of interest for human medicine, especially considering the increasing resistance to conventional antibiotics. [AO]

Ian T. Baldwin received the 2014 Jean-Marie Delwart Award

For his pioneering work and consistent excellence in the study of plant communication and plant defense mechanisms, Ian T. Baldwin received the 2014 Jean-Marie Delwart Award together with plant molecular biologist Edward Farmer. This international prize, which is endowed with $10,000, is awarded by the Jean-Marie Delwart Foundation and receives the patronage of the Académie Royale des Sciences de Belgique. [AO]

http://www.fondationjeanmariedelwart.org

Things smell good for a reason

Antioxidants are natural food ingredients that protect cells from harmful influences. Their main task is to neutralize the so-called free radicals which are produced during the process of oxidation and which are responsible for cell degeneration. Scientists from the Department of Evolutionary Neuroethology have shown that vinegar flies are able to detect these protective substances using olfactory cues. Odors that are exclusively derived from antioxidants attract flies, increase feeding behavior and trigger oviposition in female flies. [AO]

Original Publication:
During the course of evolution, animals have become adapted to certain food sources, sometimes even to plants or to fruits that are actually toxic. The driving forces behind such adaptive mechanisms are often unknown. However, scientists from the Department of Evolutionary Neuroethology have discovered why the fruit fly *Drosophila sechellia* is adapted to the toxic fruits of the morinda tree. *Drosophila sechellia* females, which lay their eggs on these fruits, carry a mutation in a gene that inhibits egg production. The flies have very low levels of $\alpha$-DOPA, a precursor of the hormone dopamine, which controls fertility; interestingly, large amounts of $\alpha$-DOPA are contained in morinda fruits. Flies that were fed with $\alpha$-DOPA can compensate for the genetic deficiency and considerably increase their reproductive success.

**Original Publication:**

Iron is important for every organism. In animals and humans, it controls hematosis and oxygen transport. However, iron ions also influence the community of microorganisms in the gut, the so-called microbiome. Gut bacteria require iron ions to grow and proliferate, and scientists from the Department of Bioorganic Chemistry have provided evidence that insects of the Noctuidae family produce a substance in their gut tissue, an aromatic quinoline carboxylic acid, that binds iron ions, thus directly controlling the growth of gut microbes. The control of iron availability in the gut is probably a widespread principle. The active biosynthesis of an iron chelator, a substance that binds iron, has now been confirmed in an insect for the first time. [AO]

**Original Publication:**

**Microbial colonization measures**

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**Toxic fruits hold the key to reproductive success**

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**Original Publication:**

**Vitamin suppliers in a bug’s gut**

The European firebug *Pyrhocoris apterus* and the African cotton stainer *Dysdercus fasciatus* feed mainly on plant seeds — and these seeds are poor sources of essential B vitamins. Scientists from the Max Planck Research Group Insect Symbiosis have found that bacterial symbionts in the insects’ gut produce these vitamins, which ensures the host’s metabolic stability and, ultimately, survival. Interestingly, the vitamin supply provided by the symbionts directly influences the gene regulation of their host: If the bacterial associates are absent, the bugs show a characteristic vitamin deficiency response. However, the symbiosis between the bugs and their bacteria is not necessarily a harmonious one: The insects are proposed to actively harvest the vitamins from the bacteria by using specific enzymes that burst open the cell walls of the bacteria. [HS/MK]

**Original Publication:**
Whether an odor is pleasant or disgusting to an organism is not just a matter of taste. Often, an organism’s survival depends on its ability to make just such a discrimination, because odors can provide important information about food sources, oviposition sites or suitable mates. However, odor sources can also be signs of lethal hazards. Scientists from the BMBF Research Group Olfactory Coding have found that in fruit flies, the quality and intensity of odors can be mapped in the so-called lateral horn. They have created a spatial map of this part of the olfactory processing system in the fly brain and shown that the lateral horn can be segregated into three activity domains, each of which represents an odor category. The categories are good versus bad, as well as weak versus strong smells. These categorizations have a direct impact on the behavior of the flies, suggesting that the function of the lateral horn is similar to that of the amygdala in the brains of vertebrates. Just as the amygdala plays a crucial role in the evaluation of sensory impressions and dangers, so may the lateral horn. [AO]

Original Publications:

For the first time, the Max Planck Institute for Chemical Ecology will host the renowned Reimar Lüst Lecture. On Friday, June 12, 2015, Pieter Dorrestein (photo on the left) from the University of California in San Diego will talk about “Social and Predictive Computing to Map Our Hidden Molecular World by Mass Spectrometry”. The lecture, which will be held at 3:00 p.m. in the lecture hall of the Abbe Centre Beutenberg, honors the achievements of astrophysicist, science manager and former president of the Max Planck Society, Reimar Lüst, who will be present.

Traces of the defensive volatile trans-\(-\)bergamotene (TAB) are trapped in the headspace of a plant. Even if only one single plant produces this odor, this has an effect on all neighboring plants. Photo: Meredith Schuman, MPI-CE / eLife

Diversity in a monoculture

Modern, machine-friendly agriculture is dominated by monocultures: One single cultivar – one genotype of a crop species – is cultivated in large areas. Favored cultivars are optimized for high yields and often contain few natural plant defense compounds. Unfortunately, these extensive monocultures of identical plants can become an ecological wasteland and cause permanent damage to the ecosystem, especially when combined with the blanket application of fertilizer and pesticides. Scientists from the Department of Molecular Ecology have demonstrated in field experiments with Nicotiana attenuata plants that it is sufficient to alter the expression of certain defense genes in individual plants to protect the whole population and to influence the diversity of the ecosystem as a whole. [AO]

Original Publication: