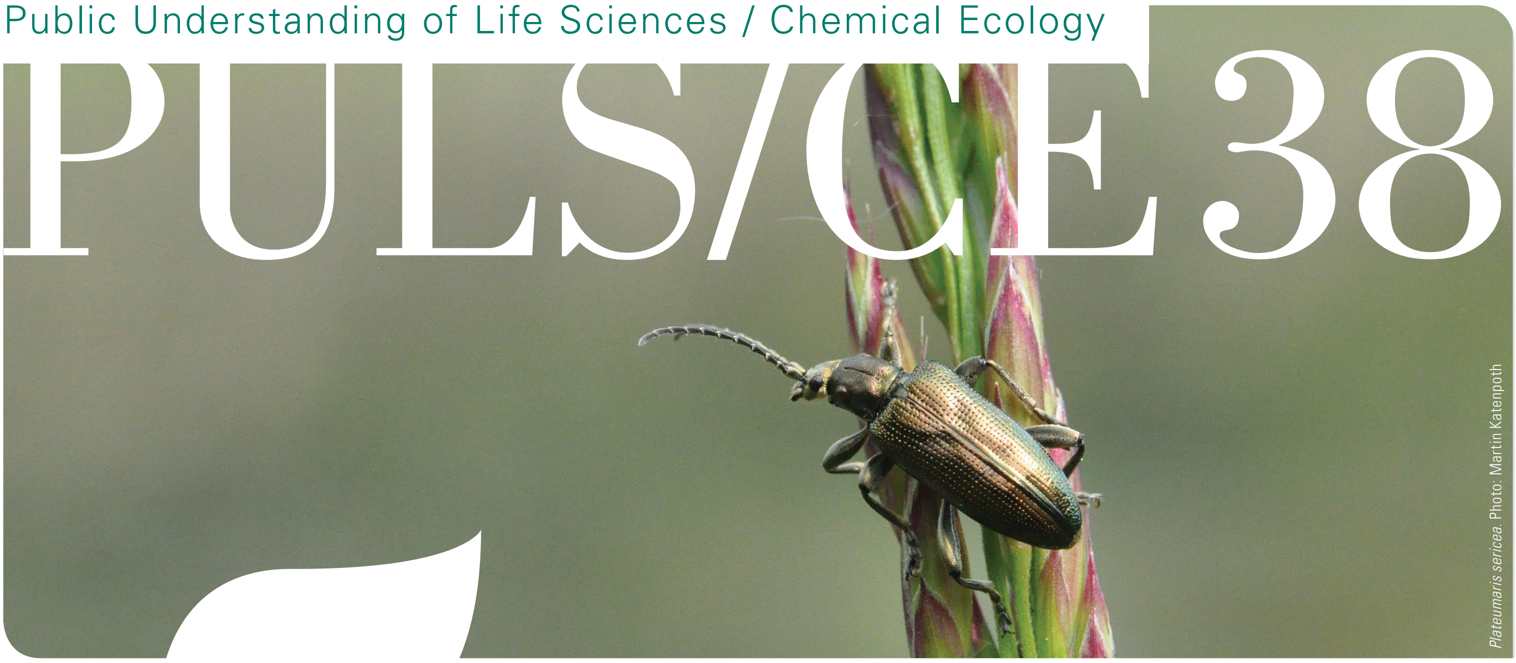
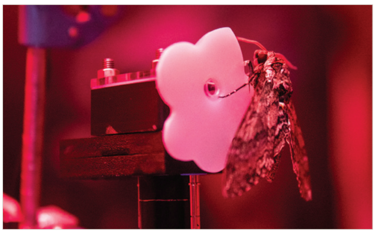
Public Understanding of Life Sciences / Chemical Ecology

PULS/CE 38



MAX PLANCK INSTITUTE
FOR CHEMICAL ECOLOGY

Newsletter November 2021



Learning in hawkmoths

The learning of odors influences the preferences of hawkmoths for certain flowers and host plants, and enables the insects to quickly find food sources and suitable oviposition sites. Olfactory cells on the proboscis, however, play no role in learning ... **p. 3**

How an ant colony cares for sick nest mates

Clonal raider ants of the species *Ooceraea biroi* are able to detect when their nestmates are sick. Instead of avoiding infected conspecifics and thus decreasing the risk of pathogen transmission, the ants increase social interactions and care for the sick ... **p. 4**

Enzyme in the larval gut activates plant defenses

Cockchafer larvae cleave sugars from a defense substance in dandelion roots using their own digestive enzymes, which increases their growth rate. At the same time, the activated plant defense deters larval feeding. The mechanism has an impact on the preference of the grubs for certain food plants ... **p. 5**

MAX PLANCK
GESELLSCHAFT

We are looking forward again!

No one knows the building better than the building services team at the Institute, especially the heads of building services and construction coordinators Johan Brandenburg (left) and Thomas Melzer (right), here in front of the construction site behind the building. Since the building services staff also have to operate, maintain, and repair buildings and systems, they are involved in the construction process. *Photo: Angela Overmeyer, MPI-CE*

Performance of the "The ICE Breakers" at the institute's summer party in September. Foto: Angela Overmeyer, MPI-CE

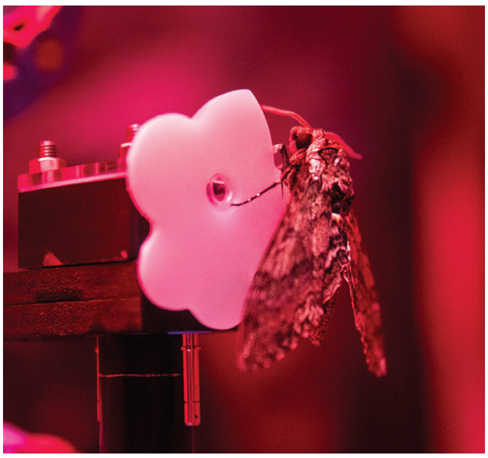
Dear readers!

For a few weeks now, excavators and cranes have again been standing on our institute grounds. Our building is being extended on the slope side in the north: a new climate chamber center will be built there by the end of 2022. The center will be used primarily by the two new Departments for Natural Product Biosynthesis and Insect Symbiosis. The new part of the building will be located completely underground - as is already the case with our Schneiderhaus - because an above-ground extension is not possible. "Connecting the new building at the foundation will be a technical challenge: It will be necessary to use additional deep-freeze machines because the minimum temperatures of our district cooling supply are not sufficient," says Thomas Melzer, who is coordinating construction together with Johan Brandenburg. However, the modifications will meet the latest scientific requirements. The two heads of the building services and their team will be fully challenged in the coming years, because the involvement of building services in the planning process is essential for the later operation of the facilities. Their current workload is on top of the core tasks of maintaining operations in the institute. However, Johan Brandenburg and Thomas Melzer are looking forward to the future optimistically, despite the disruptions to the institute's routines caused by the construction, which also includes a fundamental renewal of the ventilation system. In addition to the climate chamber center, other projects are planned that will bring the institute up to date in terms of its technical equipment: A mass spectrometry center and a microscopy center are to be built under two of the courtyards. The new climate chamber facility will significantly increase the capacity of walk-in chambers. Some of the new chambers will meet the requirements of safety level 2 of the Genetic Engineering Act, thus significantly expanding research capacities in this area. The future mass spectrometry and microscopy center will facilitate exciting new research projects. The whole institute will benefit from the upgrade of the technical equipment, especially the new departments. Read also a portrait of our new director Martin Kaltenpoth, head of the Department of Insect Symbiosis (pp. 6-7), who describes his research vision.

As we look ahead, we also want to acknowledge that after long restrictions due to the pandemic, our institute symposium was held in September under so-called 3G (*geimpft, genesen, getestet* = vaccinated, recovered, tested) conditions and as a hybrid (onsite and online) format. Finally we could engage in large-scale social exchanges, which are so important for interdisciplinary research. After the talks and poster sessions, we celebrated outside the institute with a rousing performance by our institute band "The ICE Breakers." Let's hope that the ice of involuntary contact restrictions has been broken!

Learning in hawkmoths

Scientists from the Department of Evolutionary Neuroethology have gained new insights into the learning ability of tobacco hawkmoths. The learning of odors not only plays a role in foraging: female moths are also influenced by previously learned odors when selecting an oviposition site. In behavioral experiments in the wind tunnel, the researchers gave female tobacco hawkmoths the choice of laying their eggs on a leaf of either the tobacco species *Nicotiana attenuata* or the thorn-apple *Datura wrightii*. Inexperienced females that had not previously laid an egg on a plant showed an innate preference for the leaves of *Datura*. In the second step, inexperienced females were trained on one of the two plant species and were able to lay eggs in training on either a tobacco leaf or a *Datura* leaf only. Finally, the researchers wanted to know whether this training influenced the decision for or against one of the plants. Surprisingly, just one egg-laying experience is sufficient to turn the moths' interest toward the plant on which they had previously laid an egg.



Innate preference combined with success learning appears to be an evolutionary advantage that allows the heavy insect, which spends a lot of energy flying and hovering over a plant, to lay eggs more quickly and save resources.

In contrast, the moth's second nose, the tip of the proboscis, which also has olfactory cells, does not appear to play a role in learning odors and thus making foraging decisions based on learning.

To test this, the research team developed an artificial flower that retains its odor inside the flower, and by that restricts the odor experience of the feeding moth to its proboscis, while the antennae do not get in touch with the flower odor. This experiment enabled the scientists to distinguish between odor learning with the antennae and with the proboscis. Behavioral experiments in the wind tunnel showed that moths do not learn odors that they perceive only with their proboscis. Therefore, previous experience with certain odors within the flower did not alter foraging behavior. The role of the proboscis seems to be primarily that of a tactile or gustatory organ to assess the quality of a flower.

Elisabeth Adam experimenting with tobacco hawkmoths (*Manduca sexta*).

Bottom left: *Manduca sexta* on an artificial white flower. Later, a blue flower made of acrylic was used, which was visually so appealing that it attracted moths without being fragrant from a distance. The insect could detect the odor only when it stuck its proboscis into the flower. This experimental approach ensured that potential odor learning was possible only with the proboscis. *Photos: Sebastian Reuter*

Original Publications:

Nataraj, N., Adam, E., Hansson, B. S., Knaden, M. (2021). Host plant constancy in ovipositing *Manduca sexta* **Journal of Chemical Ecology**, doi: 0.1007/s10886-021-01309-3

Adam, E., Hansson, B. S., Knaden, M. (2021). Moths sense but do not learn flower odors with their proboscis during flower investigation. **Journal of Experimental Biology** 224, jeb242780.

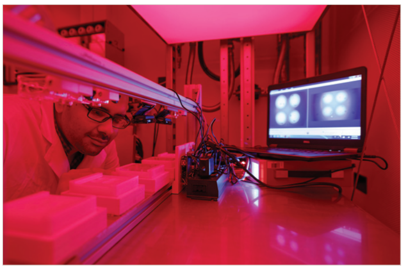
The Lise Meitner Group Social Behavior headed by Yuko Ulrich studies a social insect model, the clonal raider ant *Ooceraea biroi*. The aim of the research is to understand how these ants prevent the spread of diseases in the colony. *Photo: Anna Schroll*

How an ant colony cares for sick nestmates

In a new study on the behavior of the clonal raider ant *Ooceraea biroi*, scientists led by Yuko Ulrich from the Lise Meitner Group Social Behavior were able to show some surprising behaviors in these social insects. Not only could colonies of this species, which consist only of genetically identical workers and have no queen, detect sick nestmates through changes in their immune activity alone, they also increased grooming towards their sick conspecifics, instead of avoiding them. An evaluation of interactions between all colony members revealed that as a result, immune-challenged individuals occupied a more central position in the colony's social network. Thus, the colony responds with more care towards social partners perceived as infectious, which might have a positive effect on their immune status.

Original Publication:

Alciatore, G.; Ugelvig, L. V.; Frank, E.; Bidaux, J.; Gal, A.; Schmitt, T.; Kronauer, D. J. C.; Ulrich, Y.: (2021) Immune challenges increase network centrality in a queenless ant. **Proceedings of the Royal Society B: Biological Sciences** 288 (1958), 20211456



For the study, Mohammed Khallaf recorded the mating behavior of 99 different fly species of the genus *Drosophila*. The research team had identified the respective sex pheromones and the associated olfactory channels in the olfactory system of the flies. The goal of the study was to have a close look at the evolution of pheromone communication in the context of the relationships between the species. Five or more males, unpaired females and paired females from each species were analyzed, totaling the odors of more than 1500 flies.
Photo: Anna Schroll

The evolution of vinegar flies is based on the variation of male sex pheromones

By means of genome analyses of 99 vinegar fly species and the evaluation of their chemical odor profiles and sexual behavior, researchers from the Department of Evolutionary Neuroethology showed that sex pheromones and the corresponding olfactory channels in the insect brain develop rapidly and independently of each other. Females of the respective species are able to recognize males of the same species by their specific odor. Interestingly, closely related species in particular exhibit distinct differences in odor profiles, which helps prevent mating between these species. Males, in turn, chemically mark their female partners during mating, making them less attractive to other males.

The study is the first comprehensive analysis of the mating behavior of a large number of vinegar flies. Presumably, sex pheromones play a crucial role as the first cue to identify a mating partner of the same species. Once a female has been attracted and is ready to mate, certain mating rituals may be initiated, which include dance, nuptial gifts or song. The researchers will further evaluate the recorded mating experiments for future studies and hope that this material will motivate other research groups to take a closer look at the mating strategies of vinegar fly species. The results of this work provide a valuable basis for understanding how the production of odors, their perception and processing in the brain, and ultimately the resulting behavior drive the evolution of new species.

Original Publication:

Khallaf, M. A., Cui, R., Weißflog, J., Svatoš, A., Dweck, H., Valenzano, D. R., Hansson, B. S., Knaden, M. (2021). Large-scale characterization of sex pheromone communication systems in *Drosophila*. **Nature Communications**, 12: 4165, DOI. 10.1038/s41467-021-24395-z.

Enzyme in the larval gut activates plant defenses

A new study shows for the first time that the cleavage of sugars from a plant defense substance by a digestive enzyme in the insect gut and thus its activation can influence the preference of cockchafer larvae for certain food plants. Researchers from the Westfälische Wilhelms-Universität (WWU) Münster, the University of Bern (Switzerland) and the Department of Biochemistry at MPI-CE studied this phenomenon in larvae of the cockchafer *Melolontha melolontha* and their food plant, the dandelion (*Taraxacum officinale*). They observed that removing sugars from the plant defensive compound taraxic acid-D-glucopyranosyl ester (TA-G) in dandelion roots promotes larval growth on the one hand while, at the same time, deters the grubs from feeding. It is possible that larval avoidance of this defense guides the grubs to the lateral roots of the plant. These have lower TA-G concentrations but higher nutrient content than the main roots, which are more important for the plant's survival than the side roots. The findings contribute to a better understanding of the interactions between plants and their consumers. [WWU]

Original Publication

Huber, M., Roder, T., Irmisch, S., Riedel, A., Gablenz, S., Fricke, J., Rahfeld, P., Reichelt, M., Paetz, C., Liechti, N., Hu, L., Bont, Z., Meng, Y., Huang, W., Robert, C. A. M., Gershenzon, J., Erb, M. (2021). A beta-glucosidase of an insect herbivore determines both toxicity and deterrence of a dandelion defense metabolite. **eLife**: 10:e68642

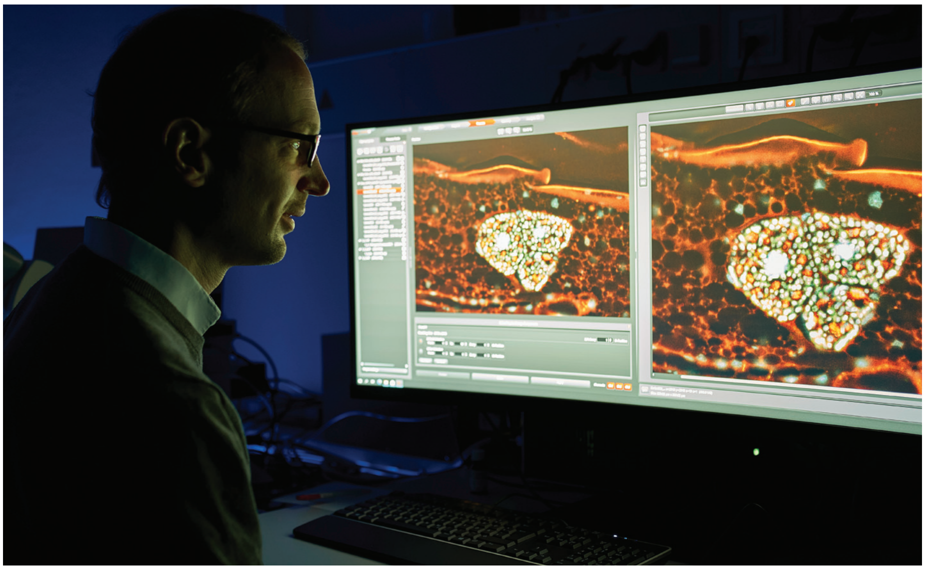
Grub under a dandelion plant: The larvae of the field cockchafer *Melolontha melolontha* feed on plant roots.
Photo: Meret Huber, WWU Münster

Prehistoric climate change repeatedly channeled human migrations across Arabia

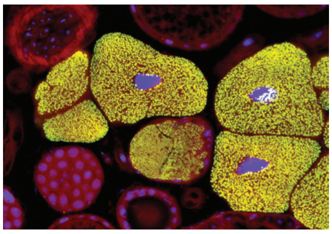
International and Saudi researchers have discovered archaeological sites associated with the remains of ancient lakes in the Nefud Desert in Saudi Arabia. The lakes were formed when periods of increased rainfall turned the region into grasslands. The team found that early humans spread across the region during various phases of "Green Arabia," each wave bringing a different type of material culture. The new research provides evidence that northern Arabia was a major migration route and a crossroads for early humans. Huw Groucutt, lead author of the study and head of the Max Planck Extreme Events Research Group, calls the new findings, which include the oldest dated evidence of humans in Arabia 400,000 years ago, a breakthrough in Arabian archaeology. The discovery of thousands of stone tools reveals multiple phases of human habitation and shows the changing nature of human culture over time. Dating of the archaeological sites revealed that each settlement dates from a time when rainfall is known to have increased in the region. As a result, the Nefud region was periodically transformed from one of the most uninhabitable parts of Southwest Asia into a lush grassland that provided opportunities for repeated population movements. [MPI-SHH]

Original Publication: Groucutt, H. S. et al. (2021): Multiple hominin dispersals into Southwest Asia over the past 400,000 years. **Nature** 597, 376 - 380

Archaeologists study the Nefud Desert in northern Saudi Arabia, where lakes among the dunes once fed early humans and herds of animals.
Photo: Eleanor Scerri



Martin Kaltenpoth is interested in the role of bacteria in the survival of insects. *Photo: Anna Schroll*



Symbiotic bacteria in specialized organs of a flower beetle (*Dasytes* sp.). *Image Benjamin Weiß, MPI-CE*

Current Publications:

Salem, H.; Kaltenpoth, M. (2022). Beetle-bacterial symbioses: Endless forms most functional. **Annual Review of Entomology** 67, 201 - 219

Wierz, J. C.; Gaube, P.; Klebsch, D.; Kaltenpoth, M.; Flórez, L. V. (2021). Transmission of bacterial symbionts with and without genome erosion between a beetle host and the plant environment. **Frontiers in Microbiology** 12, 715601

Underestimated tiny creatures

Just over a year ago, Martin Kaltenpoth was appointed Scientific Member of the Max Planck Society and a new director at the Institute. At the beginning of the year, he moved from Mainz to Jena, where he had already been leading a Max Planck Research Group between 2009 and 2015, to set up the Department of Insect Symbiosis. By September, a large part of his Mainz research group had also moved to Jena. The reconstruction of the department, which he took over from his predecessor David Heckel, is in full swing, and research is already being carried out with verve. The evolutionary ecologist, who was more interested in frogs and newts as a child and only discovered his fascination for insects during his university studies, answered a few questions for us:

Why are symbioses so fascinating?

Microorganisms are everywhere. For a long time, they were only considered potential pathogens for humans and animals, but in recent decades we have learned that they are important for the survival of most organisms as symbiotic partners. I find it exciting to study how two or more completely different organisms interact for mutual benefit. Since it is unexpected from an evolutionary biology perspective that an individual invests expensive resources in another organism, I am interested in the solutions to this paradox.

Which projects are currently in focus?

At the moment, we are focusing on bacterial symbionts in beetles that contribute to the hardening of their exoskeleton through the biosynthesis of tyrosine precursors. We study this from the molecular level to fitness consequences for the beetles, and we look at the evolutionary past of these symbioses. We are also working on symbionts of bugs, wasps, flies, and beetles that contribute to host defense, adaptation to abiotic environmental conditions, or degradation of plant cell wall components. Studying the latter helps us understand how it came about that one of the most species-rich groups of animals on earth, namely the leaf beetles, can digest plant food at all.

Has there been a particularly exciting discovery in your research life?

A particularly exciting moment was when we stumbled across the defensive symbionts of beewolves during my PhD project. A student in the group, Wolfgang Göttler, had taken electron microscope images of female beewolf antennae, and on these images densely packed bacterial cells could be seen on the surface of the antennae. I remember standing in my doctoral supervisor Erhard Strohm's office at the time, being completely surprised, and discussing what the bacteria in the antennae of beewolves could be doing. That was a very special moment. But in fact, all research results are exciting and thrilling, whether it is a gel with PCR products, a GC chromatogram or a fluorescence microscopy image. Because they all contribute to gaining knowledge. Discussing them with my research group and developing new hypotheses and experiments together is the part of research that I enjoy most.

A career in research is not always easy. What is your recommendation for future scientists?

A scientific career requires a high degree of flexibility, mobility and motivation. To achieve this, you have to be enthusiastic about your scientific questions and about the process of gaining knowledge itself. For future scientists, this means: Be aware of the things at work that motivate you and use them in a targeted way so that you don't lose your joy and fascination for research even in difficult phases. In addition, despite all our enthusiasm and ambition, we have to make sure we have a good work-life balance, especially because we have turned our favorite hobby into a profession and therefore run the risk of neglecting other areas of our lives. And last but not least, it is important to look for people who support you and give you constructive, but also critical and honest feedback.

How is it to be back in Jena and what is your vision for the next years?

It's great to be back here, as I already appreciated the special atmosphere and the excellent opportunities for interdisciplinary collaborations in different projects during my time as a Max Planck Research Group Leader. For the next few years, it is important to me that we succeed in the change generations at the Institute, and that we continue to strengthen and expand the interactions between the departments. The increasingly available techniques to experimentally and genetically manipulate even our non-model organisms represent a great opportunity for us in chemical ecology. They enable us to understand the molecular basis and evolutionary dynamics of the adaptations of living organisms to their natural environment. To study this, we need to work closely together and combine expertise at different levels of biological organization. Our Institute is currently expanding: We will get new climate chambers as well as a mass spectrometry and a microscopy center in the next years. The new research facilities will be state-of-the-art. An institute like ours is the perfect place to do science in order to better understand the ecologically and economically enormously important interactions between plants, insects and microorganisms.

The director of the Department of Insect Symbiosis Martin Kaltenpoth on the institute's green roof terrace. *Photo: Anna Schroll*

Below: *Donacia versicolorea* is a beetle in a subfamily of aquatic leaf beetles. Thanks to symbiotic bacteria, these beetles were able to open up a new food spectrum: The symbionts provision essential amino acids and help them digest pectin, an otherwise indigestible component of the plant cell wall, by providing enzymes for its cleavage. *Photo: Martin Kaltenpoth*

Sarah O'Connor. © *Sebastian Reuter*

Sarah O'Connor receives the Ernest Guenther Award

The American Chemical Society (ACS) has announced that it will present the Ernest Guenther Award in Natural Products Chemistry for 2022 to Sarah O'Connor, director of the Department of Natural Products Biosynthesis. She will be honored at the award ceremony in March in conjunction with the Society's spring meeting in San Diego.

https://www.acs.org

Jonathan Gershenzon. © *Anna Schroll*

Jonathan Gershenzon new member of the Leopoldina

Jonathan Gershenzon has been elected as a new member of the Organismic and Evolutionary Biology Section of the Leopoldina. Acceptance to the oldest natural science society in the German-speaking world is considered one of the highest scientific honors in Germany. The formal induction of the new members will take place in May 2022.

https://www.leopoldina.org

New book by Bill Hansson focuses on the sense of smell

Bill Hansson, director of the Evolutionary Neuroethology Department, has written a book about the sense of smell that was published in late October. It is called "Die Nase vorn – Eine Reise in die Welt des Geruchssinns" (*The Nose ahead - A Journey into the World of Olfaction*) and highlights how different animals, including humans, dogs and fish, use their sense of smell. He devotes central chapters to the moth as the "best smeller of all," the vinegar fly *Drosophila*, and the crabs on Christmas Island, thus presenting his research here at the Institute to a broad public. Particularly noteworthy is that he places the ecological significance of odor and odor perception in the context of global warming and environmental pollution, and shows that they pose a serious threat to the ecological balance based on chemical communication.

Save the date: Our institute turns 25!

Next year we have a special anniversary coming up, because our Institute will be no less than 25 years old. This is a reason to celebrate! A joint ceremony with the neighboring Max Planck Institute for Biogeochemistry, which has also been in existence for a quarter of a century, is planned for June 1, 2022. The keynote speaker will be deep-sea ecologist Antje Boetius. The institute is also planning a scientific symposium for September 29 and 30, 2022, to which all former staff members are particularly invited.

Impressum: PULS/CE is published semi-annually and can be downloaded free of charge on the homepage of the MPI for Chemical Ecology and is distributed electronically as PDF to subscribers. A print version will be sent on request.
Editor: MPI-CE, Jena • Managing Director: Prof. Dr. Jonathan Gershenzon (viSdP). Editorial Staff: Dr. Karin Groten, Research Coordination • Angela Overmeyer, M.A., Information and Communication • Emily Wheeler, Editing
ISSN: 2191-7507 (Print), 2191-7639 (Online)