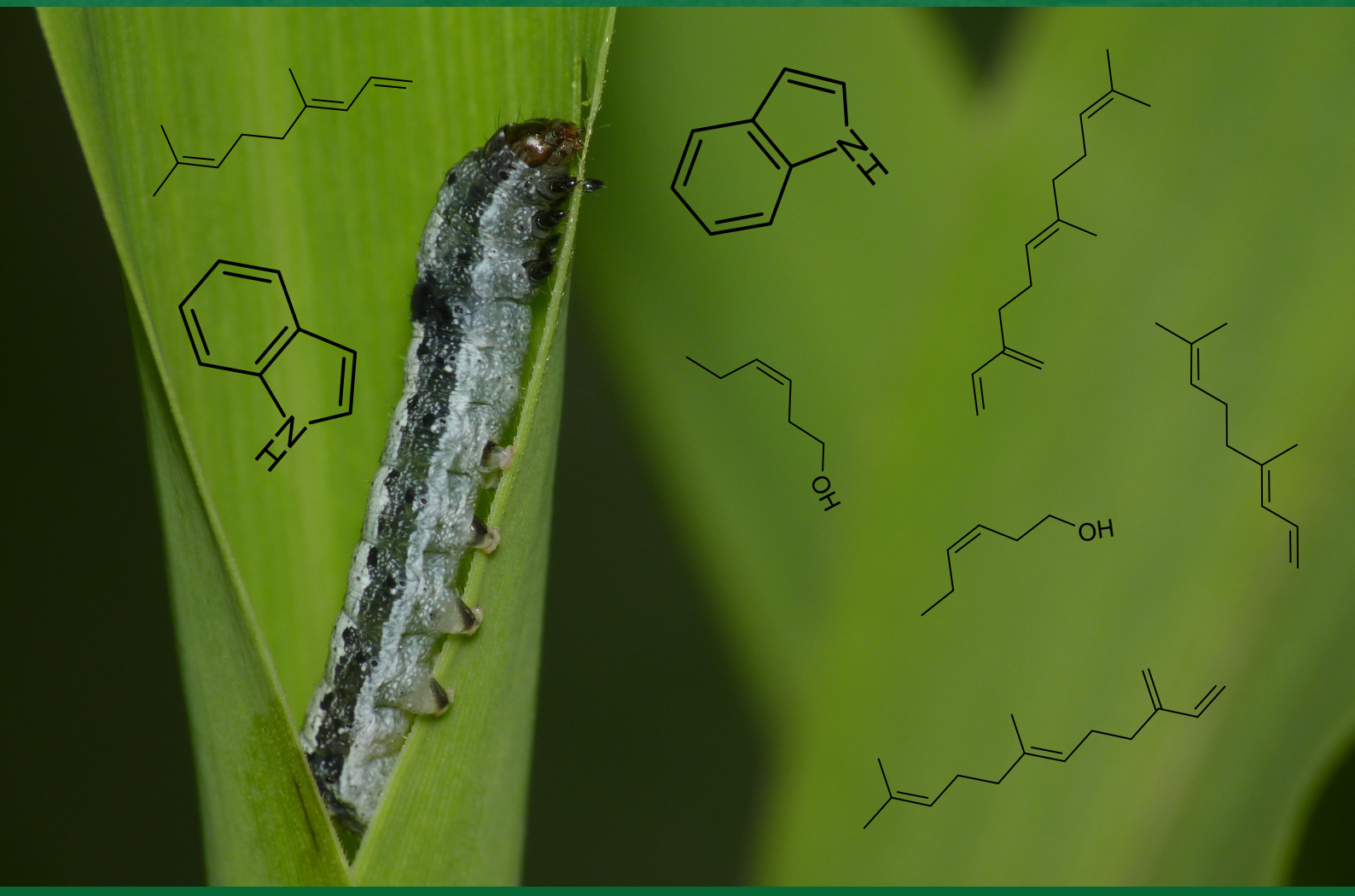
C_3E NEWSLETTER 2/2015



CENTRE OF COMPETENCE IN CHEMICAL ECOLOGY

UNIVERSITÉ DE NEUCHÂTEL

FACULTÉ DES SCIENCES

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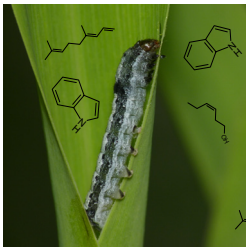

Cover illustration

Spodoptera littoralis caterpillar feeding on maize with structural formulae of indole and other volatiles released upon herbivore damage. The associated research highlight is presented on page 5. Photo credit Matthias Held.

IMPRESSUM

Centre of Competence in Chemical Ecology (C3E)
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One year old and flourishing – nine newly funded projects


Ted Turlings


Reinhard Neier


Felix Kessler

It is now a bit more than a year since the official start of the Centre of Competence in Chemical Ecology (C_3E). It was created to further push and to promote excellence in Swiss research and education in the field of chemical ecology. With this second newsletter we can proudly report that C_3E is performing on all fronts and is nicely meeting its initial objectives. Among the accomplishments are various exciting scientific breakthroughs, plenty of successful grant applications, and new appointments and equipment for the Neuchâtel Platform for Analytical Chemistry (NPAC). In this newsletter we summarize these successes, with a focus on the new research projects that were recently funded.

The highlighted publications nicely show the great diversity and interdisciplinarity of the field of chemical ecology and the "good chemistry" among the C_3E partners. Nine new research projects with a link to chemical ecology were launched and/or granted during 2015, totaling more than 4 million Swiss francs in funding. In this newsletter we portray these projects, paying particular attention to the role of NPAC. The analytical activities of NPAC also benefit many research groups beyond UniNE. This key role as an infrastructure of national and international importance has been acknowledged by the State Secretariat for Education, Research and Innovation (SERI), which is about to commit support with funds for additional equipment. This has prompted the UniNE *rectorat* to further strengthen NPAC's position, resulting in the new acquisition of a highly sensitive and robust triple quadrupole and a nano-ultrahigh pressure liquid chromatography (nanoUHPLC) system, which is presented on page 8.

As a further commitment to research at the interface between chemistry and biology UniNE has created a chair in Bio-Analytical Chemistry. It is foreseen that the new chair will play a leading role in the C_3E research activities and will take over the direction of NPAC. In December it will be decided who among the many excellent applicants will be welcomed in 2016 as the new professor. In our next newsletter we will introduce this new appointee and will report on the progress in the freshly started projects.

ORGANISATION

STEERING COMMITTEE

Ted Turlings (director C_3E) *fundamental and applied research in chemical ecology (FARCE)*
Felix Kessler (director NPAC) *plant physiology*
Reinhard Neier *organic chemistry*

COORDINATION

Thomas Degen (C_3E)
Angela Köhler (C_3E)

NPAC

Diego Carnevale *nuclear magnetic resonance unit*
Gaétan Glauser *mass spectrometry and metabolomics unit*
Bruno Therrien *crystallography unit*
Armelle Vallat *mass spectrometry and metabolomics unit*

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Redouan Bshary *behavioural ecology*
Patrick Guerin *animal physiology*
Fabrice Helfenstein *evolutionary ecophysiology*
Pilar Junier & Edith Joseph *microbiology (LAMUN)*
Brigitte Mauch-Mani *molecular and cell biology*
Sergio Rasmann *functional ecology*

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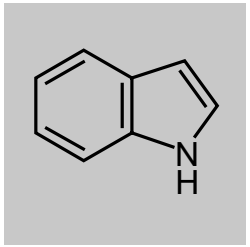
Cris Kuhlemeier *University of Bern*
Jean-Pierre Métraux & Felix Mauch *University of Fribourg*
Heinz Müller-Schärer *University of Fribourg*
Philippe Reymond *University of Lausanne*
Urs Schaffner *CABI, Delemont, Switzerland*
Florian Schiestl *University of Zurich*
Jean-Luc Wolfender *University of Geneva*

Indole is a key leaf-to-leaf alert signal

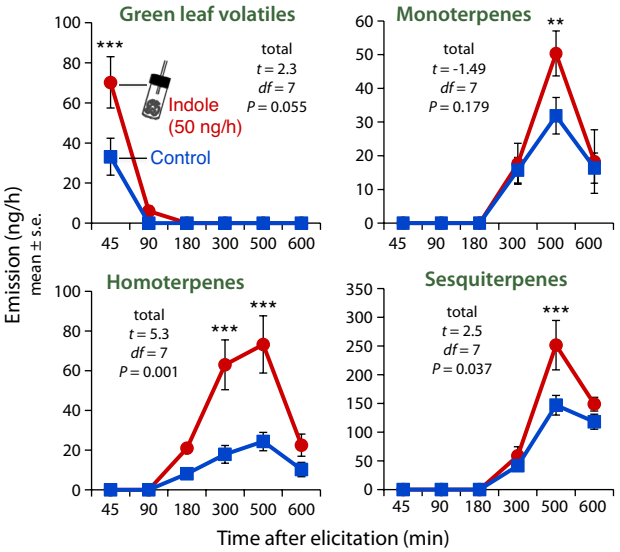
Nathalie Veyrat



Indole

In 2014, Nathalie Veyrat obtained her PhD with a thesis entitled *The Role of Indole in Maize-Herbivore Interactions* under the supervision of Ted Turlings and Matthias Erb. A part of the dissertation was recently published in *Nature Communications* in collaboration with the group of Matthias Erb at the University of Bern. The paper shows that the volatile compound indole is an essential airborne signal for the communication between maize leaves.

Herbivore-induced volatile organic compounds prime non-attacked plant tissues to respond more strongly to subsequent attacks. However, the key volatiles that trigger this primed state remained largely unidentified. In maize, the release of the aromatic compound indole is herbivore-specific and occurs earlier than other induced responses. It was therefore hypothesized that indole may be involved in airborne priming. Using indole-deficient mutants and synthetic indole dispensers, the researchers could show that herbivore-induced indole enhances the induction of defensive volatiles in other leaves of the same plant, as well as in neighbouring maize plants in a species-specific manner. Indole exposure markedly increases the herbivore-induced production of the stress hormones jasmonate-isoleucine conjugate and abscisic acid, which represents a likely mechanism for indole-dependent priming. These results demonstrate that indole functions as a rapid and potent aerial priming agent that prepares systemic tissues and neighbouring plants for incoming attacks. The findings are likely to facilitate the unravelling of the mechanisms of priming and to help testing its ecological relevance.



Exposure to volatile indole induces HIPV priming. Hybrid maize seedlings (variety Delprim) were exposed to control- or indole-releasing dispensers for 12h. They were then elicited by wounding and application of *Spodotera littoralis* regurgitant and placed into clean odour vessels. HIPVs were collected for 600 min. The graphs show the total emissions of four major families of HIPVs for control- and indole-exposed plants at different times after elicitation. Asterisks indicate statistical differences between control- and indole-exposed plants (Holm-Sidak post hoc tests, *P<0.05, **P<0.01, ***P<0.001, n = 4–5). T-values (t), P-values (P) and residual degrees of freedom (df) are shown for t-tests comparing total emissions between treatments. Adapted from Figure 2 in the publication.

Erb M, **Veyrat N**, Robert CAM, **Xu H**, Frey M, Ton J, **Turlings TCJ** 2015. Indole is an essential herbivore-induced volatile priming signal in maize. ***Nature Communications***: DOI: 10.1038/ncomms7273

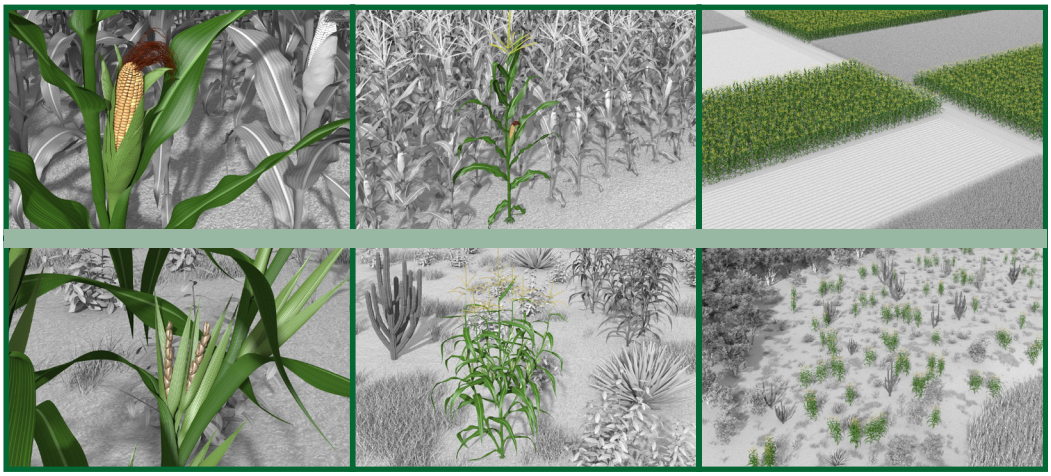
Insects fight back: a fresh look at plant domestication

Betty Benrey

The consequences of crop domestication on plant-insect interactions is one of the central research interests of the laboratory of evolutionary entomology. Betty Benrey was invited together with two other renowned experts in the field, Yolanda Chen (University of Vermont) and Rieta Gols (Wageningen UR) to write a review on this topic in *Annual Review of Entomology*, which appeared in print in early 2015. The same team made a contribution to the 15th International Symposium on Insect-Plant Relationships (SIP-15) held at UniNE in 2014, and published subsequently a second review in the Proceedings, i.e. a special issue of *Entomologia Experimentalis et Applicata*.

Crop domestication is the process of artificially selecting plants to increase their suitability to human requirements: taste, yield, storage, and cultivation practices. There is increasing evidence that crop domestication can profoundly alter interactions among plants, herbivores, and their natural enemies. The goal of the two exhaustive reviews was 1) to examine how these interactions are affected by domestication in the geographical ranges where these crops originate, where they are sympatric with the ancestral plant and share the associated arthropod community and 2) to determine how different feeding guilds of herbivorous insects and different groups of natural enemies (parasitoids and predators) respond to existing variation in wild and cultivated plant populations for plant traits typically targeted by domestication. Overall, studies show that herbivores clearly benefit from directional selection on the traits that characterize the domestication syndrome, but the effects on natural enemies are less consistent and not well documented.

The evidence generated from these studies raises an important question for sustainable agriculture: How can we maximize food production and at the same time select for resistance to insect pests?



Wild ancestors and domesticated crops - exemplified here by teosinte (bottom) and maize (top) - incorporate different levels of phenotypic variation at the plant level and at higher spatial scales owing to habitat heterogeneity and agricultural management (adapted part of a figure published in ***Annual Review of Entomology***)

Chen YH, Gols R, **Benrey B** 2015. Crop domestication and its impact on naturally selected trophic interactions. ***Annual Review of Entomology*** 60: 35-58.

Chen YH, Gols R, Stratton CA, Brevik KA, **Benrey B** 2015. Complex tritrophic interactions in response to crop domestication: predictions from the wild. ***Entomologia Experimentalis et Applicata***: DOI: 10.1111/eea.12344.

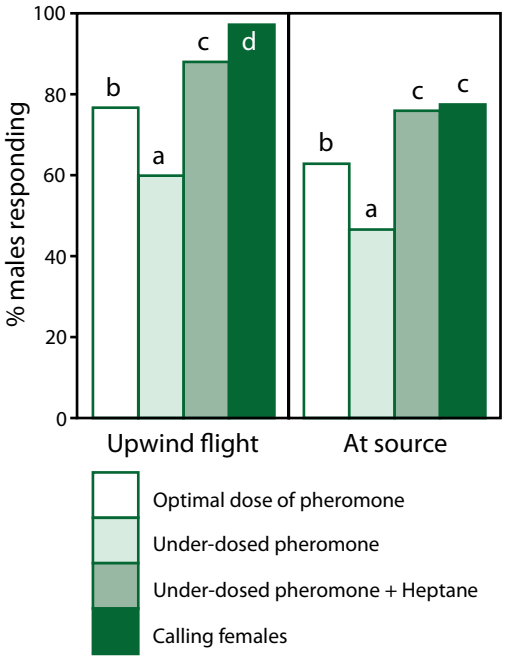
Short-chain alkanes synergize with the sex pheromones of moth pests

Patrick Guerin

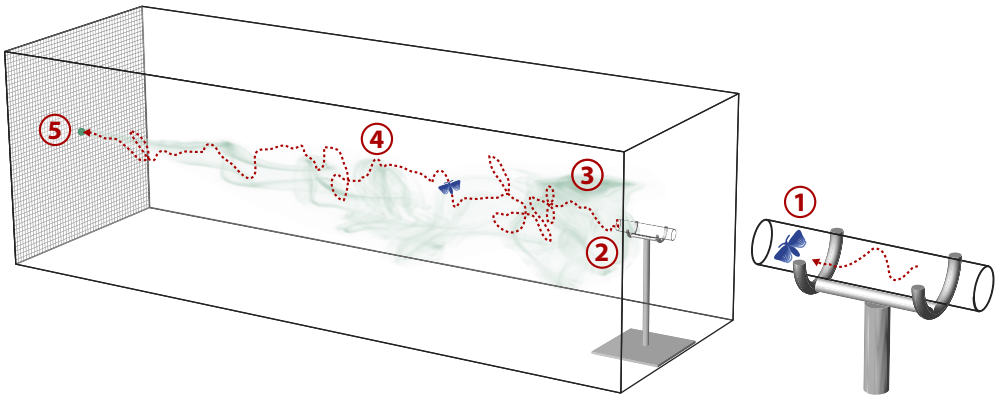
Alexandre Gurba

Cydia pomonella

Moth pests are responsible of huge crop losses across the planet. Moth sex pheromones are widely used to control these pests by mating disruption that targets male moths in open-field cultures such as cotton and rice but also to control tortricid moths in orchards and vineyards. Mating disruption requires adequate pheromone release systems, one of which is dispersion as an aerosol. Efforts are under way to augment the efficiency and reliability of this control method by adding molecules derived from host plants to the sex attractants in dispensers. Conducting behavioural assays in a wind tunnel, Alexandre Gurba and Patrick Guerin have discovered that short-chain alkanes (heptane or octane) synergize with sex pheromones in inducing oriented flight responses from males of two major crop pests, the codling moth *Cydia pomonella* on pome fruits and the European grapevine moth *Lobesia botrana* in vineyards. Their findings open the possibility to use alkanes as an alternative bioactive medium for creating pheromone aerosols. The role described for short-chain alkanes released from plants in moth behavior is the first record for such lipoxidation products in the annals of insect-plant relationships. Alkane–pheromone combinations are expected to increase the competitiveness of dispensers with females, and to reduce the amount of pheromone needed to control these pests.



Proportion of *Lobesia botrana* males undertaking key behavioural steps in response to their sex pheromone, to a mixture of the pheromone and heptane, and to calling females.



Wind tunnel bioassay. A sex pheromone plume is generated with a piezo nebulizer placed upwind. A male moth in a glass tube is placed on a stand downwind in the pheromone plume. The following behaviours of the moth are then recorded : activation (1), take off (2), lock-on to the pheromone plume (3), upwind flight (4) and arrival at the source (5).

Gurba A, **Guerin PM** 2015. Short-chain alkanes synergise responses of moth pests to their sex pheromones. ***Pest management Science***: DOI 10.1002/ps.4061

NPAC upgrades its machine park

Neuchâtel Platform of Analytical Chemistry

In May 2015, the Neuchâtel Platform of Analytical Chemistry (NPAC) acquired new powerful analytical equipment in the domain of mass spectrometry. This had become necessary because the requests for analyses had more or less reached the maximal capacity of the platform, and there was an urgent need for even more sensitive methods. Thanks to funding provided by the University of Neuchâtel, a highly sensitive and robust triple quadrupole and a nano-ultrahigh pressure liquid chromatography (nanoUHPLC) system were purchased. Both systems are connected through the so-called IonKey/MS interface, which integrates UHPLC separation directly in the mass spectrometer source. This configuration provides unprecedented sensitivity for very challenging analyses. In addition, a conventional UHPLC system, donated by Prof. Reinhard Neier, was also connected to the mass spectrometer through a conventional electrospray source. This allows for maximal flexibility for the various applications which are planned for the platform. Several applications are already running or are foreseen on the new instrument, including the quantification, at trace levels, of steroid and peptidic hormones in animals and phytohormones in plants. First analyses have already revealed an up to 10 times gain in sensitivity under conventional UHPLC mode compared to results obtained on our existing instruments.

In addition, a new gas chromatography-mass spectrometry system was acquired to replace an obsolete instrument. This machine will enable us to continue offering volatile analyses and develop new competences in the domain of metabolomics. At present, only a direct liquid injection autosampler is integrated to the system, however additional injection modes such as SPME are planned for the near future.

The ionKey/MS System integrates the UHPLC separation directly into the source of the mass spectrometer. This delivers LC-MS system performance and sensitivity that cannot be achieved any other way. The insert in the upper left corner shows the iKey Separation Device (pictures courtesy of Waters Corporation).

Ramping up the vitamins

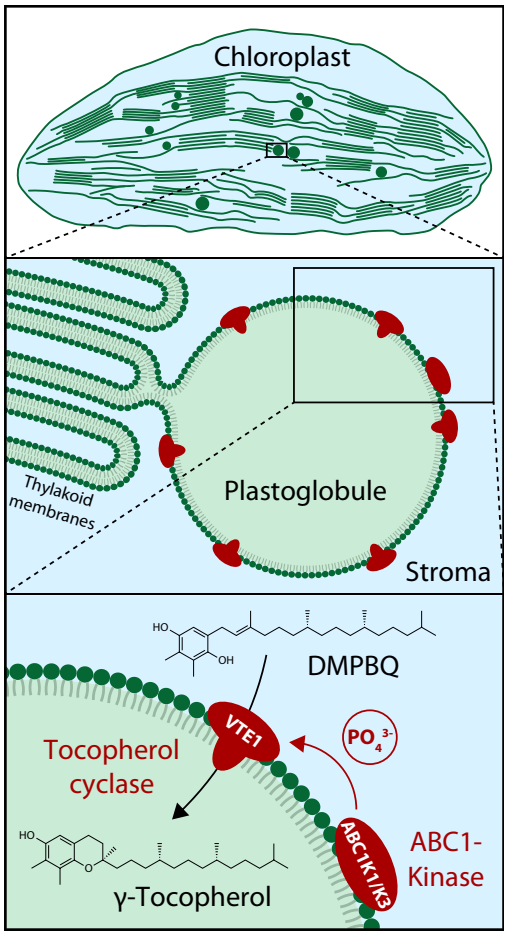
Thibaut Pralon

Venkatasalam Shanmugabalaji

At the beginning of 2015, Felix Kessler launched a new project, which builds heavily on research conducted in the framework of the NCCR *Plant Survival*. The study examines the role that the recently discovered ABC1-kinases play in the regulation of vitamin E content of plants and in the protection against harmful oxidative stress. It involves a PhD student, Thibaut Pralon, and a postdoc, Venkatasalam Shanmugabalaji.

Countless cellular processes are regulated by protein phosphorylation, including photosynthesis in plants. Kinases transfer the phosphate groups to specific target proteins, which may affect their ability to interact with other proteins. Phosphatases act in the opposite way and reverse the effects of kinases by removing phosphate groups from target proteins. In chloroplasts, non-typical ABC1-like kinases reside on lipid droplets, the so-called plastoglobules, and function to optimize photosynthesis by modifying the neutral lipid composition of the thylakoid membrane. This includes key electron transporters (plastoquinone and phylloquinone), antioxidants (tocopherols aka vitamin E) and photoprotectants (carotenoids). For example, under high light conditions, the plant produces much more vitamin E to protect the photosynthetic apparatus from oxidation. The project aims at unravelling the role of the ABC1 kinase phosphoprotein network in this process. A high-tech peptide chip will be used to identify the target proteins of the ABC1-kinases via state-of-the-art phosphoproteomics. The project will also strongly rely on the continued services of the Neuchâtel Platform of Analytical Chemistry (NPAC), which is implied in metabolomics analyses.

The results of the project will provide important insight in the activity of the major group of chloroplast kinases and give way to translation into crop plants. Weight is also attached to this applied aspect: modern techniques will be employed to screen for new tomato varieties, which thanks to mutations in the ABC1 kinases naturally produce large amounts of vitamin E.



Title	**Exploring the chloroplast ABC1-like kinase phosphoprotein network: roles in remodeling thylakoid lipid composition, photosynthesis and beyond**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Regular grant, Project funding (Div. I-III)***
Budget	CHF 429'814
Start/End	1.1.2015 - 31.12.2017

PluMBER – Patina for Metal Built hERitage

Edith Joseph

Monica Albini

Lidia Mathys

A new project has been granted to Edith Joseph (project leader) and Pilar Junier by the *Foundation for the Promotion of the Conservation of Historical Monuments*. It relies on an interdisciplinary research team of experts involved in microbiology and conservation through the collaboration of the Laboratory of Microbiology of UniNE and the Haute Ecole Arc Conservation-Restauration in Neuchâtel. On the University's side, it involves a PhD student, Monica Albini, and a technician, Lidia Mathys.

The project aims to provide a new sustainable solution for protecting architectural metals using an ecologically friendly biological treatment. The method is based on the development of an aesthetical and protective biopatina that can be applied for preserving built heritage, in particular outdoor metal monuments and historical landmarks. Outdoor metal surfaces encounter irreversible changes in their original appearance. The corrosion patina formed is considered aesthetically valuable and part of the life history of the monuments. Most often, the corrosion products present are, however, unstable and can be leached out. So far, organic coatings are employed for protecting such metal surfaces, but are unsatisfactory in terms of efficiency and durability. In addition, inhibitors are toxic and pose potential threats to human health and to the environment.

Experiment on the roof of UniMail (Faculty of Science).

Taking advantage of unique properties of metal-resistant microbes, existing unstable corrosion products could be converted into an insoluble and stable biopatina that provides the treated surfaces with long-term protection and no aesthetical alteration. The project aims to extend this process developed since 2006 on copper to iron, zinc and aluminum alloys that are commonly found as architectural parts. The application of the biopatina process on different types of alloys will result in the formation of a homogeneous patina providing the treated surfaces with a naturally aged appearance while inhibiting corrosion.

Church with zinc cladding and building with galvanized iron cladding in Mouthe, France

Title	**New ecological and sustainable solution for protecting architectural metals using an ecologically friendly biological treatment**
Funding Organization	Stiftung zur Förderung der Denkmalpflege
Budget	CHF 296'914
Period	1.3.2015 – 28.2.2018

Agora: C3E joins forces with the Papiliorama in Kerzers

Thomas Degen

Caspar Bijleveld

Chantal Derungs

Displaying a range of beautiful and emblematic butterflies, the Papiliorama in Kerzers aims at raising public awareness of the threats to tropical ecosystems and their biodiversity. With a new exposition, it strives to improve its educational programme for its visitors, which count over a quarter of a million every year. This makes it an ideal place to disseminate to the broad public some important results obtained with Lepidopteran insects as research objects at UniNE. Patrick Guerin and Ted Turlings were awarded an Agora grant from the SNF, which helps to reinforce the already existing collaboration between C3E and Papiliorama. This funding scheme aims to promote the spread of knowledge and foster dialogue between science and society.

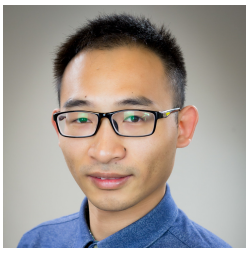
Thomas Degen, who unites experience in both research and scientific visualization, has developed the concept and will realize the visualization project in close consultation with Caspar Bijleveld, director of Papiliorama, and Chantal Derungs, head of science, education and communication, both alumni of UniNE. The public will learn about fascinating, but rather hidden aspects of butterfly biology and ecology, the focus being on the chemical ecology of insect-plant interactions. The following topics shall be highlighted in short video clips or 3D animations, which can be interactively accessed by the visitors:

- Butterfly morphology with special emphasis on sensory organs (scent, taste and vision).
- Direct plant defence through toxins and host-plant specialisation, using the Monarch *Danaus plexippus* as classic example.
- Indirect plant defence through the recruitment of natural enemies via volatile signals from insect-damaged plants. This part will showcase parts of the multitrophic system that was studied in a recently finished EuroCore project (InvaVOL) and comprises field mustard *Brassica rapa*, Great White *Pieris brassicae* and its associated parasitoids.

Title	**The inconspicuous in a conspicuous world: visualizing hidden aspects of butterfly biology and ecology at the Papiliorama**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Agora (Science Communication)***
Budget	CHF 49'848
Start/End	1.4.2015 – 31.3.2018

Elevation gradients as tool for determining the adaptive role of herbivore-induced volatiles

Alan Kergunteuil



Zhenggao Xiao

The project with which Sergio Rasmann started his engagement as an assistant professor in functional ecology at UniNE is a follow-up to his earlier Ambizione grant *A phylogenetic study on altitudinal gradients of plant defenses against herbivores: testing classic hypotheses with contemporary methods*. The study will be carried out by a post-doctoral researcher, Alan Kergunteuil, and a PhD student, Zhenggao Xiao. Plants, when attacked by herbivores, cry for help, and release odors that signal the presence of the herbivore predators. To date, it is not known whether differences in "distress call" come from changes in habitat or other biological characteristics of the plant. With the current project, this issue will be addressed by using altitudinal gradients as natural ecological laboratories and by simultaneously testing the contribution of both biotic and abiotic factors in shaping variation in below ground tritrophic interactions.

Plants and their herbivores constitute more than half of the organisms on earth. Therefore a better understanding of the evolution of plant defenses against their herbivores is central for our understanding of biodiversity and species interaction, as well as better managing insect pests in agro-ecosystems. When under above- or belowground attack, plants resist herbivores by different means, including the attraction of predators or parasitoids of the herbivores near the site of damage by producing volatile organic compounds (VOCs). This phenomenon has been referred to as indirect plant defense. The term defense here implies a fitness benefit for the plant, and consequently, an adaptive value for volatile production. It has not yet been unequivocally proven whether the production of herbivore-induced VOCs has evolved and is being maintained as a defense over evolutionary times, and whether the attraction of carnivores benefits plant fitness. In order to find further evidence in favor of the hypothesis, the project will 1) study the macro-evolution of VOCs production and the subsequent carnivore attraction using a phylogenetic comparative approach, 2) test the fitness benefits of VOCs production and nematode attraction at the genotypic (within species) level, and 3) test whether there is local adaptation in the tripartite interaction between plants, herbivores and predators along the ecological gradients. A range of grass species and predatory nematodes, which are attracted by the volatiles released by the grass roots, were chosen as study organisms. The combined approach of behavioral assays in belowground olfactometers, chemical analysis, phylogenetic modeling, and field experiments along elevation gradients in the Swiss Alps (see picture) is expected to provide answers contributing to solve the debate around the adaptive role of herbivore-induced volatile organic compounds as plant indirect defenses.

Common garden experiment from the elevation transect Lavey-Morcles, Vaud Alps, Switzerland

Title	**Attracting bodyguards: testing macro-evolutionary trends of belowground plant indirect defenses and effects on plant fitness**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Project funding (Div. I-III)***
Budget	CHF 399'767
Start/End	1.5.2015 – 30.4.2018

Birds and neonicotinoids

Mélanie Annen

Łukasz Binkowski

Passer domesticus

Passer montanus

Modern agriculture is usually characterized by the wide use of pesticides. These substances affect the trophic chain, and can even cause local extinction of populations due to lack of food (lower biomass of insects), indirect toxicity and/or induction of oxidative stress, which ultimately may negatively affect the reproduction and survival of wild animals. Together with the Swiss Ornithological Institute in Sempach, the laboratory of evolutionary ecophysiology led by Fabrice Helfenstein has started a project to evaluate the impact of some agricultural contaminants on bird health. This project involves two master students, Ségolène Humann-Guilleminot and Mélanie Annen, and a post-doc from Poland, Łukasz Binkowski.

Neonicotinoids are the most widely used insecticides in the world. They bind to nicotinic acetylcholine receptors in the central nervous system of insects, causing receptor blockage, paralysis and death. They bind more strongly to insect receptors than to those of vertebrates, but birds seem to be more susceptible than other vertebrates. Neonicotinoids are mostly used as seed dressings that are absorbed by the plant and protect all parts of the crop against herbivorous insects. In conventional agriculture, seed dressing is applied prophylactically, leading to a risk of an over-accumulation over the years. One of the core questions with regard to the environmental impact of neonicotinoids is how much they are taken up by non-target species. They are supposed to be responsible for the decline of bees. Although some adverse effects are known for other taxa, most studies on vertebrates assess only mortality and are carried out over short periods. However, it is clear that important sublethal effects are induced by much lower doses. The study aims at investigating such sublethal effects of neonicotinoids on two wild passerine birds, the house sparrow *Passer domesticus* and the tree sparrow *Passer montanus*, using a network of farms throughout Switzerland. Collaborating farmers manage their farms according to three methods using contrasted amounts of pesticides: organic, integrated production and conventional. This network of farms will be used to investigate potential links between agricultural practices, levels of neonicotinoids found in soil, crops and natural vegetation samples on the one hand, and levels of neonicotinoids found in bird plasma, bird health (oxidative stress and levels of stress hormones) and male bird reproductive capacity (sperm quantity and quality) on the other hand. In addition to this field study, we will conduct an aviary experiment in which house sparrows will be dosed with minute amounts of acetamiprid, which is applied in Switzerland on a wide range of crops. The birds' health and reproductive potential will then be monitored using the same markers as in the field study. Neonicotinoid residues and markers of oxidative stress will be quantified by the Neuchâtel Platform of Analytical Chemistry.

Ségolène Humann-Guilleminot takes a blood sample from a house sparrow.

Title	**Impact of neonicotinoids on two species of sparrows - Links with agricultural practices, bird health and male fertility**
Funding Organization	CRUS Sciex grant (40%), Federal Office for the Environment (40%), SNF overheads UniNE (20%)
Budget	CHF 123'882
Period	2015–2016

BABA or umpiring the role that β-aminobutyric acid naturally plays in plants

Andrea Balmer

Ivan Baccelli

Guillaume Gouzerh

Damien Thévenet

β-amino acids are rarely found in plants and up to now, β-aminobutyric acid (BABA) was considered as xenobiotic substance. However, the latest results obtained by the team of Brigitte Mauch-Mani at the molecular and cell biology lab, in collaboration with Reinhard Neier's group at the Institute of Chemistry and Gaétan Glauser at the NPAC, provide clear evidence that plants do synthesize BABA and its accumulation increases upon exposure to biotic and abiotic stress. This exciting result upgrades BABA to the status of a potential plant priming hormone and opens a large array of questions that will be addressed in a new SNF-funded project, which involves one doctoral student and three post-docs (see opposite pictures).

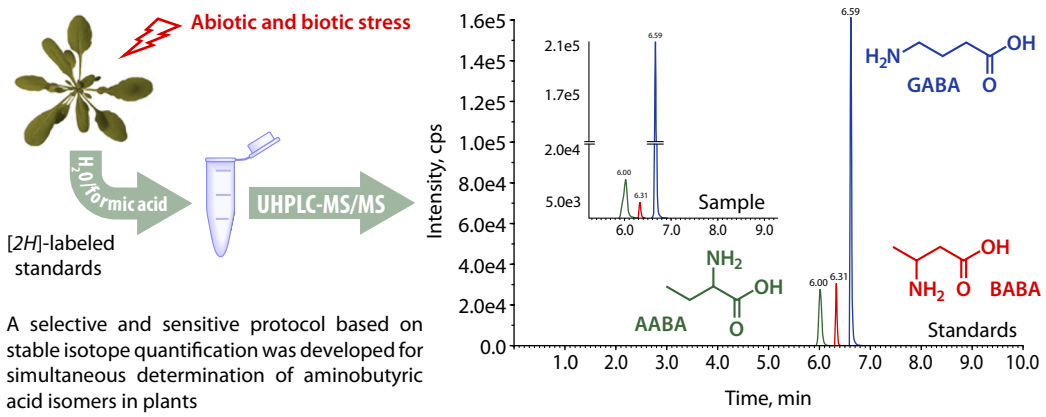
Plants treated with BABA develop an enhanced defensive capacity against a large variety of stresses. Expression of such BABA-induced resistance (BABA-IR) coincides with a faster and stronger defence response following pathogen attack or abiotic stress, a phenomenon that has been termed priming. BABA-IR is based on priming of distinct defence signalling mechanisms involving several plant hormone defence pathways.

The project will investigate the following problems:

- distribution of BABA in the plant kingdom
- role of endogenous BABA in natural priming
- biosynthetic pathway of BABA production
- induction and regulation of BABA synthesis
- catabolism and storage of BABA in plants
- perception of BABA by the plant

Along with classical plant research based techniques, e.g. screening plant mutant populations to pinpoint the regulatory genes of the biosynthetic pathway of BABA, tools for a chemistry-based approach using radiolabeled putative precursors are developed and exploited in collaboration with colleagues from the laboratory of organic chemistry (see figure for a representation of the protocol).

Priming confers enhanced stress resistance with minimal inhibitory effects on yield and fitness. Interestingly, the primed state is transferred to the descendants of a primed plant. If plants that have naturally higher levels of BABA can be identified, this trait could be exploited to introduce a higher adaptive capacity to respond to stress into our agricultural ecosystems.



A selective and sensitive protocol based on stable isotope quantification was developed for simultaneous determination of aminobutyric acid isomers in plants

Title	**Beta-aminobutyric acid (BABA) as a plant-produced priming agent: Biosynthesis, regulation and perception**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Regular grant, Project funding (Div. I-III)***
Budget	CHF 678'000
Start/End	1.5.2015 – 30.4.2018

Sinergia 2.0: sugar wars

Matthias Erb

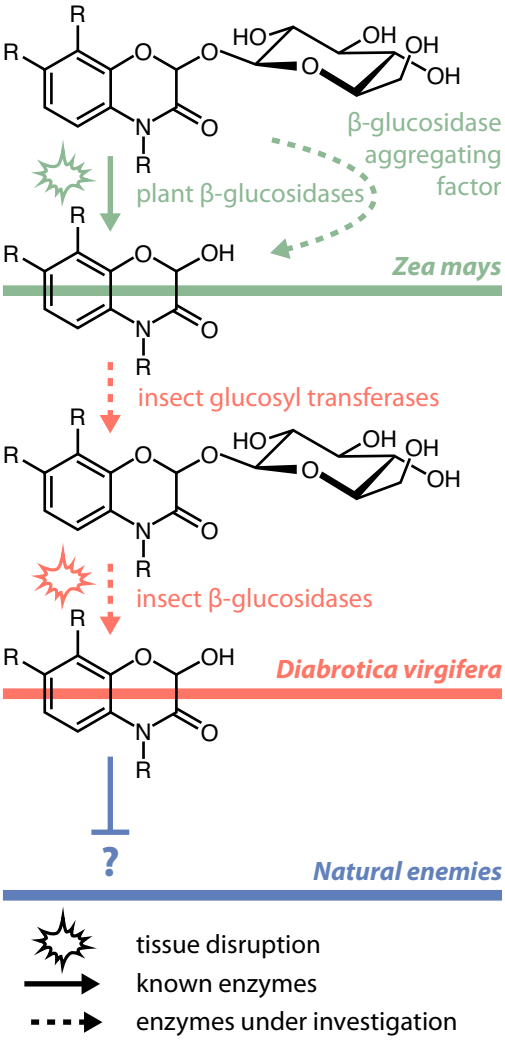
Jonathan Gershenzon

Felix Kessler

Ted Turlings

The SNF has awarded a Sinergia grant to a consortium comprising Matthias Erb (UniBE), Jonathan Gershenzon (MPI Jena), Felix Kessler (C_3E-NPAC-UniNE) and Ted Turlings (C_3E-UniNE). The new project builds largely on the results of a very successful previous Sinergia project that studied benzoxazinoid derivatives at the plant-insect interface. The project is managed by C_3E, but was conceived by Matthias Erb, who was also the driving force behind the conception and execution of the first Sinergia project. The new study will investigate gluco-modulation in a soil tritrophic system comprising maize plants, the western corn rootworm *Diabrotica virgifera* (WCR) and its natural enemies, such as entomopathogenic nematodes.

Activation of secondary metabolites by de-glycosylation is a widespread anti-herbivore defence strategy allowing plants to store harmless glycosides and hydrolyse them to toxic or deterrent products upon attack. However, various specialized herbivores can re-glycosylate the activated toxins and store them for self-defence. The study seeks a detailed understanding of the biochemical mechanisms behind this phenomenon and of its ecological consequences. The main insect resistance factors in maize roots are benzoxazinoids (BXDs; see figure), which are stored as glucosides and activated by plant β-glucosidases. Specialized WCR larvae are fully tolerant to BXDs and accumulate stabilized BXD glycosides upon BXD ingestion. Larval tissue disruption results in the rapid re-activation by putative insect β-glucosidases, which is associated with increased resistance against natural enemies. Using an interdisciplinary approach which combines analytical chemistry, biochemistry, molecular physiology and ecology, the project will identify and characterize BXD glyco-modulation enzymes in maize and WCR, manipulate them using reverse genetics and investigate their role in tritrophic interactions below ground.



Title	**Sugar wars: glucose-mediated activation, neutralization and re-activation of defensive metabolites in a soil tritrophic system**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Sinergia***
Budget	CHF 2'127'646 (529'521 sub-project Kessler; 682'305 sub-project Turlings including project coordination)
Start/End	1.10.2015 – 30.9.2018

NRP 68 Phase II: towards a new application method of entomopathogenic nematodes and bacteria

Apostolos Kapranas

EPN

Diabrotica virgifera

A proposal of Ted Turlings with Monika Maurhofer (ETHZ) and Christoph Keel (UniL) as co-applicants was retained for the second phase of the National Research Programm *Sustainable Use of Soil as a Resource* (NRP68). The objectives of this follow-up project nicely fit the third goal of NRP68, which was defined as *devising concepts and strategies for implementing a sustainable use of soil*. Dr. Apostolos Kapranas, an experienced researcher in the field, will take the post-doc position to lead the project.

Entomopathogenic nematodes (EPN) and bacteria (EPB) have great potential as biological control agents against soil-dwelling insect pests. During the first phase project, EPN populations were found to be extremely low in Swiss agricultural soils, independent of agricultural practices, as compared to soils from natural habitats, where EPN densities were higher. The situation for EPB is expected to be similar. It is therefore recommended that, in crop fields with soil insect problems, an augmentative approach be used to increase the numbers of these beneficial organisms. The greatest obstacles to an effective application of these biological control agents are the high cost of current application methods and a limited shelf-life. The team wishes to overcome these obstacles by utilizing the knowledge obtained during the first phase project in combination with a technique that was developed in a parallel SNF-sponsored economic stimulus project. It concerns a novel application method that is based on encapsulation of EPN and EPB in alginate beads, which are to be improved by supplementing them with useful plant-derived substances. Certain substances will put the EPN in a state of quiescence, which keeps them in good shape while they are embedded in the beads. Others will be used to attract and encourage the pests to feed on the beads (see figure). Both of these effects have already been demonstrated to work under laboratory conditions for certain target pests. Further optimized beads will be tested in field trials for their efficacy against several important root pests such as the Western corn rootworm *Diabrotica virgifera*, which has recently invaded Europe and is already established in Ticino.

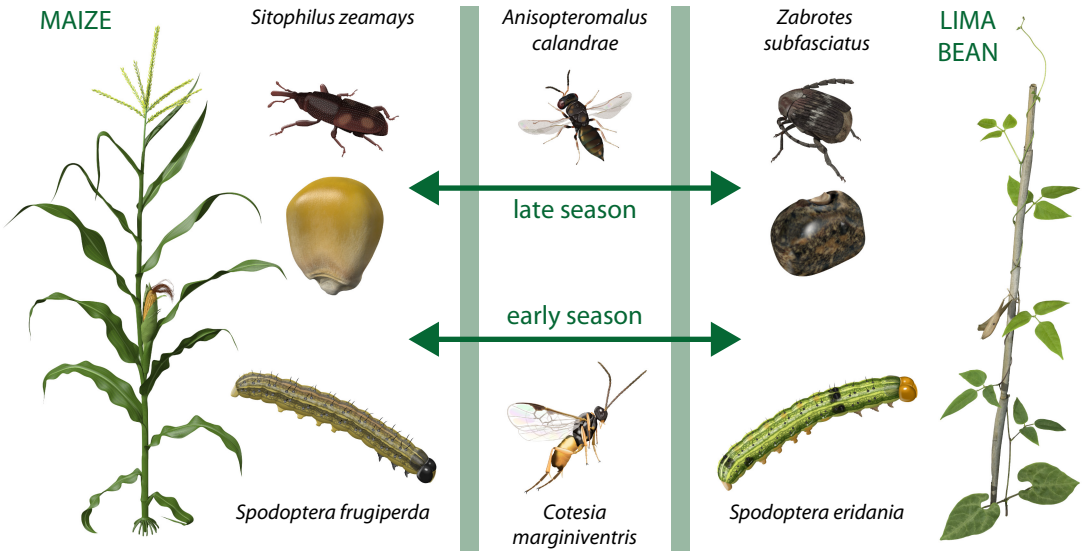
Title	**Alginate beads as vehicles for the application of entomopathogenic nematodes and bacteria against economically important soil-dwelling pests**
Funding Organization	Swiss National Science Foundation
Funding scheme	***NRP 68 Sustainable Use of Soil as a Resource (Application Phase 2)***
Budget	CHF 539'196
Start/End	1.1.2016 – 31.12.2017

Can parasitoids mediate indirect competition between herbivores?

Betty Benrey

Apparent competition is an ecological phenomenon whereby a species negatively affects another species at the same trophic level through the action of shared natural enemies. The new project of Betty Benrey will test the hypothesis that agricultural practices, with and without the use of pesticides, affect apparent competition between herbivorous insects in agricultural and neighbouring natural ecosystems, based on the notion that their natural enemies are particularly sensitive to pesticides. These cascading effects will be studied in maize and wild lima bean, which grow side by side throughout Mexico. *Spodoptera frugiperda*, the most important foliar pest of maize, has developed resistance against pesticides. Parasitism rates seem to be low in treated fields, while larvae on nearby non-treated maize are often parasitized. Lima bean plants are attacked by *Spodoptera eridania*, which shares the same parasitoids, leading to reciprocal apparent competition. Moreover, in lima bean early season herbivory can significantly reduce late season seed production and induces chemical changes that affect the performance of seed-feeding beetle larvae, as well as their parasitoids Shortly after, different beetles attack maize cobs, and their larvae again share several parasitoids with the beetles on lima bean. This results in a new apparent competition event and brings the cascading effects to full circle as shown in the below figure depicting representative examples of the organisms involved.

Behavioural, performance and metabolomics assays will be conducted in the laboratory and the field, respectively. The results will provide unique insight into how early season apparent competition may affect the one later in the season in an important agro-ecosystem. Besides contributing to fundamental ecology theory, the work will generate knowledge that will be of use for the development of cropping strategies that optimize the presence and efficacy of native biological control agents.



Title	**Agricultural practices and the cascading effects of apparent competition: A case study of trophic interactions on cultivated maize and wild lima bean plants**
Funding Organization	Swiss National Science Foundation
Funding scheme	***Regular grant, Project funding (Div. I-III)***
Budget	CHF 372'000
Start/End	1.1.2016 – 31.12.2018

Sergio Rasmann coming home

Sergio Rasmann

As PhD student in the FARCE group of Ted Turlings, Sergio Rasmann initiated the successful research on attractants for entomopathogenic nematodes culminating in an influential Nature paper published in 2005. After leaving UniNE in 2006, Sergio first did volunteer work in Bolivia and then moved to Cornell University with an SNF fellowship for a 4-year post-doctoral term in the laboratory of Anurag Agrawal. In 2011, he returned to Switzerland as a SNF Ambizione fellow at the University of Lausanne. After a short appointment as assistant professor at the University of California Irvine during 2014, Sergio accepted a position offered to him by his *alma mater*. He was nominated Assistant Professor in Functional and Community Ecology and took up his work on 1 February 2015 with the new SNF-funded research project presented on page 12.

Pilar Junier promoted to full professor

Pilar Junier

After having carried out post-doctoral research at the Max-Planck Institute for Evolutionary Biology in Plön, Germany, and at the Environmental Microbiology Laboratory (EML, ENAC) of the Federal Institute of Technology in Lausanne (EPFL), Pilar Junier moved to UniNE with an SNF Ambizione fellowship. In 2010 she was nominated Assistant Professor in Microbiology, an engagement that has now been turned into a position as Full Professor. In the field of fungi-bacteria interactions most research groups focus either on fungi or bacteria, while the team led by Pilar Junier has taken an innovative approach by considering the physiology of both partners and the evolutionary background (investments, payoffs, fitness consequences) that has allowed these interactions to emerge. Her work is revealing that these interactions are mainly chemically mediated.

ISCE Silverstein-Simeone Lecture Award for Ted Turlings

Ted Turlings

The International Society of Chemical Ecology (ISCE) has awarded Ted Turlings with the Silverstein-Simeone Medal, an award made in honor of the founding editors of the Journal of Chemical Ecology, Robert M. Silverstein and John B. Simeone. The award recognizes outstanding recent or current work at the frontiers of chemical ecology. The discovery by Ted Turlings' research group that entomopathogenic nematodes use herbivore-induced root volatiles to locate insect hosts has prompted a new line of research that focuses on belowground trophic interactions. Ted Turlings delivered his 45-minute lecture with the title *Exploiting plant distress signals for crop protection* on 3 July 2015 at the annual ISCE meeting in Stockholm, Sweden.

ISCE Early Career Award in Chemical Ecology for Matthias Erb

Matthias Erb

Matthias Erb has received the Early Career Award in Chemical Ecology 2015 from the ISCE, which honors an emerging leader in chemical ecology and recognizes cutting-edge research that will influence the future direction of the field. This award was introduced in 2014, and we would like to point out that the two so far granted prizes were given to former PhD students from UniNE, the first one going to Sergio Rasmann. As part of the award ceremony, Matthias Erb delivered a plenary lecture at the annual ISCE meeting held from 29 June to 3 July 2015 in Stockholm, Sweden. The talk was entitled *Plant toxins induce defensive signals – Evolutionary explanations for a functional paradox.*