ABSTRACTS:

Evolution of Plant Chemical Defenses: Oral Presentations

In programme order

Session 9

Did plant chemical defences evolve like the spandrels of San Marco?

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Many plants produce chemical defences that can reduce damages from herbivores and pathogens. While the evolution of chemical defences have been mainly considered to be driven by herbivores and microbes, recently advances in illustrating the biosynthesis and function of plant chemical defences suggested that some of them might have evolved from side effects of other selection pressures, the phenomenon termed by Stephen Gould and Richard Lewontin as "the spandrels of San Marco". In this talk, I will use some of our recent findings to illustrate how plant chemical defences might have evolved as side effects of other evolutionary processes. I will also discuss the future directions of studying the evolution of plant chemical defences.

Keywords: Chemical defences; evolution; the spandrels of San Marco; detoxification; biosynthesis; cellular signaling

Herbivore order and life stage, but not specialization, drive defensive responses in the crack willow

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Plants produce diverse chemical defenses that protect them against insect herbivores. These defenses often show some specificity to individual herbivores, which probably promotes their efficacy. For example, producing specific blends of Herbivore Induced Plant Volatiles (HIPVs) can help plants attract natural enemies specific to the herbivores they suffer from. Here we aimed at testing what traits of insects govern the specificity in HIPV blends. We focused on *Salix fragilis,* that harbors diverse assemblages of herbivorous insects. In a greenhouse experiment, we exposed 209 willow cuttings to a set of 24 herbivore species. We used various insects including specialists and generalists, leaf-chewers and sap-suckers, beetles, caterpillars, and hemipterans. We detected 37 volatile compounds, including mainly sesquiterpenes, and decomposed variation in their blends elicited by the willows upon attack with multivariate methods. We used the herbivore`s order, feeding guild, life stage, and specialization as explanatory variables. The variation in HIPVs was best explained by the herbivore order and life stage, with adult beetles eliciting responses significantly different from beetle larvae. Furthermore, we recorded significant differences between individual beetle and caterpillar species, suggesting specificity in HIPVs also within these two orders. In contrast, the HIPV profiles elicited by sap-sucking hemipterans did not differ from the controls. Specialization did not play a role either. In conclusion, our results show high specificity in HIPVs, with much variation being explained by herbivore orders and life stages. Such specificity can be informative to specialized natural enemies that typically use olfactory cues for host detection (e.g. parasitoids).

Keywords: Feeding guild; HIPVs; insect herbivores; leaf-chewers; *Salix*.

Light-activated Defense Strategies in Mushrooms

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Whenever insects nibble on fruiting bodies of the green *Cortinarius austrovenetus* the bite site turns reddish. The chemistry behind it is as easy as it is fascinating: Hypericin is formed by oxidation from the fungal pigment austrovenetin as soon as the fungal tissue is damaged. Inspired by this striking observation, we started to systematically explore phototoxicity in fruiting bodies. Studying over fifty different species by the means of photocytotoxicity assays and feature-based molecular network (FBMN) showed that pigments of the polyketide pathway are especially interesting. Furthermore, we could show that phototoxicity is a common trait in the subgenus Dermocybe. Photoactivity guided isolation strategies yielded several so-called photosensitizers from fruiting bodies. 7,7'-Biphyscion (BP), as example, was isolated from *Cortinarius uliginous* and – in a nanomolar range – induced apoptosis in cancer cells solely under irradiation. Moreover, we started to investigate the ecological relevance of these photo-active pigments. We hypothesized that – according to the optimal defense hypothesis – phototoxicity should be concentrated in the gills. Statistical analysis of more than forty individual fruiting bodies proved an enriched of phototoxicity in the gills by inter alia the accumulation of emodin. Here we will present our most recent photo-activated defense strategy insights from an overlooked Kingdom, from fungi.

Keywords: Cortinarius; Fungi; Photosensitizer; Pigments; Singlet Oxygen; FBMN-analysis

Impact of benzoxazinoid-dependent plant-soil feedbacks on plant performance and food quality within a crop rotation

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Plants are constantly interacting with myriads of soil-born microorganisms. Secondary metabolites that are exuded by plant roots alter the microbiota in and around the roots, which can affect the performance and resistance of the next plants grown in the same soil. How plant-soil feedbacks that are mediated by secondary metabolites influence the productivity of agricultural systems is not well understood. In an agronomically realistic two-year field experiment we evaluated the impact of maize benzoxazinoids on the performance and food quality of three winter wheat varieties. We found that maize benzoxazinoid soil conditioning increases wheat biomass accumulation as well as the final yield. In addition, insect infestation was reduced on wheat growing in benzoxazinoid conditioned soil. Analysis to elucidate possible effects on wheat food quality are in progress. Understanding how the exudation of secondary metabolites affects the performance of subsequent crops will help to assess their potential to promote sustainable agriculture in the context of plant-soil feedbacks.

Keywords: agricultural productivity; maize; plant-microbe interactions; secondary metabolites; wheat

Synthesis of Ruthenium and Magnesium-Flavonoid Complexes and their effect *in vivo* on Citrus with CVC

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We explored the antimicrobial potential of two newly synthesized antimicrobials complexes against *Xylella fastidiosa.* Several nuclear magnetic resonance (NMR) assays with high resolution and sensitivity were developed to identify new diastereoisomers in the context of octahedral ruthenium [Ru(narin)(phen)$_2$]PF$_6$ and magnesium naringenin 5-alkoxide [Mg(narin)(phen)$_2$]OAc complexes, obtained in the present work. The NMR assays proved to be powerful tools for the identification of isomers in metal complexes. Moreover, a protocol for the *in-vivo* determination of the effects of these complexes against *X. fastidiosa* was developed. The main trunks of *X. fastidiosa* infected plants were injected with the two complexes using a syringe; the number of bacterial cells in the plants following treatment was estimated via real-time quantitative PCR (qPCR). Importantly, the administration of both complexes drastically reduced the number of *X. fastidiosa* cells *in vivo*. Hence, the generation of novel antimicrobial complexes, like [Mg(narin)(phen)$_2$]OAc, [Ru(narin)(phen)$_2$]PF6, represent an important step in the long and costly process that is the development of new marketable compounds for crop protection.

Keywords: Xylella; Ruthenium; Magnesium; Flavonoid; Bactericidal

ABSTRACTS:

Evolution of Plant Chemical Defenses: Poster Presentations

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Poster Session 2

Forest edge induced physiological and chemical changes increases the susceptibility of Norway spruce (*Picea abies*) to bark beetle (*Ips typographus*) attack

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Forests of the Czech Republic have experienced devastating damages in Norway spruce monocultures caused by bark beetle mass outbreaks in recent years. Total volume of trees killed mainly by the Eurasian spruce bark beetle (*Ips typographus*) exponentially increased from 1.5 million m^3 timber annually (in 2003-2015) to 23 million m^3 timber in 2019. In response to current calamities, our research focused on plant-insect interaction between mature Norway spruce and *Ips typographus*. The research explored why certain spruce trees in the forest are more susceptible to bark beetle attack, and how external stressors, such as drought, solar radiation, and rising temperatures affect the tree defence mechanism. In a comprehensive field study, stress levels of trees were manipulated by the cutting fresh forest edges leading to sudden sun exposure. Physiological features of the trees such as sap and resin flow and secondary metabolites profile in the bark were monitored for studying the tree defence. These records were related to bark beetle attacks observed in field bioassays, which conclude the differences in tree defence between trees at the fresh forest edge and forest interior.

Keywords: European spruce bark beetle; fresh cut trees; herbivore defence; Norway spruce; resin flow; secondary metabolites

Neutral effect of multiple herbivory by prey and non-prey on indirect defense of coffee plants

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Plants under attack by multiple herbivores often release a distinct volatile blend than that emitted under attack by single herbivore. These quantitative/qualitative changes can exert a positive, negative or neutral effect on the attractiveness to the third trophic level. In a previous work, we found that herbivory by the red spider mite *Oligonychus ilicis* on coffee plants facilitates the infestation by the white mealybug *Planococcus minor*. Here, we examined weather multiple herbivory by the mite and mealybug on coffee plants influences the emission of herbivore-induced plant volatiles and their attractiveness to the predatory mite *Euseius concordis*. In olfactory behavioral tests, *E. concordis* was attracted by the volatiles emitted by prey-infested plants (mite) when contrasted to uninfested plants or non-prey infested plants (mealybug). The predatory mite preferred volatiles from multiple-infested plants over those of uninfested or non-prey infested plants. However, *E. concordis* did not distinguish the odors of prey-infested plants from those of plants under multiple herbivory. Multivariate analysis showed that volatile composition of prey-infested plants was distinct from those emitted by uninfested and non-prey infested plants, but similar to the emission of multiple-infested plants. Therefore, our results show that infestation by the white mealybug on mite-infested coffee plants does not change the composition of herbivore-induced plant volatiles emitted nor interfere on the attractiveness of the predatory mite *E. concordis*.

Keywords: *Coffea arabica*; *Euseius concordis*; herbivore-induced plant volatiles; olfactory behavior.

Transgenerational effects of maternal herbivory by a sap-sucking insect on plant resistance

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Maternal plants under herbivory pressure can transfer induced defense traits to offspring through epigenetic effects. While this phenomenon has been well studied in plant resistance against leaf feeder insects, little is known about transgenerational resistance induced by sap sucking insects. Here we studied whether maternal herbivory by the green peach aphid *Myzus persicae* (Hemiptera: Aphididae) influences offspring resistance in sweet pepper plants (*Capsicum annuum*). Mother plants were infested from the vegetative stage until fruit ripening in a greenhouse. Aphids preferred to colonize and settle on the offspring plants from uninfested plants than those from infested plants. Increased resistance of the offspring from infested plants coincided with the elevation of 60% in constitutive levels of total phenols relative to the offspring from uninfested plants. Our results showed that maternal herbivory by *M. persicae* on sweet pepper increases resistance of the offspring and levels of a putative chemical defense.

Keywords: *Capsicum annuum*; induced defenses; *Myzus persicae*; total phenols; transgenerational resistance.