ISCE 2019 Annual Meeting
Atlanta, GA
June 2- 6, 2019
Oral Presentations

Abbot P.

Chemical ecology and sociality in aphids: opportunities and directions

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Aphids have long been recognized as good phytochemists. They are small sap-feeding plant herbivores with complex life cycles that can involve cyclical parthenogenesis and seasonal host plant alternation, and most are plant specialists. Aphids have distinctive traits for identifying and exploiting their host plants, including the expression of polyphenisms, a form of discrete phenotypic plasticity characteristic of insects, but taken to extreme in aphids. In a relatively small number of species, a social polyphenism occurs, involving subadult "soldiers" that are behaviorally or morphologically specialized to defend their nestmates from predators. Soldiers are sterile in many species, constituting a form of eusociality and reproductive division of labor that bears striking resemblances with other social insects. Despite a wealth of knowledge about the chemical ecology of non-social aphids and their phytophagous lifestyles, the molecular and chemoecological mechanisms involved in social polyphenisms in aphids are poorly understood. We provide a brief primer on aspects of aphid life cycles and chemical ecology for the non-specialists, and an overview of the social biology of aphids, with special attention to chemoecological perspectives. We discuss some of our own efforts to characterize how host plant chemistry may shape social traits in aphids. As good phytochemists, social aphids provide a bridge between the study of insect social evolution sociality, and the chemical ecology

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

ISCE 2019 Annual Meeting
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Oral Presentations

Adams R. M.[1] and Jones T. H.[2]

The evolution of chemical weaponry in megalomyrmex social parasites

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Aphids have long been recognized as good phytochemists. They are small sap-feeding plant herbivores with complex life cycles that can involve cyclical parthenogenesis and seasonal host plant alternation, and most are plant specialists. Aphids have distinctive traits for identifying and exploiting their host plants, including the expression of polyphenisms, a form of discrete phenotypic plasticity characteristic of insects, but taken to extreme in aphids. In a relatively small number of species, a social polyphenism occurs, involving subadult "soldiers" that are behaviorally or morphologically specialized to defend their nestmates from predators. Soldiers are sterile in many species, constituting a form of eusociality and reproductive division of labor that bears striking resemblances with other social insects. Despite a wealth of knowledge about the chemical ecology of non-social aphids and their phytophagous lifestyles, the molecular and chemoecological mechanisms involved in social polyphenisms in aphids are poorly understood. We provide a brief primer on aspects of aphid life cycles and chemical ecology for the non-specialists, and an overview of the social biology of aphids, with special attention to chemoecological perspectives. We discuss some of our own efforts to characterize how host plant chemistry may shape social traits in aphids. As good phytochemists, social aphids provide a bridge between the study of insect social evolution sociality, and the chemical ecology

Themed Session: Chemical Communication of Social Insect Associates: Espionage, Weaponry and Stealth

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

ISCE 2019 Annual Meeting
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June 2- 6, 2019
Oral Presentations

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'**Tuning' communication among four trophic levels**

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Plants can facilitate attraction of herbivore predators and parasites with herbivore-induced volatiles (HIPVs). However, a central unknown of manipulating a natural environment is how the interactive effects of multiple plant stressors impacts belowground multi-trophic interactions. Agricultural systems, while disturbed, are useful model systems for investigating the effects of multiple stressors on plants and their related interactions because of the redundancy of pests and pathogens and thus, the predictability of the species occurring in these environments. Chemical communication among plants and animals belowground remains behind analogous current understanding of terrestrial systems both fundamentally, and from an applied perspective. Drawing upon the existing body of information on multi-trophic belowground communication, we propose development of a method to strategically and dynamically manipulate systems in a manner analogous to 'tuning an audio mixer' with hypothetical 'knobs' that could be adjusted by the user for human benefit. We suggest that biological control could be artificially up-regulated or down regulated by the action of a pest management practitioner using external forces such as volatiles to regulate predator-prey interactions with the ultimate goal of sustainable plant production.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Amalin D.[1,2], B.J.M. Almarinez[1,2,] M. Arcelo[4], M.A. Tavera[2,3], J.I. B. Janairo[1,2] and A. Zhang[5]

Updates on the sex pheromone trapping system for the control of cacao pod borer, *Conopomorpha cramerella*, in the Philippines

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Cacao is a promising high value crop in the Philippines and considered by the government as a priority crop. Before the Philippines can take the opportunity to be a major producer of cacao, production constraint such as pest management should be addressed. One of the major insect pests of cacao in the Philippines is the cacao pod borer (CPB), *Conopomorpha cramerella*, which can cause up to 50 per cent annual loss or even higher if no proper management is employed. This pest is causing considerable damage in southern Philippines. Current management of CPB heavily relies on chemical control but very expensive and not safe to human and environment. The use of sex pheromone for monitoring and control of CPB is gaining an attention as major component of IPM for cacao. A new blend of the synthetic sex pheromone of CBP showed potential in monitoring and mass trapping activities. Evaluation of the different height field installation of the trap was done. Results showed highest average trap catches in 0.1m above the canopy but not significantly different from trap installed 0.5m above and significantly lower in 0.0m (along the canopy) and 0.5m below the canopy. No CPB was trapped in traps with no lure installed 1.0m above canopy. This result confirms that courting and mating of CPB happen in an open area. Follow-up field bioassay is underway to determine the optimum number of traps installed 1.0m above canopy in 1-hectare cacao plantation.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Amsalem E, Starkey J., Brown A.

Do bumblebees (Bombus impatiens) produce brood pheromone?

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Social societies, where egg laying is monopolized by one or a few females, have evolved multiple times during the evolution but were always rooted in a simple family structure. Female reproduction in such families are often characterized by a trade-off between reproduction and brood care, yet, most work on the regulation of reproduction in social insects have focused on chemical signals and traits exhibited by adults. Here we examined the role of brood in regulating worker reproduction in B. impatiens, an annual eusocial species where reproduction is monopolized by the queen via an unknown mechanism. We found that young larvae reduced workers egg laying in a quantity-dependent manner. These effects were replicable regardless of worker age, relatedness to brood, or brood parentage/sex. However, these effects are unlikely to be mediated through a pheromone produced by the larvae, as both volatiles and non-volatiles extracts of young larvae, either starved or fully fed failed to replicate the effect of live larvae. The findings that any larvae regulate worker reproduction in this simple, yet eusocial, species highlight the role of brood in the evolution of complex eusocial insects as a mechanism for regulating worker sterility. Our findings do not support the existence of brood pheromones, in line with the small colony size and the simple social organization of bumblebees. These findings also suggest that B. impatiens queen inhibits worker reproduction through her brood.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Ayasse M. and Steitz I.

Evolution of queen pheromones in primitively eusocial sweat bees

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Chemical communication is crucial for the maintenance of colony organization in eusocial insects and queen pheromones are known to mediate important aspects of their social life, including the regulation of reproduction. Sweat bees are especially suitable for studying the evolution of chemicals associated with sociality as these bees exhibit a high variability of social behavior. In a comparative investigation on various species of eusocial halictid bees, we found higher chemical dissimilarity between castes in obligate than in facultative eusocial species, especially regarding macrocyclic lactones, which were the single common cuticle compound class overproduced in queens compared with workers [1]. Beside this, we performed bioassays to investigate whether these macrocyclic lactones function as queen pheromones in one obligate eusocial sweat bee, *Lasioglossum malachurum.* These bioassays showed for the first time that macrocyclic lactones act as a queen pheromone influencing worker behavior and reproductive physiology in a social sweat bee. Our findings support the hypothesis of the evolution of queen signals from previous fertility-linked signals, as outlined by Smith and Liebig [2]. [1] Steitz et al., J chem Ecol 2018[2] Smith & Liebig; Curr Opin Insect Sci 2017

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

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Influence of an obligate social parasite on host-nest odor and host aggressiveness

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In *Polistes* social wasps, nest odor helps learn colony odor to young wasps. However, it is unclear how the presence an obligate social parasite affects nest odor. We therefore used the montane wasp *P. biglumis* to compare nest odor changes in colonies parasitized by *Polistes atrimandibularis* versus those in free-living non-parasitized colonies. We found that, just a few days after the colony was parasitized, parasite-specific unsaturated compounds appeared and then disappeared from the surface of the host nest, which occurred concomitantly with the parasite becoming chemically indistinguishable from its host. This change contributed to the parasite's integration into the host colony. However, once a host foundress has been enslaved, she will accept and care for the parasite's brood as if it were her own. To better understand the underlying dynamics of this phenomenon, we characterized the chemical signatures of the parasite's brood (larvae and pupae) and compared them with those of the host's brood. The signatures differed in composition, and, notably, the parasite brood had particularly high levels of alkenes (especially 9-C29:1), which were absent from the host brood. Given this result, we tested the effect of the 9-C29:1 on host foundresses and found that it diminished her aggressiveness. Our novel findings shed light on an integration strategy used by a social parasite: a hydrocarbon is used as an appeasement substance to promote host tolerance toward the parasite brood.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Ballard K.

The molecular components of trail mucus in the Common Garden Snail, *Cornu aspersum*

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Cornu aspersum is an invasive land snail that has successfully colonized a diverse range of global environments. Like other invasive land snails, it is a significant pest of agricultural crops, such as citrus, grapes and canola. *C. aspersum* secretes a mucus trail when mobile which functions in locomotion and communication. This study investigated the protein, volatile and microbial components of the mucus trail, in order to gain a better understanding of the constituents of the trail mucus, and the role it may play in the environment. Mass spectrometry of mucus yielded 66 proteins, with 3 targeted for further investigation as possible pheromones. The 8 most abundant volatiles were researched to determine their potential role as a putative pheromone. Microbial diversity profiling identified a large number of species of fungi and bacteria in the trail mucus, 53% from the Order *Actinomycetales*. Bacterial cultures grown from trail mucus resulted in isolation of five species of actinomycete bacteria, 3 from the genus Streptomyces, and 2 from the genus *Nocardiopsis*, all of which showed antifungal activity against 5 common fungi. In summary, this study has provided insight into the role of snail mucus in the spread of microbial pathogens and provides a useful repository for land snail trail mucus components. This may be utilized for further research regarding snail communication and dispersal, and may be applied in the fields of agriculture, ecology and health.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

ISCE 2019 Annual Meeting
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Oral Presentations

Berasategui A.[1], Salem H.[2], Gerardo N.[1]

Host secondary metabolites drive parasite specificity in fungus-growing ants

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Fungus-farming ants cultivate fungi as food source. Across 230 known species, the ants grow a narrow range of fungal cultivars. These cultivars are hosts to fungal parasites of the genus *Escovopsis*, which can attack the cultivar, leading to colony decline. *Escovopsis* can respond to unknown host chemical cues, and their hosts can defend against *Escovopsis*. This leads to each parasite strain being able to attack their natural host and closely related ones, but not distantly related cultivars. We employed a multidisciplinary approach to understand the underpinnings driving the specificity of this co-evolved system. We generated genomic data for two *Escovopsis* strains attacking two distantly related cultivars. *Escovopsis* harbor reduced genomes that are enriched in genes involved in pathogenicity. Our analysis reveals the differential distribution of genes encoding resistance against antifungals, suggesting that each *Escovopsis* strain may employ slightly different strategies to overcome their natural hosts, which could promote host-parasite fidelity. *Escovopsis* strains facing single antifungals revealed that each strain is resistant to a distinct set of compounds, correlating with the presence of different antifungal-resistance genes in their genomes. These genomic features may be involved in overcoming host defenses and might contribute to host fidelity. To test this, we are applying CRISPR to modify *Escovopsis* to manipulate the mechanisms underlying host-specificity.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Bing J., Kessler D., Baldwin I.T.

Uncoupling pre- and post-pollination in *Nicotiana attenuata* to evaluate the potential and actual outcrossing of different pollinators

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Nicotiana attenuata, a self-compatible wild tobacco species, has a broad community of day and night active flower visitors. Since flower visitation per se does not guarantee efficient pollination, the aim of this study is to evaluate the pollinator efficiency in terms of outcrossing. Therefore, we uncouple pre- and post-pollination to gain a better understanding of potential and actual outcrossing resulting from pollination by different floral visitors. For this, we conducted experiments with transgenic plants disrupted in post-pollination mate selection (irACO) in comparison to control empty vector plants (EV) planted as pairs surrounded by four accessions (paternal genotypes) in natural and semi-natural conditions. We performed open and hand pollinations using non-emasculated flowers to allow for natural selfing rates. Seeds produced after pollinator visitation were used for genotyping to estimate outcrossing rates in irACO (reflecting potential outcrossing) and EV flowers (reflecting actual outcrossing after mate selection). Flowers visited by day pollinators in natural conditions did not contain any outcrossing, while capsules from flowers visited by *Manduca sexta* in seminatural tent experiments contained up to 70% of outcrossed seeds. We found higher potential than actual outcrossing as well as a high variation of pollen donor identity in the capsules suggesting that *M. sexta* is offering a highly diverse pool of pollen mates in comparison to other pollinators.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Birnbaum S. and Abbot P.

Trans-generational transcriptomic response to natural variation in host plant toxicity and insecticides in a specialist insect

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Insects have been challenged by plant secondary metabolites throughout their evolutionary history. An important mechanism thought to promote insecticide resistance is the ability of insects to use preexisting detoxification systems originally evolved for tolerance of plant defenses. Yet, it remains unclear what level of convergence exists in metabolic mechanisms employed against various natural and xenobiotic chemicals. How do transcriptomic responses to these stressors change in response to novel and long-term exposure? We employed an experimental evolution approach in a milkweed- specialist aphid (*Aphis nerii*) model to test the effects of a more toxic host plant species and two insecticides (a neonicotinoid, Imidacloprid, and a general homopteran blocker, Pymetrozine) on aphid gene expression and fitness over multiple generations of selection. Aphids were transferred from low toxic plants and selected on three stress treatments: a high toxic host plant species, Imidacloprid, and Pymetrozine for five generations. Whole transcriptome gene expression changes and changes in development time and fecundity were compared at generations one and five. While there were no consistent fitness costs or benefits to long-term exposure, exposure to stress is associated with increased transcriptional plasticity and changes in genes associated with the metabolism of secondary metabolites as well as genes important in transcription, translation, and post-translation processes.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Blanchard S.*°, Detrain C. °, Van Offelen J. °, Verheggen F.*

Aphid-ant mutualism under a changing climate: Impact of temperature and CO_2

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Recent studies about mutualism consider the complexity and versatility of the relationship. Because species interactions are highly dependent on the environment, the climate changes foreseen for the coming years are expected to have impacts on the evolution of mutualistic interactions. In this study, we test the hypothesis that the predicted raise of carbon dioxide concentration and temperature will impact the semiochemically-mediated interactions in an emblematic multitrophic interaction model including Vicia faba plant, the aphid pest Aphis fabae and the aphid-tending ant Lasius niger. We observed quantitative modifications of V. faba volatile emissions with cascade impact on aphid attraction toward the host-plant. Winged aphids prefer plants grown under elevated CO2 concentration. We also found that a raise of temperature increases ant mobility, along with an increase in the number of physical interactions with aphids, including the number of antennae contact. We conclude that an increase in temperature reinforces aphid-ant mutualistic interaction. Furthermore, we are investigating the sugar composition and volatile emissions of aphid honeydew, for a more complete understanding of the impact of abiotic factors on aphid-ant mutualism.

Themed Session: Language of Life Under Climate Change

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Blande J.

The effects of ozone pollution on volatile-mediated interactions

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Plants provide information to other members of their community by releasing complex blends of volatile organic compounds. The composition of the chemical blend reflects the physiological status of the plant and the information content can stimulate responses in a range of organisms. Although volatile cues and signals have the potential to structure a myriad of interactions between and within trophic levels, they are vulnerable to disturbance. Factors that affect the chemical composition of a volatile blend, or the ability of an organism to detect the blend, can impinge upon the effectiveness of volatile-mediated interactions. Air pollution may undermine the interactions at several junctures, including by altering the composition of stress-induced emissions, reacting with volatiles in transit from the emitting to the receiving organism, and by negatively affecting the process of volatile detection by receiving organisms. One particularly significant atmospheric constituent is the phytotoxic secondary pollutant ozone, which induces oxidative stress in volatile-emitting and –receiving organisms, and reacts with a multitude of phytogenic chemicals. In this presentation, a series of field and laboratory experiments examining the susceptibility of volatile-mediated interactions to ozone pollution will be presented. The emphasis will be on highlighting the need to consider the abiotic environment in order to understand and manipulate volatile-mediated interactions in the field.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Block A., Beck J., Alborn H., Robert Meagher

Herbivore-induced maize volatiles in pest attraction and control

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Maize produces a range of volatiles in response to herbivory by fall armyworm (*Spodoptera frugiperda*). These volatile cues function in indirect defense as they guide parasitoid wasps, inducing *Cotesia marginiventris*, to infested plants. Parasitized fall armyworm subsequently inflicts less damage to their host plants. Although volatiles are known to be important in plant defense, the specific function of individual compounds remains enigmatic. In this study we examine herbivore-induced volatile production in three sequenced maize inbred lines and assess the ability of *Cotesia marginiventris* to parasitize fall armyworm on the infested lines. Furthermore, we correlate production and perception of specific volatiles with attraction of larval and adult fall armyworm. These data, coupled with the available genomic data, provide the first steps toward guided molecular breeding of the herbivore-induced volatile profiles of maize, to repel pests and attract beneficial insects.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Broadhead G. and Raguso R.

Nitrogenous floral volatiles as indices of nectar amino acid content

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Honest signals are frequently maintained by costs. In conventional, learned associations costs may be imposed by receivers sanctioning dishonest signalers. Alternatively, these costs may take the form of production costs or resource limitation. Floral volatiles are often overlooked as potential sources of honest information specifically because the signal (floral scent) and reward (nectar or pollen) are frequently dissociated and little is known about the costs of scent production. Certain volatiles, however, namely some nitrogen-containing or aromatic compounds, are produced from essential amino acid precursors and may be directly linked to a plant's nitrogen status. Using the yellow evening primrose, *Oenothera flava*, we tested the hypothesis that nitrogenous floral volatiles can serve as indices of nectar amino acid content/nutritional quality and, further, examined the potential fitness benefits to pollinators attending to this index of plant quality.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Brown E., Kubanek J.

Do Phytoplankton Use Dead Competitors to Assess Predation Risk?

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Organisms are under selection pressure to assess predation risk to avoid becoming prey. In some cases, cues from injured competitors reveal to individuals that predators are nearby. Previous studies have shown that the marine phytoplankton *Alexandrium minutum* responds to chemical cues from predatory copepods by dramatically upregulating sodium channel-blocking toxins that appear to function as a chemical defense. However, it is unknown whether *A. minutum* uses other cues, such as damaged competitors, to respond to predation risk. In a multifactorial culture experiment, chemical cues from dead competitors caused *A. minutum* to change its toxin production in a species-specific manner. Intracellular toxins were affected by relatedness of the competitor, with cues from unrelated competitors inducing and those from related competitors suppressing toxin production. Additionally, there was an inverse relationship between intracellular toxin production and growth suggesting *A. minutum* experiences a trade-off. However, the link between competitor exposure and toxin production in *A. minutum* became more obscure when examining extracellular toxin concentrations. Moreover, historical co-occurrence of competitors emerged as an influence in regulation of extracellular toxin production in *A. minutum.* Together, these results reveal that relatedness and co-occurrence of the dead competitors are important to *A. minutum* when assessing whether to defend or grow.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Brückner A. and Parker J.

Single-cell biology reveals the assembly of a rove beetle chemical defense system

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Multicellular exocrine glands, where cells work collectively to synthesize bioactive secretions, provide a paradigm to study the evolution of novel cell types and biosynthetic pathways. We exploit a new unique model system – the defensive gland of the rove beetle *Dalotia coriaria*. *Dalotia* has a large defensive gland at the dorsal abdomen tip consisting at least two cell types, which produce a cocktail of three different benzoquinones (D1 cells), or the hydrocarbon solvent undecane and two esters (D2 cells). To shed light on how these cell types evolved and whether they arose from pre-existing cell types, we performed bulk and single-cell comparative transcriptomic analyses of the beetles' gland segment and compared it to other non-gland bearing segments. In total, we uncovered over 3000 genes, that are differentially expressed in the gland cells and assigned them to different cell types. Additionally, we performed stable-isotope experiments to trace potential precursors and interfere the biosynthetic pathways on both molecular and biochemical level. We found that the production of the benzoquinone irritants is likely to be related to tyrosine metabolism and derived from cuticular tanning pathways, while the alkane solvent production appears to be recruited and co-opted from the biosynthetic pathways found in oenocytes. Overall, we show how state-of-the-art single cell biology can be utilized to study biochemical ecology with unprecedented molecular and cellular resolution.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Burghardt G.M.

Snake foraging as a model Behavior Systems Approach to sequentially organized behavior

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Chemosensory mechanisms, including nasal olfaction and especially vomerolfaction, are critically important in much snake behavior. Foraging in natricine snakes has been particularly well-studied, and this paper will synthesize many decades of experimental studies on these animals, primarily gartersnakes. Much of this work involved studies of neonatal snakes, and so behavioral ontogeny is also an important aspect of this work. Behavior systems, a set of approaches developed by psychologists interested in conditioning, but based on earlier ethological studies of numerous species, is an integrated means of dealing with the sequential organization of behavior in naturalistic contexts, and is an alternative to focusing only on convenient target responses. This presentation will describe the major components of behavior system approaches with examples from the extensive literature on all aspect of foraging, along with current work underway in our laboratory. Field, genetic, physiological, chemical, social, developmental, and other types of studies all enrich our understanding of the foraging system in these snakes and its diversity and plasticity.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Caesar L.K.*, Nogo S.*, Naphen C. N.*, Cech N. B.*

Simplify: An Integrated Metabolomics Approach to Identify Additives and Synergists from Complex Mixtures

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From crude oil to biological organisms, complex mixtures are all around us. The interactions among mixture constituents form a foundation for myriad biological and chemical processes. In the field of natural products drug discovery, it has long been recognized that the activity of mixtures can result from the interaction of multiple constituents. Chemists have historically employed isolation-based approaches to reduce the complexity of mixtures to individual compounds. However, such approaches fail to incorporate multi-constituent interactions, such as synergy, that can contribute to the overall biological activity of a mixture. We have developed a strategy called "Simplify" which enables identification of constituents that interact to achieve biological effects. The Simplify approach combines biological assay results and mass spectrometric datasets and uses a metric called the "activity index" to predict which mixture constituents will, in combination, achieve the observed activity. With an extract from the botanical *Salvia miltiorrhiza* as a case study, we employed Simplify to identify constituents that work in combination to achieve antimicrobial activity. These included three compounds with additive activity and one synergist. As these results demonstrate, Simplify is a novel approach that enables prediction of key contributors to the biological effect of a complex mixture prior to isolation and is expected to prove useful across disciplines that rely on mixture analysis.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Carlson S.[1], Sneed J[2]., Gunasekera S.[1], Agarwal V.[3], Dixson D. L.[4], Paul V. J.[1]

Isolation and identification of waterborne chemical cues for *Porites astreoides* coral larvae

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Degraded coral reefs stink! Algae and cyanobacteria dominated coral reefs are indicative of declining reef health. Chemical cues from dominant community members affect the recruitment of juvenile fish and coral larvae, both of which are deterred by cyanobacteria and some algae. Our understanding of chemical cues driving recruitment has been limited to seawater soaked with individual organisms from the reef. During the last two years of fieldwork on the Mesoamerican barrier reef off the coast of Belize, we utilized natural product chemistry to analyze the molecular composition of these seawater soaks. Metabolomics analysis of seawater collected from reef, seagrass, and offshore habitats, has highlighted individual molecules responsible for this observed attraction to the reef. Utilizing a two-channel choice flume, individuals from both degraded and healthy habitats have been determined to be either attractive or deterrent to coral larvae. We are working to isolate individual molecules responsible for the attraction of *Porites astreoides* larvae from the crustose coralline algae *Hydrolithon borgesenii*. *P. astreoides* larvae are deterred by seawater that previously contained the common bloom-forming cyanobacterium *Hormothamnion enteromorphoides*. LCMS analysis revealed that the seawater contained predominantly the cyclic peptide laxaphycin A. Appreciable quantities of were then recovered from seawater that previously contained *H. enteromorphoides* and offered to coral larvae.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

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Soil microbes mediate enhanced pest resistance on organic farms

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It is well-established that organic farming practices can significantly increase soil health and plant nutrient balance while decreasing incidence of plant pathogens and insect pests. Decreased insect populations on long-term organic farms have largely been attributed to increased herbivore biodiversity and numbers of beneficial insects, such as predators. However, the role of plant defenses in these interactions has largely been ignored. The goals of this study were to determine whether organic management mediates decreased pest populations through changes in host plant resistance and to identify the mechanisms that underpin these changes. To address this, we investigated differences in pest populations, insect preference and plant defenses using on-farm and lab studies. We demonstrate that organic fields had lower pest populations compared to conventional sites and that differences were due partially to increased plant resistance. Soil microbiome sequencing and transgenic approaches coupled with multi-model inference show that changes in plant resistance were dependent on salicylic acid accumulation in the plant and rhizosphere microbial communities. Results suggest that organically managed soils and microbial communities play an unappreciated role in depressing plant attractiveness to pests by increasing plant resistance to herbivores.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Castellan I., Jones O., Miller D., Pickett J., Allemann R.

Synthetic biology routes to novel aphid semiochemicals for crop protection

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Semiochemicals (signal chemicals) can attract or repel insects away from crops. Therefore, they can be used in a strategy to protect food. In previous work, we tested the hypothesis that analogues of the precursors of semiochemicals would give rise to new semiochemicals that could be designed rationally with more useful biological properties. With the initial target being the sesquiterpene (S)-germacrene D (GD) a naturally occurring aphid repellent, associated with plant damage, novel analogues were obtained from a modification of the natural biosynthetic precursor, farnesyl diphosphate. One analogue (S)-14,15-dimethylgermacrene (DMGD) was unexpectedly a powerful attractant in laboratory behavioural assays. We have produced modified aphid repellent and attractant semiochemicals through this strategic chemical approach using enzymes. The same aphid semiochemical DMGD showed high attraction in preliminary field simulating studies. Opportunities for commercial testing have been identified, and can now underpin field trials for aphid control. We are now in the process of completing commercial scale production of DMGD and GD for the commercial field trials. After conducting these trials, anticipated results should provide evidence of attraction and repellence respectively involving pest aphids in the field. Potential outcomes from this research include the registration of DMGD and GD for wider commercial exploitation in horticultural and also in arable crops against aphid pests.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Cha D.[1], Skabeikis D.[1], Yew J.[2], Choi M.[3], Vander Meer R.[4]

Identifying trail pheromone components of the little fire ant, Wasmmania auropunctata

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The little fire ant (LFA), Wasmannia auropunctata Roger (Hymenoptera: Formicidae), is native to the neotropics, but has become one of the world's most widespread and destructive invasive ants. In Hawaii, LFA was first discovered in 1999 on the Big Island and since then has rapidly spread to neighboring islands, causing severe ecological and economic damage. Baits are considered the most viable and environment friendly control option, but currently available baits are not developed to target LFA and not particularly attractive to workers of LFA. Thus, we are identifying recruitment trail pheromone components of LFA to enhance the attractiveness and efficacy of baits. LFA develop fully functional nests on the ground and arboreally, where their foraging and retrieval of food resources is facilitated by a well-developed recruitment trail. As a first step to identify LFA recruitment pheromone components, we evaluated LFA worker behavioral response to trail marking substance(s) that was laid down on or extracted from epiphytic moss and found that LFA workers readily follow trail marking substance(s) in the laboratory and field. Updates on chemical identification of the pheromone components and their use for the improved LFA management will be discussed.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Chandler J.

Interbacterial competition and the evolution of quorum sensing

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Many bacteria exist in polymicrobial communities where they cooperate and communicate to carry out elaborate social behaviors. We are interested in quorum sensing, a type of communication used to control gene expression in a population density-dependent manner. Quorum-sensing systems frequently control the production of antibiotics, which are thought to be important for competing with other strains and species in complex communities. Previous studies of quorum sensing have primarily been on single-clone populations. Although direct studies of naturally occurring polymicrobial communities presents many challenges, recent development of laboratory 'in silico' models of mixed-strain and mixed-species populations provide an innovative approach to study quorum sensing in a controlled, simplified environment. In this talk, I will describe some of the laboratory models we have developed to study quorum sensing in complex communities. These include dual-species models of competing soil bacteria or of pathogens known to co-infect human patients. We also use models to understand the evolution of quorum-sensing systems in cooperating populations. Results with these models have shown how quorum sensing alters the dynamics of populations in multiple-strain and multiple-species communities, and that competitive interactions can influence the evolution of quorum sensing. Our approach has opened new windows into understanding bacterial community interactions and quorum-sensing ecology.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Chaves Fonnegra A.

Allelopathy in spatial competition among sponges and scleractinian corals

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Marine sponges are sessile animals that can aggressively compete for substratum against reef corals; among these, excavating sponges have been of special interest for being strongly destructive. Different allelopathic mechanisms have been proposed to understand how sponges may attack corals and conquer space in the reef, as well as the consequences of this aggression. In this talk, I summarize what we know about allelopathic mechanisms for space competition on coral reefs, and the relationship between sponge competitive strategies and the use of chemical compounds. In particularly, I focus on Cliona spp. excavating sponges as a model, and the possible uses of Clionapyrrolidine A and Serotonin in competition for space. This group of sponges allow us to explore how competitive strategies and allelopathy may change on current and future deteriorated coral reefs.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Chen L.

Waterproofing function of cuticular hydrocarbons from the imported fire ants

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CHC profiles of S. richteri are characterized by significant amounts of short-chain (C23–C27) saturated and unsaturated hydrocarbons. In contrast, profiles of S. invicta consist primarily of long-chain (C27–C29) saturated hydrocarbons; unsaturated alkenes are completely lacking. Hybrid fire ants show intermediate profiles of the two parent species. When their CHCs were removed using hexane, mass loss of freshly killed workers of S. richteri, hybrids, and S. invicta was significantly increased but the water loss transition temperature (Tc-ant) was significantly decreased. Several melting points (Tms) of each CHCs sample of different ant colonies were determined using differential scanning calorimetry (DSC). Tms of CHCs samples from S. invicta and the hybrid were significantly higher than that from S. richteri. The correlation between water-loss transition temperature of CHC blends (Tc-CHC) measured by an artificial membrane system and the highest Tms (Tm-maxs) obtained from the same CHCs sample was highly significant. These results reveal that CHCs play an important role in water proofing in fire ants, and that species having higher Tc and Tm-max retain more water under relatively higher temperature, and consequently are able to occupy warmer environments. In conclusion, CHC chemistry, at least in part, plays a role in shaping current distribution patterns of S. richteri, S. invicta and their hybrid in the United States.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Chen J., Du Y., Grodowitz M.,

Fire Ant Control in Potting Soil Using a Hexyl benzoate Based Formulation

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Red imported fire ants (RIFA), introduced from South America to the U.S.in the 1930's, have caused significant problems including human health concerns due to their venomous stings as well as causing damage to a variety of crops. RIFA are often associated with gardens and homes preferentially building their nests in potted plants. Potted plants provide RIFA ideal places to build their nests, likely because potted soil provides adequate moisture and the containers prevent ant colonies from being impacted by floods. A mound drench formulation using hexyl benzoate, a naturally occurring compound with minimal mammalian and aquatic toxicity, has shown promise in initial testing and is currently being evaluated for RIFA control. In this study, the efficacy of this formulation was evaluated against RIFA in potted plants. Residual activity and phytotoxicity were also evaluated.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Chen F.

Evolution of Biosynthesis of Volatile Terpenoids Mediating Interactions among Organisms

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Among diverse volatile organic compounds mediating various organismal interactions are terpenoids. Terpene synthases are pivotal enzymes catalyzing terpenoid formation. We have been using a combination of comparative genomics and functional genomics to determine the presence/absence of terpene synthase genes and their catalytic functions in all three domains of life. Specific examples in land plants, social amoeba and fungi will be presented to illustrate the mechanisms underlying the evolution of terpenoid biosynthesis.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
June 2- 6, 2019
Oral Presentations

Chiu C.[1,2], Keeling C.[1,3], Bohlmann J.

Detoxification of Pine Terpenoids by Mountain Pine Beetle Cytochromes P450

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The mountain pine beetle (Dendroctonus ponderosae; MPB) is an irruptive bark beetle species affecting pine forests of western North America. Pine hosts produce a viscous oleoresin comprised of terpenoids; monoterpenes, sesquiterpenes and diterpene resin acids, as a defense against insects and other herbivores. Cytochromes P450 (P450s) are enzymes that are associated with insect detoxification of host allelochemicals. This research assessed the role of MPB P450s in the detoxification of terpenoids. We showed that the MPB produces monoterpenyl esters in response to monoterpene exposure. Through a functional genomics and biochemical approach, we identified the P450s CYP6DE1 and CYP6DJ1 that may be involved in the conversion of the monoterpenes (+)-α-pinene, (–)-α-pinene, (+)-β-pinene, (–)-β-pinene, (+)-3-carene, (+)-limonene, (–)-limonene, and terpinolene to monoterpenyl esters. We showed that the products of these enzymes are present in monoterpene-treated MPB extracts. These results provide new insights into how MPB interacts with host terpenoids defenses and the roles of P450s in these interactions.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Clavijo-McCormick A. and Soriano K.

Smelly ferns: investigating responses to physical damage and herbivory in ancient plants.

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New Zealand has a high diversity of ferns including unique endemic species, and although their taxonomy and phylogeny have been well described, their biochemistry and ecology remain poorly understood. Ferns are a very ancient group of plants, and there is ample fossil evidence proving that the relationship between ferns and insects started long before the appearance of angiosperms. Exploring the chemical responses of these non-seed plants to biotic and abiotic stress may provide insights on the evolution of plant defenses, inform conservation decisions on their native ecosystems, and unearth new compounds of pharmaceutical interest. In this study, we characterized the volatile blends of six native New Zealand fern species and their changes in response to physical damage, exogenous application of jasmonic acid, and herbivory by the Wellington tree wēta (Hemideina crassidensis). The results show that all fern species respond to physical damage by increasing their volatile emissions but have variable responses to jasmonic acid. Our findings also suggest that there are specific compounds emitted exclusively in response to herbivory. This work indicates that changes in volatile emission are common responses to biotic and abiotic stress in all vascular plants but prompts further research to elucidate the signaling and regulatory mechanisms in ferns and explore the responses to herbivory in non-vascular plants.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Conboy N.[1], McDaniel T.[1], George D.[2], Donohoe P.[1], Gatehouse A.[1], Tosh C.[1],

Dynamic differences in how a commercial and wild tomato species interface with their volatile environment

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Wild ancestors of commercially grown crops are often more resistant to insect pests and in previous work we showed that a wild tomato species (Solanum pimpenillefolium) is more resistant to the glasshouse whitefly than a commercially grown tomato variety (Solanum lycopersicum var. 'Elegance'). Volatile organic compounds (VOCs) are an essential element of plant defense and here we show that S. pimpenillefolium produces a higher quantity and greater diversity of VOCs compared with the commercially grown 'Elegance'. We propose that increased emissions of whitefly repellent terpenes such as limonene could contribute to the augmented resistance observed in wild plants. We also found that both constitutive and whitefly induced volatiles from S. pimpenillefolium make these plants more attractive to Encarsia formosa, a commonly used biocontrol organism for suppression of whitefly populations. Following this we set out to understand how each of these plants respond to herbivore induced plant volatiles (HIPVs) from whitefly infested conspecifics by analyzing activity of defense related genes. We discover that wild tomato can respond more effectively to HIPVs by priming defense related genes after just 12 hours of exposure. Similar effects are only seen in 'Elegance' after 2 days of HIPV exposure. Inferior attraction to parasitoids, decreased VOC output and inability to rapidly prime defenses could all contribute to the inferior resistance to whitefly shown in this commercial variety.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Crewe R.[1], Moritz R.[2],

Sex, social regulation and intraspecific social parasitism in honey bees

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The evolution of a novel social regulatory pheromone produced in the mandibular gland of honey bees led to its parsimonious use as a sex pheromone and to a number of other evolutionary changes in social organisation. The fatty acids produced in the mandibular glands of honey bees are unique in having four important functions: the first is to act as an acidification agent for royal jelly that allows for queen rearing (10-hydroxy- 2-decenioic acid - 10HDA), the second is to act as an antibiotic in larval food (10 HDA), the third is to act as a sex pheromone for the attraction of drones (9-keto-2-decenoic acid – 9ODA), and the fourth is to act as a social regulator in caste determination through the inhibition of ovary activation in workers (QMP -queen mandibular gland pheromone). The multiple functions of the C10 fatty acids in honey bee social behavior raises questions about the origin and evolution of this communication system in honey bees. We explore the biosynthesis of this social regulatory pheromone in workers of the Cape honey bee (Apis mellifera capensis) that possess the thelytoky gene, under different social conditions in experimental colonies and show that the pheromone can be used to establish some workers as intraspecific social parasites. Worker social parasitism arises from a single nucleotide polymorphism in the thelotoky gene and provides an insight into the evolution of parasitism.

Themed Session: Chemical Communication of Social Insect Associates: Espionage, Weaponry and Stealth

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Crisan C.[1], Nichols H.[1], Steinbach G.[2], Yunker P.[2], Hammer B.[1]

Glucose enhances E. coli competitiveness against Type VI Secretion attacks by Vibrio cholerae

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Vibrio cholerae causes fatal cholera disease in humans but also inhabits marine ecosystems where it lives in multispecies microbial communities such as biofilms. Like many bacteria, V. cholerae uses a harpoon-like Type VI Secretion System (T6SS) to deliver lethal toxins into neighboring cells and to compete against other microbes in these habitats. In laboratory settings on standard LB medium, a V. cholerae strain that constitutively expresses the T6SS (T6SS+) efficiently kills target E. coli cells in a T6SS-dependent manner in a 3-hour competition assay. However, on standard LB medium supplemented with glucose, E. coli cells survival is significantly enhanced when competed with the V. cholerae T6SS+ strain. Glucose does not alter T6SS gene expression and does not impair killing of other bacteria by V. cholerae. Other sugars like galactose or lactose do not influence the ability of E. coli cells to survive T6SS attacks. Grow rates also do not play a role in the killing evasion since no difference in the number of E. coli cells was observed after 3 hours of growth on LB or LB with glucose. Confocal microscopy images of mixed V. cholerae and E. coli colonies confirm that individual E. coli cells are still susceptible to killing on glucose. We are currently testing the hypothesis that glucose alters the spatial structures of mixed colonies and allows E. coli to persist despite T6SS-mediated killing. We are also working to understand the genetic basis for this phenomenon.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Da Silva R.

Exploring plant chemical diversity with Network Annotation Propagation

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Untargeted Mass Spectrometry (MS) is one of the main methods used to explore the chemical diversity in biological systems. The annotation of small molecules is one of the most challenging steps in untargeted MS. Molecular networking has emerged as a structured way to organize and mine data from untargeted MS/MS experiments and has been widely applied to propagate annotations. Molecular networking can be used to improve the accuracy of in silico predictions through propagation of structural annotations, even when there is no match to a MS/MS spectrum in spectral libraries. We have employed reference spectral libraries as well as experimental LC-MS/MS results to validate the automated Network Annotation Propagation (NAP). NAP is built on top of in silico fragmentation performed with MetFrag. When there is a spectral library match within a molecular family of the molecular network, NAP utilizes the Fusion scoring. When there are none or very few spectral matches, NAP utilizes the Consensus scoring. We have shown that the annotation propagation improves the position of the correct candidate structure significantly. To expand NAP we have used the structural similarity among candidate structures, deriving a weighted graph. This graph was subsequently used by a random walk algorithm to calculate the probability of 'walking' through a set of candidates, departing from spectral library matches nodes. This approach allowed the information propagation to nodes not directly connected to

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Davidson-Lowe E., Swayamjit R., Murrell E., Kaye J., and Ali J.

Managing herbivore attraction through cascading interactions between cover crops, AMF, and plant volatiles in maize

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Cover crops play an important role in agroecosystems by improving soil health and reducing negative inputs to the surrounding environment. However, less is known of how cover crops affect plant-herbivore interactions in the following cash crops. Soil legacy effects persist after the cover crops are terminated and can have lasting impacts on soil microbial communities, such as arbuscular mycorrhizal fungi. Arbuscular mycorrhizal fungi (AMF) form mutualistic associations with the roots of most terrestrial plants, including the majority of agricultural crops. In addition to facilitating nutrient uptake, AMF can also influence plant phytochemistry and resistance to herbivores. In this study, we investigated how different cover crop species affected AMF colonization in maize and resistance to fall armyworm (Spodoptera frugiperda). We measured fall armyworm performance and host-plant selection in maize plants that were grown after four different cover crop treatments (fallow, pea, radish, and triticale). Volatile profiles were collected to assess which cues may be informing fall armyworm behavior. Linking cover crops to soil microbe activity and herbivore resistance can help growers intentionally select cover crops for improved pest management.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

de Roode J.

Effects of plant toxins on monarch butterfly infection, immunity and the gut microbiome

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Parasites pose major threats to their hosts' fitness, and hosts can protect themselves against infection through innate immune responses, anti-infection behaviors and microbial defenses. Monarch butterflies are specialist feeders of milkweed host plant species, which vary in their toxicity of secondary chemicals called cardenolides. Monarchs are commonly infected with a protozoan parasite, and infected females preferentially lay their eggs on high-cardenolide species of milkweed, which reduce infection in their offspring. While previous work suggests that these cardenolides directly interfere with parasite infection, current studies also indicate that milkweeds alter the monarch gut microbiome, and that the altered microbiome contributes to parasite resistance. I will summarize the anti-parasitic behaviors of monarchs and the role of the microbiome in determining parasite resistance, and also summarize studies on the effects of cardenolides on monarch innate immunity.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Deletre E., Mekonnen B., Pirk C., Yusuf A., Torto B., Ekesi S.

Trait-mediated avoidance behavior of fruit flies to semiochemicals of Oecophylla longinoda (Latreille) (Hymenoptera: Formicidae).

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Predator detection and avoidance are crucial traits for prey's survival. These anti-predator behaviors could involve chemical cues produced by the predator. Predator-kairomones could be contained in marking pheromones, skin chemicals, and metabolites of protein digestion. Among five ant species previously tested, the African weaver ant Oecophylla longinoda is one species producing repellent compounds to herbivores. However, there is no information about semiochemicals involved in repelling preys. Experiments carried out using ant-exposed and non-exposed mango fruits, revealed that, the fruit flies Bactrocera dorsalis and Ceratitis cosyra avoided and laid fewer eggs on mango discs that were exposed to weaver ants. Thereafter, choice bioassays were carried out using whole body, thorax, head and abdomens of ants extracted in hexane, methanol, ethyl acetate and water to determine their repellency. B. dorsalis females avoided abdomens extracted in water while C. cosyra were affected by abdomen extracts in hexane, methanol and water. Further assays were carried out using the glands in the abdomen and Dufour gland extracts revealed similar repellence effect. The contents of the Dufour's glands were identified using GC-MS and the repellency of the major components tested. Investigation is ongoing to test other minor components in an effort to identify possible fruit fly repellent compounds.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Derstine N[1]., Villar G[1]., Hefetz A[2]., Millar J[3]., Amsalem E[1].

Chemical characterization and behavioral responses to Dufour's gland esters in Bombus impatiens

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Social insects exhibit complex cooperative behaviors that are regulated, in part, by a variety of pheromones. However, the identity of the active compounds and their signaling role has only been characterized in a few species, most of which exhibit advanced social organization. The Dufour's gland secretion of bees contains a variety of compounds, including long-chain hydrocarbons, fatty acids, and esters, which are hypothesized to mediate nest recognition and certain social interactions. While the hydrocarbons are ubiquitous in all Hymenoptera and are believed to be an ancestral trait, the esters have been implicated in complex communicative roles in eusocial bees (e.g. fertility and sterility signals). Here, we examined the signaling role of Dufour's gland secretion, and particularly, its ester fraction, in the primitively eusocial bee Bombus impatiens. We analyzed the glandular secretion of females of different castes and social conditions and examined worker attraction and antennal responses to the different glandular components. We found that B. impatiens workers, but not queens, produce wax esters in their Dufour's gland and the overall amount of esters is higher in the presence of the queen. Workers preferred the secretion of bees from their same reproductive state and social condition and responded to components of the glandular secretion in electroantennogram assays. The roles of esters vs. hydrocarbons in eliciting behavioral responses in workers will be discussed.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Dillman A.

Condition dependent volatile cues and host choice by entomopathogenic nematodes

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Entomopathogenic nematodes (EPNs) are a guild of insect-killing parasitic nematodes that are used as biological control agents against a variety of agricultural pests. The infective juvenile (IJ) stage, a developmentally arrested non-feeding stage, is responsible for searching, finding, and invading a new host. Chemosensory information plays a central role in the decision of whether or not to infect a potential host. Furthermore, chemosensation may reveal whether a potential host is already infected with EPNs and allow IJs to differentiate between conspecific or heterospecific infections. Dispersal is an essential element of the EPN life cycle, where newly developed infective juveniles (IJs) emerge and migrate away from a resource-depleted insect cadaver in search of new hosts. Prenol is a volatile odor associated with EPN-infected insect cadavers that is repulsive to EPN IJs and attractive to some free-living nematodes, including C. elegans, and some insect larvae. We found that while prenol acts as a repulsive agent for all species of EPNs that we have tested, only some species respond to prenol as a dispersal cue. In order to understand how odorants such as prenol inform behavioral decisions, we have leveraged the natural diversity of C. elegans to identify neurons and genes that affect the response of C. elegans to prenol.

Themed Session: Language of Cooperation and Conflict: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Dixon D.

Do chemical cues hold the key to coral reef recovery?

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Chemical cues provide a "language" that coral reef organisms use to interact with each other. They are a vital component in the settlement process of incoming larvae locating a suitable reef habitat. Although the recruitment of fishes and invertebrates is critical for reef resilience, mechanisms affecting recruitment are inadequately understood. Underlying components driving behavioral choices have yet to be discovered. Advances in the fields of genetics and modeling have provided insight on settlement patterns for many marine systems. However, the basic question of "what causes an organism to select one location as opposed to another?" is still unanswered. In addition, coral reefs are degrading at an alarming rate with many reefs transitioning from complex coral dominated systems to simplistic algal-dominated communities. Loss of corals leads to the loss of reef fish, and this leads to additional coral decline because intact fish communities aid coral recovery after bleaching, predation, and other disturbances. If we are to better manage coral reef communities, we must integrate important behavioral components into management strategies such as chemically mediated behavior.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Dose B.[3], Hertweck C[1].,

Endosymbiotic bacteria of pest beetle produce chemical armoury to guard its host from pathogens

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Symbiotic interactions are a rich source of natural products. Often, endosymbionts provide biologically active compounds to their hosts in exchange for nutrition and a protected habitat. In particular, endosymbiotic Burkholderia spp. have been found to harbor an ample metabolic potential that allow them to engage in various symbiotic relationships with plants, fungi and insects. A prime example thereof is the mutualistic relationship of the pest beetles of the Lagriinae subfamily and Burkholderia gladioli. The host beetle carries the bacterial endosymbionts in specific organs within their body and transmits the symbionts from mother to offspring. Natural products produced by the endosymbiont have been suggested to protect the eggs of its host against pathogens. By genome mining and metabolic profiling of the endosymbiont we unveiled the bacterial origin of a nonribosomal peptide previously thought to be of fungal origin and investigated its biological function. The responsible assembly line is widespread among many symbiotic Burkholderia species from diverse habitats, indicating an important ecological role. Knowledge of the ecological function of natural products involved in symbiotic interactions has the potential to reveal new strategies for the treatment of pathogens.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Dowell J., Mason C.,

Impacts of physical chemistry on biosynthetic constraints of plant volatile profiles

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Plants are prime examples of organisms maximizing the usage of chemistry in relaying information concerning status conditions to neighboring plants and attracting/repelling beneficial/detrimental organisms. The central hypothesis concerning the production of specialized metabolites is primarily dependent on enzyme abundance, such that any and all constraints are due to genetic control of protein regulation. In earlier work, these canonical reactions, or reactions specified along accepted biosynthetic pathways, were considered as the only forces constraining compound diversity; demonstrating large variation surrounding the extent of covariation among enzymes and volatile profiles between species and among experimental conditions. Recently an emerging understanding of non-canonical reactions, or reactions which occur independently of accepted biochemical pathways, suggests that the physical chemistry of compounds may play a larger role in constraint of chemo-diversity than previously thought. We examine the extent of non-canonical reactions in constraint of compound diversity as well as further demonstrate the utility of physical chemistry in describing biosynthetic constraints of plant volatile profiles in a meta-analysis format across 28 studies, with experimental conditions ranging from herbivore to pathogen induction.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Drea C.[1], Harris R[2]., Grogan K.[3], Boulet M.[4]

In sickness and in health: chemical indices of stable and transient condition in lemurs

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To effectively guide animal socio-reproductive behavior, the signals used in intraspecific communication should be honest or condition-dependent. Recipients rely on variation in signal composition and quality to assess both the stable and transient condition of conspecific signalers, and respond accordingly. Because diversity at the Major Histocompatibility Complex (MHC) is critical to an animal's health and fitness, and because MHC products influence bodily secretions, an animal's body odor may signal its MHC genotype, thereby reflecting stable aspects of its quality or compatibility as a competitor, ally, or mate. Likewise, because body odor is inextricably tied to an animal's underlying physiology, it could provide a reliable avenue for the advertisement and assessment of transient health, body condition, or infection status. Using gas chromatography-mass spectrometry, we assessed the volatile genital secretions of ring-tailed lemurs (Lemur catta) at the Duke Lemur Center, to test for chemical signaling of (a) MHC-DRB gene composition (i.e., stable condition) and (b) naturally induced injury (i.e., transient condition). In both cases, we used behavioral bioassays to confirm that conspecifics were responsive to the chemically encoded information, as would be required for odorants to mediate social interaction or mate choice. The results reveal a genetic basis and production cost, respectively, to signal production that cannot be circumvented or falsified. Funded by the NSF.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 6th, 2019

Duplais C.[1], Sarou-Kanian V[2]., Massiot D.[2], Estevez Y.[1], Russell J.[3], Martineau E.[4], Giraudeau P.[4], Farjon J.[4], Moreau C.[5]

Evidence for the contribution of gut symbionts to the cuticle formation in herbivorous turtle ants Cephalotes varians through NMR spectroscopy

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Microbial symbionts that are engaged in mutualistic interactions with their host are beneficial and have likely shaped host evolution. Despite the fact that several physiological functions affected by microbial activity have been identified, little is known about the diversity of fundamental mechanisms by which microbes positively affect host metabolism. To understand the contribution of gut bacteria in herbivorous turtle ants we combined isotopic enrichment and Nuclear Magnetic Resonance (NMR) spectroscopy to track the nitrogen flow within ant individuals. Colonies of Cephalotes varians were treated with antibiotics and compared to the untreated group control. Urea-15N2 was added to the diet of both colonies for a sufficient period of time assuring the full development of individuals that were at the larval stage before starting the feeding experiment. The gut and cuticle of C. varians were analyzed using liquid-phase and solid-state NMR respectively. We confirm the contribution of bacteria in the production of aromatic amino acids in the gut and characterize for the first time 15N-enriched outcome products in the cuticle. Overall, our results provide a qualitative framework for understanding how nitrogen atoms flow from nutrients through bacteria to ants and highlight the need of future studies that quantify the evolutionary selected beneficial metabolic pathways in gut symbionts.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thurday, June 6th, 2019

Ebie J.[1], Millar J.[2], Robson S.[3], Hölldobler B.[1,4], Liebig J.[1]

Long-range regulation of reproduction in the arboreal, polydomous Weaver Ant, Oecophylla smaragdina

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Although workers in many ant species are capable of producing their own male offspring, they generally rear the queen's offspring instead. This behavior requires the workers to be able to detect the presence of a fertile queen within the colony. In polydomous species, where the colony is spread across multiple unconnected nests, the presence of the queen must be communicated across extended distances to workers that may not come in contact with the queen for long periods of time. Colonies of the arboreal Weaver Ant, Oecophylla smaragdina, are an extreme example of polydomy, with a single colony able to span multiple trees, resulting in a large portion of nest workers being physically isolated from the queen for extended periods of time. Workers experimentally isolated from the queen in laboratory nests will lay viable eggs which develop into males; however, workers kept with a queen, even if she is deceased, do not lay viable eggs. In laboratory experiments, we investigated the behavioral and chemical mechanisms that regulate worker fertility in satellite nests separated from the queen in an attempt to understand how the queen's fertility is reliably signaled across relatively long distances for extended periods of time.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Eckshtain-Levi N.[1], Shank E.[1,2]

Communication is the root of the matter; Bacillus subtilis in the rhizosphere

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In nature, bacteria are rarely found in isolation; they are most often surrounded by other microorganisms. These microbial communities have profound impacts on their hosts as well as on ecosystem-level processes. Members of those communities interact with one another via secreted small molecules generically called specialized metabolites. These metabolites have been harvested for clinical uses, particularly as antibiotics, and have revolutionized our ability to treat disease. Moreover, the ability to produce such specialized metabolites is prevalent among soil bacteria, suggesting they play vital roles in the soil. The soil and particularly the rhizosphere are a highly dense and diverse bacterial environment (up to 1010 bacterial cells and an estimated 104 species in one gram of rhizosphere soil). Thus, soil represents a fertile model for studying cell-cell and host-microbe interactions that may be chemically mediated. To explore these interactions, we focus on the ability of the bacterium Bacillus subtilis to respond to bacteria and plant roots in its natural environment. Our long-term goal is to identify functional microbial consortia and novel bioactive compounds to rationally manipulate microbial communities and improve the environment. Using coculture screening methods coupled with fluorescent reporter bioassays and a range of chemical and genetic approaches, we are identifying and characterizing microbial interactions as well as the molecular mechanisms mediating them.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Effah E.[1], Barrett P.[1], Peterson P.[2], Potter M.[1], Holopainen J.[3], Clavijo-McCormick A.[1]

Emission of volatile organic compounds by Mānuka in response to conspecifics, one native and two invasive species

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Research on competition between native and invasive plants has focused on morphological traits to estimate the competitive ability of invaders and the responses of native species; however, plants release a variety of secondary metabolites that are ecologically relevant and may contribute to the success or demise of both emitters and receivers. This is the case of plant volatile organic compounds (VOCs), which mediate multiple interactions including host-plant selection by herbivores, indirect defence, and plant-plant communication. Unfortunately, our knowledge of the roles these compounds play in competitive interactions is still limited and the chemical responses of native plants towards invaders have rarely been studied. In this study, we characterised the VOCs emitted by Mānuka (Leptospermum scoparium), a native New Zealand plant, during competition with conspecifics, another native species (Dracophyllum subulatum), and two European introduced plants (Calluna vulgaris and Cytisus scoparius). VOCs were collected under field conditions in the Central Plateau of the North Island of New Zealand using a push-pull headspace collection technique and analysed using GC-MS. The results show a significant reduction in Mānuka VOC emissions when competing with introduced species relative to conspecifics or another native species and suggest that the presence of invasive species impairs the native plants' ability to communicate chemically with their environment.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 4th, 2019

Ethington M., Ginzel M.

The influence of fungal volatiles on the attraction of the walnut twig beetle, Pityophthorus juglandis, to pheromone-baited traps in walnut plantations

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Volatile compounds associated with symbiotic microorganisms often modify the response of insects to semiochemicals. The walnut twig beetle (WTB, Pityophthorus juglandis) is the primary vector of a symbiotic fungus Geosmithia morbida, the cause of Thousand cankers disease (TCD) in walnut (Juglans spp.) trees. This disease complex has caused widespread death of walnut trees throughout the western US and recently been introduced into the native range of black walnut (J. nigra) in the eastern US. Efforts to manage WTB rely on a pheromone lure, but the lure has a limited active range. Laboratory assays have demonstrated that WTB are attracted to volatile compounds associated with G. morbida, but the ability of fungal alcohols to modify beetle response to their pheromone in the field is unknown. In this study, we performed field bioassays to determine the extent to which fungal volatiles modify the attraction of WTB to commercially-available pheromone lures. Assays consisted of multi-funnel traps baited with various fungal volatiles and pheromone lures placed within several black walnut plantations in Walla Walla, WA. Our results demonstrate that fungal volatiles can modify the attraction of WTB to pheromone lures. Knowledge of how fungal volatiles influence the chemically-mediated colonization behavior of WTB will ultimately aid in refining lures and repellents to enhance detection, monitoring and management efforts of TCD in high-value walnut plantations.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Favaris A.[1], Túler A.[1], Silva W.[1], Rodrigues S.[2], Leal W.[3], Maurício Bento J.[1]

Nerolidol-mediated rendezvous of Cyclocephala paraguayensis in bottle gourd flowers

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Beetles of the genus Cyclocephala (Coleoptera: Melolonthidae: Dynastinae) have been reported to use flowers as food, shelter and/or mating stands, as well as to pollinate several plant species. Here we show that flower volatiles guide the dynastid beetle, Cyclocephala paraguayensis to Lagenaria siceraria (Curcubitaceae). We observed that beetles aggregate on this plant, with the pioneers landing on bottle gourd plants at dusk where they feed on the reproductive parts of male flowers. Soon after many mating pairs are formed within the flowers. We surmised that flower attractants contributed at least in part for this rendezvous. Gas chromatographic analysis revealed that trans-nerolidol is by far the major component of the flower's headspace. Additionally, nerolidol elicited electroantennographic responses in both sexes of C. paraguayensis. In the field, racemic nerolidol-baited traps attracted significantly more beetles than the control ones in two localities from São Paulo and Mato Grosso do Sul, Brazil. We, therefore, concluded that nerolidol contribute to C. paraguayensis aggregation in bottle gourd flowers. It remains to be elucidated, however, whether C. paraguayensis pollinates L. siceraria.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Federle M.

Chemical Signaling and Social Behaviors of Pathogenic Streptococci

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Bacteria commonly use chemical-based cell-to-cell communication, commonly referred to as quorum sensing (QS), to coordinate a variety of behaviors across a population, including production of virulence determinants, biofilm development, and horizontal gene transfer. In recent years, the urgent need to identify new alternatives to antibiotics that fight bacterial infections has inspired the concept of inhibiting fundamental mechanisms of pathogenesis rather than inhibiting processes essential to bacterial growth. We have helped identify in Gram-positive bacteria new inter-cellular communication pathways utilizing short peptide pheromones and their cognate receptors of the Rgg protein family type. In the human-restricted pathogen Streptococcus pyogenes four Rgg paralogs provide a means to regulate genes involved in pathogenesis, natural transformation, lysozyme resistance, and host immunosuppression. It is our objective to understand the mechanisms sustaining inter-cellular communication in this organism and how chemical signaling contributes to pathogenesis and carriage. Secondly, because Rgg-family orthologs are widespread among pathogenic and commensal species of Firmicutes, it is our priority to develop small molecules and peptides that manipulate pheromone-dependent signaling. It is our objective to characterize additional Rgg pathways in various species, as well as identify small-molecule modulators of these pathways, in hopes of harnessing bacterial behaviors.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Felton G., Tan C., Peiffer M., and Jones A.

Insect Associated Virus Mediates Top-Down Effects on Plant Defenses

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Parasitic wasps or parasitoids (Braconids, Ichenumonids) inject their eggs in their caterpillars hosts, but also during oviposition, they inject a mutualistic polydnavirus (PDV). The PDV suppresses the host's immune system thus enabling the parasitoid to grow and develop within the caterpillar. Our recent findings indicate that these polydnaviruses indirectly attenuate host plant defenses by suppressing salivary elicitors in the caterpillar's oral secretions in both permissive and non-permissive caterpillar hosts. In the case of permissive hosts, the attenuation of plant defenses positively impacts the fitness of the virus, the parasitoid, and the plant. However, in cases of non-permissive caterpillar hosts that are stung by these parasitoids, the non-permissive host surprisingly benefits from the PDV through attenuation of plant defenses

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Fink P.[1], Zupo Z.[2], von Elert E.[3]

Volatile-mediated interactions between algae and aquatic herbivores in present and future oceans

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Interactions between primary producers and consumers mediated by volatile organic compounds (VOCs) are a major focus of terrestrial chemical ecology. Even though it is well known that many aquatic primary producers (algae and cyanobacteria) produce a wide range of VOCs, only little is known on the ecological functions of VOCs in aquatic ecosystems. We here show that VOCs are important semiochemicals both in marine and freshwater systems. They mediate resource and habitat finding for a wide range of invertebrates and thus serve specific ecological and evolutionary functions. However, chemical signaling may be altered by global change, e.g. by the acidification of seawater through increasing atmospheric CO2 levels. We provide evidence that VOC mediated resource recognition of various marine invertebrates is altered by seawater acidification. This might either be a consequence of pH-dependent alterations of the cues themselves, or modifications on the receptor side. It is thus extremely important to understand not only the decipher VOC mediated interactions between primary producers and consumers, but also how they may be altered in changing future oceans.

Themed Session: Language of Life Under Climate Change

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Forsberg E., Goodman A., Walters Z., Edwards R., Dinsdale E.

Identification of Functional Metabolites of Captive Sharks for Health Matrix Construction

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The skin of any aquatic animal serves as the direct interface between the organism and their environment, including available nutrients and abiotic conditions. Shark skin, which is comprised of dermal denticles above a mucus layer, hosts a diverse array of symbiotic microorganisms including bacteria, archaea and viruses. These microbiotas collectively make up the sharks' microbiome. The small molecules these microorganisms produce are identified via mass spectrometry-based metabolomics. Coupling metabolomics with metagenomic analyses provides robust taxonomic and functional community profiles of shark skin microbiomes. As anthropogenic forces cause shark populations to decline worldwide, conservational efforts aimed at evaluating shark fitness are increasingly necessary. Metabolic functions of shark-skin microbiomes are instrumental for the construction of a health matrix and aquarium populations may serve as indices for healthy microbiota community states. The San Diego Birch Aquarium at Scripps houses several species of Elasmobranches, including leopard, horn, and swell sharks and we began annual veterinary exams in the summer of 2018 to evaluate the health of these specific kelp-tank inhabitants. Here we aim to identify a core microbial composition and functional metabolites of the three shark species and compare with shark health indicators, such as blood counts, to describe the relationship between microbiome and shark health.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Fuentes J.

Air pollutants reduce the strength and alter the composition of the floral odors that insects need to locate flowers

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Flowers release blends of scents to attract insect pollinators. Scents are extremely reactive molecules. During their atmospheric transport away from sources, floral odors react with air pollutants such as ozone, hydroxyl radical, and nitrate radical. In this seminar, results from theoretical studies are presented to demonstrate the decreases in the amounts and the modifications of the blends of floral scents in polluted air masses. Scent abundances away from flowers markedly decrease in response to rapid chemical reactions, with the most reactive odors only reaching 10 – 25 % of the original abundance within downwind distances of 100 - 200 m from sources. Also, in ozone-rich environments the floral scents are more rapidly destroyed due to the concomitantly enhanced hydroxyl radical formation from the ozonelysis of floral odors. Experiments designed to test the effect of ozone concentration gradients on the ability of insects to locate flowers indicate that insects cannot locate flowers when ozone mixing ratios exceed 80 parts per billion. Theoretical and experimental results suggest that in polluted environments insect pollinators may spend more time foraging for food rather than harvesting pollen and nectar. Because floral scents are essential for pollinators to locate flowers, the research results additionally suggest that air pollutants represent an indirect stress to insect pollinators, likely disrupting of pollination of flowering plants.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Gao K.[1], Heckel D.[2], Zalucki M.[3], Groot A.[1,2]

Parasites affect sexual attraction in moths

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Parasite-mediated sexual selection is generally hypothesized to significantly contribute to the evolution of variation within and between species, and hence in the speciation process. Most of this theory has been tested in artificial systems under laboratory conditions, and both positive and negative interactions have been found. Surprisingly little data exist on how naturally occurring parasites affect sexual attraction in sexually monomorphic insects with chemical signals, which comprise the majority of species on earth, including moths. Moths are the ideal model animals to experimentally determine how parasites affect sexual attraction, as moths have a clearly defined sexual attraction, males are attracted by females through a species-specific sex pheromone, and parasites frequently occur in field populations. We recently found naturally occurring parasites on H. armigera in Australia and China, which offers the unique opportunity to determine the effects of this parasite on the sexual communication and reproductive success of their host. This parasite, a neogregarine cf Ophryocystis, has the same life cycle as O. elektroscirrha, a well-known parasite of monarch butterflies. So far, we found that parasitized females call earlier and differ in their sex pheromone quantity compared to unparasitized females. In choice experiments, we found that infected H. armigera females preferred to mate with uninfected males, while uninfected females mated equally frequently with uninfected.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Garbeva P.

Novel analytical tools helpful to understand microbe-microbe and plant-microbe chemical interactions

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The understanding of natural metabolites, that mediate interactions between organisms is the key to decipher chemical communication and interactions. However, the detection and identification of the compounds, that mediate these interactions still remains challenging. The emerging techniques such as Mass Spectrometry Imaging (MSI), Direct Analysis in Real Time High-resolution Mass Spectrometry (DART-HRMS), Liquid Extraction Surface Analysis (LESA), others, allow quick and direct analysis and provide new opportunities to study environmentally relevant metabolites in their spatial context. These approaches help to overcome limitations in traditional metabolomics techniques, that require extraction and ample amount of sample preparation. In this talk several examples will presented, where novel analytical techniques are applied to discover volatile and non-volatile compounds involved in microbe-microbe and plant-microbe interactions.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Geier B.[1], Sogin M.[1], Michellod[1], Janda M.[1], Kompauer M.[2], Spengler B.[2], Dubilier.[1], Liebekel M.[1]

Spatial metabolomics of in situ, host-microbe interactions – combining untargeted metabolite imaging and fluorescence labeling

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Chemical interactions begin on the single cell level. One of the central challenges in studying close interactions, such as animal-microbe symbioses is to link the in situ metabolome to the taxonomic identity of the symbiotic partners. Therefore, new approaches are needed to image the micro-scale organization of cells and the metabolites they produce. We developed a spatial metabolomics pipeline to image both hundreds of metabolites and the associated partners of an unculturable invertebrate-microbe symbiosis in situ. Combining high-resolution mass spectrometry imaging (MSI) and 16S rRNA fluorescence in situ hybridization (FISH) enabled us to assign spatial metabolomes to the symbiontic bacteria and single host cells. In the host, the deep-sea mussel Bathymodiolus puteoserpentis the symbiotic bacteria colonize epithelial cells, forming bacteriocytes. Our data showed that the bacteriocytes have a different lipid profile than the symbiont-free epithelial cells, indicating a metabolic adaptation to the intracellular ymbionts. We linked different metabolic phenotypes to one symbiont type by correlating the high-esolution MSI and FISH images. Visualizing metabolic responses of the endosymbionts could provide an indicator for microenvironment variations inside the bacteriocytes. Our MSI/FISH pipeline provides a new approach for visualizing chemical and physical interactions on a cellular level and the opportunity to decipher the chemical language of microbes and their hosts.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Gershenzon J.[1], Förster C.[1], Handrick V.[1], Köllner T.[1],Erb M.[2,3]

Plant defense metabolites: weapons that are also warning signs

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Plants produce an extraordinary variety of metabolites thought to be involved in defense against herbivores and pathogens. Some of these compounds serve as toxins or deterrents that act directly against enemies. Others are part of a vast network of internal signals that synchronize the production of defenses to the time of enemy attack. However, research in the last few years suggests that many compounds once considered to be toxins and deterrents are also involved in signaling processes that activate defenses. We will discuss recent findings on volatile and non-volatile metabolites that appear to have both roles. Herbivore-induced terpene and green leaf volatiles, long thought to deter some herbivores and attract herbivore enemies, are being increasingly implicated as airborne signals in plants such as poplar to warn uninfested parts of the plant about the approach of enemies. Among non-volatile defenses, the benzoxazinoids of maize are defensive weapons against leaf-chewing insects that also appear to serve as signals for deploying defenses against phloem feeding herbivores. Knowledge of which metabolites are defensive weapons, and which are simultaneously defensive signals is critical for understanding how plant defenses operate.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Girling R.[1], Ryalls J.[1], Mullinger N.[2], Langford B.[2], Nemitz E.[2], Pfrang C.[3]

Field assessments of the effects of elevated ozone and diesel exhaust emissions on insect pollination services

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Common pollutants of the troposphere, such as diesel exhaust (including nitrogen oxides - NOx) and ozone (O3), are known to react in the gas phase with some of the most ubiquitous volatile organic compounds (VOCs) emitted by flowers. This has potentially deleterious implications for the insects that use these VOCs for location and recognition of floral resources. As such, a limited number of behavioral studies have demonstrated that these pollutants may reduce pollinator foraging efficiency. To-date these studies have focused on a narrow range of pollinator species and there has been limited field-scale validation. Here we present results from a field-based assessment of the impacts of elevated diesel exhaust pollution and ozone on insect pollination services. Using a unique Free Air Diesel and Ozone Exposure (FADOE) ring facility, which emits regulated quantities of diesel exhaust and ozone, alone and in combination, from a series of 8m diameter rings, we measured metrics of pollination services on flowering Brassica nigra plants placed within the rings. Both pollutants had clear effects on insect pollinators, with significant reductions in pollinator counts and flower visits, which coincided with decreases in yield metrics of our study plant. These results support the findings of previous laboratory-based behavioral assays, providing evidence of significant negative field-scale effects of air pollution on insect-derived pollination services.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Gonzalez M., Carazzone C.

The toxic smell of a poison frog: Analysis of VOCS in Dendrobatidae family

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Chemical signals in vertebrates play important roles for communication with organisms of the same or different species, such as predators. Poison frogs had been broadly studied for their high diverse alkaloids cocktails sequestered from insects or other invertebrates consumed in the diet. VOCs are important chemiosignals found in plants, animals and even microorganisms, but their presence had never been tested in poison frogs. The aim of this study was to analyse the volatile profiles released by two species of poison frogs (Oophaga histrionica and Dendrobates truncatus) using in vivo and ex vivo sampling methods through HS-SPME/GC-MS. In addition, we analysed the alkaloid profiles of both species, with the objective of assessing the presence of a semi-quantitative correlation between volatile and alkaloid profiles. We found the presence of VOCs usually released by plants, as dihydroedulan II, and more interestingly some alkaloids were succesfully adsorbed on SPME fibers during VOCs sampling. These results showed for the very first time that some poison frogs alkaloids are sufficiently volatile suggesting a possible dual function: defense by contact (unpalability) and defense by smell (repelent) for the same compound. Comparing semi-quantitative variations between VOCs and alkaloids profiles we have discovered some correlations among them. The ecological function of the VOCs that we suggest should be studied in future investigations using real predators or models of them.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Grandi L.[1], Ye W[1]., Vallat A.[2], Glauser G.[2], Abdala-Roberts L.[3], Brevault T.[4], Benrey B.[5], Turlings T.[1]

Communication among Cotton Plants

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Like many other plants, cotton (Gossypium spp) plants, when they are attacked by insect herbivores, release specific volatile organic compounds (VOCs). These VOCs are known to repel other herbivores and to attract the natural enemies of the attackers. The herbivore-induced VOCs can also be perceived by neighboring plants and prime them for enhanced defense induction. Recent studies suggest that volatile-mediated priming can be particularly effective in cotton and has potential for application to enhance their resistance to pests. To gain more insight into this phenomenon, we exposed intact receiver cotton plants to VOCs from plants infested by Spodoptera caterpillars. Control plants were exposed to VOCs from intact plants. Subsequent measurements showed that, compared to control plants, plants that had been exposed to VOCs from infested plants exhibited a general upregulation of defense genes, had higher levels of direct defense compounds (i.e. gossypol) and were less preferred by Spodoptera caterpillars. These results confirm the important role of inducible VOCs in defense signaling among cotton plants. Next, we screened several wild cotton populations from the Yucatan peninsula in Mexico and found considerable differences in their signaling ability. We aim to identify the specific VOCs that are responsible for the observed defense induction. We are currently assessing if constitutive (fresh damage) and inducible (older damage) VOCs are different in their induction strength.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Grozinger C.

Communication among Cotton Plants

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While honey bee colonies are often thought of a harmonious "superorganisms", our studies of interactions among the queen, workers and drones have revealed a nuanced and sophisticated pheromone communication system that balances cooperation and conflict among members of the colony. Our studies provide novel insights into genomic, epigenomic, physiological and chemical mechanisms that regulate the variation in pheromone production and responses to these pheromones that shape social behavior in honey bees. We have extended these studies to other social insects (bumble bees, paper wasps, and fire ants) to begin to examine the evolution of the genomic pathways underpinning chemical communication and reproductive dominance and the interplay between social environment and individual behavior. Our studies demonstrate the power of using genomic approaches to identify and characterize social cues and signals and their impacts. Additionally, we are developing new methods to facilitate functional studies of the genes involved in these processes.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Hammerbacher A.[1], Kandasamy D[2]., Gershenzon J.[2], Andersson M.[3]

Fungal Biotransformation of Host Tree Monoterpenes Elicit Behavioral Responses in the Spruce Bark Beetle, Ips typographus

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Host selection is crucial for herbivores, which mainly rely on chemical cues to evaluate the quality of potential feeding and breeding sites. Many insects are associated with symbiotic microbes which can produce chemical signals that convey information about the nutritional, defense or colonization status of a host. The European spruce bark beetle, Ips typographus is associated with a fungal community from the genera Ophiostoma, Grosmannia and Endoconidiophora, which are suggested to be nutritional and detoxifying symbionts. In this study, we analyzed the volatiles of spruce bark inoculated with different bark beetle associated fungi and showed that the volatiles emitted changed remarkably due to fungal colonization of the bark and were dominated mainly by oxygenated monoterpenes (OMTs). Single sensillum recordings using bark beetle antennae revealed two new types of olfactory sensory neurons which were specific for fungus-produced monoterpene ketones or alcohols. Olfactometer bioassays with adult beetles revealed that the insect's preference for spruce bark diet varied depending on the identities and concentrations of host compounds, the fungal species colonizing the diet and the biotransformation products emitted. Taken together, our study showed that fungal biotransformation products of host compounds are an important source of beetle semiochemicals which could assist them in selecting suitable habitats to ensure successful development of their offspring.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Hardege J.[1], Roggatz C.[1,2]., Benoit D.[3], Terschak J.[4], Bartels-Hardege H.[1]

Marine chemical ecology in a changing world- info-disruption an overlooked impact of oceanic acidification?

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Chemical signals coordinate marine animal behavior, but little is known on how these are affected by human activities. High CO2 concentrations absorbed from the atmosphere leads to reduced seawater pH, a process termed ocean acidification. Disruption of behavior including feeding, predator – prey interactions, larval settlement or mating can have dramatic effects on species interactions potentially threatening ecosystem stability and services. We provide an overview of studies that demonstrate impacts of seawater pH on functional traits at neural, signal detection and signal response level. Using synthetic pheromones and feeding stimulants we examined responses when individuals are exposed to pH levels expected for 2100. Most biological molecules with signaling function possess functional chemical groups that are sensitive to changes in pH levels. High CO2 conditions reducing pH in aquatic environments impacts functional groups of many signaling cues, causing significant molecular changes and therefore impacts their successful reception. We show evidence for signal disruption through structural changes of cues, reduced and changed detection by the organisms, and altered behavioral responses. We conclude that signal disruption associated with ocean acidification is likely to become a threat to marine eco systems as well as aquaculture impacting upon an organism's fitness. Further studies ie on immune responses, the physiological costs, long term impacts and multiple stress.

Themed Session: Language of Life Under Climate Change

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Hayes R.[1], Coates L.[2]., O'Neill W.[2], Pegg K.[2]

Volatile production by banana plants infected with Fusarium oxysporum f.sp. cubense

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Panama disease, caused by the soil-borne fungus Fusarium oxysporum f.sp. cubense (Foc), is a devastating disease of bananas. It is caused by a number of Foc populations which vary in their host range. Race 1 and Race 4 populations are the most important internationally. When grown on rice, Race 4 isolates produce a distinctive odour, not produced by Race 1. We investigated whether volatiles of banana plants inoculated with Foc could be used to identify infected plants before the onset of disease symptoms. Banana plants were inoculated in the glasshouse with Foc (Lady Finger - Race 1 (VCG 0124) and Subtropical Race 4 (STR4) (VCG 0120); Cavendish - STR4 only). While plants were still pre-symptomatic, volatiles were sampled by SPME and analysed by GC-MS. In Cavendish plants there was no difference between treatments, however plant odours produced by Lady Finger plants infected with STR4 differed significantly to controls, and those infected with Race 1, through increases in monoterpene levels. Once plants expressed external symptoms, differences between STR4-inoculated plants and controls were no longer detected, possibly because the xylem tissue was no longer functional. Infected corm tissue sampled from STR4-inoculated plants at the end of the experiment was significantly different to the other treatments. These results are promising for early detection of Foc in bananas, assisting in management of this extremely destructive disease.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Hefetz A.

The critical role of primer pheromones in maintaining insect sociality

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The chemistry of social insects' primer pheromones was scarcely studied and only a few were chemically identified, due to difficulties in constructing proper bioassays. A major primer pheromone is the queen pheromone, involved in regulating reproductive division of labor, a hallmark of social insects. Although the number of chemically identified queen pheromones is too small to allow generalization, several features can be predicted from theoretical considerations. Queen pheromones are generally non-volatile in order to avoid saturation of the colony environment, resulting in sensory habituation. Therefore, their dispersal is actively mediated through worker – worker interactions. Queen pheromone should also be highly caste specific, qualitatively different from any worker-born pheromone, to avoid maladaptive worker response due to misidentification. A multicomponent pheromone enhances specificity and enable to discriminate between queens in polygyne colonies. The fact that in social Hymenoptera female larvae are bipotent to become queen or worker necessitate strict regulation over pheromone production. Indeed, in the honeybee the biosynthetic pathways as well as genomic expression are completely disparate between queens and workers. Here I discuss the robustness of some of the identified queen pheromones un light of the above characterization. Future advances in chemical analyses, transcriptomics, proteomics, and metabolomics will enrich our understanding of the mechanisms a

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Hermann S. and Landis D.

Risk Management: consequences of predation risk on behavior, physiology and fitness

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Understanding how insect predators alter prey abundance through direct consumption is one of the central questions in ecology. However, prey can also adjust their behavior and physiology to avoid predation and it is critical for prey to detect predators in order to respond appropriately before an attack. For example, some prey 'eavesdrop' on predator cues as an indicator of a risky situation. In our study we evaluate the influence of predator chemical cues on the behavior, performance and development of insect herbivores. We find that, in several systems, chemical cues from predatory insects are detected by their prey and that responses are context dependent. Insects that are significantly influenced by predator cues carries significant implications in fundamental biology and agroecological pest management strategies.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Hilker M.

Inconspicuous, but impactful: Insect eggs and their chemoecological interactions with enemies and plants

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While a wide range of oviposition-induced plant responses can enhance egg mortality, only few studies have shown how insects cope with them. Counteractions of insects against egg-induced plant defense call for evolutionary arms race and challenge plants to improve their defense. A recent study revealed that pine improves its defense against sawfly eggs when having previously been exposed to sawfly sex pheromones, i.e. a cue indicating impending oviposition. Hence, plants cannot only respond to the initial step of insect infestation, the egg deposition, but also to preceding cues and thus reinforce their egg-induced defense. While this is the first study showing priming of plant defense against insect eggs by insect sex pheromones, several other studies revealed that plants also prepare their defense against larvae by responding to insect eggs, i.e. to a cue indicating impending larval feeding. Plants that have received insect eggs can improve their defense efficiency against hatching larvae by amplifying and/or accelerating their responses. Our studies show that life of herbivorous insects is shaped already in its very beginning by a wide range of fascinating chemoecological interactions of insect eggs with their environment.

Themed Session: Keynote

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Hossaert-McKey M., Proffit M., Soler C., Joffard N., Alvarez N., Schatz B.

Evolution of floral scents in a nursery pollination mutualism

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Most studies of chemical mediation between plants and pollinators stress the direct impact of selection by pollinators on flower scent composition. Nevertheless, phylogeny may constrain scent composition and thereby the evolution of the emitted signal. Using a model system for obligate interactions of pollination, the interactions between figs and their species-specific pollinating fig wasps, we studied whether phylogenetic history constrains the composition of plant chemical signals that mediate interactions with pollinators. In this 'nursery pollination mutualism', the pollinators can breed only in receptive figs of their host tree, which depends in turn on the wasp as its sole pollinator. The obligate encounter of the pollinator and the receptive fig is mediated by volatile organic compounds. We collected floral scents from receptive figs using in situ headspace extraction of odors from about 30 species of several sub-genera of Ficus from different tropical and subtropical regions, and analyzed their chemical composition by GC-MS. Using phylogenies available for Ficus and both qualitative and quantitative traits of the bouquets of compounds, we ran phylogenetic comparative methods in order to reconstruct the evolution of species traits while taking into account the non-independence among species due to their phylogenetic relationships. Our results provide insights into the main factors affecting the evolution of floral scents in this species-specific obligatory mutualism.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Huberty M.[1,2,3], Choi H.[3,4], Heinen R.[1,2], Bezemer M.[1,2]

Leaf metabolomes respond stronger to soil than to foliar herbivory

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Plants change the abiotic and biotic properties of soil in which they grow and by this can influence the performance of plants that grow later in the same soil. This is known as plant soil feedback (PSF). So far PSF studies examined how this influences the biomass of plants that respond to changes in the soil. Here we investigate whether and how PSFs alter the metabolic profiles of plants. We first grew 12 plant species (6 grasses,6 forbs) individually in soil. All plant species were then grown in all conditioned soils. Half of them were subjected to aboveground herbivory by a foliar feeding caterpillar. With 1H Nuclear magnetic resonance metabolomics we determined the metabolomes of leaves of the responding plants and examined the effects of soil conditioning and herbivory. Plant species distinctly differed in the degree they influenced the metabolomes of the responding plants via their effect on the soil, but also in their sensitivity to soil conditioning and herbivory. There were no consistent differences between grasses and forbs. Remarkably, in most species soil conditioning explained more of the variation in chemical composition than herbivory. Our study highlights the important role of soils in influencing foliar chemical composition. We emphasize that PSF can have far stretching implications for aboveground plant-insect interactions and that plant-soil interactions can be an important determinant of the often-unexplained intraspecific variation in plant chemistry.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Jeffrey C., Dyer L., Richards L., Philbin C., Glassmire A.

Back to the molecule-from large scale phenomena to molecular level function, modern approaches to chemical-ecology research"

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Small molecules are central to mitigating plant insect interactions. Variation in in plant secondary metabolism is an important dimension in biodiversity. Using modern tools in organic chemistry we explore the complex chemical nature of this variation and its community level impact. Our collaborative efforts use the guidance of long-term ecological datasets, populations genomics and metabolomics data to guide detailed studies of natural products chemistry. We have recently found that composition and quantity of plant derived small molecules can dramatically vary across elevational gradients, successional gradients and during the developmental stages of a host plant. The chemical details and our approach to deciphering the complex chemical nature of this variability will be presented. Additionally, the importance of moving away from categorical characterization of plant secondary metabolism and the necessity for detailed chemical analysis in the future of chemical-ecology research will be discussed.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Chen X., Xu L., Jiang H.

Screening of the odorant-binding proteins responsible for methyl eugenol perception in the oriental fruit fly, Bactrocera dorsalis

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Methyl eugenol (ME), a powerful attractant for mature males of B. dorsalis, has been widely used for detecting, luring and eradicating this notorious fly. However, the molecular mechanism underlying the olfactory perception of ME remains largely unknown. In our study, we expanded the repository of B. dorsalis OBPs to 52 by digging the genome and transcriptome data. Furthermore, we determined the expression profiles in six body parts and five internal tissues of B. dorsalis. Seven candidate OBPs were screened out by phylogenetic analysis based on the previous study. Together with the analysis of expression patterns in the antennae of male adults treated with ME for different time gradients, the expression level of 12 OBPs showed a trend of rising first and then decreasing along with treated time. The 3D modeling of these 12 OBPs were constructed to simulate molecular docking, the results showed 6 OBPs are able to bind with ME. Based on the triple screening methods, we screened 9 candidate OBPs at present. Four OBPs were successfully expressed in E. coli and purified. The ligand-binding assays further showed that two of them have higher affinity with ME. Our results enriched the knowledges of OBPs of B. dorsalis. It will reveal the molecular mechanism on olfactory reception of ME in B. dorsalis and lay solid foundation in the research of olfactory physiological process.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Jirošová A.[1], Hradecký J.[1], Synek J.[1], Bláha J.[1], Schlyter F.[1,2], Kalinová B.[1]

Physiological basis of the aggregation pheromone production in Ips typographus

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European spruce bark beetle (Ips typographus), (Coleoptera, Scolytinae) is destructive pest on Norway spruce in Europe. The aggregation pheromone, a synergistic mixture of 2-methyl-3-buten-2-ol (MB) and cis-verbenol (cV), is proposedly produced in male hindguts. Previous experiments from 90 years suggested that MB is synthetized de novo (Lanne 1989), while cV is created by a conversion of host monoterpene α-pinene (Lindström 1989). However, the biosynthetic pathways, enzymatic apparatus, and its hormonal regulation are not known yet. We present comprehensive outline of the aggregation pheromone production in Ips typographus, focusing on different physiological factors. The time dynamic of the aggregation pheromone release, possible role of JHIII in regulation process and source of precursors in larvae were studied with using of the GCxGC-TOFMS method. Lanne B. et al. (1989) Insect Biochem 19:163-167, Lindström M. et al. (1989) J Chem Ecol 15:541-548

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Johnson J. and Polavarapu P.

Chiroptical Spectroscopy Aided by Quantum Chemical Predictions for Structural Determination of Naturally Occurring Ladderanoic Acids

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Chirality permeates through modern science, from the spin of elementary particles to all biological life. The amino acids and sugars from which proteins and nucleic acids are built exhibit chirality. Chirality of molecules used for drugs can alter their bio-reactivity. The field of chiroptical spectroscopy has been established to probe and investigate chiral molecules. A theoretical framework has been derived using quantum mechanics. Modern computing power has allowed for the implementation of routine QM predictions of spectral properties. 5-ladderanoic acid and 3-ladderanoic acid were isolated from the biomass of an anammox bioreactor and are thought to play an important role in completing the nitrogen cycle. The unique structure of the concatenated cyclobutane rings allow the ladderanes to form an unusually dense membrane around the anammoxosome, a vesicle where reduction of nitrite to nitric oxide, synthesis of hydroxylamine and hydrazine from ammonium ion and NO, and oxidation of hydrazine to N2 occur. The strongly nucleophilic hydroxylamine and hydrazine would otherwise interfere with essential cellular metabolism. However, the absolute stereochemistry of naturally occurring ladderanoic acids were not known. This missing information was derived using experimental and QM predicted Raman Optical Activity spectra, despite huge conformational space associated with these acids. The results are confirmed with Optical Rotatory Dispersion studies and X-ray Crystallography.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Keeling C.[1,2], Lévesque-Tremblay V.[1], Sergerie R.[1,2], Bernier K.[1,2]

Functional characterization of an enzyme in the biosynthesis of the aggregation pheromone trans-verbenol in the mountain pine beetle

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Mountain pine beetle (Dendroctonus ponderosae) is a significant pest of several pine species in western North America. Upon feeding on a new host, adult females release the aggregation pheromone trans-verbenol to initiate a mass-attack on the tree. trans-Verbenol is produced via the hydroxylation of host-derived alpha-pinene. Recently, it has been shown that female beetles accumulate this pheromone as a fatty acid ester at earlier developmental stages in the brood tree (Chiu et al., PNAS 2018 115:3652). The release of trans-verbenol from the fatty acid ester can be induced by feeding on the tree or by topical application of juvenile hormone. We hypothesized that an inducible carboxyesterase is involved in the hydrolysis of this ester to release the pheromone. Through prior gene expression analyses, a carboxyesterase was found that is both female-specific and inducible with phloem feeding or juvenile hormone treatment. We are now exploring the biochemical function of this carboxyesterase in vivo and in vitro. We used RNA interference to reduce the transcript abundance of this enzyme in vivo before quantifying the pheromone produced after adult females fed on pine phloem or were treated with juvenile hormone. We also have expressed this enzyme in E. coli and have assayed the purified enzyme in vitro with fatty acid esters. In this presentation, we will present the results of these experiments and discuss the role of this enzyme in host colonization by the mountain pine beetle.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Kingwell C.[1,2], Millar J.[3], Yoshimi Y.[4], Wcislo W.[2]

Evolutionary origins of social insect queen pheromones: effects of condition-dependent indices of fecundity on the totipotent worker caste of a socially flexible bee

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Queen pheromones (QPs) evolved independently in all highly eusocial insect lineages, and mitigate conflict over access to reproduction by inhibiting the ovarian development of workers. Despite their fundamental importance in regulating reproductive division of labor, the hallmark of eusociality, the evolutionary origins of QPs remain enigmatic. We studied the cuticular and glandular chemistries of Megalopta genalis bees in central Panamá, a population in which eusociality is facultative and whose tribe (Augochlorini) accounts for one of two relatively recent evolutionary origins of eusociality in the family Halictidae. Eusocial queens and solitary reproductives in this population are readily distinguished by differential production of methyl-alkanes (which are phylogenetically widespread among insects) and macrocyclic lactones (which among bees are restricted to halictid, colletid, and andrenid families). We show that these sets of compounds serve as honest indices of fertility, influence the behavior and physiologies of subordinates, and that social selection is likely to be an important factor influencing their production. We also examine the biochemical links between fertility and chemical production that may serve to keep these indices honest. Overall, our results suggest that QPs evolve via social selection on reliable chemical cues whose physiological links to reproductive state may show deep phylogenetic conservation but can also be taxonomically unique.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Kozma M., Schmidt M., Derby C.

In Search of Pheromone Receptors in Decapod Crustaceans

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Decapod crustaceans use pheromones in many aspects of their social and sexual lives. Behavioral experiments reveal that pheromones are mostly detected by the olfactory system, represented in the periphery by olfactory receptor neurons (ORNs) in aesthetasc sensilla of the antennules and in the central nervous system by the olfactory lobe. However, there are no obvious ORNs or sexually dimorphic structures in their peripheral and central olfactory pathways to provide a focus for identifying pheromone detectors. An approach to reveal the pheromone sensing pathway is through identifying chemoreceptor proteins unique to the olfactory pathway. Toward that end, we have generated and analyzed transcriptomes from two chemosensory organs – antennules and dactyls of legs – of four decapod crustaceans that are used as models of chemoreception: Panulirus argus, Homarus americanus, Callinectes sapidus, and Procambarus clarkii. We identified hundreds of candidate chemoreceptor proteins belonging to several classes, including Ionotropic Receptors (IRs), TRP channels, and Gustatory Receptors. While many IRs are expressed in both antennules and dactyls, several IRs are expressed exclusively in the antennules, leading to the hypothesis that the former are food detectors and the latter are pheromone detectors. To test this hypothesis, we have generated single cell transcriptomes of ORNs and are analyzing them for expression patterns of IRs and other candidate chemoreceptor molecules.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Kuhlisch C.[1], Schleyer G.[1], Barak-Gavish N.[1], Pohnert G.[2], Vardi A.[1]

Using untargeted metabolomics to reveal the chemical vocabulary that mediates phytoplankton interactions in the ocean

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Microalgae in the ocean are known to rapidly increase their population size, a phenomenon known as algal bloom. This increase in biomass has a great ecological influence on the marine food web, global biogeochemical cycles and the climate. The demise of a bloom is regulated by diverse microbial interactions that are mediated by chemical signaling and metabolic cross talk. We use untargeted metabolomics to decipher the 'chemical language' that mediates alga-microbe interactions and to find biomarkers that resolve them in the environment. Phaeocystis pouchetii blooms are under constant grazing pressure, which is affected by algal cell physiology. Metabolite profiling of laboratory cultures revealed diverse metabolic states throughout growth, which were correlated to the physiological state of the cells. Metabolic biomarkers were used to detect these metabolic states in P. pouchetii blooms in the North Atlantic. Emiliania huxleyi blooms are routinely terminated by viral infection. A recent study in our lab identified an algicidal bacterium, originally isolated from a natural bloom, suggesting its contribution to bloom demise. By comparing the metabolic profiles of viral and bacterial infection, we aim to identify specific metabolic biomarkers for specific modes of infection. Meta-metabolite profiling of a natural bloom in a mesocosm experiment provides a comprehensive dataset that allows to correlate biomarkers of specific interactions with taxonomic and physiological parameter.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Langford B.[1], Nemitz E.[1], Touhami D.[2], Pfrang C.[3], Girling R.[4]

Searching for flowers: How does air pollution disrupt floral signals?

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Air pollution levels in many urban areas remain above the legal limits posing major risks to human health. Rural areas are also regularly exposed to pollution transported from cities and are impacted by ozone pollution, with hemispheric background concentrations rising gradually. Ground level ozone is a priority pollutant that can damage both buildings and human health. There is strong evidence to suggest that the health of plants and insects are also at risk. For example, O3 is a powerful oxidant that reacts quickly with many of the volatile organic compounds (VOC) that form a flowers odor. These unique odour blends are used by many pollinators to differentiate between and locate floral resources when foraging for food. Therefore, air pollutants have the potential to disrupt these chemical cues and interfere with plant-pollinator interactions. In order to investigate these effects, we simulated a floral scent consisting of four volatile components, a-terpinene, b-carryophyllene, linalool and 6-methyl-5-hepten-2-one as well as an unreactive tracer compound, propane, in a 20 m wind tunnel. The subsequent downwind plume was mapped using a state-of-the-art mass spectrometer under ambient (6 ppb), medium (50 ppb) and high (140 ppb) ozone fields. The chemical loss rate of each floral component was calculated by comparison to the unreactive tracer to investigate how the unique odour of the flower, learnt by insects at source, changes under a range of pollutant conditions.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Larson N., Feldlarufer M., Zhang A.

Substituted Benzoate Compounds as Fumigant Control Agents for the Common Bed Bug (Cimex lectularius L.)

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There has been a recent worldwide resurgence of bed bug populations, and with their obligate need to feed upon humans, this is a significant pest concern. Bed bug bites can result in severe allergic reactions, with infestations also eliciting psychological stresses on the persons dealing with them through social stigma and financial burden. A combination of non-chemical and chemical controls is utilized to eliminate infestations. Unfortunately, due to widespread insecticide resistance chemical controls are failing. To overcome this issue, novel control treatments need to be explored. Therefore, we have explored the use of substituted benzoate compounds as fumigants for bed bug control. Toxicological screens were conducted on both pyrethroid-susceptible and -resistant strains of bed bugs using a 24 h Erlenmeyer flask assay. A more field like assay, Rag-in-A-Bag , was utilized to compare two of the most efficacious benzoate compounds to the commercially available bed bug fumigant Cirkil®. A reduction in the efficacy of MB within the Rag-in-a-Bag assay led to further toxicological screens within larger plastic containers with an added heat source to increase the speed of volatilization of the fumigant. Finally, EthoVision® was used to monitor the movements of individual bed bugs in relation to treated discs to characterize the behavioral effects of the fumigant compounds. This study provides evidence for further testing of benzoate compounds for bed bug control.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Lavoie S.[1], Pichette A.[2], Sweeney-Jones A.[3], Kubanek J.[3], Mazaleyrat A.[1], Dupuch A.[1]

Examples of structural elucidation of flexible molecules

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Molecular diversity among natural products is astonishing. A big step to understand the function of a chemical isolate is to elucidate its precise structure which include uncovering its absolute stereochemistry. A variety of techniques is available to probe the configuration of a molecule. For example, the improved computational power allow to predict optical and nmr properties of hypothetical models representing the molecule of interest. Still, working with the large conformational space of a flexible structure is challenging. In this talk, I will present a few examples of molecules with various origins having conformational flexibility. I will show how in silico model and noesy spectroscopy have been used to elucidate their structures.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Leroy N.[1], Jean-Thomas C.[2], François V.[1]

Silicon amendment impacts tritrophic interactions by modifying plant volatile cues

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Silicon (Si) is ubiquitous in soil and plant tissues. There is increasing evidence that Si impacts plant natural defences against abiotic and biotic stresses, including the plant volatile emissions resulting from insect herbivores. In this study, we aim at evaluating the effect of Si bioavailability on the emission of volatile organic compounds (VOCs) by maize plants (Zea mays L.) and cascade effect on a tritrophic model including Spodoptera exigua (Lepidoptera: Noctuidae) and its natural enemies. We developed a hydroponic medium, allowing maize cultivation under increasing H4SiO4 concentrations in the nutrient solution. Si concentration in maize leaves increases with the increasing Si concentration in the nutrient solution. We collected the VOCs from un-infested and caterpillar-infested maize plants and their profiles were compared among Si treatments. Gas chromatography-mass spectrometry analyses showed quantitative and qualitative differences among plants depending on the Si concentration in maize leaves. Finally, we evaluated the oviposition preferences and the development of a caterpillar on maize grown in different Si concentrations and found that Si concentrations in maize leaves impact the choice of female and fitness of S. exigua caterpillars.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Levi-Zada A., Fefer D., Madar R., Steiner S., Kaspi R.

Evaluation of false codling moth Thaumatotibia leucotreta pheromone in Israel by sequential SPME/GCMS analysis and field trials

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False codling moth (FCM) is a major pest of citrus and other crops. FCM has spread from South Africa to other countries in Africa and may spread to other citrus growing areas. Monitoring of the pest is crucial to detect this important invasive pest, but its single eggs or larvae inside fruit are difficult to discover. The pheromone of FCM was mistakenly identified in South Africa in 1968, correctly identified in 1977, but unfortunately this was followed by many other contradictory studies. In addition, at low infestations commercial lures still do not detect the moth satisfactorily. In 2011 our group reported a new technique for pheromone isolation that we call "sequential SPME−GCMS analysis" (SSGA). The SSGA method reveals the circadian-released pheromone compounds from among contaminates. The SSGA method can show the pheromone components without relying on observing the "calling" behavior of females, which may not be apparent in all species. We combined our data on FCM pheromone emission with gland dissections in order to find the ratios between all the components that were emitted in a circadian rhythm. Then we undertook component subtraction from a mixture of all components and tested these in both EAG tests on FCM males as well as in field tests. We established the optimal ratio of the essential pheromone components in field tests and then investigated different dispensers, traps, and trap heights to develop an improved monitoring system for the pest.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Li Y.[1], Jiao Y.[1], Hu X.[1], Romeis J.[2], Peng Y.[1]

Bt rice plants may protect neighboring non-Bt rice plants against the striped stemborer Chilo suppressalis

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The area planted with insect-resistant genetically engineered crops expressing Bacillus thuringiensis (Bt) genes has greatly increased in many areas of the world. Given the nearby presence of non-Bt crops (including those planted as refuges) and non-crop habitats, pests targeted by the Bt trait have a choice between Bt and non-Bt crops or weeds, and their host preference may greatly affect insect management and management of pest resistance to Bt proteins. In this study we examined the oviposition preference of the target pest of Bt rice, Chilo suppressalis, for Bt vs. non-Bt rice plants as influenced by previous damage caused by C. suppressalis larvae. The results showed that C. suppressalis females had no oviposition preference for undamaged Bt or non-Bt plants but were repelled by conspecific-damaged plants whether Bt or non-Bt. Consequently, C. suppressalis egg masses were more numerous on Bt plants than on neighbouring non-Bt plants both in greenhouse and in field experiments due to the significantly greater conspecific damage on non-Bt plants. We also found evidence of poorer performance of C. suppressalis larvae on conspecific-damaged rice plants when compared to undamaged plants. GC-MS analyses showed that larval damage induced the release of volatiles that repelled mated C. suppressalis females in wind tunnel experiments. These findings suggest that Bt rice could act as a dead-end trap crop for C. suppressalis and thereby protect adjacent non-Bt rice plants.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Liang D. and Ana Story

Re-evaluation of (Z)-9-Tricosene as a house fly attractant

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(Z)-9-tricosene was thought to be a sex pheromone of the house fly Musca domestica (Muscadae, Diptera) when first identified in 1973. Since then it has been widely used as an attractant for house flies, especially in bait applications. However, some recent published data cast doubts on its effectiveness. In order to determine whether it should be used in house fly baits, we are conducting a re-evaluation of its effectiveness as a house fly attractant. Our preliminary behavioral data indicate that it is not attractive over a distance.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Liebeke M., Geier B., Michellod D., Dubilier N.

Mapping of microbes and metabolites discovers networks of metabolic interactions and novel symbiotic factors in deep-sea mussels

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We integrated spatial metabolomics and community structure mapping in a deep-sea mussel and provide a tool to monitor metabolic processes and chemical communication in a micrometer scale ecological context. Our research revealed how the metabolic space in beneficial host-microbe interactions is interwoven and shaped by each partner. One central question in metabolomics or natural product discovery studies using mass-spectrometry is the question after the importance and origin of a compound. We show how a combination of mass-spectrometry imaging, bulk metabolomics and microscopy can pinpoint the localization of the compounds and therefor find the producer cells. With localization we gain knowledge of possible function, like molecules which locate at the interface of microbes and animal tissue are likely effectors of that interaction. We further extract novel chemistry from our complex high-resolution MS data using metabolic networks within the context of spatial segregation and the chemical composition of the molecules. We exemplary show the power of this approach with the discovery of a new group of symbiotic molecules and how they are distributed in single animals to the worlds ocean deep-sea habitats.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Linington R.

Data Analysis Strategies for Untargeted Metabolomics of Natural Products

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Despite dramatic advances in mass spectrometry hardware over the past 10 years, accurate characterization of chemical constituents from unknown mixtures remains a formidable challenge. This issue is particularly acute in the area of natural products where validated chemical standards are unavailable in most cases. It is therefore difficult to correctly describe either the set of compounds present in any mixture, or the identities of these chemical species. This uncertainty about constitution limits our ability to perform system-wide studies in a large range of areas including chemical ecology, microbial biosynthesis and natural products-based biotechnology. Were such analyses readily available to these communities this information would substantially alter the scale and objectives of many studies in these areas. Our laboratory has been developing informatics approaches to address this question, with the goal of generating compound lists for unknown mixtures that are both inclusive (i.e. contain all members) and possess low false discovery rates (i.e. have low promiscuity). Starting from mixtures of known standards we have evaluated a number of existing data processing platforms for mass spectrometry. Based on these results we have then developed a new data analysis pipeline designed to provide the research community with an unbiased, accurate measure of chemical constitution in complex mixtures. Results from this pipeline will be presented.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Lou Y.[1], Wang W.[1], Wu J.[2]

Controlling insect pests by manipulation of volatile and non-volatile defensive compounds in rice

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In response to herbivore attack, plants perceive herbivore-associated molecular patterns (HAMPs) and thus produce various volatile and non-volatile defensive compounds by activating a defense-related signaling network consist of mitogen-activated protein kinase (MPK) cascades and pathways mediated by jasmonic acid (JA), salicylic acid (SA), and ethylene (ET). These defensive compounds decrease the fitness of herbivores directly and indirectly by attracting natural enemies of herbivores. Hence, the population density of herbivores in the field could be decreased by manipulating these compounds, thereby reducing the loss of plant yield caused by herbivore infestation. Previous studies with rice have shown that herbivore attack induces the biosynthesis of a variety of defense-related signals including MPK cascades, JA, JA-Ile, SA, H2O2 and ET; these, in turn, regulate defense responses, such as the release of herbivore-induced volatiles and the accumulation of TrypPIs, thereby influencing the resistance of rice to different herbivores. Moreover, we observed that the manipulation of volatiles in rice, by genetic modification or application of synthetic chemical elicitors, has great potential for the control of pest populations. Here, I will show our recent findings from a novel synthetic chemical elicitor WJ-72. We found that WJ-72 increases the resistance of rice to piercing-sucking insect pests, thereby suppressing herbivore abundance and increasing crop yield in the field.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Lu M.

Bacterial volatile ammonia regulates the consumption sequence of D-pinitol and D-glucose in a fungus associated with an invasive bark beetle

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Interactions among microbial symbionts have multiple roles in the maintenance of insect–microbe symbiosis. However, signals mediating microbial interactions have been scarcely studied. In the classical model system of bark beetles and fungal associates, fungi increase the fitness of insects. However, not all interactions are mutualistic, some of these fungal symbionts compete for sugars with beetle larvae. How this antagonistic effect is alleviated is unknown, and recent research suggests potential roles of bacterial symbionts. Red turpentine beetle (RTB), Dendroctonus valens LeConte, is an invasive pest in China, and it leads to wide spread, catastrophic mortality to Chinese pines. In the symbiotic system formed by RTB, fungi and bacteria, volatiles from predominant bacteria regulate the consumption sequence of carbon sources D-pinitol and D-glucose in the fungal symbiont Leptographium procerum, and appear to alleviate the antagonistic effect from the fungus against RTB larvae. However, active components of these volatiles are unknown. We detected 67 volatiles by Gas Chromatography-Mass Spectrometer (GC-MS). Seven of them were identified as candidate chemicals mediating bacteria-fungus interactions, among which ammonia made L. procerum consume its secondary carbon source D-pinitol instead of its preferred carbohydrate D-glucose. In conclusion, ammonia regulated the consumption sequence of these two carbon sources in the fungal symbiont.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Lu P.

Mating behavior and attractiveness of male cuticle extracts based on electroantennogram and behavioral assay in Sirex noctilio Fabricius

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Sirex noctilio was a major forest invasive pest worldwide and has caused serious damages. After a careful observation of mating behavior and rhythm of S. noctilio, four types of male cuticle extracts were collected. Electroantennogram (EAG) and behavioral responses of both sexes to these extracts were investigated. According to sex ratio of 1:3 (female to male), wasps were put into the cages and then the number of mating couples was recorded throughout the day. Male cuticles were extracted by hexane (HPLC), and then EAG and olfactory responses of both sexes to the extracts were determined. The extracts were as follow, sample 1 (separately reared in plastic cage), sample 2 (males gathering without female), sample 3 (males attracted females, but no mating occurred), and sample 4 (after mating). The results showed that the mating process can be divided into five phases. The highest mating frequency occurred at 9:00-11:00 in a day. Both males and females had the highest selection to the sample 3 and sample 4. Male extracts could elicit much stronger EAG response from female wasps' antennae. Behavior test showed that only sample 3 was attractive to females, sample 1-4 were attractive to males. Males released pheromone which can attract both male and female wasps. We could hypothesis that males could release aggregative pheromone to attract males in the canopy after emergence, also could release likely sex pheromone to attract females once they were much closer to females.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Lu P.

Mating behavior and attractiveness of male cuticle extracts based on electroantennogram and behavioral assay in Sirex noctilio Fabricius

Beijing Key Laboratory for Forest Pest Control, Beijing Forestry University

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Sirex noctilio was a major forest invasive pest worldwide and has caused serious damages. After a careful observation of mating behavior and rhythm of S. noctilio, four types of male cuticle extracts were collected. Electroantennogram (EAG) and behavioral responses of both sexes to these extracts were investigated. According to sex ratio of 1:3 (female to male), wasps were put into the cages and then the number of mating couples was recorded throughout the day. Male cuticles were extracted by hexane (HPLC), and then EAG and olfactory responses of both sexes to the extracts were determined. The extracts were as follow, sample 1 (separately reared in plastic cage), sample 2 (males gathering without female), sample 3 (males attracted females, but no mating occurred), and sample 4 (after mating). The results showed that the mating process can be divided into five phases. The highest mating frequency occurred at 9:00-11:00 in a day. Both males and females had the highest selection to the sample 3 and sample 4. Male extracts could elicit much stronger EAG response from female wasps' antennae. Behavior test showed that only sample 3 was attractive to females, sample 1-4 were attractive to males. Males released pheromone which can attract both male and female wasps. We could hypothesis that males could release aggregative pheromone to attract males in the canopy after emergence, also could release likely sex pheromone to attract females once they were much closer to females.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Lu Y., Zhang C., Wang Z., Miao S.

Hormone involve in the biosynthesis of aggregation pheromone in Tribolium castaneum

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The red flour beetle, Tribolium castaneum (Coleoptera: Tenebrionidae) is one of world-wide cosmopolitan storage pests infesting almost all of flours and meals. T Male T. castaneum produces an aggregation pheromone attracting both sexes, and it was identified as 4, 8-dimehyldecanal (4,8-DMD). The aggregation pheromone was determined as (4R, 8R)-DMD by bioassay experiments using synthetic optical isomers. The key genes and their functions on pheromone biosynthesis pathway of T. castaneum were identified by RNA interference(RNAi) and realtime-PCR(qRT-PCR) technologies. This paper studies the effect of insect hormones such as junvile hormone and ecdysone on the pheromone production and the expression of key genes in pheromone biosynthesis pathway. The results showed that the quantification result of 4,8-DMD released and endogenous hormones titer in vivo levels after treatment with exogenous fatty acid synthesiss inhibitors and hormone analogues were indicated that 2 octynoic acid and Methoprene could inhabit on the synthesis of 4,8-DMD. There was no significant change in juvenile hormone titers and 20-hrdroxyecdysone titers after 2 octynoic acid treatment. Methoprene treatment significantly decreased juvenile hormone titers. The 20-hrdroxy ecdysone titers were significantly reduced after treatment with Mevastatin. In addition, quantification of insulin receptor gene expression level after treatment with 2 octynoic acid.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Lyles J.[1], Dettweiler M.[2], Voleti S.[3], Quave C.[1,2]

Open Source Mass Spectrometry Tools Identifying Natural Product Quorum Sensing Inhibitors Using Castanea spp. as a Model System

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Antibiotic resistant bacteria continue to be a growing worldwide health concern. The increasing use of "last-line" antibiotics and emergence of hypervirulent strains of bacteria require investigating alternate therapies. Botanically based traditional medicine practices offer one reservoir of therapies. An initial screen of Italian plants identified quorum sensing (QS) inhibitors from the leaves of Castanea sativa Mill. (Fagacaeae) used as a traditional treatment for skin infection and inflammation. Bioactivity guided fractionation, a reductionist tactic of discovery, is commonly applied to natural products research. However, the application of modern metabolomics analysis allows the study of bioactivity by more than a single purified compound. These tools provide a means to explore the potential chemical synergy and complementary bioactivities often associated with botanical medicine. To this end, leaves from over 40 trees, representing nine Castanea species and a backcross Castanea hybrid of American and Chinese Chestnuts were collected and extracted. The extracts were screened against S. aureus for anti-QS activity and investigated by HPLC-FTMS. Various open source metabolomics tools combined the anti-QS bioactivity and MS features using Compound Activity Mapping. The resulting model was dereplicated by comparison to public natural products databases. This model serves as a proof of concept for the identification of plant metabolites responsible for the anti-QS bioactivity.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Maleki A., Seidl-Adams I., Tumlinson J.,

Stomatal aperture determines the uptake and transport of green leaf alcohols in maize

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It is well known that exposure to the Green Leaf Volatile (GLV) (Z)-3-hexen-1-ol (Z3HOL) induces maize plants to mount a faster and stronger defense response to subsequent herbivory. Little is known about the uptake and the transport of Z3HOL inside the plant. Since stomata are known as the major pathways for the exchange of airborne molecules with the surrounding environment, we investigated the question of how the closure of stomata affects the delivery of GLV signals in maize seedlings. Since GLV alcohol is converted to (Z)-3-hexenyl acetate (Z3HAC) in maize, we used the emitted amount of Z3HAC from exposed plants as an indicator for Z3HOL delivery. Also, we used (E)-3-hexen-1-ol, which is not made by plants but is structurally similar to Z3HOL, to differentiate between externally provided GLV, and internally induced GLV biosynthesis. As expected, closure of stomata not only reduced the uptake of GLV alcohols but also decreased their transport rate. Environmental conditions, which close the stomata and thus reduce xylem flow rate, i.e. drought, could decrease transport of GLV inside the plant and consequently induction and priming of defenses. Additionally, we found that cut seedlings supplied with Z3HOL induced sesquiterpene biosynthesis in a dose-dependent manner, but in the dark or under ABA treatments, no induction of sesquiterpenes was recorded. The role of Z3HOL transport through the xylem in the induction of other systemic defense responses remains to be shown.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Mascuchi S., Mojib N., Chhetri B. Imhoff B., McCarty N., Kubanek J.

By which molecular mechanisms do aquatic predators' sense chemical defenses in prey? Synthesis and application of chemical defense molecular probes.

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Chemicals furnish the main form of marine sponge defense against predation, fouling, and competition. Exposure to the triterpene glycoside class of sponge compounds via chemically laced foods results in rapid rejection behavior by both bluehead wrasse fish and the genetic model zebrafish (Danio rerio). A co-receptor, RAMP-like triterpene glycoside receptor (RL-TGR), which appears to act in concert with one or more GPCRs, has recently been implicated in this chemoaversive behavior. Using molecular probes derived from sponge triterpene glycosides, we are working to localize and isolate cognate receptors in a zebrafish model. This will serve as a starting point to deconvolute the triterpene glycoside deterrence pathway and will provide useful mechanistic insight into the poorly understood process of chemoreception in marine chemical ecology.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Mason C.[1], Hoover K.[1], Felton G[1]., Raffa K.[2]

Incorporating microbes into defense syndromes: a case of working on the margins

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Herbivores are commonly confronted with suites of defenses when attacking and consuming host plant substrates. Highly effective defenses against chewing insects typically manifest as collective intersecting traits that combine to overwhelm the herbivore. It is generally recognized that herbivores co-occur with complexes of microbes. These associations can vary from being labile to possessing a more stable structure, which is influenced by herbivore life history and dietary consumption. We describe how stability and variability of microbial communities contribute to alterations in plant defense phenotypes and argue that microbes can both suppress and activate plant defenses in a variety of systems. First, we discuss work conducted in bark beetles, where we have shown metabolism of terpenoids by one group of microbes (bacteria), but induction by another group (fungi). Then, we discuss work showing how variable bacterial communities alter folivore responses to defenses, and how defense mechanisms can interact with bacterial members to be lessened or heightened in effect. We suggest that microbial interactions with herbivore-based defenses are common, but not a zero-sum game. Rather, the influence of microbes on defenses rests on several intersecting ecological variables and can extend phenotypic variation in the systems.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Mathur V.[1], Sharma G.[1], Tomar R.[1,2]

Variation in the plant-microbe association and plant metabolites in an urban ecosystem

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Plant-associated microbes form integral constituents of plant machinery affecting physiology and metabolism of both plant and microbes. The plant influences differential growth adaptations and provides nutrients to endophytes, whereas endophytes contribute to secondary metabolites, phytohormones and volatile organic compounds production in the plant. This symbiosis thus plays a major role in plant growth, resistance and resultant adaptation to high-stress environments. In urban ecosystem, especially in a metropolitan such as Delhi, roadside trees are constantly exposed to air pollution. We, therefore, evaluated the effect of air pollution on a common roadside tree, Neem (Azadirachta indica), and its associated microbes in four polluted and less polluted sites in Delhi. We hypothesized that alteration in air quality index not only influences plant physiology, but also its endophytes. A 100-fold increase in the number of endophytes was found with 1.7 times increase in pollution levels. Trees in polluted areas had abundance of Salmonella, Proteus and Citrobacter sps, and showed increased secondary metabolites such as phenols and tannin as well as decreased chlorophyll and carotenoid. Number of unique microbes were positively correlated with increased primary metabolites. Our study thus indicates that alteration in air quality affects the natural micro-environment of plants. These results may be utilized as sustainable tools for studying plant adaptations to urban ecosystem

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Mauck K., Chesnais Q., Shates T., Kenney J., Sun P.

Virus manipulation of hosts and vectors depends on pathogen traits and host context.

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Hemipteran insects are ideal vectors for plant viruses, which rely on the presence of intact cells for invasion and proliferation within hosts. During the process of infection, plant viruses can drastically alter the very same chemical and nutritional aspects of the host that mediate interactions with phloem-feeding insects. Thus, by virtue of their tremendous capacity to serve as efficient virus transporters, hemipteran vectors are frequently subjected to rapidly shifting plant suitability and palatability following host selection and virus transmission. Recognition of this challenge has led researchers to study how virus-induced changes in host-plant phenotypes influence subsequent numerical and behavioral responses by vectors, and thereby, virus fitness. As a result of this body of work, we now have evidence that plant viruses can manipulate specific host traits in ways that enhance their own transmission. This work is providing new insights into virus evolution and hemipteran feeding and plasticity, but we still lack information about the robustness of virus effects across pathosystems. Using several model systems under study in my laboratory, I will discuss the ways in which virus effects on host chemistry and vector behavior vary according to virus transmission mode, relate this to the evolution of manipulative traits, and explore the constancy of virus-induced signals over time and environmental variation.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Mbaluto C.,[1,2] van Dam N[1,2]., Martínez-Medina A.[3]

Root-knot nematode infestation facilitates Spodoptera exigua performance only during the galling stage

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Plant parasitic nematodes that intimately interact with host plant roots can systemically affect shoot herbivores by changing shoot chemistry and biomass. The impact of nematode infestation on the performance of aboveground (AG) herbivores differs among studies. We tested the hypothesis that AG effects of root nematodes depends on the stage of the nematode's infection cycle. We investigated this using root-knot nematodes and the AG feeding generalist Spodoptera exigua on tomato plants (Solanum lycopersicum cv. Moneymaker). Spodoptera exigua larvae were exposed to plants on which the nematodes were either in the infestation, galling or reproductive stage. We found that S. exigua performed significantly better on plants with nematodes in the galling stage. On these plants, S. exigua attained higher larval and pupal weights, and had a shorter pupal stage compared to larvae on control plants. We also found higher proportions of female moths emerging from plants on which the nematodes were in the galling stage. Contrary to what we expected based on the increased S. exigua performance; S. exigua feeding on the plants with galling nematodes enhanced the accumulation of jasmonates (JAs) in the leaves. This shows that the interaction between root-knot nematodes and AG herbivores depends on the nematode's infection stage. This should be taken into account when studying belowground-aboveground interactions.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Souza N.,[1] Schröder M[2]., Hayes R.[1], Bello J.[3], Nahrung[1]

Extracting IDs: chemotaxonomy in Gonipterus weevils

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Gonipterus is a genus of Eucalyptus-feeding weevils from Australia containing several cryptic species. Thus, species identification in the this genus has become a taxonomic challenge in both its native range and in countries where it is an invasive pest. In this study, we explored cuticular hydrocarbons (CHCs) of different Gonipterus species to assess their potential for species discrimination. Adult weevils were collected from various sites across Australia and kept in identical conditions prior to the study, and species were identified by examination of male genitalia and mitochondrial CO1 sequencing. Whole body hexane washes of the adult weevils were performed and analysed by GC-MS, and the peaks in the resulting chromatograms were analysed by comparison of their relative areas, retention indices, and MS fragmentation patterns. Our results show that the CHC profiles of the seven species of Gonipterus used in this study were significantly different from each other, with no difference in CHC profiles between sexes. The closely-related weevil genus Oxyops was used as an outgroup and its CHC profile was distinct from all Gonipterus species. Within Gonipterus, the compounds that contributed to species' dissimilarities were alkanes, alkenes and methyl branched alkanes, known to be semiochemicals in other groups. Within species, collection locality impacted CHC profiles. These findings demonstrate CHC analysis as a promising chemotaxonomic tool for the genus Gonipterus.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Ohdera A., Kerwin A., Avila V., Medina M.

Microbial players in the Upside-down Jellyfish (Cassiopea xamachana) life cycle

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Microbes can be key players in the normal development of metazoans, but the extent and mechanisms of these interactions have yet to be fully explored. In order to understand the linkage between microbes and the metazoan lifecycle, we investigated the role of the associated microbiome during different life history stages of the scyphozoan jellyfish Cassiopea xamachana. We found monoculture bacterial biofilms induced varying degrees of larval settlement and metamorphosis (triggering larvae to transition to the polyp stage). During the polyp stage, the onset of photosymbiosis with dinoflagellates in the family Symbiodiniaceae triggers another developmental transition (strobilation) that completes the jellyfish life cycle through the development of free-swimming ephyrae. We used genomic and transcriptomic approaches to identify the potential pathways and molecules responsible for these metamorphic transitions.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Melo A.

Screening behaviorally compounds based on reverse chemical ecology for the Chagas disease vector, Rhodnius prolixus

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Rhodnius prolixus is one of the most important vector of Chagas disease in Central and South America. Repellents like DEET, picaridin, and IR3535 are widely used as the first line against mosquitoes and other vectors, but they are ineffective against R. prolixus. Prospection of repellent molecules that can be used to avoid R. prolixus contact is needed and imperative. Association of different molecular approaches (heterologous expression, electrophysiological recording, qPCR and RNAi) with behavior bioassays allowed us to identify 4 semiochemicals physiologically active. R. prolixus behavior drastically changes when insects are challenged with these semiochemicals. Insects run away from the source of stimulus, characterizing a repellent action. Here we will discuss the importance of molecular entomology on the characterization of ligands involved in the chemical communication of R. prolixus and their implications on vector control.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Murtha A., Yount T., Miyashiro T.

Quorum Sensing between Vibrio fischeri Populations within the Squid Light Organ

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Quorum sensing is the signaling mechanism that depends on molecules called autoinducers. How quorum sensing functions within a host remains poorly understood, due to the challenges associated with identifying quorum-sensing populations in vivo. Vibrio fischeri is a bioluminescent bacterium that occupies specific sites within the light organ of the Hawaiian squid. LuxI produces an autoinducer that stimulates light production through transcription of the lux operon, which encodes luciferase. Mutants lacking either lux genes (Δlux) or luxI (LuxI-) are nonluminous in vivo and become attenuated, suggesting that transcription of the lux operon is necessary for V. fischeri to maintain symbiosis. However, squid co-colonized with both mutants emit bioluminescence. These animals frequently exhibit populations of single strain types that are spatially segregated, suggesting that the bioluminescence results from the LuxI- populations detecting autoinducer produced by Δlux populations. Indeed, expression of the lux promoter in LuxI- populations was elevated suggesting that Δlux populations induce lux expression in those LuxI- populations. However, the abundance of each strain type became attenuated 48 h later, and animal luminescence decreased, suggesting interactions between mutants decreases over time. These findings provide insight into quorum sensing in vivo, thereby increasing understanding of the molecular mechanisms impacting host-microbe symbioses.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Moris V.[1], Wirtgen A.[1], Schmitt T.[2], Niehuis O.[1]

Methyl-alkanes repulsive and/or short CHCs attractive? How the CHC profiles of male and female Odynerus spinipes (Insecta: Hymenoptera: Vespidae) change with age and which genes are causing these changes?

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Cuticular hydrocarbons (CHC) profiles, used by some insects for sexual communication can change with the insects' fertility status and/or mating status and/or age. In females of the mason wasp Odynerus spinipes, we noticed a decrease of methyl-alkanes three days after the wasps' had eclosed and an age-related shift towards "long CHCs" (> 26 carbon atoms). In order to determine if the above changes are exploited as mating cues by O. spinipes males, we first continuously sampled CHCs of females, reared with males, to characterize the CHC profiles of those females that became attractive for males. Secondly, we conducted single choice mating experiments with males and female dummies coated with CHC extracts of females of different ages and mating status. We found a decrease in the relative amount of methyl-alkanes in females, shortly before they became attractive for males. We also observed most mating attempts by males in the presence of dummies coated with CHC extracts of young virgin (three-days-old) females (carrying high abundance of short CHCs). Based on these observations, we hypothesize that methyl-alkanes communicate the fertility status of females, deterring males from mating. The ratio between the relative abundance of short CHCs and of long CHCs could as well convey the age and/or the mating status of females. We started studying the molecular basis of the above-listed CHC profile changes by analyzing transcriptomes and conducting qRT-PCRs on selected candidate genes.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Morrison W.[1], Larson N.[2], Brabec D.[1], Zhang A.[2]

Prospects for the use of methyl benzoate as an alternative fumigant to control post-harvest pests

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Historically, stored product insect pest management has been based around the use of methyl bromide and phosphine as fumigants. However, methyl bromide has been phased out of use, and there is increasing worldwide insecticide resistance to phosphine. As a result, alternative fumigant options are required to preserve the efficacy of remaining tools. One potential alternative, environmentally-friendly option is the use of methyl benzoate (MB), which is considered a food safe compound. In this study, we evaluated the direct and sublethal effects of MB exposure on the survivorship and mobility of 3-4 stored product species with diverse life histories, including Rhyzopertha dominica, Tribolium castaneum, Sitophilus zeamais, and Trogoderma variabile. Sets of insects were exposed to a control, low, or high MB or phosphine concentrations in containers with or without food for 24 or 72 h in the laboratory. Overall, R. dominica was the most susceptible to MB exposure, followed by T. castaneum. Exposure to MB induced multiple-fold decreases in the total distance moved and velocity of adults still considered alive or affected after assays. By comparison, phosphine effectively killed all individuals of all species. Our data suggests that while MB is not competitive with phosphine in controlling susceptible strains of these species, future work should address whether it could act as a niche product to control phosphine-resistant strains.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Nakabayashi R.[1]and Saito K.[1,2]

Imaging mass spectrometry: a way to visualize the localization of metabolites

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Imaging mass spectrometry (IMS) is a powerful approach for visualizing the localization of metabolites and is used in sections of organisms. Recently, this approach has been applied to identify the localization of specialized metabolites (previously called secondary metabolites) in plants. Specialized metabolites are significant natural products that are associated with certain species and accumulate in specific tissues and organs of plants. Previously, these metabolites were recognized as the byproducts of primary metabolites and were considered irrelevant. However, recent phytochemical genomics studies have shown that they have important biological functions. Comparative analysis of transcriptomics and metabolomics in transformants/mutants, which over accumulate or lack certain metabolites by editing biosynthetic genes, can be used for identifying the functions of metabolites in plants. To identify biosynthetic genes responsible for the metabolites, understanding the association of metabolite accumulation with gene expression at certain parts is important. However, this step for identifying the localization of the metabolites is time consuming. We developed methods for IMS using Fourier transform ion cyclotron resonance mass spectrometry. In this presentation, we present the localization of some specialized metabolites characterized by the IMS analysis and discuss the role of the metabolites in plants.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Naragon T., Brückner A., Parker J.

Glandular chemistry and behaviors in the beetle Sceptobius lativentris allow for intimate integration into ant colonies

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Sceptobius lativentris is one of three species of Aleocharine rove beetle found in the nests of the velvety tree ant, Liometopum occidentale. Of the three beetles, Sceptobius has integrated into the ant colonies to the greatest degree, in part due to evolved chemistries and behaviors that are absent in the other two beetle species. To overcome ant aggression upon initially entering ant nests, Sceptobius replaced the defensive gland that is present in all other higher Aleocharinae with an appeasement gland that induces a trance-like state in the ant. This novel gland secretes sulcatol, the alcohol form of the Liometopum alarm pheromone sulcatone. The beetle then mounts the stunned Liometopum ant, grasps the antennae with its mandibles and grooms the ant, transferring the nest-mate recognition pheromones from the surface of the ant to itself. The cuticular hydrocarbons that the beetle steals from the ant allow the beetle to move freely through the nest to the brood chambers, which provide a steady source of food. Using stable isotope mass spectrometry, we verified that the CHCs are stolen from the ant and not synthesized by the beetle. In conjunction with the analysis of the beetle gland, these results lay the foundations for understanding the evolution of glandular chemistries and behaviors that lead to myrmecophily.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Nevitt G.

Anthropogenic impacts on chemically-mediated foraging in marine wildlife: the problem of plastic

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Plastic contamination in marine ecosystems is a pressing environmental concern, with well documented impacts on wildlife that ingest marine debris, presumably mistaking it for food. My lab has been investigating whether marine organisms can chemically detect plastic, focusing on procellariiform seabirds as a model group. Procellariiforms are a wide-ranging, highly pelagic order of birds that rely on chemical cues including dimethyl sulfide (DMS) for foraging. DMS is produced by phytoplankton and other marine algae. Results have suggested that while unseasoned plastic is repellent to seabirds in experimental trials, the acquired odor signature of marine-seasoned plastic debris includes DMS and creates a sensory trap for susceptible marine wildlife. My presentation will provide an overview of these results in the context of anthropogenic impacts on foraging ecology.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Nevo O.[1], Razafimandimby D.[2], Valenta K.[3], Chapman C.[4], Ganzhorn J.[5], Ayasse M.[1]

Honest fruit: scent signals nutrient content across species

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Plant species with fleshy fruits offer animals rewards, such as sugar, protein, and fat, to eat their fruit and disperse their seeds. They have also evolved visual and olfactory cues to signal their presence and ripeness. Research suggests that fruit color serves as a visual signal of nutrient content. But even though many volatile chemicals used as olfactory signals derive from nutrients animals seek, it is still unknown whether fruit scent encodes information regarding nutrient content in wild fruits. Here, we examine the relationship between olfactory signals and nutrient rewards in 28 fruiting plant species in Madagascar. We show that fruit scent is strongly associated with nutrient content: nitrogen- and sulfur- containing volatile compounds in fruit scent predict protein levels, while terpenoid and methyl/ethyl esters predict sugar levels. To the best of our knowledge this is the first study to identify the connection between fruit chemical signals and nutrient rewards, suggesting that seed dispersers can infer fruit quality based on scent.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Oberlies N.

Interspecific Interactions: Chemical Diversity via Mapping the Fungal Battlefield

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A common question in the field of natural products research is: why did that organism choose to biosynthesize those compounds? Of course, the simple answer is that we, as humans, don't really know. However, the common postulate is that the secondary metabolites give the organism some sort of advantage, particularly with respect to chemical defense. If true, can we then set up experiments where organisms must 'fight' for their turf, essentially using co-culturing as a way to force the production of secondary metabolites, perhaps causing the amplification of production and/or the stimulation of otherwise silent biosynthetic gene clusters. Using a series of tools that profile the chemistry of fungal cultures in situ, our team has been pursuing these questions, both to probe some of the basics of fungal ecology and biology, as well as, to potentially generate new chemical diversity. This talk will explain some of the underlying tools used to assess the chemistry of fungal (and other microbial) cultures via mass spectrometry, and then apply those skills and databases to understanding fungal chemistry in situ.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

O'Connor S.

Chemistry and Biology of Plant Natural Products

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Plants, which make thousands of complex natural products or specialized metabolites, are outstanding chemists: plants create incredible chemical complexity from simple starting materials. Medicinal plants are known to make molecules that can be used as medicines to cure cancer, pain and other diseases. Here we will highlight how plants make these molecules and how these biosynthetic pathways can be placed into an evolutionary and biological context. We will also discuss methods by which these pathways can be harnessed by metabolic engineering.

Themed Session: Keynote

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Okosun O., Yusuf A., Crewe R., Pirk C.

Social parasites exploit chemical communication in host colonies to achieve dominance

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Pheromonal communication in honey bees is a key mechanism in maintaining the stability and integrity of the colony. Social insect parasites exploit this chemical communication in host colonies to their advantage. In particular Apis mellifera capensis, clonal workers which got established in the native range of Apis mellifera stutellata are social parasites, which exploit the pheromonal communication. The role played by chemical secretions from social parasitic honey bee workers glands in modifying behavioural interactions in A. m. stutellata host colonies were determined. Host workers were exposed to pheromonal blends from parasitic clones for a short and long time period. The results showed that A. m. capensis parasitic clones successfully used glandular secretions to achieve dominance in host colonies by eliciting retinue behaviour from host workers and inhibiting ovarian activation in these host workers.

Themed Session: Chemical Communication of Social Insect Associates: Espionage, Weaponry and Stealth

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Onaka H.

Combined-culture: co-culture with MACB induced potential secondary metabolism in actinomycetes

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Streptomyces contains 30–40 secondary metabolite biosynthetic gene clusters, however the expression of most metabolite biosynthetic gene clusters is cryptic or silent. To activate such a potential secondary metabolism, co-culture is one of attractive methods. In our developed Combined-culture [1], the activator strain is a mycolic acid-containing bacterium (MACB), and about 90% of Streptomyces species show changes in secondary metabolism in combined-culture compared with pure culture. We developed the combined-culture method for antibiotic screening, and 30 novel type of antibiotics have been isolated. Although the mechanism of secondary metabolism induction by the combined-culture is still unclear, the induction pathway would not be mediated by specific signal molecules produced by MACB but stimulated by physical contact between actinomycetes and MACB [2]. References: [1] H. Onaka, Y. Mori, Y. Igarashi, and T. Furumai, Appl Environ Microbiol. 2011, 77(2): 400-406; [2] S. Asamizu, T. Ozaki, K. Teramoto, K. Satoh, and H. Onaka, PLoS One 2015, 10(11): e0142372

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Orlova M., Treanore E., Amsalem E.

The warrior queen: interplay of aggression and fertility signaling in regulating worker reproduction in Bombus impatiens

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Reproductive division of labor, a defining feature of social insects, is often regulated by a combination of behavioral and chemical means. It is hypothesized that behavior plays a more important role in the regulation of reproduction in primitive eusocial insect species, while derived eusocial insect species rely almost exclusively on chemical signaling. Bumblebees represent an intermediate stage in evolution of sociality sharing characteristics with both primitive and derived social species, and thus serve as an excellent model to study the interplay between behavioral and chemical factors regulating reproductive division of labor. Bumblebee queens are able to inhibit worker reproduction. However, whether the queen uses behavioral means, fertility signals or both, remain elusive. Here we examined the co-occurring changes in queens' behavior and chemical cuticular profile in Bombus impatiens of different stages during their life cycle, and their effect on worker ovarian activation. Our findings suggest that the queen's aggressive behavior is crucial for inducing worker sterility. We also discuss the importance of queen's reproductive status and the interplay between her chemical signaling and behavioral activity through which regulation of reproductive division of labor in bumblebee colonies is achieved.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Osei-Owusu J.[1,2], Vuts J.[2], Caulfield J.[2], Woodcock C.[2], Osafo Acquaach S.[1], Birkett M.[2]

A low-input management system for the pest pod-borer Maruca vitrata on cowpea, Vigna unguiculate

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Cowpea, Vigna unguiculata (L.), is an important crop in Ghana and provides an accessible source of protein. Crop yields, however, are reduced by many biotic factors, especially the pod-borer Maruca vitrata that can cause up to 80% losses. Feeding damage caused to cowpea plants occurs on flower buds, flowers, tender leaves and seed pods by larvae, and this typical feeding habit protects it from applied insecticides, which are sometimes too expensive for poor rural farms. Other work on combating this serious pest has included attempts at breeding resistant cowpea varieties with traits affecting pod wall thickness, trichomes, nutritional and antibiotic content. Therefore, sustainable low-input management strategies are needed for the management of the pest. While insects use volatile organic compounds (VOCs) emitted by plants to locate their host, plants defend themselves against herbivores by releasing blends of VOCs, referred to as Herbivore-Induced Plant Volatiles (HIPVs), that can attract natural enemies and/ or deter herbivore attack. We will discuss the chemical ecological signals from cowpea important for its colonisation by M.vitrata, the volatile chemical defence response of cowpea that signal it unattractive to herbivores and HIPVs produced that are attractive to the larval parasitoid, Apanteles taragamae. Our results provide the platform for the development of future semiochemical-based pest management strategies against M.vitrata.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Patin N.

Chemical ecology in the age of microbiome science and big data

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Classic chemical ecology stories consist of a two-membered relationship and the chemistry involved in their communication. More complex examples can include three or four members, such as the fungus-farming ants and their protective bacterial symbionts. In the age of microbiome science, however, we can now many more community members and their potential ecological roles. These may include thousands of microbial species, most of which remain uncultivated. Furthermore, linking taxonomy to function in bacteria is imperfect at best. How can we address this seemingly overwhelming issue? Here I will present three examples of how microbiome science can be leveraged to provide a more complete understanding of chemical ecology in the marine environment. The first shows the measurable effects of marine actinomycete specialized metabolites on their native sediment microbial communities. The second provides new context for the bryozoan Bugula neritina, its bryostatin-producing symbiont, and the associated microbiome. Finally, combined microbiome and metabolome data provide new insight into blooms of the toxic dinoflagellate Karenia brevis. I will also discuss some of the challenges in performing rigorous microbiome science and the emerging solutions to those challenges.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
June 2- 6, 2019
Oral Presentations

Paudel Timilsena B.[1], Seidl-Adams I.[1], Refi Hind S.[2], Tumlinson J.[1]

Plant defense priming: which volatiles trigger priming in tobacco plant

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When plants are exposed to herbivore-induced plant volatiles (HIPV), they develop an enhanced capacity to activate defense responses after subsequent damage by herbivores – a process called priming. However, the component of the HIPV blend which activates defense priming in the receiver plant still needs to be elucidated. In this study, we examine the role of each group of HIPV by silencing or inhibiting its biosynthesis pathway using virus-induced gene silencing (VIGS) and chemical inhibitors, respectively. To investigate the role of an individual compound, we dispense physiologically relevant concentrations of a particular synthetic compound using slow releasing dispensers. Exposure to the complete blend of HIPV primed receiver tobacco (Nicotiana benthamiana) plants for enhanced production of all 5 groups of HIPV (green leaf volatiles (GLV), mono- and sesquiterpenes, aldoximes and indole) after simulated herbivory (mechanical damage and insect regurgitant application). When production of GLV was silenced in emitter plants, receiver plants produced comparatively lower amount of mono- and sesquiterpenes than the plants exposed to the whole blend of HIPV. Moreover, exposure to synthetic (Z)-3-hexenol alone primed receiver plants for mono- and sesquiterpene production. This suggests that GLV play an important role in inducing defense priming in tobacco plants. Further analysis of the role of other groups of HIPV is in progress.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Paul V.

Marine Chemical Ecology in a Changing Ocean

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The chemical ecology of seaweeds, sponges, soft corals and mollusks has been studied for decades. During this time, marine chemical ecology has changed in focus from studying the roles of secondary metabolites in specific consumer-prey or competitive interactions to understanding ecosystem-level processes. Macroalgae and benthic cyanobacteria are becoming increasingly abundant on coral reefs worldwide. Their secondary metabolites play important roles in chemical defenses against grazers such as sea urchins and herbivorous fishes and are also important for competition between corals and algae. Field and laboratory experiments have tested interactions between chemically defended species of algae and cyanobacteria and different life history stages of corals. On reefs experiencing increased abundance of chemically defended algae and cyanobacteria, the rebuilding of coral populations may be impaired due to recruitment inhibition caused by algal compounds. Chemical interactions are taking place under changing ocean conditions where increases in temperature and carbon dioxide concentrations are leading to ocean acidification and warming. Corals are becoming increasingly impacted by diseases under these changing conditions, and secondary metabolites play a role in these host-pathogen interactions, which can decimate coral populations. Modern 'omics' tools provide ways to study marine chemical ecology and microbial associations that would have been difficult even a decade ago.

Themed Session: Keynote

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Pavia H.[3], Berdan E.[1], Enge S.[2,3], Nylund G.[3], Wellenreuther M.[4,5], Martens G.[6]

Genetic divergence and phenotypic plasticity contribute to variation in cuticular hydrocarbons and male choice in the seaweed fly Coelopa frigida

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Cuticular hydrocarbons (CHCs) form the boundary between insects and their environments and often act as essential cues for species, mate and kin recognition. This complex polygenic trait can be highly variable both among and within species, but the causes of this variation, especially the genetic basis, are largely unknown. In this study, we investigated phenotypic and genetic variation of CHCs in the seaweed fly, C. frigida, and found that composition was affected by both genetic (sex and population) and environmental (larval diet) factors. We subsequently conducted behavioral trials that show CHCs are likely used as a sexual signal. We identified general shifts in CHC chemistry as well as individual compounds and found that the methylated compounds, mean chain length, proportion of alkenes, and normalized total CHCs differed between sexes and populations. We combined this data with whole genome re-sequencing data to examine the genetic underpinnings of these differences. We identified 11 genes related to CHC synthesis and found population level outlier SNPs in 5 that are concordant with phenotypic differences. Together these results reveal that the CHC composition of C. frigida is dynamic, strongly affected by the larval environment, and likely under natural and sexual selection.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Phelan V.

Elucidating the Chemical Dialogue of Microbes

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Microbial natural products continue to have a profound impact on human health. While environmental natural products are widely utilized in medicine, structurally related metabolites are an integral component of the communication system within human microbiome communities. These chemical signals act as directives to neighboring microbes, which influence how the microbiome community responds to environmental changes. The human microbiome is composed of diverse and biosynthetically rich microbial ecosystems with a combined genetic capacity that exceeds the number of human genes 100-fold. Recent sequencing data suggests that the genes of the microbiota harbor an understudied repertoire of natural products and other metabolites. We aim to understand the ecological roles of natural products in microbiome communities, specifically between members of the cystic fibrosis pulmonary microbiota and to elucidate their functional roles in community dynamics. To do this, we develop and apply modern mass spectrometry-based tools such as imaging mass spectrometry (IMS) and molecular networking for metabolomics analysis of microbe-microbe, microbe-host, and microbe-environment interactions to generate biological hypotheses that are further evaluated with traditional and emerging chemical, molecular, and biochemical approaches.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Pirk C., Laing C., Crewe R., Yusuf A.

Pheromonal competition between Apis mellifera capensis pseudo-clones and Apis mellifera scutellata under natural field conditions.

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Pheromones of workers and queens in honey bee colonies mediate the social interactions, including conflicts over reproduction. Workers of Apis mellifera capensis are able to escape the suppressive effects of a queen's mandibular gland pheromones and regulary become reproductive dominante in colonies of other subspecies. A. m. capensis workers can rapidly activate their ovaries and have a pheromonal head-start in producing a queen-like mandibular gland bouquet. Short-sighted selection resulted in a particular successful lineage of social parasitic A. m. capensis workers in the northern parts of South Africa. The pseudo-clonal is an ideal model to test the effect of competitive interactions on reproductive development since genetic variation is nearly absent. We compared the mandibular gland pheromonal bouquet and ovarian activation stage of the social parasites and their host workers of the neighbouring subspecies, A. m. scutellata. As expected the mandibular secretions of the parasitic workers were dominated by 9-keto-2-(E)-decenoic acid, while those of the host workers were dominated by 10-hydroxy-2-(E)-decenoic acid. However, the mandibular secretions of the host workers were also more queen-like, indicating that they were competing with parasitic workers for pheromonal dominance. The variation in the pheromonal signal and ovarian activation among the social parasites indicates several factors have to come together to be successful in gaining reproductive dominance.

Themed Session: Chemical Communication of Social Insect Associates: Espionage, Weaponry and Stealth

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Plettner E., Terrado M., Pinnelli G.,

Gypsy moth pheromone-binding proteins: molecular interactions and kinetics relevant to enantiomer discrimination

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Insects have a selective and sensitive sense of smell that is involved in key stages of their life cycles. The gypsy moth, Lymantria dispar, has a chiral pheromone, the hydrocarbon epoxide 2-methyl-(7R, 8S)-epoxyoctadecane ((+)-disparlure). Recognition of this compound by male moths is highly specific: even a few percent of the opposite enantiomer ((-)-disparlure) will cancel male upwind flight behavior. The sensor for these pheromone compounds is on the antennae, in hollow sensory hairs, which are innervated with the dendrite from an olfactory neuron which is surrounded by sensory lymph. The lymph contains pheromone-binding protein (PBP), the first species-specific gene product to selectively interact with the pheromone. The sensor on the dendritic membrane consists of a pair of transmembrane proteins, the odorant receptor with its co-receptor. The gypsy moth has two PBPs: PBP1 and PBP2, which differ in sequence, selectivity and kinetic regime of the interaction with pheromone and other ligands. PBPs could serve two roles that are not mutually exclusive: 1) solubilization of the hydrophobic pheromones in the lymph and/or 2) scavenging of excess odorant molecules to prevent sensory saturation. We have studied PBP-ligand partition, PBP-ligand interactions, as well as association and dissociation kinetics with the pheromone and with closely related analogs. We discuss the role PBPs play in molecular recognition in the pheromone detection system of the gypsy moth.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Pohnert G

Bacteria as modulators of phytoplankton dynamics – friend and foe (or innocent bystanders?)

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In marine ecosystems, algae from the phytoplankton are the most dominant primary producers, contributing substantially to aquatic food webs. Algicidal bacteria that can associate to microalgae have the capability to control the proliferation and even to lyse algal cells. But bacteria can also support algal growth resulting in a complex interaction network in the open oceans. We establish co-culturing and field studies that are paired with in-depth metabolomic investigation to unravel the relationship of bacteria and algae in the plankton. With analytical data down to a cellular resolution we are able to address resistance mechanisms in algae. This talk discusses how algal lysis, induced algal resistance against pathogens and mutual substrate utilization contribute to the observed community dynamics in the sea. Novel labeling approaches reveal that algae can switch from a heterotrophic to a mixotrophic lifestyle that allows the exploitation of substrates released during the bacterial lysis of their competitors. The targeted manipulation of natural communities in mesocosms with lytic bacteria points towards an interwoven network of chemical mediators in the open water.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Pringle E. and Mundim F.

Disruption of an aboveground tritrophic mutualism by belowground root-knot nematodes

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Understanding the eco-evolutionary dynamics of symbiotic interactions requires characterizing the mechanisms that underlie pervasive context dependence. Induced chemical responses of plants to herbivory can cross the soil boundary, such that context dependence of aboveground interactions may be driven by unseen interactions belowground. Tritrophic mutualisms among plants, ants, and hemipterans—in which ants are attracted to plants by honeydew-producing hemipterans and proceed to defend plants against other natural enemies—may commonly be influenced by root-knot nematodes because nematodes and hemipterans compete for the same plant sinks on opposite sides of the soil boundary. We tested how root-knot nematodes influenced an aboveground ant-aphid-plant interaction and found dramatic changes in the aphid-tending behaviors of ants that were related to induced changes in the chemistry of plants and aphid honeydew. Specifically, nematodes decreased aboveground soluble protein and the concentrations of UV-absorbing secondary compounds, including flavonoids and cardenolides. These chemical changes were strong enough for aphid-tending ants to switch their preference for aphids from those feeding on leaves in the absence of nematodes to those feeding on stems in the presence of nematodes. Given ants' pervasive role as ecosystem engineers, these effects could be strong enough for belowground nematodes to structure aboveground plant-animal communities.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

ISCE 2019 Annual Meeting
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Oral Presentations

Quinn R.[1] and Melnik A.[2], Raffatellu M.[3], Huttenhower C.[4], Mazmanian S.[5], Knight R.[6,7], Dorrestein[2]

Global Chemical Impacts of the Microbiome Include Novel Conjugated Bile Acids that Stimulate FXR

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A mosaic of cross-phyla chemical interactions occurs between all metazoans and their microbiomes. These microbial residents in humans are increasingly well characterized, but we have yet to elucidate the breadth of the chemical diversity the microbiome contributes. Here we use untargeted metabolomics and the mass spectrometry database GNPS to assess the global chemical differences between germ-free (GF) and colonized mice (SPF). Of the 7,913 molecules detected across 29 murine organs 14.7% were unique to SPF. Among these unique metabolites were novel conjugated bile acids with the amino acids phenylalanine, tyrosine and leucine. Searching GNPS revealed that these compounds are also present in humans and elevated in those individuals with inflammatory bowel disease (IBD). Furthermore, the Phe and Tyr conjugates strongly agonize the human FXR receptor, which is a global regulator of bile acid metabolism. Agonism of FXR reduces the overall production of bile, thus, synthesis of these molecules in the gut may provide the microbiome a reprieve from the antimicrobial properties of bile. Through 170 years of research on bile acid chemistry, our knowledge of mammalian bile acid conjugation was limited to the amino acids glycine and taurine. Here, we have identified novel conjugated bile acids produced by the microbiome that act as chemical manipulators of our own system of hepatic circulation

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Raguso R.

Unfakeable chemical cues in a mendacious world: introduction to the symposium

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Conflicts of interest in the fitness imperatives of interacting organisms may escalate to actual conflict unless individuals can utilize reliable information to make adaptive decisions. A large body of theory addresses signal honesty and the selective forces shaping signal evolution. Conventional signals are easily learnt in association with quality or reward but may be used deceptively by senders if not constrained to honesty by shared interests with a cooperative receiver (mates, altruists or mutualists). In contrast, index signals are perforce honest because they derive directly from the quality being evaluated (size, vigor, fecundity) or the resource being sought (nutrition, specific metabolites). However, indices may be used as cues, rather than signals, by third party receivers (predators, parasites) that exploit senders. Chemical indices are appealing because of the relative conservatism in the biochemical rules of life. Certain metabolites are so foundational that their information content should be difficult to fake. Our symposium explores the landscape of signal honesty through case studies of chemical indices from intraspecific social interactions (dominance in lemurs, brood assistance in facultatively social bees) to mutualistic (plant-pollinator and fruit-dispersal agent) and antagonistic (host-parasite-vector) relationships across the tree of life.

Themed Session: Chemical Indices of Quality and Health Guiding Foraging, Host- and Mate-Choice

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Ramadhar T.

The Crystalline Sponge Method as a Tool for Small Molecule Structural Elucidation

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While single-crystal X-ray diffraction (SC-XRD) remains one of the most powerful tools for structural elucidation, this technique relies upon obtaining a good crystal. This precludes the analysis of poorly crystallizable compounds, crystals that diffract poorly, amorphous solids, and liquids – all constituting a broad range of chemical space. A recent technique termed the crystalline sponge method offers an innovative way to overcome this limitation. This technique involves soaking target molecules into a crystalline matrix ("crystalline sponge") that is typically a metal-organic framework (MOF), thus allowing for analysis of the target via SC-XRD. In this talk, an introduction to the crystalline sponge method will be given and its utility for full structural determination of synthetic compounds and natural products, including relative and absolute stereochemistry, will be discussed.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Rering C.[1], Vannette R.[2], Schaeffer R.[2,3], Beck J.[1]

Nectar microbial mixtures differ from single species in volatile profiles and attraction to pollinators

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Many organisms use volatile cues to locate and assess the quality of their food and microbes may contribute to these signals. For pollinators, colonization of nectar by microbes can contribute to floral scent and influence foraging. Nectar microbe metabolism has been evaluated in single cultures, but effects of microbial consortia and subsequent impacts on pollinator acceptance of nectars is not known. Understanding pollinator response to microbial mixtures is essential because it reflects natural systems, where nectar typically hosts several thriving species. Two nectar microbes, the yeast Metschnikowia reukaufii and the bacteria Asaia astilbes were inoculated individually and together at equal cell densities. Because nectar sugar levels differentially affect microbial growth, we assessed growth and volatile production in two synthetic nectars of differing sugar content over 48h. To evaluate pollinator response, the inoculated nectars were deployed in a honey bee feeder assay.In all cases, introduced species survived and microbe solutions could be distinguished based on volatiles. Emission in co-inoculated nectar was greater than anticipated based on emission of single-inoculations and corresponding cell counts. Unique chemicals that could not be attributed to emission in single strain solutions were not detected in co-inoculations. Honey bees exhibited preferences among microbial solutions, consuming more of Asaia compared to M. reukaufii or the mixture.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Rigby K., Selander E., Lindström J., Grebner W.

Signals in the sea

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In aquatic environments chemical cues are essential for communication, especially when lacking a good set of ears and eyes. Unicellular marine phytoplankton have to rely on chemical signals in the free water masses in order to evade predation. In this talk I will explore the plasticity of phytoplankton communities and their defensive traits in response to copepodamides. Copepodamides are a group of unique lipid compounds, produced by copepods which are the phytoplankton's most abundant predator. We investigated the functional response to copepodamides by measuring bioluminescence in two species of dinoflagellates and chain length in 5 diatoms. We found that these phylogenetic distant species will up-regulate their respective defensive traits, even in the absence of a physical predator. Thereby suggesting that copepodamides function as a general alarm signal across taxa.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Robert C.

Discovering infochemical pathways shaping belowground tritrophic interactions

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Tritrophic interactions are important determinants of ecological processes. Yet, the involved info-chemical pathways remain overlooked. By combining multi-disciplinary approaches, we aimed at investigating the chemical pathways shaping the interactions between maize, the root herbivore Diabrotica virgifera and its natural enemies, entomopathogenic nematodes. Behavioral assays coupled with analytical chemistry highlighted that the specialist herbivore preferentially feeds on roots containing higher concentrations of benzoxazinoids (BXs). Using bioactivity-guided genetic pathway fractionation and complementation experiments, we found that feeding preference and performance of WCR larvae were associated with a complex made of an O–methylated, N-hydroxylated BX and iron. Untargeted metabolomics allowed us to follow BX processing in the larvae and revealed that the herbivore can specifically detoxify and accumulate MBOA-Glc and HDMBOA-Glc. Transcriptomic analyses and RNA interference-mediated silencing are in progress to identify genes involved in these processes. Behavioral and performance experiments demonstrated that MBOA-Glc acts as a repellent for the herbivore enemies, while HDMBOA-Glc reduce their growth and infectivity. Yet, further biochemical assays using infected herbivore larvae indicated that nematodes can also modulate their hosts' physiology. Understanding the chemistry of trophic interactions will provide with valuable knowledge about ecosystem functioning.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
June 2- 6, 2019
Oral Presentations
Rodriguez-Saona C.[1], Salamanca J.[2], Urbaneja-Bernat P.[1]

Manipulation of natural enemies via plant volatiles to increase ecosystem function and services

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In the past two decades, an increasing number of field studies have shown attraction of natural enemies to lures baited with synthetic plant volatiles. In general, these studies have found that natural enemy foraging behavior, in particular predators, can be manipulated in agro-ecosystems. However, whether this attraction leads to reduced pest populations, reduces crop damage, or increases crop yield remains unclear. In our study, we used methyl salicylate (MeSA), as bait to attract natural enemies, to test the hypothesis that plant volatiles (i.e., attract component), alone or in combination with companion plants (i.e., reward component), reduce pest populations and increase the crop's yield. Our results on common bean (Phaseolus vulgaris) under field conditions, showed that lady beetles, predaceous stink bugs, and syrphids are attracted to MeSA and coriander, either alone or in combination. MeSA also reduced mite populations in combination with coriander and interacted with coriander to reduce crop damage but had no effect on crop size or yield. In conclusion, our study is one of the few studies to show that manipulation of natural enemies by combining plant volatiles and companion plants in an 'attract-and-reward' approach could reduce pest populations and damage in an agricultural crop. The implications of our results on the efficacy of tactics to conserve natural enemies in agro-ecosystems, such as the 'attract-and-reward' approach, are discussed.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Roggatz C.[1], Benoit D.[2], Hardege J.[3]

More acidic = more toxic? Effects of future ocean conditions on biotoxins, signalling cues and their functioning

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Anthropogenic emissions contribute to a significant decrease of ocean pH accompanied by a rise in global temperatures over the course of this century. Although the pH and temperature sensitivity of chemical compounds with specific groups is a well-established fact for chemists, the impact of climate change on molecules mediating essential biological interactions is still poorly understood. Here we identify a range of signaling molecules involved in biological interactions that are vulnerable to pH change and show how even small changes of pH can affect their structure, conformation, charge distribution and hence function. Using a specifically developed set of computational methods validated by experimental data, we illustrate how peptide cues involved in brood care and larval release of crustaceans change significantly in their conformation and charge distribution upon protonation. Behavioural assays with these cues in different pH conditions indicate a significant loss of their signalling function corresponding to the molecular effects observed. For amino acid-based larval settlement cues, we found similar molecular changes and evidence of modified dynamics of the molecule in solution. Finally, we illustrate that future ocean conditions will lead to a more toxic ocean by increasing the abundance of the protonated forms of the two neurotoxins, saxitoxin (STX) and tetrodotoxin (TTX), which play a role in harmful algal blooms, serve as predator defense and pheromones.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
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Oral Presentations

Saha M.[1,2,3], Guan C.[1], Brakel J.[1,4], Jakobsson Thor S.[5], Weinberger F.[1]

Chemical defense of macrophytes under global change

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Marine macrophytes, the dominant primary producers in marine ecosystems are currently under the threat of rapid global change. Climate change can not only alter the physiology but can potentially impact chemically mediated interactions by altering the production of chemical cues. These macrophytes intimately interact with their microbes – a relationship that is vastly mediated by the chemistry of the algal holobiont. Biofilms, composed mainly of bacteria, are omnipresent on the surface of macrophytes. Intense colonisation can be potentially detrimental influencing fitness of the macrophyte host. However, many macroalgae like the brown alga Fucus vesiculosus are known to chemically modify such bacterial colonisation via the use of polar and non-polar surface associated defense chemicals. We found that production of such defense chemicals can be modified under the influence of low light and ocean warming. In an additional study, we investigated the impact of extreme events on chemical defense of Fucus and the eelgrass Zostera marina. While Fucus and Zostera defense chemistry underwent fluctuations under climate change stressors, we found that defense control capacity can undergo rapid adaptation during the global process of biological invasion for the red alga Agarophyton vermiculophylla. These results provided the first evidence that confrontation by new bacterial colonisers can trigger a rapid defense adaptation of aquatic weeds, which could be necessary for algal invasiveness

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Salazar Amoretti D.

Chemical Diversity: using metabolomics to study ecological processes across multiple scales.

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Plant secondary chemistry plays an important role in modulating species interactions. Still, plant chemical diversity remains an understudied component of the biological complexity. Recent advances in metabolomics have allowed exploring this dimension of diversity across spatial and biological scales. Nevertheless, little is known about how plant chemical diversity could influence biological systems across geographical scales. Here we propose multiple mechanisms by which plant chemical diversity could help forge patterns of rarity and commonness across Amazonian tree species. We also use a combination of field surveys and metabolomic approaches to assess the relationship between plant chemistry, species herbivore load, and plant abundance. Despite the large geographical distance, we found a very high consistency in species chemical composition across our sites. Contrastingly, we found almost 100% turnover in herbivore species composition between sites. Finally, we found strong associations between the local plant chemistry, local herbivore diversity, and regional species abundances. These results suggest that plants species with a high diversity of secondary metabolites could not only have a higher chance of expanding their geographical range but also have a strong competitive advantage at the local scale. In concert, our results suggest that plant chemistry, as well as plant-enemy interactions, might play an important role in the distribution and abundance of tropical plants.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Salem S.

Microbial mediation of folivory

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Symbiosis, the long-term living together of unlike organisms, is cited as a major source of evolutionary innovation. The symbioses insects form with microbes constitute some of the most elaborate and streamlined partnerships observed in nature, endowing a multitude of functions that range from the provisioning of essential nutrients, to mate recognition, to antibiotic defense against parasites and pathogens. I aim to outline the microbial diversity associated with beetles and their functional importance, specifically focusing on the central role symbionts play in the evolution of herbivory across the most diverse animal order. Using leaf beetles as a model, my talk will detail a series of adaptations evolved by these insects to house and transmit highly specialized bacterial symbionts, and discuss the physiological and evolutionary implications of engaging with a single clade of microbes for an upward of 35 million years. Leveraging data from genomic sequencing, microscopy and field experiments, I will address (i) the metabolic currencies governing beetle-microbe interactions, and (ii) how variation in these factors drastically shapes the host's nutritional ecology and evolution. The concluding theme to my talk concerns the question of how long-term symbioses with beneficial microbes impact the selective pressures for animals to maintain essential gene sets and the perils associated with outsourcing said functions to an obligate symbiont.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Sanchez S.[1], Condren A.[1], Kahl L.[2], Banzhaf M.[3], Dietrich L.[2]

Evaluation of a biofilm inhibitor using imaging mass spectrometry

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Biofilm inhibition by exogenous molecules has been an attractive target for the development of novel therapeutic due to the substantial nuisance biofilms play in antibiotic resistance. Currently there are no biofilm inhibitors on the US market but previous studies have shown that taurine-conjugated bile acids have biofilm inhibition activity in vitro. However, the mechanism of action of these acids is still unknown. We hypothesize that the presence of taurine-conjugated bile acids induces susceptible bacteria to alter their specialized metabolism, leading to the observed bioactivity. Thus, we have investigated the impacts of taurolithocholic acid (TLCA) on the clinically relevant pathogen, Pseudomonas aeruginosa strain PA14, to gain a deeper understanding of the mechanism of action and biochemical effects of TLCA. To characterize the effect of TLCA on P. aeruginosa biofilms, we used a colony morphology assay where PA14 colonies were grown on solid agar, employing tools such as LC-MS/MS and imaging mass spectrometry (IMS), and performed an in vivo virulence assay with the Galleria mellonella infection model to determine the virulence state of P. aeruginosa infecting larvae with TLCA dispersed P. aeruginosa cells and monitoring survival over 24 hours. Using our investigation with PA14 as a proof of principle for our techniques and as support for our hypothesis, we plan to investigate the same relationship with Vibrio cholerae in axenic and in vivo models.

Themed Session: Secondary Metabolites and other small Molecules as the Language in Microbiome Interactions

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Sanchez-Arcos C. and Pohnert G.

Tracing metabolites through the Earth's Critical Zone

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The Earth's Critical Zone (CZ) is the global upper surface layer that extends from the vegetation canopy to the seepage and stored groundwater. It is defined as a critical zone because all complex interactions among rocks, soil, water, air, and living organism take place there and provide life with sustainable resources. Our primary goal is to establish chemical markers to elucidate biogeochemical processes by comparing the metabolic dynamics in the CZ under different surface environmental conditions, microbial communities, and local geology. We have been using non-targeted and targeted mass spectrometry-based metabolomic approaches to detect, quantify, and identify the chemical diversity in the CZ located in the Hainich national park in Germany. Our results suggest that molecules derived from plant glycosides could be used as markers for the CZ under low human activity (Forest). Under the same conditions, we also found that predominant plant species in the surface can determine input signal types detected in groundwater, with significant metabolic changes over time due to heavy rain events. Under strong agricultural activity, our results indicated that molecules used as herbicides could be potential groundwater biomarkers in these areas. The determination of marker compounds will allow us to identify key players responsible for distinctive metabolic transformations, understand their benefits, and collect insights into how growing human activities influence the critical zone.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Schirrmacher P.[1], Roggatz C.[1,2], Hardege J.[1], Benoit D.[3]

Ocean acidification amplifies a predator related cue

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The pH of the earth's surface waters is decreasing due to a constant uptake of atmospheric CO2. Such ocean acidification rapidly changes the chemical marine environment and is of highest concern for chemical-ecological processes. To study the effects of ocean acidification on stress related chemical communication, we chose to work with 2-Phenylethylamine (PEA), a dietary predator odor detected in most mammalian urine. In aquatic systems, sea lampreys are known to avoid the smell. Although PEA has been suggested for pest control of sea lampreys, little is known about its role in aquatic environments. Here we show instead that PEA attracts hermit crabs (Pagurus bernhardus), indicating it could also function as a feeding cue. However, decreasing pH levels increases the interest of hermit crabs in the cue. To understand these observations on a molecular level, we used a range of quantum chemical methods to model PEA in different pH conditions. It is known that protonation through pH shifts relevant for climate change scenarios can change the structure and function of signaling cues, resulting in an altered olfactory perception and behavioral response. Using different solvation models, we identify differences between the two protonation states and validate our models through NMR spectroscopy. Conformational differences can partly explain our biological observations. This highlights the urgent need for more research into the susceptibility of signalling cues to climate change.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Schleyer G.[1], Shahaf N.[1,], Dong Y.[1], Aharoni A.[1], Piel J.[2], Vardi A.[1]

Visualising the metabolic cross-talk between a bloom-forming alga and its virus

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Tapping into the metabolic cross-talk between a host and its virus can reveal unique strategies employed during infection. Viral infection is a dynamic process that generates an evolving metabolic landscape. Gaining a continuous view into this process is highly challenging and is limited by current metabolomics approaches, which typically measure the average of the entire population at various stages of infection. An important ecological host-virus model system is the cosmopolitan alga Emiliania huxleyi and its specific virus, E. huxleyi Virus. In the present study, we took a novel approach to study the metabolic basis of host-virus interactions by combining a classical method in virology, plaque assay, with advanced mass spectrometry imaging (MSI), an approach we coined "in plaque-MSI". Taking advantage of the spatial characteristics of the plaque, we mapped the metabolic landscape induced during infection in a high spatiotemporal resolution, unfolding the infection process in a continuous manner. Further unsupervised spatially-aware clustering, combined with known lipid biomarkers, revealed a systematic metabolic shift during infection towards lipids containing the odd-chain fatty acid pentadecanoic acid (C15:0), as well as a reduction in a potentially new class of lipids. Applying 'in plaque-MSI' might facilitate the discovery of bioactive compounds that mediate the chemical arms race of host-virus interactions in diverse model systems. ref:Schleyer, G., Nat Microbiol 2019

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Schmidt R.[1]and Ulanova D.[2]

Microbial chemical interactions in terrestrial and aquatic ecosystems

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Microorganisms are the driving force of chemical interactions within and between organisms across terrestrial and aquatic ecosystems. These interactions range from signaling for communication to interference competition within microbial community and/or higher organisms. Up till now, many studies have focused on aboveground interactions between plants, insects and microbes. Only recently it is being recognized that belowground interactions are also tightly interlinked with interactions aboveground and vice versa. Similarly, chemical interactions are taking place in aquatic environment, i.e. interactions between free-living microorganisms in water and sediments and microbial symbiont-mediated chemical defenses of aquatic organisms. These chemical interactions are mediated by signaling compounds, that can be both volatile and water-soluble and bridge short and long distances. These compounds in most cases belong to so called specialized metabolites, i.e. terpenes. The new frontier in the field of microbial chemical ecology aims to understand mechanisms of how microbial specialized metabolites shapes interactions with their host and within microbial communities. Within this talk, we aim to highlight the importance of moving towards a more holistic picture by addressing at the host and its microbiome (holobiont), and free-living microbial communities across terrestrial and aquatic systems.

Themed Session: Microbe-Driven Chemical Communication Across Ecosystems and Hosts

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Schmidt E.

Biosynthesis of offensive and defensive chemicals in mollusks

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Marine animals contain many chemically unique metabolites that are likely used for chemical defense or for predation. Symbiotic bacteria synthesize many of the compounds. The bacteria are taxonomically diverse, they occupy a range of ecological niches, and they span the range from readily cultivable to obligately intracellular. What they share in common is that the compounds that they produce are highly correlated with the animal species that contain them, indicating a biological requirement for those compounds in nature. In addition to bacterially produced chemicals, the animals themselves make many offensive and defensive compounds. Here, we will focus on the compounds of phylum Mollusca and recent advances on their biosynthesis.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Sculfort O.[1,2], Elias M.[1], Nay B.[3], Llaurens V.[1]

Evolution of Chemical Defenses in Mimetic Heliconiini Butterfly Communities

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Heliconiini butterflies are chemically defended and display striking colors perceived as a warning signal by predators. Distantly-related species share similar color pattern within locality because of convergent evolution generated by predator learning behavior. Although chemical defenses play a key role in this convergent evolution, little is known about the toxicity evolution. These butterflies contain cyanogenic glucoside toxins either, neosynthesized and/or sequestered from plants during larval stage. Caterpillars exclusively feed on Passiflora leaves where more than 30 different cyanogenic glucosides have been reported. Molecular networking and LC-MS/MS was performed to identify and quantify toxins on wild caught 377 individuals from 32 Heliconiini species. Using the well-resolved phylogeny of Heliconiini, we uncover the toxicity evolutionary history by estimating ancestral states for each toxin and test for the effect of ecological factors such as mimetic interactions among species and host-plant specialization using phylogenetically-corrected ANOVAs. Chemical analyses revealed important variations across Heliconiini species, pointing at strong toxin diversification within the most species-rich genus: Heliconius. Moreover, butterfly species involved in the same mimicry ring contains different toxins in various concentrations and metabolic origins. Mimetic interactions and predation pressure are the main drivers of variations in chemical profile across Heliconiini.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
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Oral Presentations

Selander E.[1], Andersson M.[2], Rigby K.[1], Linström J.[1], Prevett A.[1], Grebner W.[1]

Copepodamides drive large scale trait mediated effects in the ocean

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Fear of predation may influence food webs more than actual predation. However, the mechanisms and magnitude of nonconsumptive predator effects are largely unknown in unicellular-dominated food webs such as marine plankton. We report a general mechanism of chemically induced predator effects in marine plankton. Copepods, the most abundant zooplankton in the oceans, imprint seawater with unique polar lipids—copepodamides—which trigger toxin production, bioluminescence, colony size decrease, as well as behavioral responses in a variety of marine phytoplankton. A 1-year study in the northeast Atlantic reveal that natural copepodamide concentrations are high enough to induce defensive traits in dominant primary producers when copepods are abundant. Finally we expose intact communities to direct grazing by copepods, or copepodamides without copepods, and show that the structuring effect of copepods can partly be reproduced by copepodamides alone. We conclude that copepodamides will structure marine plankton toward smaller, more defended life forms on basin-wide scales in the ocean.

Themed Session: The Chemical Ecology of Stress, Warning Signs and Fear

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Silva M.[1], Amaral J.[1], Ferreira A.[1], Lopes A.[2], Pereira S.[2]

Biosynthesis of the pyranocoumarins in Citrus sinensis and C. limonia: production of new bactericides for citrus protection and with lower risks for the environment.

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Seeds of C. sinensis (sweet orange), and of C. limonia (lime) were inoculated in gel MS medium supplemented with glucose, and when germination seedlings were around 12.0 cm in length the investigations were initially focused on confirming the homogeneity of the plantlets using RAPD and compared with that of the mother plants. All banding profiles from germinated plantlets were similar to those of the mother plant, confirming the clonal fidelity of the in vitro plantlets obtained. In roots analysis by HPLC-UV two chromatographic bands, the highest content among others, were identified as xanthyletin (1) and seselin (2), thus both were quantified. The total content of both coumarins was observed at a higher concentration in C. sinensis plantlet defined as Cs 144 and that from C. limonia coded as Cl 214. These were selected for in vitro multiplication and subsequent isotopic labeling experiments using 1-13C-D-glucose. After sixty days the seedlings were analyzed by HPLC-UV-SPE-NMR and the 13C enrichment patterns of xanthyletin and seselin indicated that the pyran ring was formed by methylerythritol phosphate pathway, and coumarin moiety was derived from the shikimate pathway in both compounds. Xylella fastidiosa causes citrus variegated chlorosis (CVC) in orange. We evaluated the effect of this bacterium on the variation of the chemical profile in Citrus plants, and prenylated coumarins were found at a higher concentration in those with CVC symptoms than those without symptoms.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Smith A.

Diversification and conservation of social signals in the cuticular hydrocarbon profile of Odontomachus ants

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The cuticular hydrocarbon (CHC) profile of eusocial hymenopterans can be the source of nestmate, fertility, and sex-based signals. How these are generated within a profile and how these signals evolve across species are largely open questions. Here, I synthesize research on CHC variation and signaling in several species of Odontomachus trap-jaw ants from the Southeastern United States. Intraspecific profile variation is extraordinarily high for native species, while introduced species lack CHC profile variation across populations. Despite intraspecific CHC profile variation, fertility-signaling compounds are conserved in their function within species. Across species, compounds and even classes of compounds that seem to be responsible for fertility signaling vary. However, compounds that differentiate males and females are more conserved across species. Finally, I report on the ant species, Formica archboldi, which has a unique predatory relationship with Odontomachus ants. This species replicates CHC profiles of the two native Odontomachus species it occurs with. Surprisingly, it replicates the intraspecific population variation in CHC profiles of Odontomachus brunneus. The CHC profile of Odontomachus and its associated species provides an especially informative example of CHC profile variation and how these chemical signals can evolve within and across species.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
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Oral Presentations

Sneed J.[1], Campbell J.[2], Looby A.[1], Paul V.[1]

Coral larvae maintain settlement preferences in the face of climate change

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Coral reefs are diminishing worldwide. Recruitment of new individuals to degraded reefs is critical for natural recovery and is impacted by many factors including the composition of the benthic community which larvae detect via chemoreception. Many coral species are attracted to and settle preferentially on some crustose coralline algae (CCA) (e.g. Hydrolithon boergesenii) over others (e.g. Paragoniolithon solubile). As seawater temperatures increase and pH levels decrease (ocean acidification) as a result of climate change, this interaction may be compromised. Calcifying organisms like CCA are particularly susceptible to negative impacts by ocean acidification. Here we examined the potential impacts of increased seawater temperature and decreased pH on the settlement preferences of two coral species, Acropora palmata and Porites astreoides. We also examined the potential impacts of these seawater conditions on the growth of preferred and non-preferred CCA species. A. palmata demonstrated a preference for H. boergesenii over P. solubile in choice experiments and this preference was not impacted by changes in seawater conditions. P. astreoides did not demonstrate a preference under any conditions. Increased seawater temperature and decreased pH significantly reduced calcification in P. solubile but not H. boergesenii indicating that future changes in seawater conditions may allow the preferred settlement substrate, H. boergesenii, to become relatively more abundant on reefs.

Themed Session: Anthropogenic Impacts on Chemical Cues, Signals and Chemoreception

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Song B., Zhang H., Mittal N.

Finding solutions from the wild --- Elevated phenolic acids contribute to broad-spectrum resistance to soybean cyst nematode in wild soybean

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Soybean cyst nematode (Heterodera glycine, SCN) is the most devastating soybean pest that causes high losses in soybean production worldwide. SCN race shift uncertainties and lack of diverse resistant varieties represent two of the biggest challenges for SCN management. To meet these challenges, we identified a novel wild soybean genotype (Glycine soja), S54, showing broad-spectrum resistance to two SCN types (HG2.5.7 and HG1.2.5.7) and elucidated the underlying resistance mechanism by integrating transcriptome and metabolome responses to infection by the two races. This global analysis identified a core set of differentially expressed genes and metabolites, including Ca2+- and salicylic acid (SA)-related signaling genes and phenolic compounds, that commonly responded to the two races. Candidate enzyme-encoding genes involved in phenolic biosynthesis were identified. This study shows that positive regulation of Ca2+-SA signaling pathways and enhanced phenolic biosynthesis might play important roles in the broad-spectrum resistance to SCN in S54.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Speck F.[1], Pohnert G.[1], Vyverman W.[2], Audoor S.[2]

Pheromone signaling in pennate diatoms to preserve the food webs' base

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Diatoms are a diverse group of photosynthetic microalgae which live in marine, fresh water and soil ecosystems. They play an important role in aquatic food webs and contribute substantially to biofilm formation. The communication of bacteria within these biofilms is well studied, but the signaling essential for the survival of single-celled diatoms is largely unknown. Diatoms possess a unique life cycle, including a sexual phase initiated when cells have become small after repeated mitotic divisions (Chepurnov et al., 2002). Recently, we discovered a two-step pheromone system in Seminavis robusta which is activated during sexual reproduction and involves a cell cycle arrest to increase mating efficiency (Gillard et al., 2013). Here we address the question whether this strategy is conserved among pennate diatoms and include chemically similar pheromones. Sexual reproduction in Cylindrotheca closterium, a benthic living marine diatom, shows similarities to the reproductive behavior in S. robusta (Vanormelingen et al., 2013). We could establish that temporary cell cycle regulation also occurs during mating in this species. By applying a non-targeted mass spectrometry-based metabolomic approach, we further provide evidence for the existence of pheromones in C. closterium mating. We successfully characterized pheromone functions in bioassays. Our results form the basis for further characterization of these signaling compounds and to what extend they are conserved among diatoms.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Stanton M. and Kato M.

Specificity of herbivore-induced volatile emissions in Piper species

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Plants in the genus Piper make up a large proportion of the understory of tropical forests and are known for their diverse secondary chemistry. Despite previous studies relating Piper secondary chemistry diversity to herbivore diversity and increased parasitism rates, little is known of the role of Piper volatile organic compounds (VOCs) in mediating ecological interactions with higher trophic levels. Here we investigate the role of Piper VOCs in host plant selection by the specialist moth genus Eois (Lepidoptera: Geometridae). Field sampling showed that herbivory by Eois sp caterpillars increases VOC release by Piper species compared to undamaged controls. In a common garden experiment with Piper crassinervium, herbivory by the specialist Eois olivaceae led to the highest amount of VOC release compared to plants treated with herbivory by the generalist herbivore, Spodoptera frugiperda (Lepidoptera: Noctuidae), mechanical damage with a pattern wheel, and undamaged controls. The principal components analysis of the VOC profiles shows that the VOC blends, released by P. crassinervium changes with each of these treatments. Additionally, field sampling of P. arboreum growing in SE Brazil with herbivory by three naturally occurring Lepidopteran caterpillars also showed a release of specific VOC blends in response to each herbivore.Ongoing GC-EAD and behavioural assays are being carried out to analyse the role of these VOCs in host plant choice by Eois sp adults. (Funding: FAPESP)

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Sullivan B.

Distinct spatial and temporal dynamics of response by a bark beetle to different components of its aggregation pheromone

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Components of multi-component, attractive insect pheromones typically must be released from the same location to achieve maximum activity, and both spatial and temporal separation of component release (which have similarities in their effect on plume interactions) can reduce or eliminate activity. However, with the aggressive tree-killing bark beetle, Dendroctonus frontalis, release points of the two major components of the aggregation pheromone (a weak attractant and a potent synergist, produced by females and males, respectively) can be separated by many meters without loss of attractive synergism. Furthermore, sequential release of these two components (alternated at intervals half of a minute) from the same release point does not appear to reduce beetle response. The implication is that plumes of the two pheromone components do not need to be congruent to elicit attraction and mediate orientation of beetles to trees where attacks are being initiated by conspecifics. Additionally, the two components apparently differ in their spatial and temporal dynamics regarding their influence on beetle behavior, and thus they presumably play distinct roles in governing beetle location of suitable hosts. I will discuss the ecological significance of this phenomenon in the context of host interactions of this and other species of bark beetle, as well as the phenomenon's relevance to beetle epidemiology and development of semiochemical management tools.

Themed Session: The Chemical Ecology of Host and Mate Selection

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Sun Q.[1], Hampton J.[2], Haynes K.[2], Zhou X.[2]

Cooperative policing behavior regulates reproductive division of labor in a termite

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Reproductive conflicts are common in societies where helping castes retain reproductive potential. One of the mechanisms regulating such conflicts is policing, a coercive behavior that directly reduces the reproductive output by other individuals. In eusocial hymenopterans, workers or the queen act aggressively toward fertile workers, or destroy their eggs. In many termite species, workers or nymphs can differentiate into neotenic reproductives after the death of king or queen. Competitions among neotenics are inevitable, and how these conflicts are resolved remains unclear. Here, we document a policing behavior initiated by neotenics that regulates reproductive division of labor in the eastern subterranean termite, Reticulitermes flavipes. Our results demonstrated that the policing behavior is carried out sequentially and cooperatively by neotenics and workers. A neotenic reproductive initiates the attack of the fellow neotenic by biting. Workers then cannibalize the injured neotenic after being recruited by an alarm signal produced by the attacker. Furthermore, the initiation of policing is age-dependent, with older reproductives attacking younger ones, thereby inheriting the breeding position. The cuticular hydrocarbon profile shifts when workers differentiate into neotenics, and as the neotenics age. This behavior represents an important mechanism regulating reproductive succession, which may be widespread in termites.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Tavera M.[1,2], Ormenita L.[1,3], Almarinez B.[1,3], Amalin D.[1,3], Janairo G.[1,2], Janairo J.[1,3]

Potential of semiochemicals in the control of cacao mirid bug, Helopeltis bakeri, in the Phlippines

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The industry of cacao is a rising market worldwide and the Philippines aims to capitalize this opportunity. However, local production is threatened by pest infestations that affects the normal yield and quality produced by farmers. The insect Helopeltis bakeri Poppius, or cacao mirid bug is a major pest of cacao in the Philippines wherein it feeds on cacao pods for growth and development. Effective and environment friendly pest management techniques are needed to control and manage their growing population. One control method is the use of semiochemicals. In this study, the volatile chemical profiles of the feeding hosts of the cacao mirid bug were obtained using solid phase microextraction coupled with gas chromatrography – mass spectrometry. Two different types of SPME fibers, 100 um Polydimethylsiloxane and 50/30um CAR/PDMS/DVB fibers were used and optimized to collect the kairomones. From the profiles, a common bicyclic sesquiterpene compound was observed. Preliminary olfactory analysis using lab reared CMB confirmed positive attraction towards the identified compound eliciting 50-90% attraction with an effective concentration of 4-23 microgram per cubic centimeter. Additionally, the mating behavior of the CMB showed that a female 96 hours after molting is considered to be sexually mature and ready for copulation. The suspected sex pheromone, alpha-pinene, was detected in the female abdomen. Bioassay of alpha-pinene would be assessed for the attraction of the male CMB.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

ISCE 2019 Annual Meeting
Atlanta, GA
June 2- 6, 2019
Oral Presentations

Terrado M.[1], Okon M.[2], McIntosh L.[2], Plettner E.[1]

Structural and Functional Studies of Gypsy Moth Lymantria dispar Pheromone-binding Proteins

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Pheromone-binding proteins (PBPs) are small (~16 kDa), water-soluble proteins found predominantly in the sensory hairs of male antennae. These proteins bind the hydrophobic pheromones, causing them to move within the lymph fluid to the pheromone receptors of olfactory neurons. Binding assays have shown that gypsy moth LdisPBP1 can discriminate the pheromone enantiomers, (+)-disparlure ((7R, 8S)-2-methyl-7,8-epoxioctadecane) and (-)-disparlure. Interestingly, (+)-disparlure is the sole pheromone released by female gypsy moths to attract the males. In contrast, (-)-disparlure is released from another related species, the nun moth, to deter male gypsy moth flight towards this species. To understand the structural basis of the enantiomer discrimination, the structure of LdisPBP1 has been elucidated using NMR. Subsequent [15N] HSQC-monitored titration experiments using the disparlure enantiomers show differences in the titration profiles. In conjunction with molecular docking studies, the residues involved in distinguishing the two enantiomers are identified. These and other results suggest that PBPs are not just passive pheromone transporters. These proteins may serve as initial molecular filters, capable of discriminating odorants that enter the sensory hairs. Understanding of the structural basis of these interactions will give insight to the role of PBPs in insect pheromone perception.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Thapa H. and Agarwal V.

Discovering genetic basis for production of ozone damaging polybromomethanes

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The atmospheric ozone layer is depleted by volatile halogenated molecules which release halide radicals in the presence of sunlight that then react with ozone. In addition to man-made chlorofluorocarbons, naturally produced polybromomethane molecules such as bromoform also contribute to the degradation of the ozone layer. Oceanic polybromomethanes are the major contributors to bromine flux in the atmosphere and are responsible for 30% of total ozone depletion. Despite the adverse environmental effect of naturally produced oceanic polybromomethanes, their biosynthetic pathway remains to be elucidated. Here we report the discovery of novel polybrominated beta-keto metabolite from the red macroalga Asparagopsis taxiformis. The newly identified hexabrominated beta-keto metabolite is an intermediate involved in the bromoform biosynthetic pathway. Using transcriptome mining approach, we have identified three vanadium-dependent haloperoxidase (VHPO) genes encoding for bromoperoxidase activity with VHPO2 and VHPO3 directly involved in bromoform biosynthesis. Our study provides platform for studying the effects of climate change and ocean acidification on the production of oceanic polybromomethanes.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Tholl D.[1], Lancaster J.[1], Lehner B.[1], Tittiger C.[2], Khrimian A.[3], Weber D.[3]

Do it yourself: De novo biosynthesis of terpene pheromones in stink bugs and beyond

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Insects employ a diverse array of terpene metabolites as pheromones in intraspecific interactions. In most cases insects have been postulated to sequester terpenes produced by host plants or microbial endosymbionts and lack the ability to synthesize terpene pheromones de novo. Our recent studies in stink bugs (Hemiptera: Pentatomidae), however, strongly support the notion that probably many insects are capable of making terpene pheromones from the same core pathway that leads to juvenile hormone biosynthesis. The stink bugs Murgantia histrionica (harlequin bug), Halyomorpha halys (brown marmorated stink bug), and Nezara viridula (southern green stink bug) produce bisabolane-type sesquiterpenoids as sex/aggregation pheromones. Using a functional genomics approach, we have identified enzymes with high similarity to isoprenyl diphosphate synthases in the core terpenoid pathway that convert (E,E)-farnesyl diphosphate to the cyclic sesquiterpene olefin or alcohol precursors of the respective pheromones, murgantiol or (Z)-alpha-bisabolene epoxide. Expression of these insect-specific terpene synthases is highly sex and tissue specific with highest expression occurring in the epidermal cell layer of the abdominal sternites or the fat body. Our studies suggest that an evolutionary emergence of terpene synthase proteins has occurred more broadly among insects.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Traxler M.[1], Pessotti R.[1], Navarro J.[2], Brodie E.[2]

Widespread occurrence of actinomycete secondary metabolism in passalid beetle colonies across the Eastern US

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Bacteria are incredible biochemists, capable of producing molecules with extraordinary functions that range from interspecies communication to all-out chemical warfare. One group of bacteria, the actinomycetes, has been the deepest source of these natural products, and they have the genetic capacity to give us many more. The goals of our work are to understand the ecological drivers of antibiotic biosynthesis by actinomycetes, and to subsequently use this knowledge to accelerate natural products discovery. A key step toward this goal is identifying experimentally tractable, ecological systems that reliably include actinomycetes and their molecules. To this end, we have identified colonies of passalid (bess bug) beetles and the root nodules of legume plants as potential systems for actinomycete chemical ecology. This talk will highlight our recent progress toward understanding the biogeography of secondary metabolism by examining antibiotics/antifungals detected directly in beetle colonies across the eastern United States. Functional synergy between these molecules, the nutrient niches of the producing organisms, and potential benefits of these molecules for the beetles will also be discussed.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Tun K., Minor M., Jones T., Clavijo-McCormick A.

Effect of the giant willow aphid Tuberolachnus salignus on plant-volatile emission and honeydew deposition in different willow clones

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The giant willow aphid (GWA) is an invasive species in New Zealand that feeds on stems of willow and poplar trees. GWA infestation can negatively affect host plants health due to the withdrawal of copious amounts of phloem sap. In addition, honeybees forage on the melezitose-rich honeydew deposited by this aphid, causing the honey to cement. Since GWA is a new invasive species in New Zealand, we have a poor understanding of its host-selection process and of the plants chemical responses to GWA infestation. The aims of our study are to characterize the volatile emissions of fifteen different willow clones and evaluate the changes in volatiles profile in response to GWA attack, and to investigate clone-related differences in the sugar composition of GWA honeydew. Volatiles were collected using a headspace sampling technique and analysed using gas chromatography-mass spectrometry (GC-MS). Twenty compounds were highly abundant in the headspace of all willow clones. Clonal variation was observed mainly in the emission of cycloisosativene, δ-cadinene, α-cubebene, and germacrene D. We also report quantitative changes in volatile emissions in response to GWA attack. Honeydew analysis revealed significant differences in the proportion of melezitose and other sugars in the honeydew of GWA feeding on different willow clones. These results help to understand the interaction of the GWA with its host plants and other organisms, aiding in the selection of willow clones for cultivation.

Themed Session: Application and Manipulation of Plant Volatiles for Crop Protection

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Ugine T.[1], Krasnoff K.[2], Grebenok R.[3], Behmer S.[4], Losey J.[1]

Aphids' micronutrient content induces sterility in male lady beetles

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Lady beetles are globally distributed and known for their ability to regulate populations of aphids. While thought of as strict predators, these beetles also consume non-prey foods like pollen, nectar and fungi.We observed widespread reproductive failures when we reared lady beetles on a diet of pea aphids (Acyrthosiphon pisum) in the absence of plants. We therefore conducted a study in which we reared beetles (Coccinella septempunctata) on a diet of pea aphids in the presence versus absence of fava bean foliage, until they were 7d-old adults. We then mated beetles factorially (sex x diet treatment) and assessed their fitness. There was a profound paternal effect of males' diet on female viability –no females that were mated to non-supplemented males laid viable eggs, and no maternal effect. Extensive nutrient testing identified sterols (e.g. cholesterol) as the limiting nutrient. Dissections of leaf and sterol-supplemented male beetles revealed that supplemented males produced significantly more sperm compared to non-supplemented control males. We also profiled pea aphid sterol content and confirmed that they contain an exceedingly low level of sterol that is orders of magnitude lower than what is reported for other insects. Additionally, we determined that beetles consume plant tissue in a sterol-state dependent manner to redress their sterol deficit, indicating that have evolved a sterol-specific appetite.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Unsicker S.[1], Gershenzon J.[1], Eberl F.[1], Bobadilla M.[1,2], Hammerbacher A.[1,3]

Hidden players: tree-insect interactions are influenced by plant pathogens

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In the last decades, the interaction and co-evolution of plants and insects have been intensively studied. However, numerous other, rather inconspicuous organisms, such as viruses, bacteria or fungi, also colonize plants. Consequently, herbivorous insects not only ingest plant material, but also compounds or tissues of microbial origin at the same time. Despite this complexity, our knowledge of tripartite interactions is rather poor, especially in trees, which are rarely the focus of plant-insect studies. Here, we investigated the influence of a widespread tree pathogen (poplar leaf rust fungus, Melampsora larici-populina) on the interaction of black poplar (Populus nigra) trees with an insect herbivore (gypsy moth, Lymantria dispar). Infection with the biotrophic rust fungus reduced indirect anti-herbivore defense of black poplar through the antagonistic interaction of phytohormones. Upon rust infection, the chemical composition of black poplar leaves and the emitted volatile blend changed, leading to the orientation of gypsy moth caterpillars towards rust-infected foliage. This preference led to an increase in the performance of caterpillars that were reared on rust-infected trees. Mechanisms explaining the behavior and performance of gypsy moth caterpillars involve direct as well as indirect plant-mediated effects of the pathogen on the insect. Our study comprises a basis for further research on plant-herbivore interactions, including plant-inhabiting microbes.

Themed Session: Insect-Microbe Chemical Communication

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Vander Meer R.[1], Chinta S., Jones T.

Tyramide fed fire ant female sexuals undergo physiological changes associated with mating

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Tyramides are derivatives of the biogenic amine tyramine. They have been found in male ants and are transferred to female sexuals during mating. Directly after mating the newly mated alates undergo physiological changes, e.g., wing loss, ovariole development, pheromone production, and wing muscle histolysis. Fire ant male and female sexuals do not mate in the laboratory and artificial insemination has had very limited success. In previous studies we demonstrated that biogenic amine levels in workers could be elevated by feeding the biogenic amine to the workers. Therefore, we feed tyramides dissolved in 10% sucrose solution to fire ant sub-colonies containing workers, brood, and female alates. The tyramide fed female alates precociously lost their wings, developed their ovaries and started queen pheromone production. Thus, ingestion of tyramides by female sexuals mimicked the physiological changes associated with mating.

Themed Session: Language of Cooperation and Conflict: Chemical Communication in Social Insects

Oral Presentation

Presentation Date: Wednesday, June 5th, 2019

Vannette R.[1], Rering C.[2], Beck J.[2], Schaeffer R.[3]

Volatile and nonvolatile metabolites mediate plant-pollinator-microbial interactions at the floral interface

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Plant-pollinator interactions are ancient, diverse and shape the evolution and ecology of plants and pollinators. Bacteria and fungi commonly and abundantly colonize flowers, yet most work on plant-pollinator interactions has neglected their potential effects on floral traits, pollinators, or their interactions. We investigated patterns of microbial occurrence in a coflowering landscape in northern California and characterized microbial effects on nectar chemistry, including volatile composition by common nectar-inhabiting yeasts and bacteria. We assessed pollinator detection of microbial volatiles using electroantennography (EAG) and behavioral responses of Apis mellifera (honey bee) and Bombus impatiens (bumble bee) to microbial volatiles, including volatile and nonvolatile metabolites. Our results demonstrate that bacteria and fungi are common inhabitants of floral nectar, and microbial species produce characteristic metabolites that are detectable by multiple generalist social bee species. Further, honey bees and bumble bees exhibit behavioral responses and preferences for distinct microbial taxa, although bee response to gustatory and scent cues differ. These results imply that variation in microbial colonization can affect floral traits as well as pollinator attraction and foraging.

Themed Session: The Chemical Ecology of Symbiotic Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Vardi A.

The metabolic cross-talk of host-pathogen arms race at sea

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Phytoplankton are unicellular algae that form massive oceanic blooms, covering thousands of square kilometres and responsible for half of the photosynthetic activity on Earth. Microbial interactions that regulate the fate of algal blooms play a profound role in determining nutrient cycling in the ocean and feedback to the atmosphere. Nevertheless, we are still lacking fundamental understanding of the cellular mechanisms and the chemical language that mediate these interactions. We therefore develop model systems in the lab, representing key biotic interaction that are dominant in algal blooms, such as host-virus, host-bacteria, predator-prey and allelopathy. By utilizing the recent advances in the field of chemical ecology, combined with cell biology and genomics approaches, we aim to understand the role of chemical signals (infochemicals) and reveal their function in mediating cell-cell interactions and cell fate decision. Specifically, we focus on how pathogens rewire the metabolic capabilities of their algal hosts as part of the infection strategy. Newly identified genes and metabolites induced during specific pathogenic interactions are used as functional biomarkers to study the impact of microbial cross-talk on the metabolic landscape of microbial food webs in the marine environment.

Themed Session: Keynote

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Vergara F.[1], Moreno-Pedraza A.[2], Gabriel J.[1]

Water availability in the soil and its effects on tropane alkaloid metabolism in Datura stramonium

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Datura stramonium is an annual plant that produces tropane alkaloids. Atropine and scopolamine are two of the most studied alkaloids in D. stramonium. Atropine and scopolamine are non-selective muscarinic acetylcholinesterase inhibitors. Atropine and scopolamine affect the central nervous system in animals and act as chemical defenses against herbivores. Molecules of atropine and scopolamine contain nitrogen. There is no evidence that D. stramonium stablishes symbiosis with nitrogen (N2) fixing bacteria. Thus, D. stramonium obtains nitrogen (NO3-) from the soil. The process of nitrogen assimilation requires the dissolving of NO3- in water. It is foreseeable that the availability of water in the soil influences the assimilability of NO3- by the roots of D. stramonium. In turn, the assimilability of NO3- can affect tropane alkaloids biosynthesis. To test this hypothesis we set up an experiment with different irrigations. To estimate the assimilability of NO3- we used tensiometers to quantify the soil water pressure. We analyzed different organs of D. stramonium grown under different irrigations using a non-targeted metabolomics approach (LC-qToF). We also determined the percentages of elemental carbon and nitrogen in different organs. Finally, we performed an absolute quantitation of atropine and scopolamine (LC-QqQ). We identified irrigations correlated with maximum production of tropane alkaloids. These findings are relevant in understanding herbivory patterns in nature.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Verheggen F. and Boullis A.

Aphids facing climate changes: Elevated carbon dioxide concentration impact aphid chemical communication and multitrophic interactions

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Our work is based on two well-documented statements: (1) The release of carbon into the atmosphere due to human activities has caused an increase in concentration of atmospheric carbon dioxide; (2) Insects are highly dependent on odor cues to communicate with conspecifics or to locate food sources. Thus, we tested the hypothesis that the chemical communication occurring between plants, phytophagous insects, and their natural enemies will be impacted by an increase in carbon dioxide concentration. We found that aphids reared under elevated CO2 concentrations ([eCO2]; 750ppm) produce and release less alarm pheromone than aphids reared under control CO2 concentrations ([cCO2]; 400ppm). We also found that the escape behavior of [eCO2] aphids was reduced. While the total amount of honeydew excreted by [eCO2] aphids was only slightly reduced, we detected qualitative and quantitative differences in the volatile emissions of aphid honeydew. We finally tested the hypothesis that the prey-searching behavior of an aphid predator is impacted by these changes in aphid semiochemistry. During dual choice behavioral assays, we found that [eCO2] aphid-infested plants were less preferred by syrphid females, but the life history traits of the resulting larvae were similar on [cCO2] and [eCO2] aphid-infested plants. We conclude that the predicted changes in greenhouse gas concentrations will impact aphid semiochemistry, with cascade effects on higher trophic levels.

Themed Session: Language of Life Under Climate Change

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Vidkjær N.[1], Ward J.[2], Kryger P.[1], Fomsgaard I.[1]

Seasonal and landscape variations in the honey bee diet investigated by MS and NMR based metabolomics

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Declining honey bee (Apis mellifera, hereafter bee) populations are receiving increasing attention, especially because bees are important pollinators of our food crops. The underlying cause of the decline is hypothesized to be multifactorial, and bees face many stressors including pathogens, xenobiotics and changes in floral resources. Via their pollen/nectar diet, bees consume essential nutrients and multitudes of bioactive plant secondary metabolites (PSMs), which have been used in human medicine for centuries. Recent findings demonstrate the potential of PSMs to also affect bee health e.g. by reducing virus loads, but the PSM profile of pollen/nectar is sparsely investigated. Furthermore, different floral resources are available in different landscapes and throughout the season, but limited knowledge exist on how such variations affect dietary composition. In a field experiment in Denmark, pollen/nectar samples were collected biweekly from four apiaries in different landscapes (agricultural, urban, forest and meadow). The experiment aims to explore the chemical variations in the diet focusing on both bioactive PSMs and essential nutrients. Thus, untargeted chemical profiling of the diet, using GC-TOF-MS, LC-MS and NMR, was performed. Seasonal as well as landscape variations in diet composition was subsequently investigated using multivariate data analysis. The results serve as a knowledge base for future detailed studies of dietary effects on bee health.

Themed Session: Metabolomics in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Von Elert E.[1], Effertz C.[1], Bigler L.[2], Hahn M.[1]

Diel vertical migration of zooplankton - Identification of the fish kairomone

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Diel vertical migration (DVM) of zooplankton is the largest synchronized movement of animals worldwide, based on the number of individuals. It has ecosystem-wide consequences such as the control of planktonic primary producers and vertical transport of nutrients. In freshwaters zooplankton species perform DVM to avoid predation by planktivorous fish. It was demonstrated already more than 25 years ago that DVM can be induced by a chemical cue released by fish, the chemical identity of this cue remained unknown. Since zooplankton is too slow to escape after it has encountered planktivorous fish, the chemical cue represents a kind of early warning sign. Here we report the structure of the kairomone. We extracted fish incubation water and performed bioassay-guided fractionation using the model organism Daphnia and a well-established behavioral indoor setup for the assessment of DVM. One out of six HPLC-fractions induced DVM in Daphnia. High-resolution LCMS-analysis of the active fraction pointed to a constitutive metabolite in fish. We were able to purify larger amounts of this metabolite and confirmed its identity by NMR. We report that the compound induces DVM in picomolar concentrations. The identified kairomone is an evolutionary ancient metabolite, which is constitutively synthesized and exuded by fish. This is the first identification of the kairomone that mediates the interaction between zooplankton and its vertebrate predator fish.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Wang C.[1,2] and Yang K.[1]

Pheromone receptors in Heliothine species: expression, function and evolution

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Heliothine species include some of the world's most devastating pest species, such as Heliothis virescens in the New World and Helicoverpa armigera in the Old World. The sex pheromone communications of these agricultural pest species have been investigated from pheromone molecules, pheromone receptors (PRs), to brains and behavior in detail. In recent years great progress has been made on the molecular mechanisms of pheromone perception, in which PRs play a key role in determining selectivity of pheromone-sensitive olfactory receptor neurons. In this presentation, we focus on the functional characterization of PRs in the heliothine species, summarize recent progresses in identification of the receptor tuned to principal sex pheromone components including Z11-16:Ald, Z9-16:Ald, Z9-14:Ald, and other related alcohols and acetates. Evolution of PRs in ligand selectivity is also discussed. The research strategies, skills and notices in PR functional analyses, especially using the Xenopus laevis oocyte expression system, are reviewed. Finally, we propose research topics on PRs in Heliothine species in the future.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Wang M.

Screening behaviorally active compounds based on fluorescence quenching in combination with binding mechanism analyses of SspOBP7, an odorant binding protein from Sclerodermus sp.

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Reverse chemical ecology approaches based on the recognition and transport function of odorant binding proteins (OBPs) have been used to screen behaviorally active compounds of insects. In the first place, behaviorally active compounds from Sclerodermus sp., an important ectoparasite of Monochamus alternatus Hope, were screened by SspOBP7. The Fluorescence quenching assays revealed that only six of 19 ligands that had binding affinities in fluorescence competition-binding assays formed complexes with SspOBP7. Pursuing this further, two non-polar ligands, terpinolene and (+)-α-longipinene showed strong attractant activities for Sclerodermus sp. The pH change could lead to conformational transition of SspOBP7 from one state to another, which results in low binding affinities at low pH. Finally, a mutational analysis of the SspOBP7 binding cavity proved that changing the cavity had a greater effect on non-polar ligands, and the specific recognition of ligands by SspOBP7 might depend mainly on the appropriate shapes of the cavity and ligands. The most obvious finding to emerge from this work is that the use of fluorescence quenching to study the binding mechanism of OBPs could aid reverse chemical ecology approaches by narrowing the scope of candidate behaviorally active compounds.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

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Changing the Way We Think About Defining Molecular Structure: Routine Application of Quantum Chemistry to NMR Problems

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Theoretical calculations of molecular geometries and NMR parameters have advanced significantly over the past decade. These calculations provide a framework for the design of novel NMR experiments and revitalization of older experiments. Applications important within the pharmaceutical industry and the field of natural products chemistry include calculations to support studies aimed at defining the constitution and configuration of small molecules, analysis of peptides in anisotropic media, conformational sampling, and spectral simulations for the analysis of crystal structures. Theoretical methods, most of which are based on QM DFT calculations, provide better strategies for choosing the optimal experiment for a specific task (e.g. using HMBC vs. ADEQUATE). DFT methods have also provided a foundational basis on which to enhance NMR tools for structural analysis. It is now common to simultaneously utilize two or three orthogonal methods (e.g. RDC/RCSA, chemical shifts, J-couplings, NOE/ROE, etc.) to afford robust structure confirmation. DFT methods are now highly efficient and these calculations can be carried out in parallel in a time frame comparable to that required for the collection of the experimental data.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

Oral Presentation

Presentation Date: Tuesday, June 4th, 2019

Wyeth R.

Chemosensory navigational strategies of aquatic slugs and snails

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Aquatic gastropods frequently rely on water-borne chemicals to find prey and mates and to avoid predators. The navigational strategies they use are likely to be either chemotaxis or odour-gated rheotaxis, depending on the flow conditions. Our research has focused on these chemically-driven navigational strategies in aquatic gastropods and the corresponding chemosensory systems. In the nudibranch, Tritonia diomedea, sensory nerve lesions showed that a single rhinophore (cephalic sensory tentacle) provides sufficient input to produce normal navigation, strongly suggesting they navigate by odour-gated rheotaxis. Follow-up tests of how input from two rhinophores might be beneficial for navigation in more complicated chemical environments have been inconclusive thus far. We have also tested navigational responses to aversive odours in the slugs, and our finding indicate that navigation with respect predators is not simply the opposite of navigation towards attractive odours. We are now testing chemosensory navigational responses in the freshwater snail, Lymnaea stagnalis. These animals can live in quite different flow conditions, and our goal is to ultimately establish whether the snails switch between chemotaxis and odour-gated rheotaxis, depending on the conditions. Finally, and unsurprisingly, we are also finding evidence suggesting other sensory modalities (vision, magnetoreception) may augment navigation based on chemical cues.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Yan F., Li W., Bai R., Li J., Zhou L., Wang G.

Screening and development of plant origin attractants for the control of crop insect pests

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Due to shortcomings of insect pheromones in field applications, such as luring only males, low efficiency in trapping-killing, as well as high cost in synthesis, chemicals of plant origin can be very promising candidates for use in safe management of crop insect pests. In this study, we screened bioactive chemicals from variety of plant species and developed attractants for safe control of several crop insect pests, i.e., cabbage moth (Barathra brassicae), oriental armyworm (Leucania seperata) , scarabs (Holotrichia oblita, Holotrichia parallela and Anomala corpulenta). Following collection and analyses of plant volatiles, bioactive chemicals were screened with EAG or GC-EAD and bioassays. Blend of chemicals used as baits were tested, alone or with the pheromones, for trapping insect pests in the fields. Based on 5-year laboratory screening and field tests, series of plant origin attractants of blend of chemicals were obtained for safe control of crop insect pests of both males and females.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Yon F.[1], Haverkamp A.[2], Bing J.[3], Baldwin I.[3], Knaden M.[3], Hansson B.[3]

Interference effect of multiple plant scents on Manduca sexta foraging

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Volatile compounds in nature work as cues to detect organisms in the surroundings, either attractive or repellent. These volatile cues are used to navigate the environment by many animals, allowing them to find food sources, mates or avoid dangers. In the Great Basin Desert (USA), we can find the hawkmoth Manduca sexta and several plant species on which it can opportunistically forage and/or oviposite. Some of these plant species that we focus on are: Datura wrightii, Nicotiana attenuata and N. obtusifolia, and Mirabilis multiflora, which can be attractive or even repellent based on volatile composition. These plants present night scented opening flowers and can co-occur at a same site. Using a grid experimental design to trap volatiles with PDMS tubing for GCMS analysis, we tested at night different combinations of flowering plant species and released single hawkmoths to observe their foraging behavior and test the hypothesis of scent interference. We observed that some volatiles, for example those of N. attenuata do not reach high intensities far in the grid; while some attractive scents can mask less attractive or repellent flowers and make them choosable as food source. The results of the tested plants don't suggest for a negative navigational interference effect but rather for a positive navigational effect where the more attractive scents mask less desirable flowers and allow them to be visited in a close range with possible pollination benefits.

Themed Session: Chemical Biology Approaches for Interactions Among Organisms

Oral Presentation

Presentation Date: Thursday, June 6th, 2019

Yusuf A., Pirk A., Crewe R.

Eavesdropping into host communication: the bee louse Braula coeca selects its host using kairomones

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The bee louse Braula coeca had until recently a global distribution that coincided with its host the Western honey bee Apis mellifera L. The adult fly usually attaches itself to a worker and steals food out of the host's mouth. However, not all worker bees carry Braula and the mechanism used by the bee louse to select a particular host is poorly known. We sampled and analysed using gas chromatography, the mandibular gland secretions (MDG) of worker bees that were carrying and those not carrying Braula from queenright colonies of A. m. scutellata. MDG profiles were qualitatively identical containing the five main MDG components, but workers carrying Braula had proportionately more methyl p-hydroxybenzoate (HOB) and the queen substance 9-oxo-2(E)-decenoic acid (9-ODA). Quantitatively, bees with Braula had higher amounts of the pheromones with a mean of 6.02 µg per bee, compared to 3.62 µg per bee for those not carrying Braula. A multiple comparison between all the components in the MDG profiles shows that, irrespective of the colony sampled, bees carrying and those not carrying Braula are different in both the proportions and concentrations of pheromones except for the worker component 10-hydroxy decanoic acid (10-HDAA). Braula is thus capable of using kairomones as cue that allows it to benefit from trophallactic dominance by selecting individuals that have a higher probability of being fed so as to get enhanced access to food.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Zhang A.[1], Feng Y.[1], Vanhove W.[2]

Evaluation of attract-and-kill strategy for management of cocoa pod borer in Malaysia cocoa plantation

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In South-East Asia, cocoa production is dramatically affected by cocoa pod borer (CPB) infestations. As an alternative tool to chemical control, the efficacy of attract-and-kill strategy (CPB sex-pheromone as attractant and Delta trap without sticky liner sprayed with cypermethrin solution as killing station) was evaluated and compared with current standard CPB management approach during two main cocoa harvest seasons (2015-2016) in Malaysia (with 100 µg and 33.3 µg CPB-pheromone loading per station, respectively). In both seasons, attract-and-kill strategy was highly effective at reducing male flight activity ($p < 0.05$) in attract-and-kill plots comparing with standard CPB management plots. For the percentage of CPB-infested pods, the attract-and-kill strategy (100 µg) was as good as the conventional pesticide spray applications of cypermethrin ($p = 0.083$) in first season. However, it was significantly ($p = 0.021$) reduced in the second season with lower pheromone loading (33.3 µg), indicating that this semiochemical based strategy is far superior to and more feasible than the currently applied conventional synthetic pesticide treatment and is therefore a good alternative in CPB integrated pest management.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

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Whiteflies can fool their host plants, but not their parasitoids

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Herbivorous insects and plant pathogens commonly trigger chemical defenses in plants, including the release of specific volatiles. Herbivore-induced plant volatiles are used by many parasitoids to find hosts. Another role of inducible volatiles is to alert undamaged plant tissues of incoming attack. When neighboring plants perceive these alert signals, they also prepare themselves in a way that they respond faster and stronger when they are assaulted by the same attacker. In the case of chewing insects, this so-called priming involves the plant hormone jasmonic acid (JA), but in the case of an attack by a pathogen, the enhanced defense responses are usually dependent on salicylic acid (SA).

It is known that phloem-feeding whiteflies trigger SA defenses in plants, at the cost of JA-dependent defenses. As a result, the plants become more suitable for whitefly development. We found that this apparent host plant manipulation extends to whitefly-induced volatiles, which also are characteristic for pathogen attack, for instance the monoterpene β-myrcene. Neighboring plants that perceive whitefly-induced volatiles wrongly prepare themselves for pathogen attack and thus become more suitable for the next generation of the whiteflies. The specialist parasitoid *Encarsia formosa* is not misled by this signal manipulation. In greenhouse trials, with various *Arabidopsis* mutants we showed that the parasitoid uses SA-triggered emission of β-myrcene for host location. Hence, unlike host plants, the parasitoid is not fooled by the whitefly's signal trickery. Understanding the mechanisms and signals that are involved in these plant-plant interactions may lead to new strategies to enhance crop resistance.

Zhu J.

Discovery of natural product-based repellent compounds against blood-sucking insects

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Plant-based repellent compounds have been widely used against blood sucking insects in veterinary and public health fields. Use of botanical repellents against mosquitoes has become one of the most efficient ways to prevent disease transmission. However, one of the biggest shortcomings of plant-based repellents are short-lived in their effectiveness. Therefore, it is necessary to discover and explore more resources to discover more plant-based repellents with extended longevity. In this presentation, I will report findings of long-lasting repellent compounds from coconut oil that can provide repellency lasting up to 2 weeks against several types of blood-sucking insects. Over 90% of repellency/feeding deterrence have been demonstrated against biting flies, ticks, mosquitoes, cockroaches and bed bugs. It also acts as a bio pesticide that inhibits larval growth and deters female oviposition of stable flies. In some cases, the strength of repellency from this natural repellent product is even stronger than the golden standard, universal insect repellent, DEET (N,N-Diethyl-3-methyl-benzamide). Easy-to-apply formulations developed for topical applications has been successfully used on cattle under field condition and provide over 5 days of repellency against biting flies.

Themed Session: Natural Product Application in Insect Pest Control

Oral Presentation

Presentation Date: Monday, June 3rd, 2019

Zhu F. and Moural T.

Mechanisms of chemical adaptation in terrestrial and aquatic insects

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Chemoreception in terrestrial and aquatic insects plays a very important role in many crucial insect behaviors, such as searching for food, mating, localization for oviposition, aggregation, and escaping from dangers. Chemoreception is mediated by membrane-bound receptors, soluble proteins, named as odorant-binding proteins and chemosensory proteins, as well as odorant-degrading enzymes and their partners. These proteins are abundantly expressed in the lymph of chemoreceptor structures, e.g. insect antennae, palpi, and tarsi, which emphasis their essential functions in chemical signal processing. Here we identified several chemoreception proteins from antennae or male tarsi in terrestrial and aquatic insects by using forward and reverse genetic approaches. We then investigated their potential functions in chemical communication and xenobiotic adaptation.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

Oral Presentation

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