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

Williamson R.[1], Liu Y.[2], Buevich A.[3], Cohen R.[3], Wang X.[3], Martin G.[4], Ndukwe I.[3]

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

Peng-Jun Zhang[1], Jia-Ning Wei[2], Chan Zhao[1], Ya-Fen Zhang[1], Chuan-You Li[3], Shu-Sheng Liu[4], Marcel Dicke[5], Xiao-Ping Yu[1], and Ted Turlings[6]

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

Presentation Date: Monday, June 3rd, 2019

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

Adams S. A., Schulz S., and Gillespie R.

Chemical Species Recognition in an Adaptive Radiation of Hawaiian Spiders.

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The mechanisms by which reproductive isolation evolves and is maintained in adaptive radiations is central to fundamental processes such as reinforcement, sensory drive, and hybridization. Particularly important are situations where ecologically distinct incipient sister species co-occur geographically, resulting in frequent encounters between diverging species and necessitating finely tuned recognition mechanisms for species to maintain reproductive isolation. This is seen in adaptive radiations of Anolis lizards, cichlid fish, and Hawaiian Drosophila. In these systems however, much of the work has been done within the domain of human perception – visual and auditory cues. Chemical cues are one of the most ancient and widespread modalities of communication, yet their importance in species recognition and reproductive isolation remains to be studied in the context of adaptive radiations. This study focuses on the role of chemical species recognition cues in reproductive isolation and speciation within a well-studied adaptive radiation of Hawaiian Tetragnatha spiders in which ecologically distinct sister species co-occur, and visual and auditory cues appear to play little or no role in species recognition prior to mating.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 99

Agnihotri A., and Xu W.

Molecular study of *Helicoverpa armigera* odorant binding proteins to better understand the insect chemosensation

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Like many other organisms, insects also use multiple external stimuli to regulate behaviours such as feeding, egg laying, and mating. These activities are initiated and driven by specific chemosensory signals in terms of olfaction or gustation. Odorant-binding proteins (OBPs) are one of the crucial aspects of insect chemosensory system, which plays an essential role in transporting the hydrophobic volatile odorant molecules through the sensillum lymph and deliver these ligands to the olfactory receptors. In this work, we aim to study the molecular interaction and the physiological functions of Helicoverpa armigera OBPs and understand the biochemical mechanism of OBP functions in insect chemosensation. Based on the available genome and transcriptome data, we have shortlisted the OBP candidates showing high expression in the Antennae and Tarsus of H. armigera. The molecular cloning and in-vitro protein expression methodology have been used to obtain a high amount of candidate OBPs. Further, by applying the reverse chemical ecology approach, these proteins are functionally characterised based on their interaction with the host plant volatile ligands. In-silico protein-ligand interaction study has also been performed to understand the binding patterns and ligand affinity of these proteins with corresponding plant volatile ligands. This study improves our understanding of the chemosensory mechanism of insects and aims to enhance the scholarly knowledge of insect-plant interaction.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 61

Alborn H. T., Bruton R. G., and Beck J. J.

A Comparison of Three Solventless Volatile Collection Techniques for Analysis of Plant, Insect, and Microbe Semiochemicals

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Volatiles play an important role in inter-organismal communication by plants, insects, and microbes. To better understand and exploit these interactions, headspace volatiles are routinely collected and analyzed. Ideally, the ecological system studied should help guide the choice of collection and analysis technique (e.g., static vs. dynamic); however, often the choice is governed by availability or tradition. Within these constraints it is still necessary that each system detect and provide a realistic, in situ or in vitro volatile profile of the studied system. Using a defined blend of compounds to mimic a simple, natural bouquet we compare the strength and weaknesses of three solventless, techniques: SPME, SPDE (needle trap), and an in-house designed thermal desorption system. For comparison purposes, a small volume direct head space and an established chemical desorption method were used. We found that qualitative as well as quantitative differences could be correlated with adsorbent sampling capacity and structural bias, but to an even greater extent by factors such as gas phase equilibrium and sampling volumes. The discoveries were used to provide a general guidance for selection of techniques for natural and agricultural chemical communication applications.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 19

Alvarez Costa A., Gonzalez, P. V., Harburguer L. V., and Masuh H. M.

***Eucalyptus nitens* (Myrtaceae) essential oil as an alternative natural repellent against Aedes aegypti and Anopheles pseudopunctipennis (Diptera: Culicidae)**

UNIDEF-CONICET

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Anopheles pseudopunctipennis (Theobald) is the main vector for malaria in Latin-America. Aedes aegypti (L.) (Diptera: Culicidae) is the vector of dengue, yellow fever, Zika, and chikungunya. The use of repellents based on natural products is an alternative for personal protection against these diseases. We evaluated the repellence of the essential oil of E. nitens against Ae. aegypti and An. pseudopunctipennis. The essential oil was extracted and analyzed by GC-MS. The repellence of the essential oil, 1,8-cineole and DEET against both species of mosquitos was evaluated using the plaque repellency method, which consisted in analyzing the behavior of individual females of these mosquitoes exposed to a filter paper half impregnated with the tested compounds. We tested the repellence of the three treatments against Ae. aegypti by the arm-in-cage method. The main components of the essential oil were terpenes and β-triketones (flavesone, leptospermone, and isoleptospermone). A repellent activity to the essential oil and DEET against both species were found but no significant response to 1,8-cineole was detected. We detected the increased locomotor activity of Ae. aegypti exposed to the essential oil. The total protection time of the essential oil (97.50 min) against Ae. aegypti was significantly higher compared with 1,8-cineole (5.00 min) and similar compared with the DEET (196.67 min). The good repellent activity of E. nitens essential oil could be due to the cyclic β-triketones.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 67

Amorós M. E., Lagarde L., Do Carmo H., Heguaburu V., and González A.

Advances in the development of an attractant for *Diploschema rotundicolle* (Coleoptera: Cerambycidae)

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The citrus borer, Diploschema rotundicolle (Coleoptera: Cerambycidae), is a longhorn beetle native to South America and regarded as a serious citrus pest in Uruguay. High infestation levels cause an overall deterioration of the tree structure, resulting in important yield reduction. Currently, the only available management strategy is cultural control by trimming off infested branches, which is expensive in labor costs and mostly inefficient. Our work aims at the development of an effective trapping system that could eventually be used for management strategies of this pest. Our work on the chemical communication system of D. rotundicolle has shown that males produce large amounts of (3R)-3-hydroxy-2-hexanone and some minor compounds, including 2,3-hexanediol and 2,3-hexanedione. This a nocturnal beetle, and preliminary work has shown attraction to light traps. In this work a field trail was carried on, in which the pheromone and light stimulus were tested in cross-vane traps in a citrus grove, during the summer of 2018/19. Tested attractants included the racemic hydroxyketone, racemic hydroxyketone plus hexanediol, led light, led light plus the two pheromone compounds, and isopropanol as control. Preliminary results show higher catches in light traps with pheromone than in light traps alone, suggesting that light and chemical stimuli can be used in combination to enhance field trapping of D. rotundicolle.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 84

Arriola K., Meier L., Mongold-Dyers J., Hanks L. M., and Millar J.G.

Synthetic Strategy and Absolute Stereochemistry of a Novel Polyketide, the Likely Aggregation-Sex Pheromone of *Graphisurus fasciatus* (Coleoptera: Cerambycidae)

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The Cerambycidae constitute one of the most diverse and economically important beetle families. Exploiting insect semiochemistry as a strategy for integrated pest management has proven successful, and while the chemical ecology of longhorn beetles has progressed substantially within the past decade, our overall knowledge of cerambycid semiochemistry is still limited. The first polyketide cerambycid pheromone was only recently discovered, indicating the chemical space occupied by cerambycid semiochemicals is more diverse than initially thought. Herein, we describe the isolation and identification of a male-specific polyketide from the cerambycid Graphisurus fasciatus, which is a likely candidate for its aggregation-sex pheromone. The absolute configuration of this novel polyketide was identified through a modular synthetic approach, whereby multiple stereoisomers were synthesized in predicted biased ratios, allowing unequivocal structural elucidation of the natural stereoisomer from 16 possible stereoisomers.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

POSTER

Number: 39

Avila C., De Castro-Fernández P., Nestorowicz I., Moreno-Salazar C., and Angulo-Preckler C.

How will global change affect Antarctic chemical ecology?

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Future climate change scenarios predict an increase of 1.8-4ºC in sea surface temperature. Polar regions seem to be among the most vulnerable, given that polar species are in general stenothermal and less capable of enduring temperature shifts. Antarctica is a still unexplored area of our planet, where biological diversity and even more, chemical diversity remain vastly unknown. Our research group has been studying marine benthic ecosystems in different Antarctic areas, producing many interesting discoveries regarding both new species to science as well as new natural products. Since 1998, the Antarctic research projects ECOQUIM, ACTIQUIM, DISTANTCOM, and BLUEBIO aimed at gaining a better understanding of the diversity and structure of Antarctic benthic marine communities, both at biological and chemical levels. To do so, among other aspects, we studied the ecological activity of marine natural products from benthic organisms by in situ chemical ecology experiments. In contrast to what happens in other regions of the planet, benthic Antarctic ecosystems are ruled by a strong environmental stability, only comparable to that observed in caves or abyssal regions, and thus the interactions between organisms become a very important factor in structuring these communities. Many of these interactions are regulated by natural products. How climate change may affect Antarctic marine chemical ecology is the subject of our most recent studies and we present here our preliminary results.

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

POSTER

Number: 2

Bae M.

Chemical Warfare between Microbial Symbionts of Fungus-Growing Ants

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Recent chemical investigations into bacterial symbionts of fungus-growing ants has led to the identification of several secondary metabolites that play key roles in maintaining the health of this complex system.1,2 In a classic mutualism, bacterial symbionts provide bioactive small molecules, i.e. dentigerumycin, selvamicin, that combat both disease and predation within the nest.1-6 My work has focused on uncovering the chemical interactions occurring between the bacterial symbiont and fungal pathogen. I discovered the Pseudonocardia sp. strain, ICBG1122 producing the cyclic peptide antifungal agent, dentigerumycin, displayed potent and selective inhibitory activity against a strain of the pathogenic fungus that originated from the same nest as ICBG1122. In the newly developed trans-well system, which was designed to uncover molecular interactions between microbes,7 new analogs of conocandin from pathogen fungus were highly-induced only when exposed to dentigerumycin. Conocandin B and C showed highly-potent inhibitory activity against Pseudonocardia sp. ICBG1122. Based on the further bioinformatic studies for mutants of S. aureus,7 we hypothesize that conocandins are targeting the FabH in Pseudonocardia sp. and thus preventing the Psuedoncardia from generating branched chained fatty acids. From this study we have gained interesting insights into the complex interactions occurring between fungus-growing ants, cultivar fungus, symbiotic bacteria, and pathogenic fungus.

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

POSTER

Number: 30

Balakrishnan P., Damodaram K. J. P., Parepally S. K., Murugan T. R. L., and Subbaraya U.

Role of host plant volatiles in adult attraction and auto dissemination of entomopathogenic fungi, with Banana fruit scarring beetle, *Nodostoma virdepenne* (Jac.)

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Adult leaf and fruit scarring beetles (Nodostoma virdepenne (Jac.), Chrysomelidae: Coleoptera) exclusively feed on banana leaf as well as developing fruits causing both qualitative and quantitative losses. The management practices till to date are being dominated by chemical insecticides as suitable eco-friendly management measures are lacking. Therefore, an attempt was made to study the scope of the host plant volatiles (= kairomones) mediated attraction for the successful trapping of adult beetles and subsequent contamination with entomopathogen, Beauveria bassiana for developing potent autodissemination technology. As the beetles are monophagous and prefer to feed on the newly emerging leaf, flag leaf, flower bract, leaf mid rib and developing fingers, preliminary studies using these plant parts as bait in conventional trap along with B. bassiana (1x109 CFU/g) conclusively established the attraction of beetles to the trap and subsequent mortality to the tune of 100%. Further attempts to isolate and identify the host plant volatiles that can be synergistically used in the traps revealed the presence of butyl 3-hydroxybutanoate, 2,7-dimethyl-1-octanol, 2-pentanol, 3-chloro-4-methyl-, (R*,R*)-(±)-, 2,6,10-trimethyltetradecane, 3,7,11-trimethyl-1-dodecanol, 4-Acetyl-m-xylene, benzyl oleate, 2-hexadecanol, 2,6,10-Trimethylhexadecane, propanoic acid, 2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-yl)-, 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester, 14-hydroxy-14-methyl.

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

POSTER

Number: 3

Balaraman P., and Plettner E.

Ecological Role of Cytochrome P450cam (CYP101A1) in the Chemotaxis of *Pseudomonas Putida* (ATCC 17453) Towards Camphor

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The camphor-degrading P. putida (ATCC 17453) is an aerobic soil bacterium, which can use camphor as its sole carbon and energy source. The genes responsible for the catabolic degradation of camphor are encoded on the extra-chromosomal CAM plasmid. A monooxygenase, cytochrome P450cam, mediated hydroxylation of camphor to 5-exo-hydroxycamphor is the first committed step in the camphor degradation pathway. Under low O2 levels, P450cam catalyzes an unusual reduction reduction to produce borneol form camphor. Borneol has been previously demonstrated by us to downregulate the expression of P450cam. To evaluate the role of P450cam and the consequences of borneol based down-regulation of P450cam under low O2 conditions, we performed chemotaxis assays with camphor induced and non-induced P. putida strain ATCC 17453 using camphor, borneol, oxidized camphor metabolites and known bacterial attractants (D)-glucose, (D) - and (L)-glutamic acid. In addition, we have used 1-phenylimidazole, a P450cam inhibitor, to explore if P450cam plays a role in the chemotactic ability of P. putida towards camphor. We demonstrated that camphor, a chemoattractant, became toxic and chemorepellent when P450cam was inhibited. We have also demonstrated the effect of borneol on chemotaxis and found that the bacteria chemotaxed away from camphor in the presence of borneol. This is the first report describing chemotactic ability of P. putida ATCC 17453 and the crucial role of P450cam in this process.

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

POSTER

Number: 60

Beránková K., Schlyter F., and Jirošová A.

Design of the new monoterpenyl dispensers with required release rate

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The bark beetle Ips typographus is the most aggressive, tree-killing pest of conifer forests. During the last 25 years, its outbreaks have increased rapidly in the middle Europe as a result of climate changes. Therefore, it is very important to find new alternative defense measures close to nature with the possible use in management. One of them is the search for chemicals from its ecological niche and testing their biological activity. The promising candidates to expose the repellent effect for Ips typographus are oxygenated monoterpenes, compounds with provable electroantennographic activity and specific sensilla located on Ips typographus antenna. Its behavioral activity will be tested in large-scale field experiment in bark beetle pheromone traps. Here, we report the new design development of eight oxygenated monoterpenes dispensers and optimization its release rate in dependency on time. We create dispensers with required release rate of 0.1, 1 and 10 mg per day. The lowest level corresponds to the natural rate of evaporation of these substances from natural sources. The highest rate of evaporation is a potential repellent dose. The release rates of dispensers were estimated by weighting per time unit under the constant condition. The terpinene-4-ol, estragole and carvone were chose for developing of the prediction methodology for creation of the dispensers with the required release rate.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 68

Body M., Appel H. M., Grant, T. N. L., Gray, D. J., and Schultz, J.C.

Gall induction by Phylloxera on grape leaves – An integrative approach

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Galls are highly specialized structures arising from atypical development of plant tissue induced by another organism. Many different kinds of organisms can induce galls on plants, including viruses, fungi, bacteria, nematodes, mites and insects. However, gall-inducing insects produce the most diverse galls in nature, ranging from simple stem swellings to complex structures that are ornamented with bright colors and spines. An insect-induced gall is a modified growth of plant tissue induced by a reaction to the presence and activity of an insect. The insect induces a differentiation of tissues with features and functions of an ectopic organ. These structures are thought to provide adaptive advantages to gall-inducers by providing protection to the galling insect from natural enemies and environmental stresses, and also an adequate nutrition. Gall formation is a complex and close interaction between the gall-inducing insect and its host-plant resulting from molecular cross-talk between two independent genomes. Many have noted that galls often resemble flowers or fruit, but the mechanism at the origin of gall induction is still unknown. In this study, we (i) characterized how the gall-inducing insect Daktulosphaira vitifoliae reshapes the leaf morphology of the grapevine Vitis riparia during gall induction and development, and (ii) investigated whether galling insects hijack plant flowering pathways to induce galls. We used an integrative approach that included using microscopy.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 58

Böttner L., Niephaus E., Prüfer D., Gronover C. S., and Huber M.

Ecological functions of natural rubber biosynthesis in Russian dandelion

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Natural rubber, a cis-1,4-polyisoprene with more than 10,000 isoprene units, is one of the economically most important plant polymers. Although its phylogenetically widespread distribution and likely convergent evolution suggests important adaptive functions for plants, the ecological roles of these compounds remain unknown. We investigated the effects of natural rubber on herbivore resistance and root microbial colonization during the interaction of the high-rubber producer Taraxacum kok-saghyz with its soil-dwelling enemy, the common cockchafer (Melolontha melolontha). In a choice experiment addition of ecologically relevant 1,4-cis-polyisoprene concentrations to diet deterred M. melolontha feeding. In a non-choice setup M. melolotha larvae gained less weight on artificial diet supplemented with 1,4-cis-polyisoprene compared to diet with solvent control. Moreover, transgenic T. kok-saghyz plants deficient in natural rubber biosynthesis suffered stronger reduction in above ground biomass accumulation under M. melolonhta attack compared to control plants. These experiments provide the first line of evidence that natural rubber protects plants from herbivore attack. Whether natural rubber additionally restricts the colonization of microorganisms under root herbivory will be addressed in future microbiome analyses.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 26

Brzozowski L., and Mazourek M.

Role of cucurbitacins in insect preference in *Cucurbita pepo*.

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Cucurbitacins are intensely bitter and toxic terpenoids of the Cucurbitaceae family that have been implicated in mediating herbivore preference. While many herbivores are dissuaded by the presence of cucurbitacins in plant tissue, some beetles (Coleoptera: Chyrsomelidae) have evolved specialized metabolism to sequester cucurbitacins for their own defenses. However, it is yet unclear whether this relationship is maintained between Cucurbita pepo crops (i.e. zucchini, summer squash), and an agricultural pest, the cucurbit-specialized striped cucumber beetle (Acalymma vittatum). Of the specialized beetles, A. vittatum is relatively insensitive to cucurbitacins, and C. pepo crops have relatively low levels of cucurbitacins. We thus developed a genetic mapping population to address two objectives: (1) determining the genetic basis of cucurbitacin production in C. pepo, and (2) establishing the role of cucurbitacins in A. vittatum preference through a selection experiment. Overall, we identified one major effect locus controlling cotyledon cucurbitacin production. We also demonstrated that A. vittatum leaf damage and cotyledon cucurbitacin production is independently regulated. There is ongoing work to fine map the locus, and explore the generality of this result in other Cucurbitaceae crops.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

POSTER

Number: 15

Būda V., Aleknavičius D., Apšegaitė V., Radžiutė S., Blažytė-Čereškienė L., Servienė E., and Butkienė R.

Is buckthorn and fruit fly interaction mediated by yeasts?

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Sea buckthorn fly, Rhagoletis batava L., is the most important pest of sea buckthorn (Hippophae rhamnoides Hering) (SB) berries. Females lay their eggs into the berries and after maggot eclosion those cause significant damage. The yield and its quality decreases causing economic loses for farmers sometimes up to 100% (e.g. Shalkevich et al., 2014). Demand of SB berries is increasing, for wide use in food, cosmetics and medicine industry, thus ecologically friendly methods for pest control are needed. Data on chemoecology of the pest could be useful looking for new biocontrol methods. To identify volatile organic compounds (VOCs) present both in emissions of SB berries as well as in several yeast species occurring on the berries which elicit EAG responses both in females and males of buckthorn fly, was the aim of the present report. Among yeast species which occur on SB berries, Pichia kudriavzevii was identified and VOCs were collected by SPME and analyzed. Among 35 VOCs identified by GC-MS method, 10 were recorded as EAG-active. Those were 8 esters and 2 alcohols: ethyl acetate, ethyl propionate, ethyl butanoate, 2-methylbutyl-/3-methylbutyl acetates, 3-methylbut-1-yl propionate, 3-methylbutan-1-ol, ethyl hexanoate, ethyl octanoate, 2-phenylethyl acetate, and 2-phenyl ethanol. Both laboratory and field behavioural tests of the EAG-active VOCs are in progress. The study was supported by Research Council of Lithuania grant No. DOTSUT-12 (09.3.3-LMT-K-712-01-0099).

Themed Session: Insect-Microbe Chemical Communication

POSTER

Number: 38

Buellesbach J.[1], Gadau J.[1], Tsutsui, N.[2], Schmitt, T.[3], and Niehuis, O.[4]

From wasps to ants: What unifying elements can be found in phylogenetically and functionally diverse cuticular hydrocarbon profiles hinting at a commonly evolved chemical language?

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As the earliest and most wide-spread form of communication, chemical signaling has permeated through all known taxa of life. Insects, in particular, have exploited chemical signaling as their primary mode of communication. Cuticular hydrocarbons (CHC), the dominant fraction of the insects' epicuticle, form the basis for a wide array of different chemical signaling systems while primarily functioning as desiccation barrier. However, how exactly information is coded, preserved and communicated in the vastly diverse CHC profiles found in different insect taxa remains largely unassessed. My main goal is to decipher the signaling properties of CHC profiles in different representative Hymenopteran model organisms where CHC provide the main cues for interaction systems as diverse as sexual attractiveness and species recognition for solitary taxa (e.g. the jewel wasp Nasonia vitripennis) as well as nestmate and colony recognition for eusocial taxa (e.g. the Argentine ant Linepithema humile). Integrating genetic, chemical and behavioral methods, intriguing similarities in the key CHC signaling compounds begin to emerge despite the high diversity in information content. This strongly suggests that the main signaling properties in CHC profiles are evolutionary conserved traversing vast phylogenetic boundaries, delivering the first hints at elements of a unified, common "chemical language".

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 20

Cepeda M. R.[1], Fisher C. L.[2], Lane T. W.[2], and Kubanek J.[1]

Natural Products to Protect Algal Biofuel Ponds

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Microalgae are known to benefit from bacterial communities through nutrient exchange whereby algae provide organic carbon to bacteria in return for vitamins and minerals. Preliminary studies suggest that microalgae in open biofuel ponds could also benefit from specific bacteria consortia that chemically defend them from rotifer predation, thus preventing biofuel pond crashes, but the mechanism of action is unknown. These studies indicate that aquatic bacteria consortia potentially produce protective molecules that deter predators and understanding the chemical ecology of these systems would lead to a cost-efficient way of minimizing algal predation in open algal biofuel ponds. The microalga Microchloropsis salina, the rotifer Brachionus plicatilis, and co-occurring communities of aquatic bacteria are a model system for understanding how bacteria consortia mediate microalgal-predator interactions. This project consists of three main aims where the first is to determine whether the protective molecule(s) are small organic metabolites, biomacromolecules, or intracellular bacterial toxins. 1H NMR and mass spectrometry-based metabolomics are used to obtain chemical profiles of bacteria consortia in order to identify putative defenses against rotifer predation. The method developed for identifying protective molecules in this system could further be applied to other microalgal open outdoor systems to target predators that prey on additional commercially valuable microalgae species.

Themed Session: Other

POSTER

Number: 104

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

Chhetri B. K.[1,2], Lavoie S.[2,3,4], Sweeney-Jones, A. M.[1,2], Mojib N., Polavarapu P. L.[5], and Kubanek J.[1,2,3,6]

Spectroscopic and computational approaches for determining the three-dimensional structure of the antifungal diterpene glycoside, peyssonnoside A

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Secondary metabolites play vital roles in ecosystems where they are used by organisms for interspecific, intraspecific, and environmental interactions. Their ecological functions typically manifest themselves by binding to specific protein receptors. Consequently, the three-dimensional structures of secondary metabolites are critical; related organic molecules with slight structural differences often exhibit completely different biological effects. Two diterpene glycosides, peyssonnosides A–B, sharing an unprecedented carbon skeleton were isolated from the marine red alga Peyssonnelia sp. The strong antifungal activity of peyssonnoside A against the marine fungus Dendryphiella salina (IC50 = 0.14 μM) along with a high natural abundance (0.42% of dry weight) suggests that it acts as an antimicrobial defense. The structures were deduced by extensive NMR and mass spectral analysis. A unique application of quantitative rotating frame Overhauser effect spectroscopy (ROESY) NMR spectroscopy was employed to determine the absolute configuration of the aglycone of peyssonnoside A, wherein the known configuration of the molecule's sulfated β-D-glucose moiety was used as an internal probe. The absolute configuration was confirmed by comparison of experimental optical rotatory dispersion (ORD) with values predicted with density functional theory (DFT) calculations. These combined approaches enabled elucidation of the full 3-D structure of an ecologically important marine natural product.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

POSTER

Number: 40

Clavijo-McCormick A., Nakano M., Trewick S., and Morgan-Richards M.

Mate choice and sexual communication in the New Zealand stick insect *Clitarchus hookeri*.

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New Zealand has a unique natural heritage, including multiple native and endemic species of arthropods. Understanding their reproductive behaviour may provide valuable information for their conservation, and that of their habitats. The New Zealand stick insect Clitarchus hookeri is particularly interesting in this regard, since it has both sexual and asexual (parthenogenetic - female only) populations distributed throughout the country. This work aimed to explore the morphological and chemical traits associated with sex (male vs. female), and different reproductive strategies for females (sexual vs. parthenogenetic) across populations; and to test the ability of males to discriminate between sexual and parthenogenetic females for their pre- and post-copulatory choices. We found clear morphological and chemical traits distinguishing males from females, namely differences in body mass, leg length, antennal length, and volatile organic compound emissions during the peak mating hours. However, sexual and parthenogenetic females overlapped in their morphology and chemical traits. Concurrently, males failed to discriminate between sexual and parthenogenetic females both in pre- and post-copulatory choices preferring females with lighter body weight irrespective of their reproductive mode. This study suggests that parthenogenetic females still retain traits linked to sexual reproduction in spite of their potential costs.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 85

Cofer T. M., Jones A. C., Seidl-Adams I., and Tumlinson J. H.

Phylogenetic analysis of the mechanisms for altering green leave volatile (GLV) emissions in herbivorous Lepidoptera

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Green leaf volatiles (GLVs) are six-carbon aldehydes, alcohols, and their esters that are produced by nearly all plants upon damage. GLVs function as within- and between-plant signaling molecules, and can serve as foraging cues for insect herbivores and their natural enemies. Our research, and that of others, show that GLV emissions are decreased, and that their emission profile may be modified, when insect oral secretions are applied to damaged leaves. To date, three mechanisms have been identified by which insect herbivores alter GLV emissions: 1) an isomerase that converts the GLV (Z)-3-hexenal to (E)-2-hexenal, 2) a hydroperoxide dehydratase that modifies the substrate required for GLV biosynthesis, and 3) a small, heat-stable molecule that appears to bind (Z)-3-hexenal, thus preventing its release. Here, we apply a phylogenetic analysis to these mechanisms to determine their evolutionary relationships across common lepidopteran families. We show that the small molecule occurs in nearly all families surveyed, while genes encoding the hydroperoxide dehydratase are present in only three. Similarly, we find that the (Z)-3 to (E)-2 isomerase is restricted to only two closely related families. These results suggest that Lepidoptera have evolved multiple strategies to alter GLV emissions. However, rather than being redundant, these strategies act at specific steps in the GLV biosynthetic pathway, undoubtedly with downstream effects on both the insect and its host plant.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

POSTER

Number: 32

Colazza S.[1], Guarino S.[1], Arif M. A.[1], Millar J. G.[2], Arriola K.[2], and Peri E.[1]

Novel diterpenes from *Brassica oleracea* var botrytis seedlings mediate host location by the stink bug *Bagrada hilaris*

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Bagrada hilaris Burmeister, the painted bug, is a pest of various vegetable crops of the Brassicaceae family, being particularly damaging to young seedlings. In this study, the role of volatile organic compounds (VOCs) emitted by seedlings of three Brassica species on host location by B. hilaris was evaluated. Volatiles from B. oleracea seedlings were collected and bioassayed with B. hilaris individuals, using electroantennographic and behavioral techniques. When crude extracts of the VOCs from B. oleracea seedlings and liquid chromatography fractions thereof were bioassayed, B. hilaris individuals were attracted to the crude extract, and to the non-polar fraction containing hydrocarbons, whereas there were no responses to the more polar fractions. GC-MS analysis indicated that the main constituent of the non-polar fraction is a diterpene hydrocarbon, with trace amounts of several other diterpene hydrocarbons. These results suggest that this diterpene, alone or in combination with one or more of the minor compounds, is a key mediator in this insect-plant interaction. The main diterpene has a molecular weight 272 Da with chemical formula C20H32 and is a compound new to science. It was isolated in microgram quantities by a combination of liquid and preparative gas chromatography, and identified by a combination of microchemical tests and mass and NMR spectral data.

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

POSTER

Number: 4

Colazza S.[2], Salerno G.[1], Frati F.[1], Conti E.[1], Peri E.[2], and Cusumano A.[3]

The emission of oviposition-induced plant volatiles exploited by an egg parasitoid depends on the mating status of an herbivorous stink bug female

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Plants respond to insect egg deposition with emission of oviposition-induced plant volatiles (OIPVs) which can recruit egg parasitoids of the attacking herbivore. The elicitor responsible for OIPV emission is not known in the case of plants induced by stink bug oviposition. In this work we conducted behavioural and biochemical investigations to localize the source of the elicitor that attracts egg parasitoids and elucidate the role of host mating in elicitation of plant responses. We used as model study organisms a tritrophic system consisting of the egg parasitoid Trissolcus basalis (Wollaston), the stink bug host Nezara viridula (L.) and the plant Vicia faba L. We found that egg parasitoid attraction to plant volatiles is induced by extracts coming from the dilated portion of the stink bug spermathecal complex. However, attraction only occurs if extracts are obtained from mated females. Parasitoid were not attracted when extracts coming from the accessory glands of male hosts were applied. SDS-PAGE electrophoresis correlated with olfactometer observations as the protein profile of the dilated portion of the spermathecal complex is affected by the stink bug mating status. This finding suggests that post–copulatory physiological changes in this reproductive structure trigger OIPV emission and egg parasitoid attraction. This study lays the basis for the chemical characterization of the elicitor responsible for OIPV emission.

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

POSTER

Number: 5

Coll Aráoz M. V.[1,2], Hill J.[1], Fernandez, P. C.[3,4], Albarracín E. L.[1], and Virla E.G[1,5]

Dalbulus maidis and Peregrinus maidis, both phloem feeding hopper species, induce different volatile profiles in maize. Consequences for a natural enemy

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Upon herbivory several biosynthetic pathways are activated and the response of a single plant species to different species of herbivores and even different instars of the same herbivore may be specific (Gouinguene et al, 2003). Natural enemies exploit these herbivory induced volatile profiles to find their preferred hosts, sometimes involving complex context-dependent analysis of chemical cues (De Moraes et al 1998). Dalbulus maidis (DeLong) (Hemiptera: Cicadellidae) and Peregrinus maidis (Ashmead) (Hemiptera: Delphacidae) are phloem feeding hopper species associated with maize that serve as vectors of several maize stunting and viral diseases. Both hopper species damage maize plants by removing sap and also because females lay their endophytic eggs in the nerves of the blade, cutting holes into the plant tissue with their ovipositor. Dalbulus maidis is a specialist herbivore that has a long history of coevolution with the genus Zea like maize (Zea mays L.) and its wild relatives, the teosintes (Zea spp.). Unlike D. maidis, P. maidis apparently adapted to maize as a host in post-Columbian times and it is a polyphagous insect, most frequently associated with Sorghum spp., but has also been found on Panicum spp. and other grasses. The eggs of both hopper species are parasitized by the wasp Anagrus virlai Triapitsyn (Hymenoptera: Mymaridae). However, parasitism on P. maidis seems to be occasional and Hill et al. (2019) demonstrated that A. virlai preferred odours from plants ind.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 86

Crisan C., Chandrashekar H., Hill S., Lieberman R., and Hammer B. K.

A Type Six Secretion System gene cluster found in V. cholerae environmental strains encodes a novel toxin

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Vibrio cholerae, the waterborne etiological agent responsible for fatal cholera disease, employs a Type VI Secretion System (T6SS) to compete against other bacterial and eukaryotic cells. The T6SS is a harpoon-like macromolecular apparatus that can puncture adjacent cells to deliver toxic proteins and confer a competitive advantage to V. cholerae in environmental and host habitats. Regulatory and structural T6SS proteins are found on a large gene cluster in V. cholerae strains, while additional components and toxins are located on auxiliary gene clusters. Previously, we identified a novel T6SS auxiliary gene cluster (Aux 4) in several V. cholerae strains of environmental origin and predicted a novel toxic protein encoded within the cluster (Tve4, Type VI Vibrio Effector 4). No conserved motifs or catalytic sites indicative of function were identified in the amino acid sequence of Tve4. Tve4 induced toxicity in E. coli when expressed in the periplasm but not in the cytoplasm. A patient-derived V. cholerae reference strain encoding the Aux 4 cluster outcompeted the parental strain lacking the Aux 4 cluster in a T6SS- and Tve4-dependent manner. Confocal microscopy revealed that Tve4 can induce lysis of target cells and suggests this novel toxin possesses bactericidal activity. We are currently working to understand the regulation of the Aux 4 cluster in the native strain and to determine the biochemical function of the Tve4 protein.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 62

Demko A. M.[1], Klau L. J.[1], Muskat M.[1], and Jensen P. R[1.2].

Linking sediment characteristics with microbial communities and their metabolites

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Bacteria are a vital component of the earth's ecosystem and exhibit an extraordinary amount of diversity relative to the rest of life. These microbes play an integral role in the food web and nutrient cycling, are symbiotically associated with countless organisms, and can be both a source of disease and/or an agent of mitigation through the natural products they produce. Previous research has found correlations between the microbial communities in marine sediments with various environmental characteristics, but few studies have explored those connections using next-generation sequencing or considered the role of spatial variability in community dynamics. Furthermore, the use of environmental metabolomics as a method to assess the secondary metabolite profiles of marine sediments can give us insight into the role these compounds are playing in structuring and maintaining the microbial community. Thus, the goal for this project was to utilize next-generation sequencing in conjunction with environmental metabolomics and sediment characteristics to study the microbial community of tropical marine sediments across varying spatial scales. Ultimately, we hope to gain insight into sediment microbial community dynamics and the role secondary metabolites play in shaping these complex marine ecosystems.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 48

Dowell J., and Mason C.

An evolutionarily relevant definition of 'Eavesdropping' and 'Communication'

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Current hypotheses surrounding the evolution of emission and perception of volatile organic compounds (VOCs) as a communication mechanism among plants lies in their importance as internal signals. VOCs released from damaged organs induce resistance in undamaged organs of the same individual faster than vascular signaling and independent of anatomy. Earlier work shows the reduction in efficacy of VOC induced resistance as genetic and physical distance of populations increase, although the pattern of decay is not supported at the interspecies level. As evidence supports the occurrence of interspecies VOC-mediated induction, variable responses not explainable by shared evolutionary history pose a critically missing mechanism for describing the transition of the phenomenon from communication to 'eavesdropping'. As evolutionary theory necessitates fitness consequences for 'true communication', it is important to disentangle chemically mediated induction events from reciprocal self-recognition (communication) among individuals from unidirectional signal interpretation (eavesdropping). Here we present several theoretical models hypothesized to lead to communication or eavesdropping, while presenting a series of experiments to disentangle this question in a phylogenetically informed manner using the annual clade of Helianthus.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 21

Du Y., and Chen J.

Attraction and olfactory responses to ylang ylang oil in red imported fire ant, *Solenopsis invicta*

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Ylang ylang oil is an essential oil extracted from the fragrant yellow flowers of the tree Cananga odorata. The red imported fire ant, Solenopsis invicta Buren, is one of the most successful invasive ants in the world. Intriguingly, the electrophysiological study (electroantenno-graph, EAG) revealed that ylang ylang oil elicited extremely high EAG response in S. invicta male alates, intermediate high EAG response in S. invicta worker and female alates. In addition, strong and significant EAG response can be detected in other 12 widespread insect species beside S. invicta. Subsequently, gas chromatography-mass spectrometry (GC-MS) coupled with EAG determined that benzyl acetate (BA), prenyl acetate (PA), benzaldehyde were key compounds in ylang ylang oil, which are responsible for the extremely high EAG response in S.invicta male alates. Furthermore, behavior (digging assay and two choices) assays indicated ylang ylang oil, PA and BA could be potential attractants for S. invicta. The additional EAG responses to over 30 acetates in S. invicta worker, female and male alates demonstrated that large diversity of EAG tuning responses ranges in structural different acetates. Our findings could be particularly interesting not only to increase the knowledge of the S. invicta olfactory system but also to better develop the sustainable fire ant control strategies based on manipulating chemosensory communication.

Session/symposium: Natural Product Application in Insect Pest Control

POSTER

Number: 69

Fischer, A., de Sa, S. M., Varney, J., Gries R., and Gries G.

Female false black widow spiders adjust their web architecture and pheromone deposition on it in response to conspecific female presence

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Females of cob-web spiders such as the false black widow Steatoda grossa can alter the architecture of their webs in relation to external cues to upturn prey-capture, safety, or mating opportunities. Here, we tested the hypothesis that female S. grossa respond to mate competition in that they change the architecture of their web and the amount of pheromone they deposit on it in response to the number density of webs in the microhabitat. In each of seven replicates of experiment 1, three females (low-number density) were allowed to build their webs in the same room for two days. Following a 12-day intermission, the same three females were then be allowed to build a new web for two days together with 27 other females (high-number density) present in the same room. The design of experiment 2 was similar except that females first build their webs in the high-number density setting and then in the low-number density setting. The females' web architecture in low- and high-number density settings were measured and all webs were extracted individually to quantify the amount of pheromone present. Our data support the hypothesis that females change their web architecture, and the amount of pheromone they deposit on it, in response to the number density of webs in the microhabitat.

Session/symposium: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 87

Fisher C. L.[1], Reese K. L.[2], Cepeda M. R.[3], Jaryenneh J. J.[1], Kubanek J.[3], and Lane T. W.[1]

The Good, the Bad, and the Algae: Chemical Analysis of Microalgal Cultures

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Open ponds are likely to succumb to unpredictable, devastating crashes as a result of algal biomass loss by one or several deleterious species. We are interested in identifying signature chemicals and natural products to aid in early pond crash detection, define the mechanism of protection from algal grazers, and discover novel high value products to support algal biotechnology and biofuel economy. We have surveyed the production of algal volatile organic compounds by microalgae in the presence and absence of the algal grazers. So far, we have determined some putative carotenoid breakdown products to be volatile biomarker signals for grazing of Microchloropsis salina by the marine rotifer Brachionus plicatilis. Additionally, we are performing chemical analysis of M. salina with various marine bacterial communities to (1) identify the mechanism of protection of some specific bacterial communities from grazing by B. plicatilis and (2) discover novel antimicrobial natural products for antibiotic resistance efforts. From our recent screen of 75 chemical extracts of diverse algal-bacterial origin, we found 25 extracts to have antimicrobial properties against bacteria and/or fungi. We will be performing chemical analysis to identify the active natural products in these extracts. Through these diverse, concerted efforts, our work in identifying novel volatile biomarkers and antimicrobial natural products will support and enhance national energy security and biosecurity efforts.

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

POSTER

Number: 100

Galassi F. G., Picollo M.I., and Gonzalez A. P.

Aggregation in the head lice (Pediculus humanus capitis): response to and chemical analysis of volatiles and no volatiles from their own faeces.

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The head louse Pediculus humanus capitis (De Geer) (Phthiraptera: Pediculidae) is a cosmopolitan human ectoparasite that causes pediculosis, one of the most common parasitic arthropod conditions in humans. The mechanisms and / or chemicals involved in the lice aggregation are still unknown. In this study, we evaluated the response of head lice to faeces extracts and volatiles that emanate from their faeces. In addition, we identified the volatiles components of the faeces and the extracts. The volatiles were collected by means of Solid Phase microextraction (SPME) and the extracts obtained were chemically analyzed by GC-MS. The faeces were extracted in three different solvents with increasing polarity (Hexane, dichloromethane and methanol) and analysed by HPLC-MS. Twenty-nine volatiles were identified in the faeces, with the main compounds being the aldehydes (hexanal, nonanal, decanal). Head lice were highly attracted by the blend own faeces volatiles, as well as by the methanol extract with feces (the higher polarity solvent). Only two purines, uric acid and guanine, were found in the HPLC-MS analysis of faeces extracted in methanol. The results of this study indicate that lice can use volatiles and non-volatiles chemical signals that generate aggregation behaviours.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 88

Geedi R.[1], Ranger C. M.[1], Canas L.[2], Reding M. E.[1] and Castrillo L.[3]

Microbial Volatile Emissions Mediate Attraction of a Generalist Herbivore to a Fatal Fungus

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Some insect herbivores use microbial volatile organic compounds (MVOCs) to detect and avoid entomopathogenic fungi, but MVOCs can also function as attractants. Attracting insect hosts would be beneficial to Beauveria bassiana since it requires direct contact for infection and has no other active mechanisms of dispersal. We conducted a series of experiments to assess host-pathogen interactions between the generalist insect herbivore Myzus persicae and B. bassiana. The specific objectives were to assess M. persicae behavioral responses to B. bassiana, and identify MVOCs from B. bassiana. A variety of behavioral bioassays determined M. persicae were preferentially attracted within 10-15 minutes to cultures and dry conidia of B. bassiana. Mortality risk of M. persicae also dramatically increased from their attraction to B. bassiana. Solid phase microextraction-gas chromatography-mass spectrometry (SPME-GC-MS) identified MVOCs emitted by cultures and conidia of B. bassiana. Forthcoming olfactometer studies will assess the behavioral responses of M. persicae to these MVOCs as individual compounds and blends. Characterizing and enhancing the attraction of M. persicae to B. bassiana could improve the efficacy of biopesticide and mycoinsecticide tactics as part of IPM programs. Key words: Beauveria bassiana, Myzus persicae, virulence, host-pathogen interactions, microbial volatile organic compounds, entomopathogen.

Themed Session: Insect-Microbe Chemical Communication

POSTER

Number: 36

Gerdt J.[1], Brancucci N.[2], De Niz M.[2], Marti M.[2], and Clardy J.[1]

The Chemical Ecology of Stress, Warning Signs and Fear

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The malaria-causing protozoan Plasmodium falciparum infects hundreds of millions of people annually. It is transmitted by mosquito vectors, and senses chemical cues from the human and mosquito hosts in order to finely regulate its life cycle. One of the parasite's key life cycle transitions occurs in an infected human: asexual Plasmodium cells mature into sexual gametocytes. Gametocytes are incapable of multiplying further within the human, but instead are the transmissible form that can be taken up by a new mosquito vector. Therefore, each Plasmodium cell's gametocytogenesis "decision" determines whether that individual will remain in the human host for another cycle of multiplication, or leave the body to infect a new host. We hypothesized that Plasmodium senses chemical cues in its human host to determine whether or not it should commit to its transmissible gametocyte form. Indeed, using an in vitro gametocytogenesis assay and activity-guided fractionation, we found that human serum lysophosphatidylcholines (lysoPCs) inhibit gametocytogenesis. Metabolomics studies revealed that Plasmodium depletes lysoPCs from both in vitro culture and within hosts in vivo. Therefore, we conclude that asexual blood stage Plasmodium senses its chemical environment in the human host; after it senses depleted levels of lysoPC, the parasite converts to the transmissible gametocyte stage. This finding can be leveraged to identify molecular targets against the transmission of malaria.

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

POSTER

Number: 79

Gonzalez P. V., Rodriguez M., Costa A.A., Masuh H., and Harburguer L.

δ- Dodecalactone a natural origin substance as a candidate mosquito repellent for *Aedes aegypti* (Diptera: Culicidae).

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Aedes aegypti is the main vector of arboviral diseases. The first line of defense that is possible to constitute between mosquitoes and humans is the use of repellents. N,N-diethyl-3-methylbenzamide (DEET) is a synthetic insect repellent used worldwide. δ-dodecalactone is an aliphatic lactone widely found in vegetable tissues. This study evaluate the repellent effect on Ae. aegypti females of δ-dodecalactone alone and in combination with DEET through different behavioral bioassays. A petri dish with a filter paper divided into a treated zone (different concentrations of δ-dodecalactone alone and in combination with DEET) and a control zone. The individual behavior of the females was analyzed with the Ethovision XT video tracking software, which allowed the automated tracking and quantification of the behavior. We calculate behavioral variables and the repellency index. A decrease in the activity variables was observed for those concentrations that showed a repellent effect with δ-dodecalactone alone and in combination with DEET. Bioassays on pigeons were conducted with a section of skin impregnated with the effective concentrations of δ-dodecalactone. We obtained 100% feed inhibition (FI) with δ-dodecalactone alone and in combination with DEET during the 120 min of the assay. Also 100% FI was obtained with 7% δ-dodecalactone (same as commercial use dose for DEET). The results showed an effective repellent effect of the δ-dodecalactone alone and in combination with DEET.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 70

Goodwin R. J. A.

The impacts of microplastic ingestion on the physiology of a marine worm, *Nereis diversicolor*

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Since the industrial revolution humans have placed a heavy reliance upon synthetic materials to facilitate modern life. This extensive utilization has caused exponential growth of the world's plastics production from 1.7 million tonnes during the 1950s, to over 5 million tonnes in 2018. There is a growing concern that plastics pose an increased threat to marine life. It is estimated that 10% of plastic waste will enter the world's oceans. Plastics that enter the ocean are subject to mechanical and chemical processes that progressively degrade them into smaller fragments called microplastics. Microplastic is found in the stomachs of many marine animals, readily accumulates in body tissues and microplastic toxicity is expected to have negative fitness costs. The present study aims to identify how microplastic exposure and/or ingestion impacts key fitness traits, in Nereis Diversicolor, sampled in the Humber estuary (N=1200), FTIR analysis will be performed to identify microplastic content of body tissues and deduce a geographical origin. The effects of microplastics toxicity on overall fitness will be tested by exposing N. Diversicolor (N=500) to similar types of microplastic found in the Humber, using a series of behavioral assays. The overall goal of the study is to highlight fitness costs associated with microplastic toxicity and is expected to inform the impact of feeding responses associated with microplastic toxicity, which may cause ramifications on plastic production.

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

POSTER

Number: 101

Guo X., Miao C., Li W., Zhao M., Wang X., and Dong S.

Ovipositional choice response of *Helicoverpa assulta* mated females to volatiles derived from different tobacco species

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Mated females of the oriental tobacco budworm, Helicoverpa assulta (Guenée) (Lepidoptera: Noctuidae), showed much stronger ovipositional preference to Nicotiana rustica than to N. tabacum. This result was confirmed in the comparison of solvent extracts. A total of 37 components was detected in the headspaces of the two Nicotiana species during different stages (vegetative stage and flowering stage) by gas chromatography-mass spectrometry (GC-MS). Among these, nicotine, nonanal, (E)-3-hexen-1-ol, and D-limonene, were major components. However, when synthetic volatile blends mixed in corresponding natural ratios of different species at different stages were compared, a mixed result were obtained. When volatile blends derived from tobacco vegetative stage were compared, H. assulta preferred N. rustica to N. tabacum; the rank was reversed when those derived from tobacco flowering stage were compared. Further testing on the ovipositional choice response to individual volatiles indicates that nonanal and nicotine showed oviposition-stimulating effect on H. assulta, while benzaldehyde showed significant oviposition-deterring effect on H. assulta. Keywords: elicoverpa assulta; Tobacco, Nicotiana rustica; Nicotiana tabacum; Volatile; Oviposition #.

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

POSTER

Number: 6

Hansen B., Collins A., El-Hifnawi L., and Traxler M.

The Root Nodule Microbiome: A Model System for Microbial Chemical Ecology

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Microbiomes and their complex network of chemically-driven interactions are inherently difficult to decipher. Synthetic communities attempt to deconstruct these interactions, however, they are limited in their ecological relevance. With a model system reflecting the natural environment, we can assess community interactions in the context of ecological theory without encountering these limitations. Our candidate for such a system is the root nodule of alfalfa and its simplified accessory community. The nodule is a symbiotic structure that forms on the roots of leguminous plants and provides a niche for Rhizobia and a small accessory community. After growing alfalfa in a variety of soils, harvesting nodules in a time-course framework, and profiling the community using 16S sequencing, we developed a plant-mediated method of selection to arrive at a 5-member community capable of producing antimicrobial compounds in vitro. To understand the role of antibiotics in structuring this community, we grew plants in gnotobiotic conditions and aimed to detect production in planta using analytical chemistry, while also characterizing the impact a single strain has on community structure. Taken together, these data suggest that the antibiotics they produce may be influencing the accessory community profile. Once this community is fully characterized, we envision this experimental model to serve as an approach to address the role antibiotics play in mediating interactions within a microbiome.

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

POSTER

Number: 80

Hansen L.[1], Xu T.[1], Hao D.[2], and Teale S.[1]

Host Olfactory Percepts of *Anoplophora glabripennis* and *Anoplophora chinensis*

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The Asian and Citrus Longhorned Beetles (Anoplophora glabripennis and Anoplophora chinensis) are East Asian Cerambycids whose outbreak and invasive tendencies have made them an international pest control focus. Both species are broadly polyphagous, infesting a variety of common trees including Acer, Salix, and Populus species. The host range of Citrus Longhorned Beetle also includes economically valuable fruit trees such as Citrus and Prunus species. We investigated the comparison of host and nonhost headspace volatiles as a method to determine the host percepts of the two pests and improve monitoring lures. Static headspace aerations were collected from seven species of hardwoods. The quantities of Asian Longhorned Beetle antennally active volatiles in hosts and nonhost samples were then compared using multivariate statistical methods to determine host indicative compounds for both species. Monitoring lures containing a subset of Asian Longhorned Beetle host indicative compounds were evaluated in Bengbu, China alone and in combination with 4-(n-heptyloxy)butan-1-ol and 4-(n-heptyloxy)butanal, pheromone components that have previously been reported to significantly attract both species. Host indicative compounds were not significantly attractive by themselves and did not synergize attraction to the pheromone components.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 89

Hardege J.D., Schirrmacher P., Roggatz C., Benoit D. M., and Bartels-Hardege H.

Impacts of ocean acidification on chemically-mediated behaviours – from signalling cue to behavioural response

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Ocean acidification, also named the 'evil twin of climate change', is a growing threat to life in our oceans. Besides global warming, climate change leads to a rapidly increasing absorption of atmospheric carbon dioxide. The disturbed ocean carbon chemistry and a decreasing pH level pose a major threat to chemical-ecological processes. Here we give an overview of how this acidification can impact chemically-mediated behaviours. We thereby look at the effect of ocean acidification at different levels from the signalling cues themselves via the reception of cues to the actual behavioural and physiological responses. Our research highlights that a wide range of behaviours are affected by pH shifts relevant for climate change scenarios. Foraging, mating, brood-care and settlement of marine invertebrates are altered at one or more of the investigated levels. As all these interactions are fundamental to a functioning ecosystem, we urgently need to develop a more detailed understanding of the mechanisms by which ocean acidification impacts marine life to be able to predict and model such future impacts.

Themed Session: Language of Life under Climate Change

POSTER

Number: 44

Hoffman-Campo C. B., Magalhães S. P., Da Graça J. P., Zeraik M. L., and Nunes E., Gazzoni D. L.

Volatile compounds of soybean flowers (Glycine max l.Merrill) by microextraction at the solid phase combined with gas chromatography coupled to mass spectrometry (SPME-GC-MS)

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Bees are currently observed in soybean (Glycine max L. Merrill) field, even if this plant is considered cleistogamic and self-pollinated. However their effect on the pollination of soybean plants remains unsolved. Volatile organic compounds (VOCs) released by flowers are one of main plant attractants for pollinators, and the aim of this studies was optimizing a method to VOCs collecting and making possible the metabolite analyses exclusively released by floral tissue. Optimization of the static headspace (HS) and solid phase microextraction (SPME) techniques were performed and gas chromatography (GC) coupled to mass spectrometry (GC-MS) was used to analyze VOCs produced by soybean flowers. Three SPME fibers with different polarities as polydimethylsiloxane (PDMS), polydimethylsiloxane/divinylbenzene (PDMS/DVB) and divinylbenzene/carboxene/ polydimethylsiloxane (DVB/CAR/ PDMS) were tested with flowers of 'BRS 399' and 'DONMARIO 6563'. In general, the SPME technique plus PDMS/DVB fiber showed a greater amount of VOCs in both cultivars. After using SPME plus PDMS/DVB fiber, 45 VOCs were detected from `DONMARIO 6563`. A few flowers VOCs here were previously reported in other soybean structures and the method developed has an innovative contribution. The identification of VOCs released exclusively by soybean flowers, and this achievement potentially will allow further studies for better understanding of the interaction between soybean flowers and pollinators.

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

POSTER

Number: 28

Hoffman-Campo C. B., Parpinelli R., Alves J., Vagner T., Nunes E. O., and Gazzoni D. L.

Carbohydrates profile on nectar of soybean flowers

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Although the soybean is considered a self-pollinating crop, pollinators like honey bee (Apis mellifera) are observed foraging on soybeans fields. Several studies have been performed, but still there is no consensus among scientists about the role of pollinators found on soybean crop, and several questions remain unanswered, mainly regarding soybean yield increase. This study aimed to evaluate the adequacy of the soybean nectar sugar profile as a floral reward to pollinators. A chromatographic analytical multi-detection method for 8 different sugars (fructose, glucose, saccharose, maltose, erlose, melezitose, raffinose and stachyose) was developed, by using HPLC with refractive index detector. The operational conditions were: mobile phase (ACN/H2O – 75:25, v/v), flow (1.4 mL.min-1), oven (T=35°C), column (µBondapackTM) and pre-column with the same conditions. Calibration curve, limits of detection and quantification were established. Nectar samples were collected from flowers (purple and white) of soybean grown on field and greenhouse, and analysed by the methodology described above. The sugar profile mainly varied in a quantitative basis. The ratio fructose/glucose of the samples was ± 1.17, and sugars like erlose, melezitose, raffinose and stachyose were not detected, but they might show up as we expand the study using a broader soybean genetic array, as there are evidences that both the sugar profile and the amount of sugar on soybean nectar are genetically controlled.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 22

Hoffman-Campo C. B., Cotrim G., Aquino M., Gazzoni D. L., Oliveira Junior A., and Nunes E. O.

Metabolomics fingerprint on soybean leaves in response to variation of the potassium amount on soil fertilization

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Metabolomics studies were performed to evaluate the effect of potassium (K) on the secondary metabolites profile on the tissue of soybean leaves. A field experiment was settled using four rates of K (0, 40, 80 and 160 kg.ha-1 K2O) applied on the soil. Soybean leaves were collected at V6 stage and extracted with MeOH/H2O (80:20 v/v). Aliquots of leaf extracts were analyzed by UPLC-QTof-MSE, ionization for ESI, in negative mode. The raw data were analyzed by MarkerLynx XS 4.1 (Waters) to identify potential chemical markers influenced by the treatments. Principal component analysis (PCA) was performed and metabolites were discriminated by multiple orthogonal partial least-squares discriminant analysis (OPLS-DA). The total number of detected ions (m/z) after data processing were 1458, and 13 metabolites belonging to the linolenic acid, cutin, suberine, wax, phenylpropanoids mainly flavonoids and terpenoids metabolism. Most of detected compounds are related to plant defense mechanisms, thus further studies should be performed, regarding the role of K on soybean resistance to stresses caused by pathogens and insect-pests.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 49

Ibarra Bouzada L., Concha I. M., García M., Perusset A., Cecere C., León J. R., and Guerenstein P.

Olfactory responses in the brain of triatomines, hematophagous insects vectors of Chagas disease

CICyTTP (Centro de Investigaciones Científicas y Trasferencia de Tecnología a la Producción)- Fac. de Bioquímica y Cs. Biológicas (Universidad Nacional del Litoral)

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Chagas disease is an important vector-borne neglected tropical disease. The prevention of vector-borne transmission of Chagas disease in endemic areas relies on suppressing house infestations by triatomine bugs. Triatoma infestans is the main vector species in the southern cone countries of South America. We aim at developing an efficient host-based odor blend attractant to be used as a lure in a trap to monitor triatomines. In insects, odorants are detected by olfactory receptor cells (ORCs) mainly on the antenna. Insect ORCs project to the antennal lobe (AL) in the brain. The AL is the first information-processing center of the olfactory system. Odor mixtures are more attractive than single odorants. In order to understand how information about potentially attractive odor mixtures is processed in the triatomine brain it is necessary to study the responses of AL neurons to single odorants and their mixtures. Using a multichannel recording technique we recorded the activity of neurons in the AL of T. infestans nymphs upon stimulation with synthetic and natural odorants. Responses to a number of synthetic and natural odorants or their mixtures were obtained. Synthetic odors included (+)a-pinene, valeric acid, 1-octen-3-ol, nonanal, isobutyric acid, isobutylamine, ammonia, indole, benzyl alcohol, acetophenone, pyruvic acid, L(+)lactic acid, 3-methyl 1-butanol, and propionaldehide;(some of them not previously known to be detected by triatomines).

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 90

Johnson T., Kula R. R., and Hanks L. M.

Identification of natural enemies by proxy: deployment of aggregation-sex pheromones of longhorned beetles (Coleoptera: Cerambycidae) facilitates the discovery and identification of their parasitoids

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The use of pheromones is critical for the location of mates for many species of beetles in the family Cerambycidae. Parasitoids are known to use pheromones of their hosts as kairomones to locate opportunities for oviposition. We conducted a field study to test the hypotheses: species of parasitoids would be attracted to pheromones of their host species, but not those of other cerambycid species, as well as that attraction to pheromones can be used to predict host relationships. Bioassays were conducted in a wooded area in east-central Illinois, USA during June - August 2016 using transparent sticky traps. We baited traps with one of the following pheromones of cerambycids diluted in isopropyl alcohol: anti-2,3-hexanediol, syn-2,3-hexanediol, anti-2,3-octanediol, syn-2,3-octanediol, or isopropyl alcohol (solvent control). We found a significant treatment effect for Wroughtonia sp. (probably ferruginea), with the greatest number of individuals captured only on traps baited with syn-2,3-hexanediol. Wroughtonia ferruginea has been reported as a parasitoid of the cerambycid Neoclytus acuminatus which produces syn-2,3-hexanediol as its pheromone. This result constitutes support for both of our hypotheses. Because N. a. acuminatus has become invasive in Europe, W. ferruginea may be a candidate for biological control of N. acuminatus in these locations. Further research on the host-specificity and behavior of W. ferruginea should be conducted to determine if this is viable.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 71

Jones T. H., Curry C. J., Wolfin M. S., and Baker T. C.

The structure and synthesis of two EAD active ketols from the mushroom fly *Megaselia halterata*

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The phorid mushroom fly, Megaselia halterata (Wood) is a pest of commercial mushroom production. The adult flies spend the majority of their time mushroom houses laying their eggs in compost, and the larvae feed on and destroy growing mycelium. Although 3,6-dimethyl-2,4-heptanedione was identified in 1982 as a female specific (sex?) pheromone of M. halterata, we have recently observed two other EAD active components in the whole-body extracts of M. halterata whose structures were established by unambiguous synthesis as the diastereomers of 2-hydroxy-3,6-dimethylheptan-4-one. The relative stereochemistry of each isomer was determined by comparison of their 13C nmr spectra to the published spectra of simpler analogs. Bioassays are ongoing to confirm the behavioral activity of these EAD active compounds.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 91

Joubert J., Hammerbacher A., Hurley B., and Schroder M.

Host preference of Gonipterus sp. 2 and chemical analysis of susceptible and resistant Eucalyptus species

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The Eucalyptus snout beetle (Gonipterus sp.2) is a re-emerging pest of eucalypt plantations around the world. Gonipterus prefers to feed on specific Eucalyptus species. However, the mechanisms underlying this preference is poorly understood with multiple studies showing different levels of resistance for the same species. Since the chemical cues behind this selective feeding behaviour are largely unknown, we conducted a series of feeding preference trials in the laboratory. This allowed us to rank several of the Eucalyptus species present in South Africa by their relative level of resistance to feeding. Different genotypes of 3 Eucalyptus species showing different levels of resistance were selected for analysis using both gas chromatography as well as liquid chromatography coupled to mass spectrometry. We discovered several compounds that either correlated strongly positively or negatively with insect feeding preference. Furthermore, we developed an artificial diet for Gonipterus which can be used in future to study the physiological effects of the compounds we identified.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 72

Karthi S., and Senthil-Nathan S.

Comparative efficacy of two mycotoxins from *Beauveria bassiana* (Bals.) Vuill. and *Metarhizium anisopliae* (Metchnikoff) Sorokin against *Spodoptera litura* Fab. and their non-target activity against the earthworm, *Eudrilus eugeniae* Kinb.

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Entomopathogenic fungi are feasible and effective against the agricultural pest. In the current research we intensive on bioactive comparison of two widely accepted entmopathogens against the destructive pest Spodoptera litura (Fab.) through the assessment of larval tolerance and regulation of antioxidants and non-target impact on the soil dweller worm, E. eugeniae, in evaluation to commercial pesticides. The entomopathogenic fungus exposure resulted in the modification of the levels of detoxification enzymes as well as significant increases in catalase and superoxide dismutase activity after exposure of entomopathogenic fungus. Bioassay results showed that B. bassiana and M. anisopliae displayed larval mortality against third and fourth instars. Correspondingly, sub-lethal dosage of B. bassiana showed slightly higher alterations in the development as compared to M. anisopliae. Gut-histology revealed that mycotoxins dosage (4×105) showed significant changes in the midgut tissues as compared to control

larvae. The non-target screening through artificial soil assay on beneficial worm E. eugeniae, with mycotoxins B. bassiana (5×108 conidia/ml/kg) and M. anisopliae (5×108 conidia/ml/kg) showed less toxicity as compared to Monocrotophos (10 ppm/kg). Current results suggest that the fungal mycotoxins of M. anisopliae and B. bassiana significantly reduce the development of lepidopteran pests, while having only lesser impact on beneficial earthworms.

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

POSTER

Number: 81

Kinnby A., White J., Toth G., and Pavia H.,

Ocean acidification affects the growth and chemical defense of a habitat forming seaweed and the condition of a snail grazer

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Ocean acidification driven by anthropogenic climate change is projected to cause a drop in pH of 0.4 units by the year 2100. Previous studies have shown that seaweeds grown under such conditions developed tissue damage, and that calcified herbivores struggle to maintain shell density. It is not clear how these changes might impact interactions between algae and herbivores, e.g. through changes in respiration and growth rates, or defense production. We cultured Fucus vesiculosus for 30 days in the projected future pCO2 (1100 ppm) with genetically identical controls in ambient pCO2 (400 ppm). After this, we conducted grazing experiments using Littorina littorea, acclimated to the relevant pCO2 treatment. We found increased growth in algae exposed to high CO2-levels, and a lower phlorotannin content. The grazers had a significantly higher condition index but consumed less when exposed to elevated pCO2.

The implications of changing abiotic factors on individual species are relatively well understood, but predicting changes to interspecies relationships is more challenging. Our results demonstrate some of the changes in algae, grazers, and their interaction, with likely consequences for algae, grazers, and their predators. The changes in surface area and phlorotannin content in F. vesiculosus suggest increased vulnerability to mechanical damage. This could have effects on coastal ecosystems by reducing both the habitat available to small animals and the food available for grazers.

Themed Session: Language of Life under Climate Change

POSTER

Number: 45

Kofsky J., and Song B.

Identification of novel SCN resistance strategies in wild soybean

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The domestication process of crop plants often involves selection for agronomic traits against the plant's intrinsic resistance strategies. Thus, domestication processes decrease genetic variation, making crop plant varieties more susceptible to pests than their wild relatives. Domestication of the wild soybean (Glycine soja) accounts for a major loss is genetic diversity. The G. soja gene pool is indisputably more diverse than the cultivated soybean (Glycine max) due to a primary loss of nucleotides in domestication and continued loss due to selection and modern breeding practices. Therefore, we dissect the diversity contained in the wild soybean population, which has been going through differential stress from varying environments, as a naturally adapted source of resistance. In this study, resistance to Soybean Cyst

Nematodes (SCN) is investigated in a newly identified SCN resistant ecotype. In order to investigate the global gene expression changes, we compare RNA seq-based transcriptomes of the novel SCN-resistant wild soybean ecotype vs. other resistant and susceptible genotypes. All accessions were inoculated with SCN HG type 2.5.7. This project identified candidate genes and associated pathways involved in SCN resistance and advances the long-term goal to develop SCN resistant soybean cultivars, which has crucial significance to agriculture and environmental sustainability.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 23

La Forgia D., Jaffuel G., Herrera R. C., Turlings T. C. J., and Verheggen F.

The lure of hidden death: Attractive volatile organic compounds to attract wireworms towards entomopathogenic nematodes

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Most of the research on the interactions between insect herbivores and plants focus on the aboveground parts, but there is a growing interest in belowground plant-insect interactions. Like most soil dwelling pests, wireworms use Volatile Organic Compounds (VOCs) released from the rhizosphere to locate a suitable host. It has been proposed that specific VOCs can be used in attract-and-kill strategies with

biological alternatives to pesticides. In order to develop such an attract-and-kill strategy, we aimed to (1) identify VOCs from maize roots that are particularly attractive to wireworms and (2) select an entomopathogenic nematode (EPN) that readily infects and kills wireworms. Field observations have revealed considerable differences between two maize varieties in infestation levels by wireworms. We identified the VOCs from their roots and found that the less susceptible variety released a more complex VOC blend than the other. Two VOCs, hexanal and β-caryophyllene, were found in the VOC profiles of maize and potatoes, and were tested for attractiveness in olfactometer assays. We are also testing the combination of these compounds in alginate beads containing EPN for attractiveness and biocidal effects under laboratory conditions. Using VOCs as attractants and EPN as biological agents represent a promising alternative to pesticides that remains to be evaluated in the field.

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

POSTER

Number: 7

Liu F., Kong X., Zhang S., and Zhang Z.

Identification and Syntheses of the Sex Pheromone of *Micromelalopha troglodyta* from China

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Micromelalopha troglodyta (Graeser) is one of serious defoliators of poplars in China. The gas chromatography-electroantennographic detection (GC-EAD) results indicated that male moth antenna was detected to elicit sensitive reaction to one component of the sex gland extract of the virgin female

moth; Based on gas chromatography-mass spectrometry (GC-MS) data of the extract and the additive derivative of 4-methyl-1,2,4-triazoline-3,5-dione (MTAD), 13,15-octadecadienal has been identified as the main active component of sex pheromone of this insect; But the configuration of these double bonds have not been determined, due to lacking of standard compounds. This project is to stereoselective synthesize four geometric isomers of 13,15-octadecadienal [(13Z, 15Z), (13Z, 15E), (13E, 15Z) and (13E, 15E)-octadecadienal], using the C12+C3+C3 strategy. With biological activity test to identify the composition information of the active component. The above study provides a reference for the use of sex pheromone to monitor the population and control of this pest.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 92

Liu Y., and Wang G.

Patterns in the distribution and functional conservation of olfactory receptors among lepidopterans underscore the flexibility of OR repertoires

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Odorant receptor (ORs) play a central role in olfactory system, and functionally characterizing OR repertoires is an essential step for studying olfactory mechanisms of certain insects, yet there have only been a few reports outside Drosophila melanogaster. Here, we report our comprehensive profiling of the receptor functions of the entire OR repertoire of the cotton bollworm Helicoverpa armigera using our highly flexible and sensitive analytical platform. Our in vitro screen with a large diversity of 67 plant volatiles as triggers revealed robust responses of HarmORs as 28 of the 44 ORs responded to the triggers. Further, our functional comparison with S. littoralis revealed that tuning reactivity of ORs can differ substantially, only a small number of ORs function conservatively. One of the functional conserved ORs-HamOR42 was predicted to be essential for sensing of phenylacetaldehyde, this is confirmed by follow-up in vivo studies through CRISPR/Cas9 combined with electrophysiological and behavioral experiments. Our research provides a reference for further studies of olfactory mechanisms in Lepidoptera and opens the door for genetic-based manipulation of OR-mediated insect behaviors.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 66

Lortzing V., Valsamakis G., Fuchs B., Fatouros N., Kunze R., and Hilker M.

Prepared by timing: The dynamics of plant anti-herbivore defense primed by insect egg deposition

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Plants can take insect egg deposition as “warning” of impending larval herbivory and then reinforce their feeding-inducible defenses. Pieris brassicae larvae perform worse on egg-deposited Arabidopsis thaliana plants than on egg-free ones. This priming effect depends on salicylic acid-(SA-) mediated signaling and enhanced expression of defense-related genes.We addressed the questions: (i) How long must the egg stimulus persist on a leaf until the plant displays a “primed response” and (ii) does egg deposition accelerate the feeding-induced defense response? The questions were addressed by measuring the larval performance and A. thaliana gene expression at one to six days after egg deposition and by determining the kinetics of phytohormone levels after the onset of larval feeding. Our results show that A. thaliana reaches its fully primed state when having “experienced” P. brassicae eggs for five days, i.e. one day before larvae hatch. The transcript levels of “primeable” marker genes correlated with the power of the priming effect of previously egg-laden plants on larvae (readout: reduction of larval weight). Furthermore, our phytohormone data suggest that the plant´s response to egg deposition accelerates the subsequently feeding-induced defense response of A. thaliana against P. brassicae. We conclude that the plant invests in “full priming” shortly before larvae will hatch, and then seems to speed up its defense against the actual threat, the feeding larvae.

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

POSTER

Number: 102

Maleki A. F., Seidl-Adams I., and Tumlinson J. H.

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: Language of Life under Climate Change

POSTER

Number: 46

Martin C., Vanderplanck M., Boullis A., Francis F., and Verheggen F.

Forensic chemical ecology: how do necrophagous insects perceive and impact the smell of a cadaver?

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After death, corpses undergo a complex decaying process, during which volatile organic compounds (VOCs) are released. Necrophagous insects use these VOCs to find their feeding and oviposition sites. The impact of the presence of necrophagous insects on a cadaver on the cadaveric VOC profile, remains to be tested. In this study, dead rats were left to decompose under four modalities: (i) without necrophagous insects, (ii) in presence of Lucilia sericata, (iii) in presence of D. frischii and (iv) in presence of both Lucilia sericata and D. frischii. VOCs released during the different decaying stages (fresh, bloated, active, advanced and dry remains) were sampled with thermodesorption tubes (Tenax Ta®) and analysed by GC-MS. Solvent-eluted SuperQ® filters were also used to collect cadaveric VOCs to be used during subsequent behavioural trials. All rats went through the five decomposition stages with the exception of rats decomposing without insects. The volatile profiles differed among decaying stages, but were not affected by the presence of insects. During a multiple-choice bioassay, blowflies were exposed to the four above-mentioned blends of odours, and were shown to prefer the odour of a corpse where conspecific larvae were present. Two-dimensional gas chromatography coupled with high resolution mass spectrometer analysis should be performed in the future to reveal indicator compounds of the presence of necrophagous insects.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 93

Martini X., and Stelinski L.

Development of a push-pull system for the redbay ambrosia beetle *Xyleborus glabratus*, vector of the laurel wilt pathogen

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Laurel wilt is a vascular disease that has caused extensive mortality of trees and shrubs in the Lauraceae family, which include species such as Redbay, Persea borbonia and avocado P. americana. Laurel wilt is caused by the fungus Raffaelea lauricola that is vectored by the exotic redbay ambrosia beetle, Xyleborus glabratus. We discovered that levels of methyl salicylate (MeSA) significantly increased in redbay three days post inoculation with R. lauricola, and that X. glabratus was significantly repelled by MeSA in olfactometer bioassays. We decided to test MeSA in field condition, as well as verbenone, an anti-aggregation pheromone that has been found to repel a wide diversity of bark beetles. During the experiment conducted on cut redbay bolts, we observed a decrease in terms of arrivals to the bolts as well as number of boring holes found in the bolts at the end of the study for both MeSA and verbenone treatments. However, on subsequent experiments conducted on whole trees on a larger scale only verbenone significantly repelled redbay ambrosia beetles. In a final step, we included verbenone in a push-pull system in forest and avocado grove settings. In redbay, the attractant used was α-copaene while ethanol was used in avocado orchards. In both situations, we were able to significantly reduce the number of beetles attacking redbay and avocado. In redbay, we were able to reduce beetle populations by nine fold as compared with untreated controls.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 73

Matsunaga T., Goldman-Huertas B., Karageorgi M., Suzuki H., and Whiteman N. K.

Evolution of olfactory receptors tuned to mustard oils in a leaf-mining drosophilid fly

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Insects are equipped with an array of chemoreceptors that play a major role in their adaptive behaviors. Trophic shifts often coincide with chemoreceptor expansions through receptor duplication events. When a gene duplication event gives birth to a new Or gene, purifying selection is relaxed for one of the gene copies. Thus the second copy of this receptor could reshape the response curve to increase sensitivity to olfactory cues in the new environment. However, the adaptive significance of this consequence has not been largely demonstrated. In the drosophilid clade Scaptomyza, the herbivorous S. flava evolved from microbe-feeding ancestors. In S. flava, Or67b was triplicated into three paralogs (SflaOr67b1-3), and they show signatures of positive selection. The closely related microbe-feeding S. pallida and D. melanogaster, on the other hand, have only one copy of the Or67b ortholog. The ortholog of Or67b in D. melanogaster (DmelOr67b) responds to several ligands, including green leaf volatiles (GLVs). This suggests that the SflaOr67b1-3 could also be involved in the detection of GLVs, which are the only volatiles S. flava responds to in its host plant. We use SflaOr67b1-3 as a model system to test whether the response curves of the SflaOr67b1-3 have been reshaped. We utilized empty neuron system to characterize the odorant response curves of SflaOr67b1-3 and Or67b in S. pallida (SpalOr67b). We round that DmelOr67b and SpalOr67b, but not SflaOr67b1-3, are activated by simila.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 27

Maynard L. D., and Whitehead S. R.

Ecological patterns and significance of secondary metabolites in a Neotropical shrub, *Piper sancti-felicis*

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Rooted in place, plants often rely on secondary metabolites to mediate interactions with other organisms. Both attraction of mutualists and defense against antagonists are thought to be mediated by secondary metabolites. Piper is one of the largest genera of flowering plants, containing about 1,000 species. This study describes the secondary metabolites occurring in the infructescences of Piper sancti-felicis and their functional significance in ecological interactions. We focus on one group of compounds: alkenylphenols. We had three specific objectives: 1) to elucidate the structures of the major alkenylphenol compounds present in the infructescences of P. sancti-felicis; 2) to describe the natural variation in alkenylphenol composition throughout infructescence development and across individual plants; and 3) to test the ecological significance of the alkenylphenols in fruit defense against fungi. Results suggest that alkenlyphenol concentration in infructescences significantly differed among individual plants, developmental stages, and individual compounds. Alkenylphenol concentration was higher in unripe infructescences compared to inflorescences with high interspecific variation. Results from the microdilution bioassays revealed that as alkenylphenol concentration increases, absorbance decreases. This is the first study to describe alkenylphenols in P. sancti-felicis and their ecological function as defensive secondary metabolites, possessing anti-fungal properties.

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

POSTER

Number: 82

Meents A. K., Chen S., Reichelt M., Lu H., Bartram S., Yeh K., and Mithöfer A.

A single volatile induced systemic herbivore resistance in leaves of sweet potato (*Ipomoea batatas*)

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Plants perceive and respond to volatile signals in their environment. Often, neither the perception mechanisms nor the nature of these signals is known. Upon herbivory, blends of volatile organic compounds (VOCs) are released from infested tissues to attract predators of higher trophic levels and /or initiate systemic defense reaction in leaf-to-leaf and plant-plant communication. We show in leaves of the crop Ipomoea batatas (sweet potato) that herbivory-induced jasmonate phytohormones accumulate locally but the defense-related Sporamin polypeptide, a protease (trypsin) inhibitor, accumulates systemically. Among various herbivory-induced VOCs, one abundant compound was identified as (E)-4,8–dimethyl–nonatriene (DMNT). This homoterpene is sufficient for an airborne systemic induction of defensive Sporamin protease inhibitor activity in neighboring sweet potato plants. This induction is jasmonate independent and does not need any further priming-related challenge. Responsiveness to and strongly induced emission of DMNT is restricted to a herbivory-resistant cultivar (Tainong 57) while a susceptible cultivar, Tainong 66, neither emitted significantly higher levels of DMNT nor showed reaction to this VOC. This result is consistent with the finding that Spodoptera larvae feeding on DMNT-exposed cultivars gain significantly less weight on Tainong 57 compared to Tainong 66. Our results indicate a highly specific, single volatile-mediated plant-plant communication in sweet potato.

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

POSTER

Number: 8

Mevers E., Pishchany G., Su L., Kolter R., Ajo-Franklin C., and Clardy J.

Bacterial-derived electron shuttle

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Shewanella oneidensis MR-1 is a facultative anaerobic γ-proteobacterium that has the ability to utilize a diverse suite of terminal electron acceptors, including insoluble solid metal oxides. The mechanisms underlying how MR-1 indirectly shuttles electrons to these solid substrates are poorly understood. In 2000 chemical analyses of MR-1's spent supernatant revealed that MR-1 excretes a small labile molecule that has the ability to recover anaerobic respiration of mutants on solid substrates, but the active metabolite was never identified. Revisiting this lack of identity with specialized resin, HR-LCMS analysis, and total synthesis, led to its identification as 2-amino-3-carboxy-naphthoquinone (ACNQ). ACNQ potently recovers anaerobic respiration in a mutant strain (ΔmenC: menaquinone mutant) on solid substrates (EC50 of 25 nM) and can significantly increase current generation in Mtr-expressing E. coli strains. ACNQ is derived non-enzymatically from a primary metabolite, 1,4-dihydroxy-2-naphthoic acid (DHNA) and is produced by all other anaerobic bacteria (facultative and obligate) investigated. In summary, the discovery of ACNQ provides a better understanding as to how MR-1 shuttles electrons to insoluble terminal electron acceptors. This discovery has several potential applications, including medical uses like treatment of mitochondrial disease and bioenergy.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 63

Mitchell R. F., Jenson A., Scully E. D., and Oppert B.

An emerging model of odorant receptor evolution in insect pests of stored products

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Odorant receptors (ORs) are the primary mechanism by which insects detect volatile compounds, and presumably are among the first genes affected by ecological shifts in insect populations. Thus, we are documenting the evolution of ORs in the context of stored product pests, which are thought to have originally fed on isolated and unpredictable seed heads and rodent stores before transitioning to human granaries over the last several millennia. Previous genomic annotation of the model beetle (and grain pest) Tribolium castaneum suggested an extensive but contracting OR suite, attributed to relaxed selection on olfaction in a stable anthropogenic environment. Here, we test this hypothesis by genomic annotation of ORs from additional stored product pests, including the lesser grain borer (Rhyzopertha dominica; Coleoptera: Bostrichidae), mealworm (Tenebrio molitor; Coleoptera: Tenebrionidae), khapra beetle (Trogoderma granarium; Coleoptera: Dermestidae), and Indianmeal moth (Plodia interpunctella; Lepidoptera: Pyralidae). Initial results support the hypothesis that stored product pests are experiencing a reduction in chemosensory breadth.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 64

Mittal N., and Song B.

Accumulation of iso-flavonoids and phenolic acid conjugates in response to soybean cyst nematode in wild soybean (*Glycine soja*)

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Plants produce a wide range of biologically active metabolites to protect themselves against attacking pests. Elucidating the key metabolites and associated pathways underlying defense responses is critical in understanding the molecular mechanisms of plant chemical defense. Non-targeted metabolomics analysis has emerged as a useful strategy to increase our understanding of the resistance-related (RR) metabolites and pathways in plant-pathogen interactions. In this study, we performed a non-targeted metabolomic analysis to determine and compare the roles of key metabolites and pathways in response to infection by the soybean cyst nematode (SCN, Heterodera glycines) in wild soybean (Glycine soja). SCN is the most devastating pest causing significant losses in soybean yield. A comparison of the metabolic profiles among SCN-resistant (S54) and susceptible (S67) genotypes showed clear differences, mirroring the effects of isoflavonoids (daidzein, daidzin, malonyl daidzin, formononetin, and iso-formononetin), as well as phenolic acids and phenolic acids-derived hydroxyl and methylated glucoside esters, in defense. To the best of our knowledge, these findings uncover the first metabolomics-based network for defending against SCN HG type 1.2.5.7 (SCN-2). The results of the present research can facilitate the future metabolic engineering to develop novel and diverse soybean cultivars with enhanced SCN resistance and/or improved nutraceutical value.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 50

Yuki Miyake, Erina Ohno, Tatsuya Hojp, Miyoshi Yamashita, Akihiro Bana, Takeshi Kinsho

Synthesis of Tomato leafminer, Tuta absoluta, sex pheromone and its application in field mating disruption

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The Tomato leafminer (TLM), Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), is the most serious pest of tomato in many countries. This pest, native in South America, invaded into Spain in 2006 and is now widespread in Europe, Africa and Asia. Its infestation makes crops unmarketable.Insecticide application against TLM has been used, however, it is sometimes ineffective because of rapidly developing resistance. Pheromone-based mating disruption (MD) to control this serious pest has been strongly desired.Female produced sex pheromone of TLM consists of two components, (3E,8Z,11Z)-tetradeca-3,8,11-trienyl acetate and (3E,8Z)-tetradeca-3,8-dienyl acetate. We have established an economical and safe production method of TLM sex pheromone using a key C-5 building block. Coupling reaction of the C-5 and C-9 building blocks enables industrial production of both active ingredients.Field MD trials using tube-type dispensers (ISONET®-T) have been conducted in several European countries including Italy and Spain. MD efficacy was demonstrated through suppression of the male trap capture and reduction of the damage. We will explain one of the sustainable insect management strategies for TLM.Keywords: Tomato leaf miner, Tuta absoluta, mating disruption, ISONET®-T

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 74

Victoria Moris, Katharina Christmann, Thomas Schmitt, Oliver Niehuis,

Looking back in time: study of old pinned museum samples of Odynerus spinipes females (Insecta: Hymenoptera: Vespidae) reveals the geographic structure of the two chemotypes across the species' distributional range.

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The mason wasp Odynerus spinipes presents an extraordinary case of intrasexual CHC profile dimorphism. O. spinipes females are able to express one of two different CHC profiles (chemotypes) that differ qualitatively from each other. Females with different chemotypes seem to differ exclusively in this trait and keep their chemotype during their entire lifespan. The frequency of the two chemotypes in natural populations of O. spinipes has never been investigated. In order to determine whether both chemotypes are present in similar ratios in all geographic regions, we studied the CHCs of specimens stored in museum collections and collected from across the species' distributional range. Specifically, we analyzed via GC-MS the CHC extracts of a total of 1,210 specimens of the species. Intriguingly, we were capable in reliably identifying the chemotypes of most samples, some collected 200 years ago. While we find both chemotypes in samples from Europe and from the Far East (the presumed geographic origin of the species), we discovered significant geographic structure in the frequency of the two chemotypes. The geographic structure in the chemotype frequencies could indicate differential selection regimes and/or different dispersal routs during the colonization of Europe by this Euro-Siberian faunal element. The present results pave the route for disentangling these factors in future studies by providing information where to best collect samples for population genetic analyses.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 94

Mohammad Munir Mostafiz, Aijun Zhang, Kyeong-Yeoll Lee

Naturally-occurring compound methyl benzoate against the sweet potato whitefly, Bemisia tabaci MED (Q biotype), one of the most important vectors for plant viruses

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Methyl benzoate (MB) is a plant-derived volatile organic compound with insecticidal properties, but such activity has not been evaluated against the sweetpotato whitefly Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae), a major crop pest. In this study, we tested methyl benzoate control efficacy on B. tabaci infecting tomato plants in a greenhouse, specifically measuring contact and fumigant toxicity, as well as repellent activity. For direct spray applications of 0% (control), 0.1%, 0.25%, 0.5%, 1%, 2% MB onto tomato leaves infested with adults of B. tabaci (< 5-d-old), 2% MB showed the highest corrected mortality (100%) at 24 h post-treatment. For residual toxicity in which the same MB solutions were sprayed onto tomato leaves and allowed to dry for 2 h before <5-d-old adults were released, the 2% MB also showed the highest corrected mortality (100%) at 48 h post-treatment. The lethal median concentration (LC50) for eggs, fourth-instar nymphs, and adults were 0.3%, 0.2%, and 0.2%, respectively. In pot culture experiments, 1% MB concentration was found more effective at killing nymphs and preventing adult eclosion than all other concentrations, and gave 100 percent population reduction compared with the control. MB repelled adult whiteflies and caused 96.5% fumigant toxicity within 10 h post-treatment. Our results suggest that MB has strong potential as an environmentally friendly biopesticide for control of B. tabaci but field trials and further greenhouse studies need.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 75

Raimondas Mozūraitis, Dominykas Aleknavičius, Sandra Radžiūtė, Laima Blažytė-Čereškienė, Elena Servienė, Vincas Būda

Effect of the volatiles released by yeasts related to sea buckthorn Hippophae rhamnoides berries on behaviour of Rhagoletis batava flies.

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Yeast released volatiles are used by insects as olfactory cues for finding feeding and oviposition sites. Those olfactory cues have a large impact regulating insect behaviour and fitness consequently drawing increased attention in integrated pest management programmes. The yeast strain SB-16-15 was isolated from spontaneous fermentation of Hippophae rhamnoides berries and identified as Pichia kudriavzevii. Thirty-nine volatiles were sampled and identified from the headspace of P. kudriavzevii yeasts by solid phase micro extraction, gas chromatography and mass spectrometry techniques. Ten of those volatiles elicited antenna responses of Rhagoletis batava flies one of the most serious pest of H. rhamnoides berries. In the two-choice experiments, R. batava flies preferred the mixture comprised of nine synthetic compounds analogous to EAD active volatiles released by yeasts compare to the solvent control. Female flies were significantly attracted to the mixture at the concentration 0,1 µl/ml and showed no preference to the mixture at the concentration1 µl/ml versus control while males reacted positively to the synthetic blend at the concentration 1 µl/ml. Herein, for the first time, behaviour modifying effect of H. rhamnoides berry related yeast volatiles was shown revealing the application potential of those allelochemicals in pest management programs of R. batava flies.

Themed Session: Insect-Microbe Chemical Communication

POSTER

Number: 37

Michael Ng, Siu Lung Ng, Tobias Hoffmann, Brian K. Hammer

Novel Regulation of Type VI Secretion System in Environmental Vibrio cholera

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The waterborne bacterial pathogen Vibrio cholerae resides within dense multispecies microbiomes in aquatic environments and in the human gut where is causes cholera disease. Like other bacteria, V. cholerae competes for resources in these habitats using a Type VI Secretion System (T6SS) weapon that can lyse competitors by piercing neighboring bacteria and delivering toxic cargo. Based on studies with strains of V. cholerae derived from patients, it was proposed that triggering of the T6SS in V. cholerae requires one of two signaling factors 1) QstR, which is activated by external quorum sensing molecules and chitin, or 2) TfoY, which is activated by internal second messenger molecules. We sequenced several dozen strains of V. cholerae from environmental sources, identified the T6SS genes in each, and documented that most engaged in T6SS-dependent killing of target E. coli cells in laboratory condition in the absence of chitin. For many environmental strains tested, deletion of both the qstR and tfoY genes revealed that neither is required for T6SS-dependent target cell killing. From these results, we predict that a novel signaling factor(s) participates in T6-mediated aggression in V. cholerae. Genetic analysis, including mutagenesis, is being conducted to identify such a factor, which will broaden our understanding of how bacteria coordinate competitive behaviors in response to chemical signals.

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

POSTER

Number: 83

Linh Nguyen, Roberto Brenes

Metabolic detoxification of the metabolite emodin produced by the common buckthorn (Rhamnus cathartica) by the Green frog Lithobates clamitans (Ranidae)

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The secondary metabolite emodin, present in the invasive common buckthorn (Rhamnus cathartica), has been related to morbidity and mortality of amphibian larvae. However, the effect of the metabolite in older tadpoles with fully liver and kidney function has been unknown whether the compound could be metabolized by amphibians as seen in higher vertebrate groups such as mammals. To demonstrate the relationship between organ function and survival, Green frog (Lithobates clamitans) tadpoles of different developmental stages were exposed to synthetic emodin at different concentrations of 0.5 ppm, 1 ppm, and 2.5 ppm to determine if older tadpoles with higher levels of liver function can neutralize the metabolite. During the experiment, tadpoles were monitored daily for signs of morbidity or mortality and all animals were necropsied and the liver and kidney removed for histopathology. Preliminary results showed differences in time of mortality among size classes ($F_{3,19}=189.5$, $P<0.05$), as well as a strong relationship between size and time of death with small animals dying at a faster rate than older individuals

(Pearson=0.483, P<0.05). Higher concentration showed relatively faster mortality (Pearson=0.321, P<0.05) and most of the surviving individuals presented visually the effects in liver and kidney. Signs of metabolic detoxification, like hepatocellular swelling and other hepatic injuries, are still assessed thorough histopathology analysis.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

POSTER 18

Vincensius Surya Putera Oetama, Stefan Pentzold, Yannick Pauchet, Wilhelm Boland
Chlorophyll detoxification? Learning from Spodoptera littoralis

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Chlorophyll (Chl) is the green pigment which is found ubiquitously in plants, algae, and bacteria. It is classified as a natural product that is needed in the photosynthesis. The degradation pathway and enzymes involved in Chl degradation are known in plants during leaf senescence. However, the mechanisms in chewing insects are not known. The previous study has shown the detected Chl catabolites were similar as in the plants. In the present study, the suspected liable protein – Chlorophyllide binding protein (CHBP) – has been identified using transcriptome and proteome analysis from regurgitate of S. littoralis. The gene functional analysis using RNAinterference has shown the importance of the gene and indicating a metabolic change detected in the feces. We also found a lower survival rate in larvae injected with gene specific dsRNA, where gene expression was decreased up to 80%. Heterologous expressed CHBP in

insect cells was used for ligand assay and revealed that not only chlorophyllide, but also Chl could be bind to CHBP. Photo toxicity assay in the expressed and non-expressed CHBP insect cells showed the higher susceptibility in the expressed CHBP insect cells. These findings lead to the understanding this mechanism as a Chl detoxification. Moreover, the alteration of gut's condition compare to feces' yielded new finding of several catabolic compounds. Putting together pieces of the puzzle hopefully will bring the understanding of the Chl degradation mechanism.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

POSTER

Number: 41

Taylor Paret, Melanie JA. Body, Elizabeth S. Haswell, Reginald B. Cocroft, Heidi M. Appel
To hear without an ear: Mechanosensation in plants

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Plants respond to herbivory by increasing the production of chemical defenses. Early defense signaling depends on the plant's ability to quickly detect the attack and activate the appropriate signaling cascades. Response cascades begin with the perturbation in plant plasma membrane potential and change in the calcium concentration, eventually leading to the increase of plant chemical defenses. The plant can recognize wounding, insect oral secretions, and insect feeding vibrations to identify the "attacker", and

thereby respond accordingly. Mechanosensitive conductance Small (MscS) channels are located between the cell wall and the plasma membrane in higher plants. MscS channels in plants respond to many of the same stimuli as the Mechanosenstive (MS) channels in animals. These channels can respond to unique stimuli, including cell wall damage and plant-pathogen interactions. Recently, our lab has shown that plants respond to insect herbivory vibrations by priming the production of chemical defenses that will deter insect feeding. By playing recordings of feeding vibrations produced by the White Cabbage caterpillar Pieris rapae back to the plant Arabidopsis thaliana, we can prime the production of chemical defenses in the absence of the insect. In this study, we will use A. thaliana wildtype plants, and MSL mutants with different combinations of nonfunctional MSL channels. Plants receive either caterpillar feeding vibrations or a silent sham.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 59

Sulav Paudel, Edwin Rajotte, Gary Felton

Temperature regulates the activity of herbivore salivary defense elicitor, Glucose Oxidase

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Interactive effect of temperature and herbivore salivary defense elicitors is largely unknown. Using experimental warming and a combination of biochemical and herbivory bioassays, we evaluated the effect of elevated temperature on the activity of Glucose Oxidase, salivary defense elicitors of Helicoverpa zea

and subsequent effect on plant defensive enzymes. The activity GOX in caterpillar was regulated by temperature and the activity decreased at a warmer temperature. This was surprising as the temperature within physiological limits is predicted to increase enzymatic rates in insects. Further, induction of defensive enzymes was reduced when insects from warmer temperature fed on plants as compared to caterpillars grown at low temperature. Subsequently, a low level of defensive enzymes was correlated with reduced herbivore growth in the bioassay.

Themed Session: Language of Life under Climate Change
POSTER

Number: 47

Cynthia Perkovich, David Ward

Oak tree differentiation of defense and reallocation strategies in response to herbivore pressures

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Plant strategies against herbivory may involve defending themselves by producing plant secondary metabolites (PSM), regrowing to negate injuries from tissue loss (tolerance), or reallocating resources to better defend or protect themselves from further damage. We investigated the strategies of oak plants to minimize herbivory by investment in tannins and reallocation of non-structural carbohydrates. Oak species may differentially invest in defenses and reallocation depending on the intensity and location of herbivore feeding. We simulated the effects of herbivory by removing 25% or 75% of oak tissue, removing either the apical or lateral meristems. The investment in defenses may act as a selective pressure driving herbivore diversity and behavior. Using 12 oak species from different parts of a well-supported phylogeny, we applied five treatments of simulated herbivory, varying in intensity and location. The 12 species were chosen to represent a broad array of geographical and phylogenetic diversity. Using an untransformed statistical analysis, we found that oak species invest differentially in defensive mechanisms. We will also present a more thorough phylogenetic comparative analysis of the data to determine if differences in defense and reallocation strategies are a result of adaptation to herbivory or if defense and reallocation strategies are associated with particular oak lineages.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

POSTER

Number: 16

Rita de Cassia Pessotti, Matthew Traxler

Investigating the semi-social beetle Odontotaenius disjunctus as a model for actinomycete chemical ecology

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Some insects harbor in their bodies and colonies microbes, e.g. actinomycetes that are capable of producing diverse specialized metabolites. However, in many cases the ecological role of these compounds remains an open question. We are currently investigating Odontotaenius disjunctus, a Passalidae semi-social beetle, as a model for studying chemical ecology in insect-microbe association. These beetles live in decaying logs across the Eastern US. We subjected frass from 22 colonies across 11 US states to metabolomic analysis. We found that the metabolome of frass material is surprisingly uniform across large geographic distances. Interestingly, the antibiotic actinomycin was detected in multiple colonies. An actinomycin producer, Streptomyces padanus, was isolated from 86% of the colonies. This species also produce the antifungal filipin, which was also detected in some frass samples. When tested together, Actinomycin D and Filipin III showed synergistic effect against the entomopathogenic fungus Metarhizium anisopliae. These results indicate that O. disjuctus and its associated microbiome is a potential system to investigate the chemical ecology of natural products in the context of insect-microbes associations. Beyond this, the prevalence of Streptomyces padanus from the same environment across large geographic distances provides a unique opportunity to study the evolution of microbial specialized metabolism in the context of symbioses.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 51

Kelsey Poulson, Kyle Mayers, Helen Fredricks, Benjamin Van Mooy, Elizabeth Harvey
What makes algae tasty: combining lipidomics and grazing assays to explore chemical drivers of palatability

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Marine phytoplankton are responsible for half of global primary productivity, yet 70% of this productivity can be lost daily due to protist grazing, demonstrating major top-down control on the abundance and composition of phytoplankton communities. However, protist grazing is modulated by the interplay among morphological (e.g., calcification), chemical, and behavioral characteristics of prey. To gain a more comprehensive view of what influences grazing on the bloom-forming coocolithophore Emiliania huxleyi, we performed a series of grazing assays on multiple E. huxleyi strains that vary in levels of calcification. In these assays, both ingestion and growth rates of the grazer, Oxyrrhis marina, were variable, even among calcified strains of E. huxleyi, suggesting additional drivers of prey quality. In order to identify these drivers, we assessed the lipid make up of four different E. huxleyi strains using mass spectrometry-based lipidomics and found that the lipidomes of these strains are statistically distinguishable using partial least squares discriminant analysis. Additionally, E. huxleyi lipidomes mapped onto calcification state: those strains displaying a greater degree of calcification also displayed a more similar lipidome. Thus, lipids specific to certain E. huxleyi strains are targets for future investigation as indices of prey value. These results highlight the importance of biochemical composition in mediating predator-prey dynamics among the plankton.

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

POSTER

Number: 31

Melany Puglisi, Skylar Carlson, Stanley Budzynski, Jason Kwan

Role of Caulerpin and Other Metabolites in Formation of the Microbiome of Caulerpa spp.

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Thirteen strains of Vibrio, including known pathogens to benthic marine organisms, have been isolated from the surface of Caulerpa cylindracea in the Atlantic Mediterranean. High densities of microbial populations on the surface of the algae suggest an algal-bacterial association that may increase the fitness of C. cylindracea. The objective of this study was to explore the role of metabolites from Caulerpa spp. in the formation of the algal microbiome. A panel of 38 strains of surface-associated bacteria (SAB) isolated from Caulerpa spp. were used to screen the solvent partitions of common species of Caulerpa spp. from the Florida Keys. Minimal growth inhibition (8.4%) and growth inhibition (6.6 %) was observed. Subsequent bioassay-guided isolaton of the active extract from C. sertularioides against Vibrio sp. from the surface of C. mexicana yielded caulerpin and two derivatives that significantly promoted the growth of Vibrio sp. below natural concentration (1.8 ug/mL). Settlement assays conducted in the laboratory showed that caulerpin induced settlement of Vibrio sp. from the seawater. In addition, 30% of the unidentified SAB tested were induced to settle when exposed to the H2O partitions from C. racemosa, C. sertularioides and C. cupressiodes and CHCl3 partitions from C. sertularioides and C. cupressiodes. Caulperin and other metabolites may play a role in the chemical mediation of Caulerpa microbiome.

Themed Session: Other

POSTER

Number: 105

Haili Qiao, Pengfei Lu, Sai Liu, Changqing Xu, Jun Chen

Volatiles from Aquilaria sinensis damaged by Heortia vitessoides larvae deter the conspecific gravid adults and attract its predator Cantheconidea concinna

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The effects of induced plant responses on herbivores are categorised as direct, by reducing herbivore development, or indirect, by affecting the performance of natural enemies. Here, we investigated a tritrophic system, which included the herbivore Heortia vitessoides, its host plant Aquilaria sinensis, and its predator Cantheconidea concinna. Herbivore-damaged A. sinensis plants released significantly greater amounts of volatiles than undamaged and mechanically damaged plants, with an obvious temporal trend. One day after initial herbivore damage, A. sinensis plants released large amounts of volatile compounds. Volatile compounds release gradually decreased over the next 3 d. The composition and relative concentrations of the electroantennographic detection (EAD)-active compounds, emitted after herbivore damage, varied significantly over the 4-d measurement period. In wind tunnel bioassays, mated H. vitessoides females showed a preference for undamaged plants over herbivore and mechanically damaged A. sinensis plants. In Y-tube bioassays, C. concinna preferred odours from herbivore-damaged plants to those from undamaged plants, especially after the early stages of insect attack. Our results indicate that the herbivore-induced compounds produced in response to attack by H. vitessoides larvae on A. sinensis plants could be used by both the herbivores themselves and their natural enemies to locate suitable host plants and prey, respectively.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 95

Navneet Rai

Molecular characterization and phylogenetic analysis of Culicinae mosquitoes (Diptera: Culicidae) collected from Northwest India

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Characterization of Culicine mosquitoes collected from Northwest India has been done using both morphology and molecular based taxonomy by COI gene. A ~500bp sequences of mitochondrial Cytochrome Oxidase I (COI) gene were analyzed to construct molecular database and to establish the phylogenetic relationship among 14 Culicinae mosquito species. The sequences were found to be A+T rich and in substitution the rate of transitions was higher than the rate of transversions. Conspecifics showed <2% divergence (range = 0% to 0.9%), whereas interspecific divergence was >2% with K2P (range = 6.4% to 18.2%). Sequence divergence was much higher among species in different genera ranging from 11.0% to 21.3%. Species from the two mosquito tribes (Aedini and Culicini) mostly clustered with other members of their tribe in Neighbor-Joining tree. The tree also showed a separation of species of the sitiens-Group from pipiens-Group.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 25

Lana Resende de Almeida, Ana Maria Obino Mastella, Marina Amaral Alves, Rafael Garrett, Maria João Ramos Pereira

What does metabolomics say about Neotropical Mustelids (Mammalia, Carnivora)?

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Chemical signs act on a wide range of intra and interspecific interactions. In mammals they consist of a complex mixture of volatile and non-volatile compounds. The latter are associated with territorial marking and resource use due to their continuous signaling capacity. Chemical profiles from non-invasive biological material, such as feces, have great potential to contribute to ecological knowledge, mostly for species showing elusive behavior or low population densities. Using Neotropical Mustelidae as model we developed a non-invasive methodology for species identification, as well as to investigate the chemical diversity of non-volatile components in fecal samples. We collected ca. 70 fecal samples from captive individuals of four mustelids occurring in Brazil: Lontra longicaudis, Eira barbara, Galictis cuja and Galictis vittata; these were analyzed by liquid chromatography coupled to high-resolution mass spectrometry. Multivariate data analysis (PCA, PLS-DA and HCA) successfully discriminated the three genera, revealing a chemical similarity between the species of Galictis. We identified over 100 compounds in the fecal samples, including bile acids and food components. Our results suggest that chemical profiles from non-invasive fecal sampling allow species-specific identification within the Mustelidae and potentially within the Carnivora, allowing fast confirmation of the presence of rare or elusive species, contributing for better supported wildlife management plans.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 52

Lora Richards, Casey Philbin, Matt Paulsen

Intraspecific phytochemical variation in Ceanothus velutinus along an elevational gradient and the associated herbivores

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Phytochemical diversity is an emerging focus of research on plant functional diversity. Recently, we have set forth on quantifying the "phytochemical landscape" (Hunter 2016), to understand how spatial and temporal variation in phytochemistry across multiple scales can affect the diversity of multitrophic interactions associated with Ceanothus velutinus (Rhamaceae). We set up two elevational transects on the eastern slope of the Sierra Nevada mountains near Reno, NV covering an elevational range of 1600m to 2500m. Along these transects we established temporary 10m plots and recorded plant diversity and lepidopteran herbivore diversity as well as collected Ceanothus leaves for chemical analysis. We visited the plot and collected data monthly from the beginning of summer through fall. Using an untargeted metabolomics approach we analyzed 500 leaf samples using LC-MS to quantify the how phytochemistry varied along the elevational gradient and seasonally. We linked this variation to herbivore community, and phenology. By identifying the contributions of phytochemical variation on herbivore communities across the landscape, we can begin to understand the role of phenotypic variation and in the maintenance interaction diversity

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 53

Ursula Röse, Andrea L. Call, Katharina H.C. Röse, Emma Tobin, Kristin M. Burkholder
Antimicrobial properties of three red and brown marine macroalgal species

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Macroalgae are very abundant in the intertidal zones of the coast of Maine despite considerable herbivore pressure. This implies that they may contain defense mechanisms that protect them against herbivore and microbial attack. We investigated three macroalgal species for their antimicrobial activity on an array of WHO priority pathogens. The brown alga Fucus vesiculosus, and red algae species Chondrus crispus and Ahnfeltia plicata were collected from the intertidal zone of the Gulf of Maine. Algae were extracted with solvents of different polarity including methanol, dichloromethane and pentane and their antimicrobial activity was investigated against four gram positive pathogens (methicillin-sensitive Staphylococcus aureus strain Newman (MSSA), methicillin-resistant Staphylococcus aureus (MRSA) strain USA300, Bacillus cereus, Listeria monocytogenes) as well as five gram negative pathogens (Pseudomonas aeruginosa, Proteus mirabilis, Salmonella Typhimurium, Klebsiella pneumoniae, Escherichia coli). Antimicrobial activity was tested in a disc diffusion assay followed by a Minimum Inhibitory Concentration assay. All three algal species tested showed antimicrobial activity against several human pathogens. Of the three solvents tested, extractions with methanol, showed the highest antimicrobial activity. Of nine human pathogens tested, S. aureus (MSSA) and S. aureus (MRSA), P. mirabilis, S. Typhimurium, and K. pneumonia were inhibited by algal extracts.

Themed Session: Biosynthesis of Secondary Metabolites in Chemical Ecology

POSTER

Number: 17

Carmen Rossini, Anna Paula Burgueño, María Eugenia Amorós, José Buenahora, Andrés González
Oviposition cues for the Asian citrus psyllid, Diaphorina citri (Hemiptera: Liviidae)

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The Asian citrus psyllid (ACP) is the vector of Huanglongbing, the most destructive citrus disease. Preliminary work has shown that ACP prefers to oviposit on Duncan grapefruit and Sweet Orange. Rough, Eureka and Cravo lemons showed variable results, whereas Citron was not preferred. Searching for biomarkers that may serve as kairomones for ACP females, the volatile organic compounds (VOCs) and the CDCl3 and D2O extracts from shoots of the mentioned varieties (N = 6/species) were analyzed by GCMS and NMR respectively. All processed data were submitted to multivariate analyses (MetaboAnalyst4.0). For the D2O extracts, the chemical profiles of Sweet orange and Duncan grapefruit were grouped; being different from the profiles of Citron while the Eureka, Cravo and Rough lemons exhibited intermediate profiles. These results correlated to the oviposition preference (PLS model, permutation test: P = 0.048). Correlation was traced to chemical shifts in the NMR spectra corresponding to compounds with aromatic and sugars moieties in their structures. We are currently working to determine the identity of these compounds. Among the 81 VOCs characterized, limonene and a mixture of limonene, (E)-β-ocimene, Methyl N-methylanthranilate, β-elemene and β-caryophyllene exhibited different ACP capture ratios than the control in 2-choices cage experiments (GLM, P <0.05). These results suggest that the ACP could use a combination of volatile and non-volatile cues to choose its oviposition plants.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 54

Jordano Salamanca, Escuela de Ciencias Agrícolas, Pecuarias y del Medio Ambiente, Vanessa Garzón-Tovar, Escuela de Ciencias Agrícolas, Cesar Rodriguez-Saona, Cristina Mendoza

Herbivore-induced plant volatiles to attract natural enemies in agroecosystems: Are 2 better than 1?

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Herbivore-induced plant volatiles (HIPVs) are emitted by many plants after herbivore feeding and oviposition damage. Both methyl salicylate (MeSA) and benzaldehyde (BEN) are HIPVs known to attract natural enemies in agroecosystems. In this study, we hypothesized that combinations of these HIPVs are better at attracting natural enemies (predators and parasitoids) than each HIPV alone. For this, we conducted field experiments with MeSA-, BEN-, or MeSA+BEN- baited sticky traps in coffee farms in the region of Sumapaz, Colombia. Treatments were: (a) MeSA; (b) BEN; (c) MeSA + BEN; and (d) control (-MeSA -BEN), replicated three times in four different farms in a randomized complete block design. Every fifteen days sticky traps were collected and the number of natural enemies (predators and parasitoids) counted, for a total of four months. Insect predators of the family Syrphidae were attracted to BEN alone. Anthocoridae were attracted to BEN alone, the predatory thrips Franklinothrips vespiformis (Thysanoptera: Aeolothripidae) to MeSA alone, and both to the combo MeSA+BEN. MeSA in combination with BEN also attracted more Chrysopidae than the others treatments. For parasitoids, Megaspilids were attracted to MeSA alone. On the other hand, Aphelinidae and Mymaridae showed an attraction to BEN and MeSA alone. This study shows the potential of combining multiple HIPVs to increase natural enemy attraction for enhanced conservation biological control in an agroecosystem.

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

POSTER

Number: 9

Mariana Sanchez, Arnubio Valencia, Joe Louis, Blair Siegfried, Ana Maria Velez

Evaluating CO2 Receptor Genes Through Parental RNAi as Potential Targets for Western Corn Rootworm Management

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The western corn rootworm (WCR) is an insect considered the most significant pest of corn in the United States Corn Belt, where the yield reduction and management cost exceed more than 1 billion dollars every year. Given that WCR has evolved resistance to different management strategies, the need of developing novel and efficient tools has increased. The RNA interference (RNAi) is the newest tools developed for WCR management. However, current target genes are highly conserved housekeeping genes, which generates concerns in effects on non-target organisms. Therefore, we are exploring gustatory receptor genes which are associated with WCR biology, and have been reported as species-specific genes. Three gustatory receptor genes (gr) have been identified in WCR and are believed to be involved in CO2 detection, the primary host-finding cue used by neonates in the soil. In the current study, a parental RNAi (pRNAi) approach was used to evaluate those genes. Herein, WCR adult females were treated with dsRNA for gr genes (gr1, gr2, and gr3) ten days after mating, observing gene knockdown in adults, eggs, and larvae for gr1 and gr2. Phenotypic analysis in larvae also showed behavioral disruption of finding CO2 cues after knocking-down the gr2 gene through pRNAi. These results demonstrated for the first time the effectiveness of parental RNAi in a non-development-related gene. Additionally, this research is pioneering in the study of rootworms genes involved in cues perception.

Themed Session: Chemical Biology Approaches for Interactions among Organisms

POSTER

Number: 24

Antonio Santana, Kelly Silva, Dannielle Costa, Chryslane Silva, Gilson Chia, Henrique Goulart, Antônio Santana

Chemical composition of the extract of the anterior wing of Eupalamides cyparissias Fabricius (Lepdoptera: Castniidae) and its role in chemical ecology

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Eupalamides cyparissias is a pest for the Arecaceae family, represented by the economically relevant cultures of palm oil and coconut. The main damage caused by the insect is the formation of galleries in the plant strain. The control of this Lepidoptera is difficult and is based on the mechanical harvesting of caterpillars, pupae and adult insects to reduce the incidence of adults in the field and thus curtail any new generation. As it is an endophytic insect, the use of insecticides to control the caterpillar is inefficient and therefore more efficient control methods are urgently required. The use of semiochemicals (pheromones) for pest control appears as a viable alternative that does not affect the product and does not affect the environment. The present work aims to identifying the chemical profile of extracts obtainedfrom the anterior wing of E. cyarissias, of 24-hour old males and females. They were obtained by extraction with HPLC-grade hexane, during 20 min. The extracts were analyzed by gas chromatography coupled with flame ionization detector and mass spectrometry. The Kovats index was calculated, as usual, using the same stationary phase of the analyzed samples.The chemical profiles analyzed in both extracts ranged from linear hydrocarbons to esters, alcohols and terpenes, in addition to a specific male compound. These results is bringing the opportunity to have a pheromone for monitoring and control of E. cyarissias.

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

POSTER

Number: 10

Fredrik Schlyter, Annette, Johansson, Hjortsberga, Prague, Alnarp

Detection dogs trained to recognize spruce bark beetle pheromones outperform human experts in locating spruces recently attacked

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For forest protection, the rapid detection of bark beetle infestations is required to successfully implement a management strategy that relies on sanitation felling of recently infested trees within 2 −3 weeks of attack. However, human detection generally requires close inspection (≤ 1m) of trees, and is therefore time-consuming, costly, and not always practical. Detection dogs trained to recognize synthetic pheromone compounds from spruce bark beetles has been shown to detect naturally infested spruce trees. In this study we compared detection dog teams to human experts in finding recent natural attacks. In a first trial several new dog-handler teams were trained to recognize trees attacked by spruce bark beetles. These teams were tried in several field plots and ware compared with a trained forest inspector in the same areas. In a second, larger scale trial an insect expert from the Swedish Forestry Agency did a first inspection in a wildfire damaged area and the same area was in following spring inspected by detection dog teams. In both trials dog-handler teams were more efficient than trained human experts in finding early bark beetle infestations both in infestations found in the area and particularly in time spent. In a parallel poster of EXTEMIT-K, location of experimentally induced attacks (i.e. positions known) were tested in a similar way -check it out to see what happened!

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

POSTER

Number: 11

Gerald Schneider, Lauren Maynard, Susan Whitehead

Frugivory and the dispersal of phytochemistry: the divergent secondary metabolomes of fruit and leaves in bat-dispersed Neotropical Piper plants

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Over 50% of angiosperm species depend on frugivorous animals to disperse their seeds. Yet, while a wealth of phytochemistry has been found in fruits, patterns of ecological and evolutionary interplay between fruit phytochemicals and seed dispersers remain largely opaque. Metabolomic techniques have enabled the elucidation of these patterns through comparisons across multiple species and plant tissues. Using this approach, we investigated the components and scales of phytochemical diversity distinguishing fruit from leaves across 12 co-occurring bat-dispersed species in the genus Piper. Further, we investigated the relationship between phytochemical diversity and bat diet. Across species, our metabolomic comparisons indicated divergence between fruit and leaves at the levels of both chemical composition (all $p<1x10-5$) and structural complexity (all $p<1x10-5$). This trend was most pronounced at the scale of interspecific β-diversity, with unripe and ripe fruit pulp more divergent than leaves in both structural (both $p<1x10-5$) and compositional (unripe $p=0.007$; ripe $p=0.013$) comparisons. Next, we found that Piper species' occurrence in field-collected bat fecal samples was positively correlated with the structural complexity of ripe pulp across 6 of 7 species ($R2=0.89$, $p=0.003$). This suggests that selective pressures on phytochemistry in fruits are fundamentally different from those in leaves, with seed disperser interactions potentially driving phytochemical diversification.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 55

Stefan Schulz, Christian Schlawis, Stefan Schulz

Structure elucidation without NMR - A combined approach using GC/MS, GC/IR, DFT calculations and synthesis

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Structure elucidation of minor amounts of compounds in complex mixtures, a problem often encountered in Chemical Ecology, is difficult. Usually GC/MS is used for this purpose for volatile or lipophilic compounds. Additional information is obtained from high-resolution MS data or micro reactions. Finally, a structural proposal is formulated that has to be verified by synthesis. If the synthetic compound does not match the natural one, this process has to be repeated with the next proposal, culminating in substantial synthetic effort. We present here orthogonal techniques that reduces the required synthetic effort to a minimum. Direct disposition GC/IR allows the analysis of material in amounts as low as 10 ng, with a chromatographic resolution similar to that of a GC/MS system. The IR data give information on functional groups, but IR cam be of more use. A third analytical dimension can be added by DFT calculations of IR spectra. Instead of synthesizing a set of compounds, the respective simulated IR spectra allows selection of the most likely candidate structure, thus drastically reducing required synthetic effort. We will present this approach in the identification of unique salinilactones produced by marine Salinispora bacteria. Salinilactones are unprecedented cyclopropabutanolides that show toxicity in brine shrimp assays and are structurally related to the A-factor, a signaling compound in some actinomycetes. The use and the limitation of our approach is presented.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

POSTER

Number: 42

Jacqueline Serrano, l Peter J. Landolt, J. Steven McElfresh, Jocelyn G. Millar

Progress with the identification of pheromones from North American click beetles (Coleoptera: Elateridae)

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The click beetles (Coleoptera: Elateridae) comprise a large family with ~10,000 identified species, a number of which are important agricultural pests. To date, relatively few click beetle pheromones or pheromone candidates have been identified, and most of these are from one subfamily. Furthermore, most known or suspected pheromones have been identified from species native to Europe and Asia, where they are used to monitor and manage a number of pest species. Identification of pheromones for North American species would be immediately useful because of the current resurgence of a number of species as pests of major crops such as corn, wheat, and potatoes. We hypothesized that the known pheromones of Asian and European species might be conserved within closely related taxa, and thus also used by North American congeners. We synthesized and field tested a library of known elaterid pheromones and analogs, which resulted in the identification of neryl hexanoate and neryl octanoate as pheromones or likely pheromones for four species in the genera Idolus and Dalopius. In addition, several novel pheromone structures have been identified from other North American species in the genera Melanotus and Cardiophorus, with these structures often bearing little similarity to any previously identified click beetle pheromones. Although elaterid pheromone research is in its infancy, structural patterns are beginning to emerge within related taxonomic groups.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 96

Jacqueline Serrano, J. Steven McElfresh, Yunfan Zou, Jocelyn G. Millar

Identification of Aggregation-Sex Pheromone Components for a "Living Fossil", the False Click Beetle, Palaeoxenus dohrni Horn (Coleoptera: Eucnemidae)

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Insect pheromones have rarely been exploited in surveys or studies of rare and endangered species, despite their potential as powerful, highly selective attractants for target species. Here, we report the identification, synthesis, and field bioassays of male-produced aggregation-sex pheromone components for a rare false click beetle species, Dohrn's elegant eucnemid beetle, Palaeoxenus dohrni Horn. This species is endemic to the mountain ranges in southern California, USA and is the only extant species in its genus and subfamily. Analyses of extracts of headspace volatiles collected from adult beetles revealed several male-specific compounds. Two of these compounds, identified as (E)-2-nonen-4-one and (R)-2-nonanol, elicited electroantennographic responses from antennae of both sexes. In field bioassays, a blend of the two compounds attracted both sexes, whereas the individual compounds were not attractive. The identification of an attractant pheromone should provide a useful tool for determining the range and estimating population densities of this iconic species.

Themed Session: Other

POSTER

Number: 107

Salina Som, Denis S. Willett, Hans T. Alborn
Moisture effects on belowground volatile diffusion and degradation

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Above ground herbivory can induce release of plant volatiles that attract natural enemies of the herbivores. Similarly, roots can release herbivore induced volatiles that attract beneficial organisms such as entomopathogenic nematodes belowground. Unlike their aboveground counterparts, belowground volatile signals interact with solids, liquids, and gases as they move through soil pore spaces. These interactions influence belowground signaling, can create non-linear diffusion profiles, and result in surface adsorbtion and degradation of volatiles in space and time. By examining diffusion and degradation in sand-filled microcosms, we found that the diffusion profiles of E-β-caryophyllene, d-limonene, pregeijerene, α-pinene, germacrene-d, and linalool were affected by moisture and pH. Furthermore, the common plant volatile linalool was non-diffusive below ground. In addition, we discovered a novel pathway for the degradation of linalool into rapidly diffusing belowground signals. These findings suggest areas for future exploration and highlight the importance of abiotic factors when

studying belowground semiochemically-based interactions such as attraction of beneficial entomopathogenic nematodes to plant roots infested by host insects.

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

POSTER

Number: 12

Maria Sousa

Antennal morphology of a bark beetle predator M. signaticornis

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The long legged flies (Dolichopodidae) is one of the largest families of Diptera, where most of the species are predators and play an important ecological role as natural enemies of a wide variety of organisms. Many species from Medetera genus, for example, are known to prey on Scolytidae brood at early developmental stages and have been indicated for the biological control of bark beetle pests such as Ips typographus. The fly females identify a tree under bark beetle attack from a distance. After landing they 'scan' the surface searching for bark beetle galleries. The females oviposit their eggs at the entrances of bark beetle galleries and the eclosed larvae mine through the bark and into the bark beetle larval galleries, where they predate on the bark beetle brood during their development. Although, the importance of these predators have long time ago been identified, little information is available regarding Medetera host-prey location and it is still not clear how the different Medetera spp locate infested trees or how they locate

their prey underneath the bark. Antennae and maxillary palps are the main olfactory organs known in Diptera. The aim of this project is to use scanning electron microscopy (SEM) to study the antennal morphology of M. signaticornis, which is one of the most important Ips typographus predator found in Sweden.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

POSTER

Number: 33

Lindsay Spiers

Feeding preferences of herbivorous fish and sea urchins: potential implications for the recovery of degraded reefs

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The long legged flies (Dolichopodidae) is one of the largest families of Diptera, where most of the species are predators and play an important ecological role as natural enemies of a wide variety of organisms. Many species from Medetera genus, for example, are known to prey on Scolytidae brood at early developmental stages and have been indicated for the biological control of bark beetle pests such as Ips typographus. The fly females identify a tree under bark beetle attack from a distance. After landing they 'scan' the surface searching for bark beetle galleries. The females oviposit their eggs at the entrances of bark beetle galleries and the eclosed larvae mine through the bark and into the bark beetle larval galleries,

where they predate on the bark beetle brood during their development. Although, the importance of these predators have long time ago been identified, little information is available regarding Medetera host-prey location and it is still not clear how the different Medetera spp locate infested trees or how they locate their prey underneath the bark. Antennae and maxillary palps are the main olfactory organs known in Diptera. The aim of this project is to use scanning electron microscopy (SEM) to study the antennal morphology of M. signaticornis, which is one of the most important Ips typographus predator found in Sweden.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

POSTER

Number: 34

Sprayberry, J., Kass, S., Roma, N., and Domardsky, A.,

How much is too much? Scent-pollution and odor-recognition in bumblebees.

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Bumblebees often forage in anthropogenically-modified sensory landscapes. We know that floral-odor signals are used by foraging bumblebees, and have a basic understanding of how olfactory systems encode complex odor blends. However, our understanding is not nuanced enough to predict how perception of learned odors is influenced by scent pollution. Previous studies indicate that foraging can be negatively impacted by anthropogenic modulation of odors. This study investigates the extent of odor contamination that will result in behavioral disruption. Using an associative-learning paradigm

bumblebees are trained to associate an odor with a food reward, then offered a choice between the associative odor (AO) and a contrasting odor (CO). Contrasting odors range from novel scents (a simple task) to blends of the AO with a novel scent (a harder task). Experimental odors are complex blends of odorants; blending novel odors with the AO increases the amount of structural overlap between the AO and CO, allowing us to test the amount of odor contamination that the bumblebee olfactory-processing system can tolerate before the AO is no longer recognized. This hypothetically indicates the level of odor pollution that is likely to disrupt odor-driven foraging behavior. Defining a 'level' of pollution is non-trivial; this project also presents a novel method of representing complex odor blends in a multidimensional computational space, which allows us to quantify scent-contamination.

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

POSTER

Number: 1

Svatoš, A., Kaftan, F., Manezes, R., and Gajdošová, S.

Untargeted metabolomics of simulated herbivory: Mass spectrometric imaging and metabolic profiling of Arabidopsis thaliana show reallocation of metabolites upon mechanical wounding.

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Question on metabolic reaction of plants to herbivory stress is still largely unanswered. Recent reports indicates reallocation of primary metabolites to young tissue and towards roots associated with regulation of biosynthetic pathways [1,2]. Biological experiments are typically supported by targeted metabolomics because nontargeted metabolomics did not provided suitable tools for a large scale identification of

metabolites and rather provides set of features may be representing interesting metabolites.Current development in metabolomics data dereplication and novel instrumentation with fast scanning capacity opens possibility for a large scale identification of metabolites. Three weeks old A. thaliana were mechanically wounded and 1-7 leaves, apical meristem, cotyledon and roots extracted and analyzed on Q-Exactive HFX coupled to UPLC chromatographic separation. MS and DDA-measured MS/MS spectra were uploaded to GNPS [3] and Sirius [4] programs for metabolite identification. Several hundreds of metabolites were identified. Glucosinolates, principal defensive compounds of Brassicales order, show significant reallocation toward meristem and roots as upon mechanical wounding.1. S. Zhou, Y-R Lou, V. Tzin, G. Jander. Plant Physiology,169: 1488–1498, 2015.2. S. Gómez, A. D. Steinbrenner, S. Osorio, M. Schueller, R. A.Ferrieri, A. R. Fernie & C. M. Orians. Entomologia Experimentalis et Applicata 144: 101–111, 2012.3. Wang, M., et al. Nature Biotechnology 34.8 (2016): 828-

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 56

Sweeney-Jones, A.M., and Kubanek J.

Early Identification of Known Molecules in Complex Mixtures Derived from Marine Organisms that Exhibit Pharmacological Activity

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For the chemist seeking to discover novel secondary metabolites, identifying known compounds early is essential to avoid re-isolating molecules. Natural product chemists often examine literature for taxonomic groups of interest to find known secondary metabolites. In cases where the organism is well-studied, the probability of isolating known compounds is high. Methods such as 1H NMR spectroscopy and LC/MS are useful for drawing comparisons between complex mixtures and data reported in literature for pure compounds. Additionally, MS/MS data can be used to build molecular networks comparing molecules in the mixtures to known compounds included in the Global Natural Products Social Molecular Networking website. Marine varieties of the chemically rich phylum Cyanobacteria have nearly 800 secondary metabolites reported. A cyanobacterium Moorea bouillonii attracted our attention for its potent antimalarial activity. Due to the high probability of identifying known chemistry, the methods described above were applied throughout the purification process. The natural products ulongamide A and lyngbyabellin A, which are cytotoxic against cancer cell lines, as well as a novel analog of lyngbyapeptin A were tentatively identified in the extract. These compounds were subsequently purified to confirm their novel antimalarial activity. Employing these methods expedited the identification of known molecules and consequently minimized the resources required for structure determination.

Themed Session: Integrated Approaches for Structure Determination in Chemical Ecology

POSTER

Number: 43

Tosh, C.R., Conboy, N.J.A, McDaniel, T., et al.

French marigolds protect tomato plants from glasshouse whiteflies through the emission of airborne limonene

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Gardeners in temperate regions often claim that planting marigolds next to tomato plants protects the tomatoes from the glasshouse whitefly (Trialeurodes vaporariorum Westwood). Here we present two large-scale glasshouse trials corresponding to the two main ways growers are likely to use marigolds to control whiteflies. In the first, marigolds are grown next to tomato throughout the growing period. Here the association with marigolds significantly slows whitefly population development. Adding whitefly-attractive 'pull' plants around the perimeter of plots has little effect, but reducing the proportion of marigolds and introducing other non-hosts of whiteflies (basil, nasturtium and Chinese cabbage) also reduces whitefly populations on tomato. The second experiment assesses the efficacy of marigolds when used as an 'emergency' measure. Here we allow whitefly populations to build to a high density on unprotected tomatoes then introduce marigolds. Limonene is a major chemical component of French marigolds and whiteflies dislike the odor of this compound so limonene dispensers are added as an additional treatment. "Emergency" marigold companion planting yielded minimal reductions in whitefly performance, but the use of limonene dispensers was more effective. Companion planting short vine tomatoes with French marigolds throughout the growing season will slow development of whitefly populations. The use of limonene dispensers placed near to tomato plants also shows promise.

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

POSTER

Number: 13

Traczyk, E., Funderburk J., McAuslane, H., and Martini, X.

Predatory Search Behaviors of a Minute Pirate Bug, Orius insidiosus (Hemiptera: Anthocoridae), in Response to Thrips Contact Cues

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The western flower thrips are an economically destructive pest within agroecosystems worldwide through the transmission of numerous Tospoviruses, often resulting in fruit loss or downgrading. Natural enemies of the flower thrips, such as the minute pirate bug, Orius insidiosus, have been shown to successfully suppress and control western flower thrips populations better than calendar insecticide applications, and prefer western flower thrips over related species. Additionally, contact cues, such as western flower thrips alarm pheromone, have been shown to alter the foraging behaviors of Orius predators, acting as kairomones that result in arrestment behavior. The implementation of other potential contact cues, such as shed cuticle and fecal material, in exploiting Orius behavior has yet to be studied. The following experiments explored the inducing effects of western flower thrips tracks on Orius predatory search behaviors. Using motion-tracking software, Y-tube and arena bioassays, and mass spectrometry, the behavior-inducement and profile of thrips tracks were studied to determine if chemical compounds in the tracks served as arrestants and whether those compounds could be utilized to exploit Orius predatory search behaviors. Initial data show that thrips tracks alone result in arrestment behavior of O. insidiosus in arena and Y-tube trials. Analysis of chemical components and biosynthesis are necessary to determine the practicality of field and greenhouse implementation.

Themed Session: Chemically-Mediated Consumer-Prey Interactions

POSTER

Number: 35

Uefune, M., Abe, J., Urano, S. Nagasak, K, and Takabayashi, J.

The use of plant volatiles that attract the parasitoid wasp Cotesia vestalis for the biological control of diamondback moth larvae

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Plants infested by herbivorous arthropods release volatiles called herbivory-induced plant volatiles (HIPVs). We have been studying ecological functions of HIPVs in a tritrophic system of crucifer plants, diamondback moth (DBM) (Plutella xylostella) larvae and their parasitoid wasps Cotesia vestalis. One of the ecological functions of HIPVs from crucifer plants infested by DBM larvae is to attract C. vestalis females. α-pinene, sabinene, n-heptanal and (Z)-3-hexenyl acetate detected in the headspace of cabbage plants infested by DBM larvae are involved in the attraction. We also showed that the synthetic blend of the four compounds attracted C. vestalis females under both laboratory and field conditions. Further, the blend enhances the host-searching efficacy of C. vestalis on plants: the wasps show longer residence time and searching time on plants with the synthetic blend than they do on those without the blend. The number of encounter/oviposition by the wasps on plants with the blend is also higher. Based on these data, we conducted field experiments using the synthetic blend to control DBM in commercial greenhouses, and in open agricultural fields. The results of the field experiments will be discussed.

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

POSTER

Number: 14

Urbaneja-Bernat, P., Rodriguez-Saona, C., Cloonan, K., Salazar-Mendoza, P., and Zhang, A.

Wild blueberries are more attractive than cultivated blueberries to the invasive vinegar fly Drosophila suzukii

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Highbush blueberry is a crop native to the northeast USA that has been domesticated for only about 100 years. During the breeding process, blueberries were selected for several agronomic traits but most importantly for large fruit size and high yields. In the present study, we conducted choice tests to compare the attraction of the invasive pest Drosophila suzukii to wild and cultivated blueberries. We also conducted headspace analysis and gas chromatography-electroantennogram detection (GC-EAD) assays to identify antennally-active compounds. Fruit from wild and cultivated blueberries, growing in proximity, were sampled from three different sites in the Pinelands national reserve in New Jersey (USA), a region where blueberries were first domesticated and with a forest understory consisting largely of wild blueberries. In choice bioassays, D. suzukii flies were more attracted to volatiles from wild than cultivated blueberries. Wild blueberries emitted higher amounts of volatiles than cultivated blueberries. Nine EAD-active compounds were identified from wild blueberries and are currently being tested in behavioral assays. Overall, our results show that breeding for agronomic traits has lowered volatile emissions in blueberry fruit, which decreased attraction to D. suzukii. This study documents the potential effects of crop domestication on an invasive frugivorous insect pest.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 76

Van Alstyne, K.L., Bartlett, S., and Eisenlord, M.

Defenses against Wasting Disease in the Eelgrass Zostera marina

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Eelgrass meadows are critical habitats in coastal waters of North America and Europe, including the Salish Sea. The eelgrasses that form the foundation of these meadows are threatened by a variety of interacting stressors, including nutrient pollution, changing environmental conditions associated with climate change, and disease. The primary disease threat to eelgrasses is the protist Labyrinthula zosterae, which infects eelgrasses throughout their range. Phenolic compounds have been hypothesized to be the primary chemical defense against Labyrinthula in the eelgrass Zostera marina; however, only one phenolic compound, caffeic acid, has been shown to inhibit Labyrinthula growth, and caffeic acid was absent from a collection of Z. marina from Ship Harbor, Washington. To determine whether Z. marina in the Salish Sea produces chemical defenses against L. zosterae, we collected eelgrass from Padilla Bay and created crude extracts, which were then partitioned into polar and non-polar fractions. In laboratory bioassays, both fractions inhibited the growth of L. zosterae when incorporated into an agar-based medium at natural concentrations. Further work is currently being done to isolate the compounds responsible for this inhibition. Our results show that multiple eelgrass compounds are involved in inhibiting wasting disease in the Salish Sea.

Themed Session: Other

POSTER

Number: 106

Vander meer RK[1]., Porter S[1]., Cardosa Y[2].

Phorid Flies and their attraction to host fire ants

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Phorid flies are parasites of fire ant workers. They find fire ant worker,attack and lay an an egg in their thorax. The developing larva migrates to the ant's head where it develops and just prior to pupation the ant dies and its head falls off. The ants remove the head/pupa to the midden pile outside the ant nest where the fly emerges to an adult ready for business. We will look at how the flies find their hosts through use of the ants chemistry.

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

POSTER

Number: 29

Vošvrdová N[1]., Modlinger R[1]., Johansson A[2]., Jakuš R[1]., Turčáni M[1]., Schlyter F[1].

Use of trained dogs as a possible alternative to detect bark beetle attacked spruce trees

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Spruce stands in the middle Europe has been experiencing intensive European spruce bark beetle (Ips typographus) calamities in recent years. There are many causes of this gradation. One of them is the late clearing of the infested trees – currently due to insufficient processing capacity. For the bark beetle calamity management is the most important the on-time detection of the freshly infested trees. Detection failure causes rapid spreading of bark beetles. To the present, visual inspection of the trunk by bark beetle specialist was the only reliable method how to locate bark beetle attacks. Here, we are reporting the way of the early detection of freshly attracted spruce tree with the using of olfaction cue of specially trained detection dogs. These dogs are trained on synthetic Ips typographus pheromone compounds (2-methyl-3-buten-2-ol, cis-verbenol, ipsdienol, verbenone). Consequently, we setup the forest test to compare detection efficiency and detection speed of dog with handler vs bark beetle specialist. Results showed higher speed and efficiency of the pair dog and its dog handler within the detection of the early attacked trees.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 77

Li Y., Wang Z.

Loosing the Arms Race: Sensed but Ignored by Greater Wax Moth on Bee Alarm Pheromones

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The greater wax moth (GWM), Galleria mellonella L. is one of main pests of the honeybees. The larvae burrow into the bee comb, which not only damages the bee comb, degenerating bee products, but also cause severe effects like driving the whole colony to abscond. In the present study, we used electroantennogram (EAG) and Y maze, oviposition site choice bioassay to test whether GWM could eavesdrop on bee alarm pheromones (IPA, OA, BA and 2-HP), to target on bee colony, or the bee alarm pheromones would effect their preference of oviposition site. The results turned out that GWM showed highly electrophysiological response to these four compounds of bee alarm pheromones even in a low concentration (100ng/μl), while they showed highest response to OA than the other three main bee alarm components (BA, IPA and 2-HP). But GWM behavioral results showed no significant preference or avoidance to these four bee alarm pheromones. These results indicate that bees are loosing the arm race since GWM could sense bee alarm pheromones, however, these alarm pheromones were ignored by GWM.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 97

Zhang H-J[1,2,3]., Xu W[3,4]., Chen Q-m[1]., Sun L-N[1]., Anderson A[2]., Xia Q-Y[1]., Papanicolaou A[3,5].

Sensory neuron membrane proteins (SNMPs) in moths

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Sensory neuron membrane proteins (SNMPs) play a critical role in the insect olfactory system but there is a deficit of functional studies beyond Drosophila. Here, we provide functional characterisation of insect SNMPs through the use of bioinformatics, genome curation, transcriptome data analysis, phylogeny, expression profiling, and RNAi gene knockdown techniques. We curated 81 genes from 35 insect species and identified a novel lepidopteran SNMP gene family, SNMP3. Phylogenetic analysis shows that lepidopteran SNMP3, but not the previously annotated lepidopteran SNMP2, is the true homologue of the dipteran SNMP2. Digital expression, microarray and qPCR analyses show that the lepidopteran SNMP1 is specifically expressed in adult antennae. SNMP2 is widely expressed in multiple tissues while SNMP3 is specifically expressed in the larval midgut. We functionally characterised SNMP1 in the silkworm using RNAi and behavioural assays. Our results suggested that Bombyx mori SNMP1 is a functional orthologue of the Drosophila melanogaster SNMP1 and plays a critical role in pheromone detection. Split-ubiquitin yeast hybridization study shows that BmorSNMP1 has a protein-protein interaction with the BmorOR1 pheromone receptor, and the co-receptor (BmorOrco). Concluding, we propose a novel molecular model in which BmorOrco, BmorSNMP1 and BmorOR1 form a heteromer in the detection of the silkworm sex pheromone bombykol.

Themed Session: Molecular Mechanisms in Terrestrial and Aquatic Chemical Ecology

POSTER

Number: 65

Yang C-q[1]., Deng J-c[1], Qin W-t[1], Yang W-y[1,2], Liu J[1,2].

Metabonomics Analysis of Soybean Pod Response to Field Mold Infection

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Prolonged, continuous rainfall is the main climatic characteristic of autumn in Southwest China, and it has been found to cause mildew outbreaks in pre-harvest soybean fields. Previous research found that some kind of soybean pod has mildew resistance. In order to explore the field mildew resistance mechanism of soybean pod, UPLC-Q-TOF/MS untargeted metabonomics method was adopted to characterize the metabolic response of ND12 (sensitive) and D49 (resistance) after infecting with Fusarium moniliforme. And the key metabolic pathways were scheduling target validation. The results showed that infected by fungal for 7 days, 182 metabolites including Flavone, fatty acids and other secondary metabolites were significant changed in pod of D49 while 50 metabolites especially the sugar and amino acids were significant changed in pod of ND12. The metabolic pathway analysis showed that the starch and sucrose metabolism, phenylalanine, tyrosine and tryptophan biosynthesis, pentose and glucuronate interconversions were obviously responded in the pod of ND12, and the Linoleic acid metabolism, flavone and flavonol biosynthesis were strongly responded in the pod of D49. The sequential monitoring results of different kinds of soybean pod fatty acid and isoflavone component response to field mould showed that field fungal infection can promote the accumulation of isoflavones in fungus resistant soybean pod, and weaken the accumulation of linolenic acid, linoleic acid and other nutrients.

Themed Session: Metabolomics in Chemical Ecology

POSTER

Number: 57

Yang K.

Evaluation of trap designs and food attractants for trapping *Eucryptorrhynchus scrobiculatus* (Coleoptera: Curculionidae)

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Eucryptorrhynchus scrobiculatus (Motschulsky) is a serious pest of tree of heaven, Ailanthus altissima (Mill.) Swingle in China. Laboratory choice tests were conducted to compare attractiveness of vinegar, ethanol, apple juice, the vinegar-ethanol mixture (VE), vinegar-apple mixture (VA), ethanol-apple mixture (EA) and vinegar-ethanol-apple mixture (VEA) to E. scrobiculatus. VEA showed significantly higher attractiveness to E. scrobiculatus than vinegar, ethanol, apple juice alone, VE, VA or EA. The field experiments were conducted to evaluate the efficiency of commercial pitfall traps baited with different ratios of VEA (Apple: VE, m:m) for trapping E. scrobiculatus. Field evaluations showed that the number of marked and wild E. scrobiculatus in traps baited with the VEA (Apple: VE, 30:70 ratio, m:m) was significantly higher than traps baited with other ratios of VEA. Further testing of four types of trap baited with this VEA (Apple: VE, 30:70 ratio, m:m) indicated that captures in homemade pitfall trap design were significantly higher than in any other trap design (commercial pitfall traps, cross-vane versus traps and six-unitfunnel traps). The results demonstrated that homemade pitfall traps baited with the VEA (Apple: VE, 30:70 ratio, m:m) have potential for E. scrobiculatus monitoring.

Themed Session: Natural Product Application in Insect Pest Control

POSTER

Number: 78

Zhang, Y.

Identification of Caragana plant volatiles, overlapping profiles, and olfactory attraction to *Chlorophorus caragana* in the laboratory

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Chlorophorus caragana (Coleoptera: Cerambycidae) is a trunk borer that feeds on Caragana shrubs in the desert. There are five species of Caragana plant in the distribution area of Ch. caragana. We investigated damaged Caragana plants in the field. Olfactory responses of female Ch. caragana to plants and identified volatile compounds from Caragana plants were further evaluated. Caragana davazamcii was severely damaged in the field, followed by Caragana microphylla. No damage was found to the other three species. Behavioral experiments showed that C. davazamcii, C. microphylla, and Caragana korshinskii were attractive to female insects. Caragana ordosica could repel and avoid female insects. Caragana brachypoda had no effect on the orientation behavior of female insects. Seventy volatile components were identified from the Caragana plants, and (Z)-β-ocimene, 1,3-pentadiene, (Z)-3-hexenyl acetate, perillene, chrysanthenone, and limonene were the most abundant volatiles identified from the Caragana plants. The volatiles were categorized into three groups. Those most attractive to Ch. caragana consisted of chrysanthenone, 1,3-pentadiene, and (Z)-β-ocimene. Those repelling Ch. caragana consisted of perillene, dibutyl phthalate, nonanal, and pentadecane, and those irrelevant to each other consisted of (Z)-3-hexenyl acetate, 1-octene, nonene, decanal, (Z)-3-hexenol, and α-pinene.

Themed Session: The Chemical Ecology of Host and Mate Selection

POSTER

Number: 98

Xu C., Su J., Wang M., and Zhou A.

Chemical and visual cues mediate mutualism between ghost ant *Tapinoma melanocephalum* and invasive mealybug *Phenacoccus solenopsis*

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Many studies have demonstrated ant tending protects hemipterans from predators and parasitoids. However, it's unclear how ant tending helps hemipteran defend against their natural enemies. Our previous studies showed that there is a close mutual relationship between ghost ants, *Tapinoma melanocephalum* and invasive mealybug, *Phenacoccus solenopsis*. Parasitism of *P. solenopsis* by the dominant endoparasitoid, *Aenasius bambawalei*, was significantly reduced on plants with ants. Interestingly, the parasitoids are seldom attacked by ghost ants. It is unclear how the ghost ants adversely affect parasitoids. In this study, we evaluated the effects of chemical and visual cues involved in the mutualism on the performance of *A. bambawalei*. Our results showed that honeydew produced by P. *solenopsis* can obviously attract *A. bambawalei*. When supplied with less honeydew, searching activity and longevity of *A. bambawalei* were significantly reduced, resulting in a significantly lower rate of parasitism. We also found that *A. bambawalei* avoided pygidial gland secretions and visual cues of ghost ants. Parasitism rates in plants treated with pygidial gland extracts and individual components, such as 6-methyl-5-hepten-2-one and actinidine, were significantly lower than those in control plants. In conclusion, honeydew consumption by ants may negatively influence the performance of parasitoids. The pygidial gland secretions and visual cues of ghost ants also significantly inhibit the parasitism.

Themed Session: The Chemical Ecology of Symbiotic Interactions

POSTER

Number: 103