NEWSLETTER 2020

LEQCI
Laboratory of Chemical Ecology and Insect Behaviour

USP

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Cover illustration

Apple fruit moth, *Argyresthia conjugella*, flying in the wind tunnel. Adapted from original photo by Erling Fløistad, Nibio, Norway

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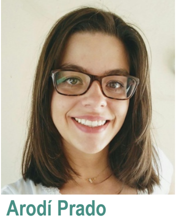
Unveiling the complexity of Chemical Ecology

José Maurício S. Bento



Arodí Prado Favaris

Composed of several biomes, such as tropical forests (Amazon and Atlantic Forests), dry forest (Caatinga), savannah (Cerrado), wetland (Pantanal), and grassland (Pampas), Brazil stands out as the most biologically diverse country in the world. At the same time, Brazil is one of the largest producer and exporter of agricultural products, including coffee, sugarcane, soybean, beef, orange, corn, and cotton. Thus, encompassing basic and applied research, the country still has a lot to do as a natural cradle of biodiversity with enormous potential for chemical ecology discoveries.

The Laboratory of Chemical Ecology and Insect Behaviour (LEQCI) belongs to 'Luiz de Queiroz' College of Agriculture (ESALQ), a centre of excellence for undergraduate and graduate programs in agricultural sciences of the University of São Paulo (USP), the largest and most important higher education and research institution in Brazil. In 2021, LEQCI will turn 15 years old, and we are excited to launch our first newsletter. We want to share the latest scientific discoveries, new projects, and updates on the laboratory infrastructure with you through an annual newsletter. Thus, we hope to contribute to a greater understanding of chemical ecology and give society, funding agencies, and collaborative private companies feedback regarding their investments.

Our purpose is to promote research excellence in chemical ecology and high-quality scientific training for students, researchers, and other professionals. During all these years, LEQCI built up a sizeable group consisting of 20 postdoctoral researchers, 28 PhD students, and 20 master's students, and most of them hold positions in various public and private institutions.

Since its foundation, LEQCI has established productive international collaborations and exchanges to bring to Brazil the most current and modern knowledge and technology in chemical ecology. In this sense, we are immensely grateful to the following institutions and colleagues: Université de Neuchâtel, Switzerland (Prof. Ted Turlings); Max Planck Institute for Chemical Ecology, Germany (Dr. Jonathan Gershenzon and Dr. Ian Baldwin); Penn State University, USA (Prof. Consuelo de Moraes, today at ETH Zürich, Switzerland); University of California-Davis, USA (Prof. Walter Leal); Wageningen University & Research, The Netherlands (Prof. Marcel Dicke), University of California-Riverside, USA (Prof. Jocelyn Millar); University of Illinois, USA (Prof. Lawrence Hanks); and Texas Tech University, USA (Prof. Paul Paré).

LEQCI was built in two steps. The first was thank to Fuji Flavor CO's donation and the second step was within the National Institute of Science and Technology (INCT). The expertise of LEQCI in behavioural and chemical ecology is complementary to that of the groups that compose INCT in Semiochemicals – USP-ESALQ (headquarter), Federal University of Paraná (Prof. Paulo Zarbin), Federal University of Viçosa (Prof. Eraldo Lima), and Federal University of Alagoas (Prof. Euzébio Santana). More recently, we started a new partnership with Prof. José Roberto Parra to improve biological pest control (São Paulo Advanced Research Center for Biological Control, SPARCBio). In addition to all partnerships, LEQCI has always had financial resources for research thanks to the São Paulo Research Foundation (FAPESP), the National Council for Scientific and Technological Development (CNPq), the Coordination for the Improvement of Higher Education Personnel (CAPES), and the Fund for Citrus Protection (Fundecitrus). And looking to the future, LEQCI has established cooperation with private companies to discover and develop new strategies for sustainable pest management using semiochemicals.

FAPESP CNPq CAPES Fundecitrus SCIENCE AND SUSTAINABILITY IN CITRICULTURE inct SEMIOQUÍMICOS NA AGRICULTURA SPARCBIO ESALQ

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Tritrophic interactions: a case study of the earwig *Dorus luteipes* and associated preys on *Zea* spp. plants


Natalia Naranjo


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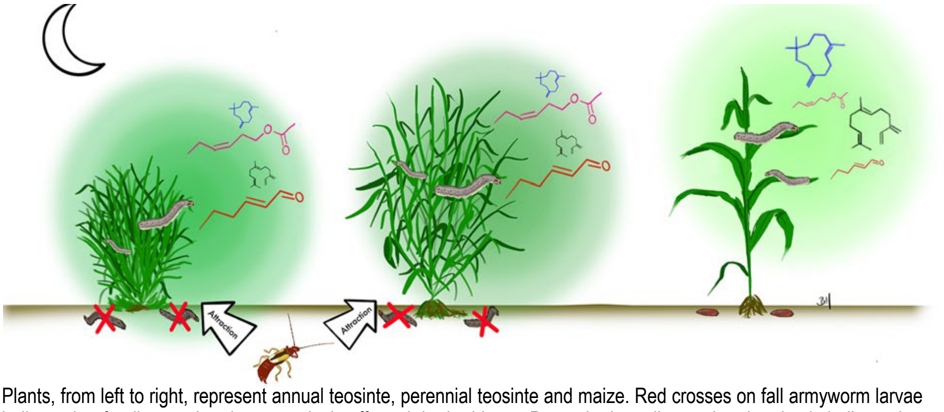
It is known that plants under attack by herbivorous arthropods emit a complex blend of compounds called herbivore-induced plant volatiles (HIPVs), which are important signals in host/prey searching by parasitoids and predators, and that plants respond differently to herbivory depending on the time of the day when the damage was inflicted. Also, there is increasing evidence that crop domestication can alter interactions among plants, herbivores, and their natural enemies. The former PhD student Natalia Naranjo-Guevara and collaborators demonstrated by two recent publications that the earwig *Doru luteipes* (Dermaptera) is a night-active natural enemy that orients by nocturnal HIPVs and the chemical defences of modern maize are lost due to domestication.

The first paper, published in The Science of Nature, reports the first evidence of the response of nocturnal predators to volatile blend emitted by damaged plants. During the day, although the earwigs were walking actively, they (1) did not fed on suitable lepidopteran prey *Spodoptera frugiperda* and (2) did not discriminate the volatiles of undamaged maize plants from those of herbivore-damaged maize plants. In addition, olfactometry assays confirmed that *D. luteipes* was attracted to nocturnal HIPV blends triggered by herbivory of either lepidopterian preys, *S. frugiperda* or *Diatrea saccharalis*; and the earwig preferred volatile blends from short-term over long-term damaged maize plants. The attraction of *D. luteipes* to short-term volatile blends possibly increases the chances of the earwig finding suitable prey, as damage by caterpillars and aphids to crop plants elicits the emission of green leaf volatiles (GLVs). In total, 10 compounds were detected in the blend emitted by maize plants at night and short-term plant volatiles were comprised mainly of fatty acid derivatives while the long-term damaged plant volatile blend contained mostly terpenoids.

Studies have demonstrated that domesticated plants, such as maize, have reduced defenses against herbivores in detriment to intensely selecting for rapid growth and high yield, when compared with their wild ancestors' species known as teosintes (*Zea* spp.). Therefore, the second paper, published in the journal Chemoecology, researchers explored how domestication of *Zea* plants influences insect-plants interactions through plant defence. Experiments on food utilization by *S. frugiperda*, olfactometry bioassays and plant volatile collections were conducted. Caterpillar growth and survival were reduced on teosintes relative to maize. Whilst *S. frugiperda* that fed on perennial teosinte had lower food intake indices, those on annual teosinte showed lower food utilization indices relative to maize. Interestingly, as in the first paper, we suggest that GLVs have an important role in earwig attraction. The earwig preferred HIPVs emitted by teosintes over those emitted by maize, but it did not discriminate between odours of herbivore-damaged annual and perennial teosinte. The nocturnal HIPV blend from maize contained the lowest total amount of fatty acid derivatives, while it had higher total amounts of terpenes compared to teosintes. Thus, this study shows that the teosintes are better defended than maize in terms of direct and indirect defences; however, the perennial teosinte have stronger direct defences against the fall armyworm than the annual teosinte. In conclusion, both studies bring a new contribution to the knowledge about plant defences in a tritrophic context and predatory strategies in *D. luteipes*, which would promote alternatives to optimize the conservation and biological control of pest by predators in the field.



Plants, from left to right, represent annual teosinte, perennial teosinte and maize. Red crosses on fall armyworm larvae indicate that feeding on the plant negatively affected the herbivore. Pupae in the soil near the plant basis indicate that the fall armyworms reached the pupal stage after feeding on the plant. Arrows near the predatory earwig indicate its olfactory preference for herbivore-induced plant volatiles. Compositions of the blends emitted by herbivore-damaged plants are indicated by the size of molecules and colour intensity.

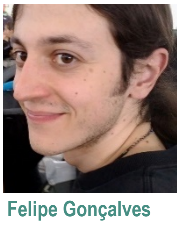
Naranjo-Guevara N, Peñaflor MFGV, Silva DB, Bento JMS. 2020. A comparison of the direct and indirect defence abilities of cultivated maize versus perennial and annual teosintes. **Chemoecology**. https://doi.org/10.1007/s00049-020-00329-x

Naranjo-Guevara N, Peñaflor MFG, Cabezas-Guerrero MF, Bento JMS. 2017. Nocturnal herbivore-induced plant volatiles attract the generalist predatory earwig *Doru luteipes* Scudder. **The Science of Nature** 104: 77. https://doi.org/10.1007/s00114-017-1498-9

Silicon as an elicitor of induced defences in wheat


Reinaldo Oliveira


Maria F. Peñaflor

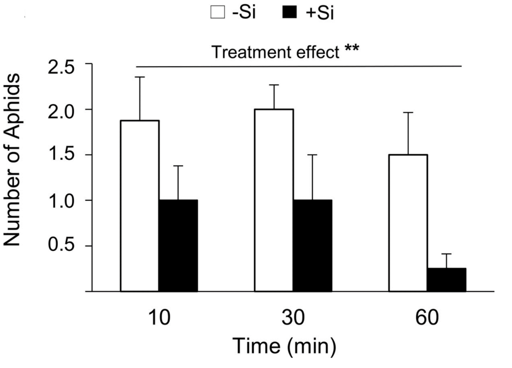

Felipe Gonçalves


Weliton Silva

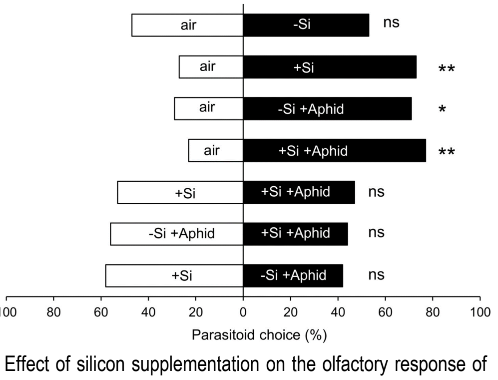
The bird cherry-oat aphid *Rhopalosiphum padi* is one of the most important pests of wheat worldwide, especially because it transmits the pathogen barley yellow dwarf virus (BYDV). Although parasitoids can provide a significant control of cereal aphid populations, chemical control is widely employed to suppress population of *R. padi* in cereal crops, causing undesirable effects, such as development of resistance. In this context, silicon supplementation offers a promise for aphid management in order to rely less on pesticides. In a paper published in PLoS ONE, the group investigated whether Si supplementation alters wheat volatile emissions that influence the bird cherry-oat aphid olfactory preference and the aphid parasitoid *Lysiphlebus testaceipes*.

Even though Si accumulation in wheat did not impact aphid performance, they found that *R. padi* preferred constitutive volatiles from -Si wheat over those emitted by +Si wheat plants. However, the parasitoid was attracted to volatiles from +Si uninfested wheat, but not to those from -Si uninfested wheat. Using GC-MS analyses the group identified that +Si uninfested wheat plants emitted increased amounts of a single compound, geranylacetone, compared to -Si uninfested wheat, but similar to those emitted by aphid-infested treatments. By contrast, Si supplementation in wheat did not alter composition of aphid-induced plant volatiles.

The findings in this paper indicate that Si supplementation in wheat has potential to control the bird cherry-oat aphid population because Si accumulation in plants makes them less likely to be colonized by the bird cherry-oat aphid at the same time that recruits its parasitoid *L. testaceipes*, working as an elicitor of induced defences in wheat.



Olfactory preference of *Rhopalosiphum padi* to Si-supplemented (+Si) and non-Si supplemented (–Si) wheat plants in arena choice assays along time course.



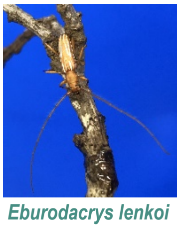
Effect of silicon supplementation on the olfactory response of *Lysiphlebus testaceipes* to wheat volatiles.

Oliveira RS, **Peñaflor MFGV**, **Gonçalves FG**, Sampaio MV, Korndörfer AP, **Silva WD**, **Bento JMS**. 2020. Silicon-induced changes in plant volatiles reduce attractiveness of wheat to the bird cherry-oat aphid *Rhopalosiphum padi* and attract the parasitoid *Lysiphlebus testaceipes*. **PLoS ONE** 15: e0231005. https://doi.org/10.1371/journal.pone.0231005

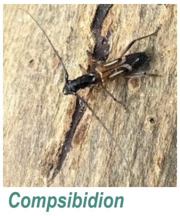
Pheromone motifs create species-specific pheromone channels in South American cerambycid beetles

Weliton Silva

Fernando Madalon



Eburodacrys lenkoi



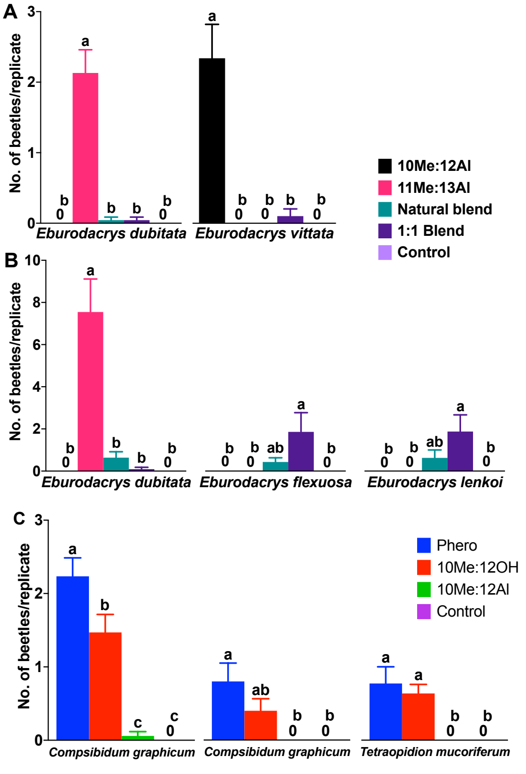
Compsibidion graphicum

A growing body of evidences has shown that some pheromone structures produced by adult beetles of the family Cerambycidae are highly conserved among both closely related and distantly related species, in which the beetles may produce similar or even identical pheromone components. As a part of an ongoing project aiming the identification of attractant pheromones of South American cerambycid beetles, Weliton Silva and collaborators have elucidated the pheromone chemistry of six cerambycid species in the subfamily Cerambycinae, tribes Eburiini and Neoibidionini.

In a first approach they found that adult males of the cerambycid *Eburodacrys dubitata* sex-specifically produce 11-methyldodecanal, whereas males of *E. assimilis* produce this compound along with the one carbon homolog 10-methyldodecanal, which has been previously identified as the aggregation sex-pheromone for the congener *E. vittata*. During field bioassays testing these aldehydes alone and in blends, adults of both sexes of *E. dubitata* were only significantly attracted to traps containing the 11-methyltridecanal as a single component and, in the same fashion, conspecifics of *E. vittata* were attracted to 10-methyldodecanal traps. Despite no adult of the target *E. assimilis* was caught during the trials, two congeners, *E. flexuosa* and *E. lenkoi*, were serendipitously attracted to traps containing 1:1 blend of 10-methyldodecanal and 11-methyltridecanal. Analysis of headspace volatile extracts of adult males of these species revealed that they indeed produce a blend of same aldehydes.

In a second approach, analysis of aeration extracts of adults of the *Compsibidion graphicum* and *C. sommeri* revealed that conspecific males of both species produce a blend of 10-methyldodecanal along with the analogous alcohol 10-methyldodecanol. Traps containing the reconstructed blend of these compounds attracted conspecific males and females of both species. A third cerambycid species in the same tribe Neoibidionini, *Tetraopidium mucoriferum*, was also attracted in significant numbers by the treatment traps, but the semiochemistry of this species remains unknown.

Taken together, these results offer compelling evidences that functionalized 10-methyldodecanes, along with the homologous functionalized 11-methyltridecanes, are shared pheromone components of several South American cerambycid species. However, it remains to estimate which enantiomer of each compound is produced by each species through bioassays of the enantiomers, or possibly non-racemic mixtures of the two enantiomers of each component. This will be critical since species may discriminate the enantiomers, and the synergism between enantiomers might also be critical for attraction of several cerambycid species.



Mean (± 1 SE) number of adult males and females of cerambycid beetles caught during field bioassays in Brazil testing attractant pheromones for species of genus *Eburodacrys* (A; Site 1) and (B; Site 2) and *Compsibidion* (C; Site 3). Treatments: 10Me:12Al = 10-methyldodecanal; 10Me:12OH = 10-methyldodecanol; 11Me:13Al = 11-methyltridecanal; Phero = blend of 10Me:12Al and 10Me:12OH in the same ratio produced by adult males of *Compsibidion* species; Natural blend = blend of 10Me:12Al and 11Me:13Al in the same ratio produced by adult males of *E. assimilis*; 1:1 Blend = 1:1 blend of 10Me:12Al and 11Me:13Al; Control = solvent (isopropanol).

Silva WD, Hanks LM, Alvarez JCS, **Madalon FZ**, **Bento JMS**, Bello JE, Millar JG. 2020. Variations on a theme: two structural motifs create species-specific pheromone channels for multiple species of South American cerambycid beetles. **Insects** 11: 222. https://doi.org/10.3390/insects11040222

Barometric pressure affects the decision-making in foraging efficiency of ants

Fernando Sujimoto

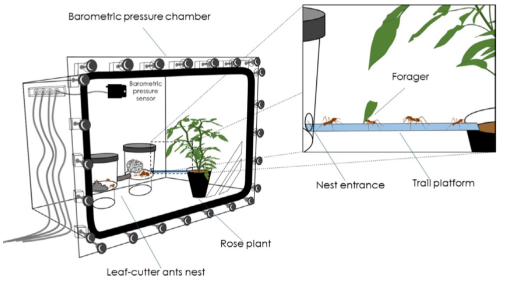
Camila Costa

Atta sexdens

Among all activities displayed by social insects, searching for food is essential for colony survival. However, many external activities can impose barriers or even be hazardous for the entire society. Differently from in-nest activities, foraging places the workers at great risk and many challenges imposed by abiotic variations, such as temperature and humidity. However, barometric pressure appears to substantially affect insect behaviour. Since high-pressure systems are followed by dry, sunny weather, pressure drops are associated with rain and strong wind, which can be devastating for social insects. Therefore, the perception of changes in barometric pressure would allow them to sense impending weather and make appropriate foraging decisions.

Given that many environmental threats can be mitigated or avoided by certain behaviour shifts, the goal of this study was to verify if social insects can detect barometric pressure variations as cues to assess foraging risks, using the leaf-cutter ant *Atta sexdens* as a model. Leaf-cutter ants have a division of labour based on groups of workers with morphological adaptations for particular tasks, with foragers seeking for leaves to feed their fungus gardens. Foraging starts with the scout, which searches for suitable plants in the surroundings and, after finding one, communicates and recruits other workers through a trail pheromone. However, foraging performance of scouts and foragers can be severely affected by micro-weather factors near their nests. In this sense, Fernando Sujimoto and collaborators addressed the following questions: (1) how does high or low barometric pressure affect the worker recruitment? (2) do the patterns of cutting and loading of leaves change under high or low pressure compared to a steady condition?

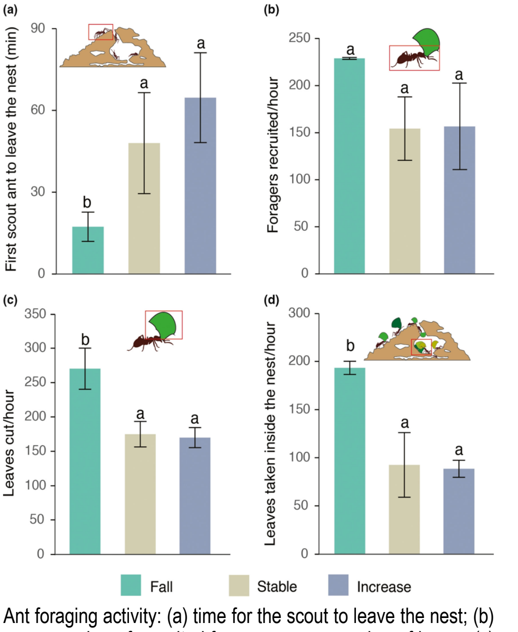
Three *A. sexdens* colonies with 3-year-old were housed in a barometric pressure chamber and the following pressure regimens were tested: (a) steady (control; 950 mbar of pressure); (b) high pressure (958 mbar); (c) low pressure (942 mbar). After the treatment pressure (high, steady, or low pressure) was reached, the colony entrance was opened and ants accessed a rosebush through a platform. Foraging activity was video-recorded and measured as leaves/time since workers mostly cut and carried the entire leaf and not fragments. The time taken by the scout to leave the nest and the total number of recruited foragers were observed.



The first indication of the workers perception of barometric pressure variation was the time taken for the scouts to leave the nest to search for food. In lower pressure, scouts left their nests 2.8 times faster than in steady pressure, and 3.7 times faster than in higher pressure. Thus, during the barometric pressure drop, these individuals left the nest more rapidly compared to the increased and steady pressure conditions. The scouts' readiness may be related primarily to a capacity to forecast natural phenomena, hastening the foraging in order to avoid adverse factors such as raindrops.

Despite the larger number of leaves cut (1.5 times more than in steady or high pressure) and brought into the nest (2 times more than in steady or high pressure) during the pressure drop, this difference was not due to a larger number of recruited foragers for collecting leaves. The total number of workers on the trail in pressure-variation treatments did not differ, indicating that foraging efficiency is related to individual perceptions of pressure changes and then, to maximization of foraging capacity by each ant. Therefore, while subject to a stressor agent, the effort of all individuals to carry and effectively bring a larger amount of food to the colony, shows their high capacity for collective decision-making.

These data indicate that leaf-cutter ants are able to perceive a pressure drop, an important environmental phenomenon that is indirectly related to rainfall and strong winds. Furthermore, barometric pressure affects the decision-making in foraging efficiency of ants, permitting them to maximize food collection and reduce the exposure to environmental risks.



Ant foraging activity: (a) time for the scout to leave the nest; (b) mean number of recruited foragers; mean number of leaves (c) cut and (d) brought to the nest.

Sujimoto FR, **Costa CM**, **Zitelli CH**, **Bento JMS**. 2020. Foraging activity of leaf-cutter ants is affected by barometric pressure. **Ethology** 126: 290-296. https://doi.org/10.1111/eth.12967

Bacteria in the foam may confer protection to spittlebug nymphs

Mateus Tonelli

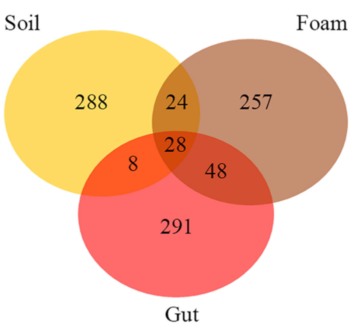
Mahanarva frimbiolata

Scientists from the Laboratories of Chemical Ecology & Insect Behaviour and Soil Microbiology characterized the composition of the bacterial community present in the foam produced by nymphs of a cercopid spittlebug (*Mahanarva frimbiolata*), comparing it to communities found in the soil and the spittlebug gut. Nymphs of *M. frimbiolata* produce a distinctive foam while feeding on host plants and several functions have been attributed to this foam, such as the protection against high temperatures, desiccation, and natural enemies. Because of the humid nature of the foam and its proximity to the soil, there is a continuous threat of fungal and bacterial infestation in nymphs. How nymphs are protected from microbial attack is little understood, although associations between insects and beneficial microorganisms as a protective adaptation are common. Therefore, the presence of beneficial microorganisms in the foam covering the nymphs might have a protective function in *M. fimbriolata*.

Using DNA extraction and posterior gene sequence analysis, the scientists were able to identify and quantify the bacterial community in the three environments sampled: foam, soil, and spittlebug gut. Results showed that the foam produced by the nymphs of *M. fimbriolata* harbours a complex community of microorganisms, including some that were previously reported as defensive symbionts of insects. Analysis of the microbiomes in the nymph gut and the soil close to the foam showed that the microorganisms in the foam were more closely related to those in the gut than in the soil, suggesting that the bacteria are actively introduced into the foam by the nymphs.

Foam samples hosted 257 specific operational taxonomic units (OTUs), while gut and soil samples hosted 291 and 288 specific OTUs, respectively. Twenty-eight OTUs were shared among the foam, gut, and soil samples. Actinobacteria was present predominantly in the foam and nymph gut, whereas Proteobacteria was found in all environments, but with higher frequency in the foam than in the gut and soil.

The ubiquity of Actinobacteria species in the environment and their capacity to produce substances with antimicrobial activity has probably predisposed them to be involved in defensive symbioses with soil-dwelling insects. In further experiments, the researchers want to isolate and identify the substances in the foam to better understand the protective mechanisms in this interaction.



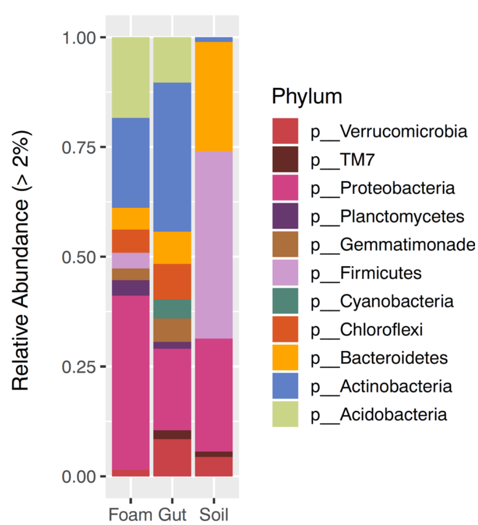


Diagram showing the proportion of operational taxonomic units of exclusive and shared bacteria, and relative abundance (%) of bacteria phyla in the foam produced by *Mahanarva fimbriolata* nymphs, in the gut of nymphs, and in the soil close to the foam.

Tonelli M, Cotta SR, Rigotto A, Dias ACF, Andreote FD, **Bento JMS**. 2020. The composition of the bacterial community in the foam produced by *Mahanarva fimbriolata* is distinct from those at gut and soil. **Brazilian Journal of Microbiology** 51: 1151-1157. https://doi.org/10.1007/s42770-019-00211-1

What pollinators see does not match what they smell

Researchers from the University of Campinas and our lab investigated the correlation between individual fragrance profiles of deceptive orchids (*Ionopsis utricularioides*) and their colour as perceived by the pollinators' visual system. Using as model organisms *Apis mellifera* and *Melipona quadrifasciata* – exotic and native bee species in Brazil, respectively – the researchers found no colour-fragrance association in individuals, either by comparing fragrance profiles with the colour variable saturation or by comparing them with the placement of individuals in the colour hexagon for both bee species. They conclude that the lack of correlation would increase the floral variability perceived by bees, and this variability could disrupt avoidance learning of deceptive flowers, enhancing the efficacy of the plant's deceptive pollination mechanism.

Aguiar JMRBV, Ferreira GS, **Sanches PA**, **Bento JMS**, Sazima M. 2021. What pollinators see does not match what they smell: Absence of color-fragrance association in the deceptive orchid *Ionopsis utricularioides*. **Phytochemistry** 182. https://doi.org/10.1016/j.phytochem.2020.112591

Earwigs use nocturnal HIPVs from arugula plants inoculated with a PGPR as host cues

A research team from the Norwegian University of Life Sciences, Fontys University of Applied Sciences, and our lab showed that the interactions between a plant growth-promoting rhizobacteria (PGPR), arugula plants, and two different species of caterpillars affect the foraging behaviour of the predatory earwig *Doru luteipes*. By assessing earwig preference towards herbivore-induced and PGPR-inoculated plants, the scientists showed the occurrence of a synergistic effect in which earwigs were attracted by plants that presented both conditions. This positive interaction of PGPR and indirect plant defence enhances the benefits of the use of plant-associated microbes in agriculture.

Bell K, **Naranjo-Guevara N**, **Santos RCD**, Meadow R, **Bento JMS**. 2020. Predatory earwigs are attracted by herbivore-induced plant volatiles linked with plant growth-promoting rhizobacteria. **Insects** 11: 271. https://doi.org/10.3390/insects11050271

Important bee pollinators for Brazilian crops

Researchers from several Brazilian research institutions and our lab used a dataset on Brazilian bee-crop interactions (261 records of unique crop-pollinator interaction, 144 bee species, and 23 crops) to determine important bee species for crop pollination and discuss their management in agroecosystems. Despite the importance of social species, solitary bees accounted for 56% of all the interactions. The analysis showed the most important bee species for crop production, providing useful guidelines to develop new strategies for the sustainable management and conservation of crop pollinators in Brazil.

Giannini TC, **Alves DA**, Alves R, Cordeiro GD, Campbell AJ, Awade M, **Bento JMS**, Saraiva AM, Imperatriz-Fonseca VL. 2020. Unveiling the contribution of bee pollinators to Brazilian crops with implications for bee management. **Apidologie** 51: 406-421. https://doi.org/10.1007/s13592-019-00727-3

Attraction of the sugarcane billbug to vinasse and its volatile composition

In a collaboration, the Biological Institute and the University of São Paulo identified how vinasse, a residue from ethanol production, can attract *Sphenophorus levis* in sugarcane fields. Using gas chromatography–mass spectrometry (GC–MS) the researchers identified the presence of primary alcohols, terpenes and organic carboxylic acids in vinasse. When a mixture of these synthetic compounds was tested, a strong attraction of the insects was observed. These data explain how vinasse can contribute to the infestations of *S. levis* in sugarcane fields and can help on the development of new strategies to control this pest.

Martins LF, **Tonelli M**, **Bento JMS**, Bueno CJ, Leite LG. 2020. Attraction of the sugarcane billbug, *Sphenophorus levis*, to vinasse and its volatile composition. **Chemoecology** 30: 205-214. https://doi.org/10.1007/s00049-020-00310-8

Response of *Orius insidiosus* to multiple herbivory

Under natural conditions crops undergo attacks from various pests. Multiple herbivory by arthropods with the same feeding mode yields variable effects. In this study, the effect of multiple herbivory in rose plants by two cell-content feeders, *Tetranychus urticae* and *Frankliniella insularis*, revealed quali- and quantitative differences in the volatile blends. However, the predator *Orius insidiousus* did not discriminate the odours of thrips- or mite-infested plants from multiple-infested plants. *Orius insidiosus* seems to be a potential biological control agent for controlling spider mites and thrips in rose plantations once it is able to find prey regardless of the co-occurrence of both herbivores.

Sousa ALV, **Silva DB**, Silva GG, **Bento JMS**, **Penãflor MFGV**, Souza B. 2020. behavioural response of the generalist predator *Orius insidiosus* to single and multiple herbivory by two cell content-feeding herbivores on rose plants. **Arthropod-Plant Interactions** 14: 227-236. https://doi.org/10.1007/s11829-019-09729-5

Tomato plants as mediators of multitrophic interactions


Diego Magalhães

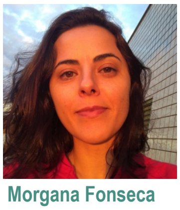

Tomato

A new FAPESP-funded research project aims to investigate the underlying mechanisms involved in plant-mediated interactions between the non-pathogenic plant growth-promoting rhizobacteria (PGPR) *Bacillus amyloliquefaciens*, the herbivore *Tuta absoluta*, predatory mirid bugs, and pollinators, using commercial and wild tomato plants. Beneficial soil-borne microbes, such as PGPR, can affect the interactions of plants with insects at different trophic levels. However, the underlying mechanisms of plant-mediated interactions between rhizobacteria and insects are still poorly understood. Plant growth-promoting rhizobacteria have been characterized by increasing nutrient acquisition and plant growth. These beneficial microbes may also confer broad-spectrum resistance to insect herbivores, by increasing direct and indirect plant defences, both above and belowground, mainly via the release of volatile organic compounds. Soil microbial communities can still influence floral characteristics, thus potentially altering pollinator attraction and visitation. Finally, another important aspect that can alter species interactions is plant domestication. Thus, the understanding of plant defence signalling could be exploited as an important tool to enhance tomato resistance to pests. Dr. Diego Magalhães will take the post-doc position to lead the project.

Title: **Multitrophic interactions influenced by plant growth-promoting rhizobacteria in commercial and wild tomato plants**

Funding Organization: São Paulo Research Foundation (FAPESP, grant number 2019/24492-6)

Sex pheromones for sugarcane pest management


Morgana Fonseca


Sugarcane borer

One of our projects from the partnership with SPARCBio aims to provide a new sustainable solution for the management of the key pest of sugarcane crops. The caterpillars of the sugarcane borer, *Diatraea saccharalis* (Lepidoptera: Crambidae), trigger significant damages to plants mostly by boring and tunnelling the stems. Because of these features of the caterpillar behaviour and the large extent of cultivated areas, the sampling system for monitoring this pest demands laborious and time-consuming processes (e.g. for opening and counting caterpillars inside the stems). Moreover, the effectiveness and growth of biological control, the main strategy to the management of this pest, depends on accurate timing of release of the parasitoids in the presence of their specific host stages. Therefore, there is a considerable growing demand for a reliable monitoring system for this pest, which would reduce costs and promote biological control. Much effort has been devoted to investigate the sex pheromone of the sugarcane borer with this purpose, however, it has not yet been fully elucidated. To address this need for more efficient detection of pest infestation, this project aims to further investigate the sexual pheromone of *D. saccharalis*, in order to provide a commercial formulation to be used in a trap monitoring system. This study will be carried out by Morgana Fonseca, the new post-doctoral fellow in the group, and also involves the technician and PhD student Arodí Favaris, and Prof. Paulo Zarbin, our partner from the Federal University of Paraná.

Title: **Sustainable management of the sugarcane borer, *Diatraea saccharalis*, with sex pheromones**

Funding Organization: São Paulo Research Foundation (FAPESP, grant number 2020/12994-4)

Endophytic insect-pathogenic fungi as inducer of plant defences

Marvin Pec

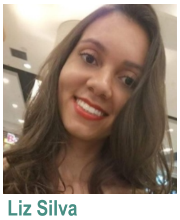
Sugarcane

Entomopathogenic fungi have been used in pest control for over a hundred years, and, in addition to this role, recent studies have shown that they have other ecological functions, such as in plant growth promotion, plant disease antagonism, and also endophytism. Endophytic insect-pathogenic fungi live inside plant tissues without causing any damage to them. When fungi colonize plants, they activate various mutualistic interactions with their hosts, such as resistance to biotic (e.g. attack of diseases and pests) and abiotic stress (e.g. salinity, drought, heavy metals), and this may impact plant growth. In this sense, these endophytic microorganisms that act both as plant mutualists and as insect pathogens offer multiple promising strategies to be used in integrated pest management. This also meets one of the greatest challenges of science, which is to promote sustainable agriculture while increasing productivity. In this context, the main goal of this project is to study the effects of endophytic fungi across trophic levels in sugarcane crops. Specifically, in the first trophic level we aim to investigate the effect of colonization of sugarcane seedlings by an isolate of endophytic insect-pathogenic fungi (*Metarhizium robertsii*) as an inducer of plant defences. Subsequently, we will examine how this affects sugarcane borer (*Diatraea saccharalis*) infestations and, indirectly, its natural enemy, the parasitoid *Cotesia flavipes*. We also seek to understand the mechanisms involved in each of the trophic interactions in this food web. This project will be conducted by the PhD student Marvin Pec.

Title: **Endophytic insect-pathogenic fungi as inducer of plant defenses to promote pest resistance**

Funding Organization: Coordination for the Improvement of Higher Education Personnel (CAPES grant 88887.482584/2020-00)

Do volatiles from bushy stunt-infected maize affect leafhopper behaviour?



Liz Silva

Maize

Maize can be affected by diseases that belong to the stunting complex. Two of these diseases are caused by bacteria, a phytoplasma that is involved with the maize bushy stunt disease, and a spiroplasma that causes corn stunt disease, which is the maize rayado fino. The pathogens involved are transmitted by the corn leafhopper *Dalbulus maidis* (Hemiptera), in a persistent propagative relationship. Outbreaks of diseases of the corn stunt complex have occurred in the past in Brazil, especially with the advent of second season maize, which ensures the continuity of crops after the harvest. Recently, maize bushy stunt disease has been a concern of producers in different Brazilian states, including São Paulo and Santa Catarina. This disease causes a number of symptoms, such as stunting and shortening of the internodes (which characterizes the stunting), multiple cobs, and ear malformation, and reddening of the leaves. Little is known about the reaction of maize genotypes used in Santa Catarina, which are also recommended nationwide, on attractiveness to *D. maidis*, as well as on the response to diseases transmitted by this insect. There is also evidence that *D. maidis* prefers to land and oviposit on healthy maize plants than on plants infected with maize bushy stunt. In this sense, this study aims to detect possible difference in the colonization of maize varieties developed by EPAGRI and hybrids widely used by *D. maidis*, as well as the reaction of these materials to corn stunt complex diseases. Preference tests will be performed in the field and in the laboratory. Genotypes that show any difference in preference assays will be submitted to laboratory tests of choice using olfactometer and volatile compounds produced by these materials will be collected in order to know possible substances that may be involved in attractiveness or insect repellency. In addition, a maize bushy stunt phytoplasma isolate will be obtained in Santa Catarina and submitted to olfactometry test. Healthy and infected plants will have their volatile profile compared. The identification of compounds involved in attracting or repellency of *D. maidis* will allow the knowledge of the reaction of these genotypes to the insect at a more refined level, which may impact the incidence of the diseases. These compounds could be potential tools in the future for the management of this vector using field insect manipulation strategies, less dependent on traditional chemicals. This study will be carried out by the master's student Liz Silva and Dr. Maria Cristina Canale, our collaborator from the Agricultural Research and Rural Extension Company of Santa Catarina State (EPAGRI).

Title: **Do volatiles from healthy and bushy stunt-infected maize affect *Dalbulus maidis* behaviour?**

Funding Organization: Coordination for the Improvement of Higher Education Personnel (CAPES)

Our research focuses on investigating the behaviour and semiochemicals evolved in the ecological interactions of insects, plants, and microorganisms. For the headspace collection of volatile organic compounds (VOCs) and olfactometry, our facilities include an integrated system of purified and humidified air supply. The laboratory is equipped with gas chromatography (GC) instruments for sample analysis: one GC coupled with a flame ionization detector (GC-FID) for screening extracts and compounds quantification; one GC-FID with electroantennography detection for selecting bioactive compounds; two GCs with a mass spectrometer (GC-MS) for compounds identification. To carry out behavioural experiments, the laboratory also comprises many facilities, including a wind tunnel for measuring responses of flying insects to semiochemicals under three light conditions; a computer-controlled barometric chamber for observing insects under barometric pressure variation; and different kinds of olfactometers.