ESF – Travel Gordon conference 2012 - Scientific report

a) Summary

The Gordon Research conference on plant volatiles took place at the Ventura Beach Marriott hotel, Ventura, CA, from January 29 to February 3, 2012. The conference was entitled: Plant Volatiles: Ecology, Biosynthesis, Regulation and Animal Perception of Floral and Vegetative Volatiles, Plus their Roles in Human Flavor and Agriculture. The chair and co-chair of the event were Jonathan Gershenzon and Harry J. Klee, respectively. There was a record attendance for the meeting of 152, gathering international experts from many different countries.

Two presenters from the laboratory of Fundamental and Applied Research on Chemical Ecology (FARCE, Neuchatel, Switzerland) were reporting results related to the Inva-Vol project: Professor Ted Turlings and post-doctorate researcher Gaylord Desurmont. Ted Turlings gave an oral presentation entitled "Selecting entomopathogenic nematodes for increased effectiveness in biological control using plant volatiles" during the session “Volatiles in agriculture”, and Gaylord Desurmont gave a poster presentation entitled “Alien interference: disruption of volatile-mediated interactions between plants and parasitoids by invasive insect herbivores” in poster session 1.

The meeting was also attended by two other Inva-Vol participants, Prof. Florian Schiestl and his PhD student Judith Trunschke, who gave an oral and a poster presentation, respectively. Also, present were members of other EuroVol projects, in particular a large delegation from Wageningen, lead by Prof. Marcle Dicke. Drs. Marcel Dicke, Florian Schiestl and Ted Turlings, all mentioned Eurovol during their presentations and explained their respective contribution. EuroVol flyers that we provided by the Eurocore head-office were distributed by Ted Turling and Marcel Dicke to all the participants.

b) Final programme of the event

Day 1
7:40 pm - 9:30 pm Volatiles in Human Flavor and Taste
Discussion Leader: Efraim Lewinsohn (Newe-Yaar Research Center)

Day 2
9:00 am - 12:30 pm Volatile Biosynthesis: Pathways and Evolution
Discussion Leader: Alain Tissier (Leibniz Institute of Plant Biochemistry)
4:00 pm - 6:00 pm Poster Session I
7:30 pm - 9:30 pm Regulation of Volatile Biosynthesis
Discussion Leader: Robert Schuurink (University of Amsterdam)

Day 3
9:00 am - 12:30 pm Ecology of Vegetative Volatiles - Plant Defense
Discussion Leader: Consuelo De Moraes (Penn State University)

4:00 pm - 6:00 pm Poster Session I
7:30 pm - 9:30 pm Ecology of Plant-Associated Volatiles
Discussion Leader: Martin Heil (Cinvestav-Unidad Irapuato)

Day 4
9:00 am - 12:30 pm Ecology of Floral Volatiles
Discussion Leader: Stefan Dötterl (University of Bayreuth)
4:00 pm - 6:00 pm Poster Session II
7:30 pm - 9:30 pm Ecology of Floral, Fruit and Seed Volatiles
Discussion Leader: Manfred Ayasse (University of Ulm)

Day 5
9:00 am - 12:30 pm Volatiles in Agriculture
Discussion Leader: John Beck (US Department of Agriculture, Albany)
4:00 pm - 6:00 pm Poster Session II
7:30 pm - 9:30 pm Animal Perception of Plant Volatiles
Discussion Leader: Jeff Riffell (University of Washington)

c) Scientific content of the event

Plants perfume the air around them with a large range of volatile compounds that are critical for their reproduction, defense and internal signaling. These chemically diverse substances have long been studied by both chemists and biologists for their scientific importance, as well as their roles as perfumes, flavorings, pharmaceuticals, pest protection agents and modifiers of atmospheric chemistry. In 1999, a Gordon Research Conference on floral volatiles was initiated and later vegetative volatiles were also added to the agenda. This conference met four times (1999, 2002, 2007 and 2009). This new 2012 conference had a broader basis and cover all plant volatiles, including those released by leaves, roots, flowers and fruit.

The new Gordon Research Conference on Plant Volatiles took a multi-disciplinary approach to its subject treating both basic and applied aspects in depth. A central theme was the function of volatiles in plant defense, reproduction and communication, as well as their importance in the evolution of plants and the animals, fungi and microbes that interact with them. On the plant side, the multi-faceted mechanisms by which plants synthesize, store and release volatiles has also been covered. On the animal side, the ways in which animals, including pollinators, herbivores and herbivore enemies perceive volatiles was examined. In addition, some of the many uses of volatiles in foods, beverages and agriculture were also included. The aim to bring together researchers from fields as different as food chemistry, insect neurobiology, plant enzymology and pollination ecology to exchange their latest results, share ideas and start new collaborations on plant volatiles in an inter-disciplinary context was fully met.

d) Presentations made by the participants

Abstract of the presentation by Ted Turlings

Selecting entomopathogenic nematodes for increased effectiveness in biological control using plant volatiles

Seven billion and counting…. the ever-increasing human population is putting unprecedented pressures on our natural resources. Arguably the biggest contemporary challenge for humanity is to meet world's current and future food security. About one third of the potential crop yield is still lost to insect pests and pathogens, but rapid advances in the fields of metabolomics and genomics offer new opportunities to explore plant traits that may help to develop strategies to combat these pests.

We use a chemical ecological approach to better understand the interactions among maize plants, pest insects and the natural enemies of the pests. For example, with the latest chemical analytical techniques and with the use of mutant maize plants we think we have found an explanation for the voraciousness of one of the most important pests to maize, the Western corn rootworm or *Diabrotoca virgifera virgifera*. Larvae of this beetle were found to prefer to feed on nutritious crown roots of maize, which are also very well-defended by benzoxazinoids[1], toxic compounds that normally deter herbivores from feeding on the roots. The rootworm larvae, however, are not affected by the toxins and use them to identify these roots[2], which are rich in sugars and amino acids.

One of the solutions to fight corn rootworm are entomopathogenic nematodes, tiny parasitic worms that kill the larvae within days. We have discovered that the nematodes use a chemical signal that is specifically emitted from maize after rootworm attack[3]. However, this signal, the sesquiterpene E-(β)-caryophyllene is not emitted American maize varieties[4], which makes these varieties far less attractive to the beneficial nematodes. By genetically transforming an American maize line we a caryophyllene-synthase gene from oregano, we restored caryophyllene emission in this line and field experiments revealed that this resulted in enhanced protection by nematodes against rootworm damage[5]. These examples show that a good understanding of chemically mediated interactions among plants and insects can lead to novel strategies for crop protection.

Abstract of the presentation by Gaylord Desurmont

Alien interference: disruption of volatile-mediated interactions between plants and parasitoids by invasive insect herbivores

Plant volatiles are of key importance for the foraging behavior of predators and parasitoids in search of prey or hosts, and the specificity of these chemically-mediated interactions results from shared evolutionary history between the interacting species. We propose that parasitoids

can readily use plant-produced volatiles to distinguish between hosts and non-hosts, but that invading insect herbivores may disrupt these finely-tuned interactions and negatively impact the foraging behavior of native parasitoids. Using *Brassica rapa* and its complex of native herbivores and parasitoids as a study system, we investigated the effect of two invasive herbivores (*Spodoptera littoralis* and *Heliothis virescens*) on the foraging behavior of 4 native parasitoids. In a 6-arm olfactometer setting, we simultaneously tested parasitoid attraction to plants (1) undamaged, (2) damaged by the parasitoid's host herbivore, (3) damaged by a native non-host, and (4) damaged by an exotic non-host. Although plants damaged by non-hosts were more attractive to parasitoids than undamaged plants, they were considerably less attractive than plants damaged by hosts. There was no overall difference in attractiveness between plants damaged by native non-hosts and plants damaged by exotic non-hosts, but *H. virescens* damage was found to cause more parasitoid attraction than *S. littoralis* damage. These results show that invasive herbivores can impact infochemical networks between plants and natural enemies, but that invasive herbivores do not necessarily have a greater impact on specific plant-parasitoid interactions than native herbivores. Because disruptive effects are highly association-specific, exotic herbivores may greatly differ in their "disruption potential" in their invasive range.

e) Evaluation of the impact of the scientific event on the EUROCORES programme

The Gordon conference on plant volatiles gathered most of the world-class experts in this field, and showing several presentations funded by the EUROCORES attracted international attention on the aim, main objectives, and specificities of the program. In addition to drawing positive attention, the event was a perfect opportunity to interact and exchange ideas with renowned researchers from various fields. Despite its seemingly specific focus, the topic of plant volatiles is highly multi-disciplinary and gathered researchers with broad areas of expertise, from biochemistry to fundamental and applied ecology, phylogeny, and genetics. Potential future collaborations were discussed at the meeting and will help reaching some of the objectives on the Inva-Vol project in a near future.

f) Other comments / annexes

Gaylord Desurmont's poster presentation is attached as an appendix to this report.

Alien interference: disruption of volatile-mediated interactions between plants and parasitoids by invasive insect herbivores

Gaylord A. Desurmont[1,2] and Ted C. J. Turlings[1]

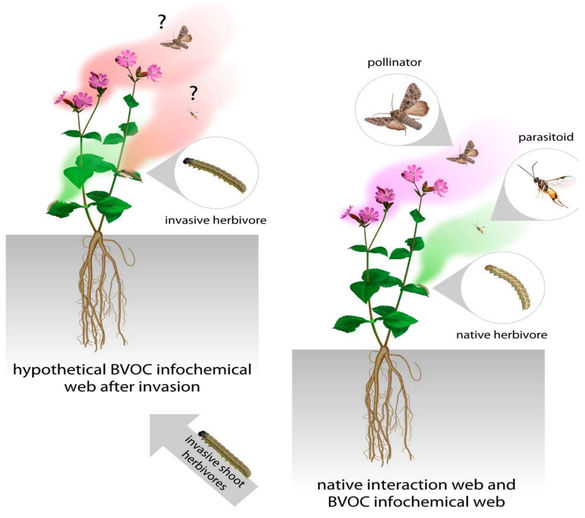
[1] Fundamental and Applied Research in Chemical Ecology laboratory, university of Neuchâtel, Switzerland [2] Contact: gaylord.desurmont@unine.ch

Background

•Plant-produced biogenic volatile organic compounds (BVOCs) induced by herbivores serve as key foraging cues for parasitoids in search of hosts.

•Exotic insect herbivores, as they invade new environments and colonize new host plants, may induce changes in BVOCs production and negatively impact parasitoid foraging success.

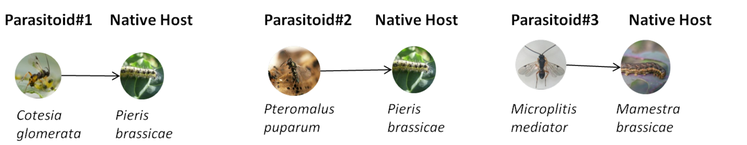
•We advance the idea that plant-parasitoid infochemical interactions are more robust to disturbances in BVOCs caused by native (non-host) herbivores than by exotic herbivores.



Methods

•The plant *Brassica rapa* (Brassicaceae) and its complex of native herbivores and parasitoids, and the invasive herbivores *Spodoptera littoralis* (Lepidoptera, Noctuidae) and *Heliothis virescens* (Lepidoptera, Noctuidae) were used as a study system (table 1).

•In a six-arm olfactometer, non-experienced parasitoids had the choice between plants (1) undamaged (=Control), (2) damaged by the parasitoid's native host (=NH), (3) damaged by a native non-host (=NNH), and (4) damaged by an exotic non-host (=ENH), and (5) two empty arms (Blank).



ENH / NNH	*Spodoptera littoralis*	*Heliothis virescens*
Mamestra brassicae	5	5
Plutella xylostella	4	-

ENH / NNH	*Spodoptera littoralis*	*Heliothis virescens*
Mamestra brassicae	5	3
Plutella xylostella	5	4

ENH / NNH	*Spodoptera littoralis*	*Heliothis virescens*
Pieris brassicae	9	-
Plutella xylostella	7	5

Table 1. Organisms used for the study, and number of replicates used for each combination Parasitoid / native host (NH) / native non host (NNH) / exotic non host (ENH). One replicate = six consecutive releases of six parasitoids.

Results

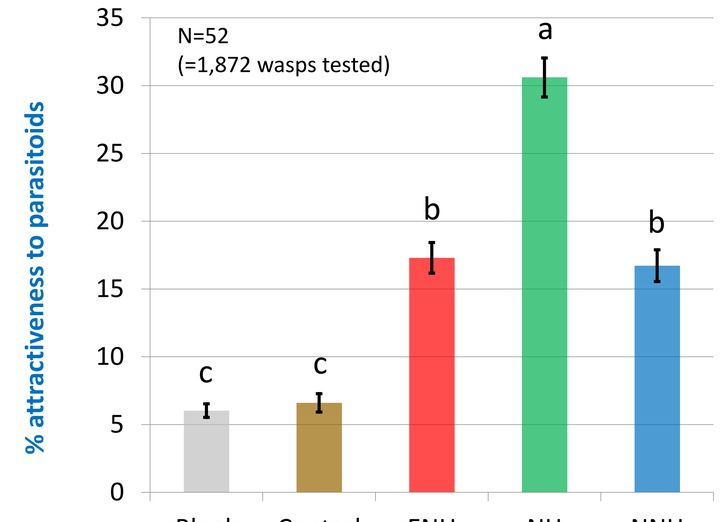


Figure 1. Plants damaged by non-host herbivores (ENH and NNH) are more attractive than undamaged plants (control), but less attractive than plants damaged by hosts (NH).

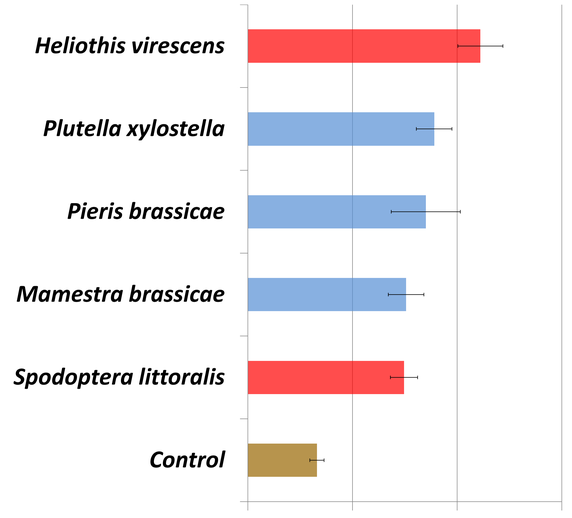


Figure 2. Herbivores, **when used as non-hosts**, differ in their attractiveness to native parasitoids (blue=native species, red=exotic species, brown=undamaged plants).

Interpretation and discussion

•Parasitoids can readily distinguish between plants damaged by different herbivores and show a preference for plants damaged by their host.

•Exotic herbivores can have an impact on parasitoid foraging behavior (i.e. attraction to plants infested by non-hosts), but not necessarily more than native non-host herbivores.

•Because disruptive effects are highly association-specific, exotic herbivores may greatly differ in their "disruption potential" in their invasive range.

•Future work will focus on investigating other detrimental effects of exotic herbivores on parasitoids (e.g. failure to detect hosts on doubly infested plants) and evaluate the relevance of these results in more realistic settings.

Acknowledgements

•This research was funded by the European Science Fundation and is part of the Inva-Vol project, which focuses on consequences of insect invasions for plant-insect interactions mediated by volatile organic compounds.

•Many thanks to Oliver Balmer, Elodie Beltz, Jeff Harvey, Rieta Gols, Roland Reist, and Phillipe Reymond for providing insects for the study.