



Networking / Dissemination Activity Scientific Report Form

Form (Word or PDF file) to be completed and uploaded via the online system within two months of the completion of the event for the following activities: working group meetings, seminars, workshops, symposia, conferences, summer schools, training programmes and specialised courses (graduate-level and continuing education), EUROCORES programme invited sessions at larger conferences, working group meetings (e.g. publication meetings).

a) Summary

Plants release a large range of volatile compounds that are critical for their reproduction, defence and internal signalling. These chemically diverse substances have long been studied by both chemists and biologists for their scientific importance, as well as their roles as perfumes, flavourings, 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 was organised five times (1999, 2002, 2007, 2009 and 2012). This new 2014 session had a broader basis and covered all plant volatiles, including those released by leaves, roots, flowers and fruit.

The 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 defence, 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 mechanism 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 at the beginning of the conference. 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.

With 139 attendees, the 22 EuroVOL participants represented 14% of the audience and the ESF contribution was highly important and well received. Their presence was evident and clearly mentioned by the main organiser André Kessler. The Eurovol participation and contribution was frequently mentioned and acknowledged by the GRC representative and meeting organisers. Posters and oral presentation always mentioned the funding from the ESF/Eurocore program.

b) Final programme of the event

In the below event program EuroVol participants are **highlighted in yellow**.

SUNDAY

4:00 pm - Arrival and Check-in (Office Closed 6:00 pm - 7:45 pm)

8:00 pm
6:00 pm Dinner
7:30 pm - Welcome / Introductory Comments by GRC Site Staff
7:40 pm
7:40 pm - Plant Volatiles in Human Affairs
9:30 pm
Discussion Leader: **Susan Ebeler** (University of California Davis)
7:40 pm - **Eric Block** (University at Albany)
8:05 pm "Smelling Sulfur"
8:05 pm - Discussion
8:15 pm
8:15 pm - **Anne Plotto** (USDA)
8:40 pm "Approaches to Understand the Complexity of Fruit Flavor"
8:40 pm - Discussion
8:50 pm
8:50 pm - **Earl Carstens** (University of California, Davis)
9:15 pm "Neurobiology of Trigeminal Sensations Elicited by Plant-Derived Chemicals"
9:15 pm - Discussion
9:30 pm

MONDAY

7:30 am - Breakfast
8:30 am
9:00 am - Biosynthesis and Regulation of Volatile Organic Compounds
12:30 pm
Discussion Leader: **Rayko Halitschke** (Cornell University)
9:00 am - **Jonathan Gershenzon** (Max Planck Institute for Chemical Ecology)
9:25 am "Biosynthesis of Minor Volatiles with Major Effects"
9:25 am - Discussion
9:30 am
9:30 am - **Harro Bouwmeester** (Wageningen University)
9:55 am "Metabolic Engineering as a Tool to Elucidate the Biosynthesis and Biological Role of Volatiles"
9:55 am - Discussion
10:00 am
10:00 am - Coffee Break
10:30 am
10:30 am - **Birgit Piechulla** (University of Rostock)
10:55 am "Volatile-Mediated Plant-Microbe Interactions"
10:55 am - Discussion
11:00 am
11:00 am - **Massimo Maffei** (University of Turin)
11:25 am "Plant-to-Plant Communication through Volatile Organic Compounds"
11:25 am - Discussion
11:30 am
11:30 am - **Sandra Irmisch** (Max Planck Institute for Chemical Ecology)
11:45 am "Volatile Nitriles Produced by CYP71 Enzymes are Involved in Direct Defense in Poplar"
11:45 am - Discussion
11:50 am
11:50 am - **Itay Gonda** (Agricultural Research Organization)
12:05 pm "The Production of S-methyl Thioacetate in Melon Fruit is Mediated by a Novel Methanethiol Acyltransferase Enzyme"
12:05 pm - Discussion

12:10 pm
 12:10 pm- **Philipp Zerbe** (Michael Smith Laboratories)
 12:25 pm "Gene Discovery of Modular Diterpene Metabolism in Non-Model Plant Systems"
 12:25 pm- Discussion
 12:30 pm
 12:30 pm Lunch
 1:30 pm- Free Time
 4:00 pm
 4:00 pm - Poster Session
 6:00 pm
 6:00 pm Dinner
 7:30 pm - Sensory Physiology of Volatile Perception
 9:30 pm
 Discussion Leader: **Robert A. Raguso** (Cornell University)
 7:30 pm - **Donald Wilson** (New York University School of Medicine)
 7:55 pm "Experience-Dependent Perception of Odor Mixtures"
 7:55 pm - Discussion
 8:05 pm
 8:05 pm - **Sonja Bisch-Knaden** (Max Planck Institute for Chemical Ecology)
 8:30 pm "Female Sense of Smell: Olfactory Coding in Silkmoths"
 8:30 pm - Discussion
 8:40 pm
 8:40 pm - **Christina Kelber** (Technical University of Darmstadt)
 8:55 pm "The Olfactory System of Closely Related Bee Species - Neuroanatomical Correlations to Social Organization and Floral Preference"
 8:55 pm - Discussion
 9:05 pm
 9:05 pm - **Pratibha Yadav** (Indian Institute of Science, India)
 9:20 pm "Does It Smell like the Host? Perception of Host Volatiles by the Ovipositor of Parasites in the Fig-fig Wasp System"
 9:20 pm - Discussion
 9:30 pm

TUESDAY

7:30 am - Breakfast
 8:30 am
 8:30 am Group Photo
 9:00 am - Ecological Functions of Floral Odors
 12:30 pm
 Discussion Leader: **Florian Schiestl** (University of Zürich)
 9:00 am - **Santiago Ramirez** (University of California Davis)
 9:25 am "Chemical and Genetic Basis of Adaptation in the Euglossine Bee-Orchid Mutualism"
 9:25 am - Discussion
 9:30 am
 9:30 am - **Danny Kessler** (Max Planck Institute for Chemical Ecology)
 9:55 am "The Ecological Functions of Floral Chemistry"
 9:55 am - Discussion
 10:00 am
 10:00 am - Coffee Break
 10:30 am
 10:30 am - **Nicolas Vereecken** (Université Libre de Bruxelles)
 10:55 am "Phylogenetic Patterns of Floral Scents and the Evolution of Pollination by Sexual Deception"
 10:55 am - Discussion

11:00 am

11:00 am - **Adam Shuttleworth** (University of KwaZulu-Natal)
 11:25 am "Lascivious Goats and Hairy Lobes: Chemical Ecology and Evolution of South African Carrion and Dung Mimicking Flowers"

11:25 am - Discussion
 11:30 am

11:30 am - **Pengjuan Zu** (University of Zürich)
 11:45 am "Heritability of Floral Volatiles"

11:45 am - Discussion
 11:50 am

11:50 am - **Dani Lucas-Barbosa** (Wageningen University)
 12:05 pm "Changing Odours and Colours: How Plant Responses to Pollination and Herbivore Infestation Affect the Behaviour of Flower Visitors"

12:05 pm - Discussion
 12:10 pm

12:10 pm - **Benoît Boachon** (CNRS-IBMP)
 12:25 pm "Defense against Insects Visiting *Arabidopsis* Flowers Involves a Multitask Linalool Oxidase"

12:25 pm - Discussion
 12:30 pm

12:30 pm Lunch

1:30 pm - Free Time
 4:00 pm

4:00 pm - Poster Session
 6:00 pm

6:00 pm Dinner

7:30 pm - Advances and Trends in Volatile Analytical Chemistry
 9:30 pm

Discussion Leader: **Ales Svatos** (Max Planck Institute for Chemical Ecology)

7:30 pm - **Emmanuel Gaquerel** (Max Planck Institute for Chemical Ecology)
 7:55 pm "Multidimensional Analysis of Herbivory-Induced Volatile Emissions Reveals New Insights into Signals Tuning Sesquiterpene Production"

7:55 pm - Discussion
 8:05 pm

8:05 pm - **Armin Hansel** (University of Innsbruck)
 8:30 pm "Reaction of Ozone with the Plant Surface: Ozone Sink and Source of Oxy-VOC in the Atmosphere"

8:30 pm - Discussion
 8:40 pm

8:40 pm - **Zoltan Takats** (Imperial College London)
 8:55 pm "Direct Mass Spectrometric Profiling of Biological Tissues - From Imaging Mass Spectrometry to Rapid Identification of Bacteria"

8:55 pm - Discussion
 9:05 pm

9:05 pm - **Rabi Musah** (University at Albany-State University of New York)
 9:20 pm "The Utility of Direct Analysis in Real Time Mass Spectrometry in Plant Root Metabolome Profiling - The Case of *Mimosa pudica*"

9:20 pm - Discussion
 9:30 pm

WEDNESDAY

7:30 am - Breakfast
 8:30 am

9:00 am - Herbivore-induced Volatile Emission: Mechanisms and Functions of Induction
 12:30 pm

Discussion Leader: **Erik Poelman** (Wageningen University)

9:00 am - **Nicole van Dam** (Radboud University Nijmegen)
 9:25 am "Back to the Roots: Induction of Belowground Volatiles"

9:25 am - Discussion
 9:30 am

9:30 am - **Joop van Loon** (Wageningen University)
 9:55 am "Two Herbivore Species on One Plant: Effects on Volatile Emission and Consequences for Indirect Plant Defense"

9:55 am - Discussion
 10:00 am

10:00 am - Coffee Break
 10:30 am

10:30 am - **Kaori Shiojiri** (Kyoto University)
 10:55 am "Using Plant Communication for Agriculture"

10:55 am - Discussion
 11:00 am

11:00 am - **Martin Heil** (CINVESTAV, Irapuato, Mexico)
 11:25 am "Plant Volatiles Play Multiple Roles in Direct, Induced and Associational Resistance to Insects and Pathogens"

11:25 am - Discussion
 11:30 am

11:30 am - **Ursula Roese** (University of New England)
 11:45 am "Inducibility of Volatile and Non-Volatile Compounds in Brown Macroalgae and Their Effect On Herbivore Behavior"

11:45 am - Discussion
 11:50 am

11:50 am - **Andrea Occhipinti** (University of Turin)
 12:05 pm "Plant Volatiles Mediate Non-Trophic Interactions between Ants and Butterflies Revealing a Novel Mechanism of Social Parasitism"

12:05 pm - Discussion
 12:10 pm

12:10 pm - **James Blande** (University of Eastern Finland)
 12:25 pm "Adsorption of Volatiles can Facilitate Associational Susceptibility"

12:25 pm - Discussion
 12:30 pm

12:30 pm Lunch

1:30 pm - Free Time
 4:00 pm

4:00 pm - Poster Session
 6:00 pm

6:00 pm Dinner

7:00 pm - Business Meeting
 7:30 pm

Nominations for the next Vice Chair; Fill out Conference Evaluation Forms; Discuss future Site & Scheduling preferences; Election of the next Vice Chair

7:30 pm - Plant Volatiles and Atmospheric Chemistry
 9:30 pm

Discussion Leader: **Francesco Loreto** (National Research Council of Italy - Institute for Plant Protection)

7:30 pm - **Kolby Jardine** (Lawrence Berkeley National Laboratory)
 7:55 pm "Increased Allocation of Stored Carbon to Tropical Isoprene Emissions under Elevated Temperatures"

7:55 pm - Discussion

8:05 pm
 8:05 pm - **Jörg-Peter Schnitzler (Helmholtz Zentrum Munich)**
 8:30 pm "Isoprene and Co. - Impact on Herbivore-Tree Interactions in Poplar and Oaks"
 8:30 pm - Discussion
 8:40 pm
 8:40 pm - **Jarmo Holopainen (University of Eastern Finland)**
 8:55 pm "Modification of Herbivore-Induced Plant Volatiles by Air Pollutants - Ecological Effects"
 8:55 pm - Discussion
 9:05 pm
 9:05 pm - **Violeta Velikova (Institute of Plant Physiology and Genetics, Bulgaria)**
 9:20 pm "Genetic Manipulation of Isoprene Emission: A Broad Prospect for Changes in Plant Metabolism and Functionality"
 9:20 pm - Discussion
 9:30 pm

THURSDAY

7:30 am - Breakfast
 8:30 am
 9:00 am - Evolutionary Biology of Volatile Signaling
 12:30 pm
 Discussion Leader: **Martin Heil (CINVESTAV, Irapuato, Mexico)**
 9:00 am - **Nadir Erbilgin (University of Alberta)**
 9:25 am "Similarity of Secondary Compounds between Ancestral and Novel Host Plants Promotes Invasiveness of a Herbivorous Species in a Naive Host Ecosystem"
 9:25 am - Discussion
 9:30 am
 9:30 am - **Hyun Jo Koo (Salk Institute for Biological Studies)**
 9:55 am "Protein Epistasis and the Biophysical Constraints on Catalytic Promiscuity of Plant Terpene Synthases"
 9:55 am - Discussion
 10:00 am
 10:00 am - Coffee Break
 10:30 am
 10:30 am - **Berta Alquezar (Instituto Valenciano de Investigaciones Agrarias)**
 10:55 am "Biotechnological Strategies to Combat Pests in Agriculture: Blocking Attractiveness or Induction of Repellency against Two Important Citrus Pests through Modulation of Terpene Metabolism"
 10:55 am - Discussion
 11:00 am
 11:00 am - **Amy Parachnowitsch (Uppsala University)**
 11:25 am "Measuring Selection on Floral Volatiles: What Can and Can't We Learn from 30 Years of Phenotypic Selection Estimates?"
 11:25 am - Discussion
 11:30 am
 11:30 am - **Kelsey Byers (University of Washington)**
 11:45 am "The Role of Three Floral Volatiles in Pollinator-Mediated Reproductive Isolation in Monkeyflowers (*Mimulus*)"
 11:45 am - Discussion
 11:50 am
 11:50 am - **Ariana Navarro-Melendez (CINVESTAV, Irapuato, Mexico)**
 12:05 pm "Effects of Endophytic Fungi on the VOC Profile of Their Host Plant *Phaseolus Lunatus* (Lima Bean)"
 12:05 pm - Discussion
 12:10 pm

12:10 pm- **Susanna Pollastri (National Research Council of Italy - Institute for Plant Protection)**
12:25 pm "Isoprene Improves Photochemical Efficiency and Reduces Heat Dissipation Need in Plants at Physiological Temperatures"

12:25 pm- Discussion
12:30 pm

12:30 pm Lunch

1:30 pm - Free Time / **EuroVOL meeting**
4:00 pm

4:00 pm - Poster Session
6:00 pm

6:00 pm Dinner

7:30 pm - Applications of Volatile Signaling in Agriculture
9:30 pm

Discussion Leader: **Ted Turlings (University of Neuchâtel)**

7:30 pm - **Zeyaur Khan** (International Center for Insect Physiology and Ecology, Kenya)
7:55 pm "Exploiting Plant Volatiles for Crop Protection in Africa through Push-Pull Strategy"

7:55 pm - Discussion
8:05 pm

8:05 pm - **John Beck** (USDA)
8:30 pm "Orchard-Specific Volatile Attractants for the California Tree Nut Insect Pest Navel Orangeworm"

8:30 pm - Discussion
8:40 pm

8:40 pm - **Ian Kaplan** (Purdue University)
8:55 pm "What Happens when Crops are Turned On? Simulating Constitutive HIPVs for Enhanced Biocontrol - Pest Interactions across an Agricultural Landscape"

8:55 pm - Discussion
9:05 pm

9:05 pm - **Ana Rodriguez** (FUNDECITRUS)
9:20 pm "D-limonene Downregulation in Transgenic Citrus Fruits provides Resistance to the Important Fungus *Phyllosticta Citricarpa* through Increased Accumulation of Monoterpene Alcohols"

9:20 pm - Discussion
9:30 pm

FRIDAY

7:30 am - Breakfast
8:30 am
9:00 am Departure

List of posters with EuroVOL participants

Monday- Biosynthesis/ Regulation and Agriculture

Poster nb	Author	Affiliation	Co-authors	Title	Category
3	Loreto, Francesco	Consiglio Nazionale delle Ricerche (CNR)	Violeta Velikova Mastaneh Ahrar Andrea Romano Dilyana Doneva Vesela Yordanova Marco Michelozzi Mauro Centritto Claudio Varotto Francesco Loreto	Isoprene emission in Arundonoideae that have potential as biofuel plant species	Agriculture
9	Brunetti, Cecilia	National Research Conference - IPP	Massimiliano Tattini, Violeta Velikova, Claudia Vickers, Martina Di Ferdinando, Alice Trivellini, Silvia	Isoprene stimulates phenylpropanoid metabolism in drought stressed tobacco plants: an	Biosynthesis Regulation

			Fineschi, Giovanni Agati, Francesco Ferrini, Francesco Loreto	ABA affair?	
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Tuesday- Ecology

11	Lucas-Barbosa, Dani	Wageningen University	Dani Lucas-Barbosa, Pulu Sun, Anouk Hakman, Teris A. van Beek, Joop J.A. van Loon, Marcel Dicke	Changing odours and colours: how plant responses to pollination and herbivore infestation affect the behaviour of flower visitors	Ecology
20	Weldegergis, Berhane	Wageningen University	Feng Zhu, Erik H. Poelman and Marcel Dicke.	Influence of drought-stress on plant-insect interactions	Ecology
21	Welte, Cornelia	Radboud University Nijmegen	Rob de Graaf, Nicole van Dam, Mike Jetten	Isothiocyanate degradation by the intestinal microbiota of root fly larvae	Ecology
24	Zu, Pengjuan	University of Zurich	Florian P. Schiestl	Heritability of floral volatile	Ecology

Wednesday- Atmospheric Sciences and Analytical Chemistry

2	Blande, James	University of Eastern Finland	Tao Li	Adsorption of volatiles can facilitate associational susceptibility	Analytical Chemistry
6	Ghirardo, Andrea	Helmholtz Muenchen	Jörg-Peter Schnitzler	Post-harvesting release of CO ₂ and reactive VOC from woody biomass	Atmospheric
7	Giron Calva, Patricia	University of Eastern Finland	Tao Li, Jarmo Holopainen and James Blande	Plant-to-plant signaling by airborne signals at elevated atmospheric ozone concentration	Atmospheric
8	Gouinguene, Sandrine	University of Neuchatel		Ecology of Plant Volatiles, from Molecules to the Globe (EuroVOL)	Atmospheric
12	Khaling, Eliezer	University of Eastern Finland	Erik H. Poelman.Laboratory of Entomology, Wageningen University, P.O. Box 8031, NL-6700 EH Wageningen, The Netherlands.	Volatile emission profile of Brassica nigra plants under ozone and herbivore stress: From laboratory to field conditions.	Atmospheric
14	Papazian, Stefano	Umeå Plant Science Centre	Stefano Papazian, Eliezer Khaling, James Blande, Benedicte Albrechten	Metabolomics and plant volatiles under ozone stress conditions	Atmospheric
15	Pollastri,	Institute for	Tsonko Tsonev, Francesco	Isoprene improves	Atmospheric

	Susanna	Plant Protection - CNR	Loreto	photochemical efficiency and reduces heat dissipation need in plants at physiological temperatures	
18	Trowbridge, Amy	Indiana University	Richard P. Phillips, Philip S. Stevens, Jorg-Peter Schnitzler	Up-rooting surface- atmosphere exchange models: How mycorrhizal associations affect canopy and soil VOC emissions	Atmospheric

Thursday- Evolution and Plant-Herbivore Interactions

9	Desurmont, Gaylord	University of Neuchatel	Ted C. J. Turlings	Impact of volatiles induced by exotic insect herbivores on the attraction of natural enemies: a test of the specificity and robustness of infochemicals	HerbivoryInteractions
10	Dicke, Marcel	Wageningen University	Ana Pineda, Erik Poelman	Herbivore-induced plant volatiles: are insect-plant interactions interactions between insects and plants?	HerbivoryInteractions
11	Gols, Rieta	Lab. for Entomology, Wageningen University	Mingui Fei, Tze yi Huang and Jeffrey Harvey	The effect of rearing history on volatile- mediated foraging behaviour of a parasitoid	HerbivoryInteractions
15	Li, Tao	Univeristy of Eastern Finland	Tao Li, James Blande, Jarmo Holopainen	Atmospheric transformation of plant volatiles reduces plant apparency to herbivores	HerbivoryInteractions
17	Ponzio, Camille	Wageningen University	Camille Ponzio, Rieta Gols, Berhane T. Weldegergis, Marcel Dicke	Caterpillar-induced plant volatiles remain a reliable signal for foraging wasps during dual attack	HerbivoryInteractions
18	Zhu, Feng	Wageningen University	Berhane T. Weldegergis, Jeffrey A. Harvey, Marcel Dicke, Erik H. Poelman	Do herbivore identity matter to host searching of hyperparasitoids	HerbivoryInteractions

c) Description of the scientific content of the event (abstracts can be provided)

Florian Schiestl organised on Monday afternoon, during the free time, a seminar to discuss the variability of plant volatiles collection. All participants were welcomed; many junior scientists attended this seminar to discuss with experts of chemical analysis of plant volatiles, different problems occurring during collection of volatiles.

Changing odours and colours: how plant responses to pollination and herbivore infestation affect the behaviour of flower visitors

Dani Lucas-Barbosa, Pulu Sun, Anouk Hakman, Teris A. van Beek, Joop J.A. van Loon, Marcel Dicke
Laboratory of Entomology, Wageningen University, P.O. Box 8031, NL-6700 EH Wageningen, The Netherlands

Plants may face a trade-off between defence and pollinator attraction. Here we have investigated the role of inducible plant secondary metabolites in this trade-off. Flowers offer nectar and pollen as reward for pollinating insects that take care of plant reproduction. These rewards are advertised by the diversity of flower forms, sizes, colours and odours characteristic of angiosperms. Insect pollinators associate flower visual and odour cues with the quality of nectar and pollen. Plants may respond to pollination with changes in flower traits, and, in so doing, may drive pollinating insects to a flower that has not been pollinated yet. Plants also respond to herbivory and these responses may alter flower traits and the quality of nectar and pollen, and thereby, influence feeding preferences of flower visitors. In this study, our objective was to investigate how plant responses to pollination and insect herbivory in terms of flower odours and colour affect the behaviour of insect pollinators, i.e. syrphid flies and butterflies. Syrphid flies mainly feed on pollen of *Brassica nigra* plants, whereas butterflies feed on nectar and select *B. nigra* plants as food plant for their larvae. Our results show that plants respond to pollination and herbivore infestation with changes in the profile of volatiles and phenolics, i.e. altering odour and colour of flowers. Interestingly, herbivore infestation and pollination influenced the volatile and phenolic profile of leaves and flowers differently, and these changes in turn, influenced the behaviour of the insects in different ways. Butterflies use different cues when searching for an oviposition site or nectar source. Plant responses to pollination seem more prominent than responses to herbivory when regarding phenolics, and the other way around, when regarding volatile compounds. We will discuss these results in the context of trade-offs between plant defence and pollinator attraction.

Linking Metabolomics and Volatile Profile of Plant Defense Under Ozone Stress Conditions

Stefano Papazian, Eliezer Khaling, James Blande, Benedicte R. Albrechtsen

Ozone (O₃) is a major air pollutant with concentrations increasing due to anthropogenic activity. The strong oxidant power of O₃ can affect plant growth and defense systems, such as JA and SA signalling, glucosinolates, phenolics and volatile compounds. In this study we investigated the metabolism of the black mustard *Brassica nigra* defending against the white-cabbage butterfly *Pieris brassicae* under high O₃. Primary and secondary metabolism have been linked to volatile emissions. Multivariate analysis has been applied in order to distinguish herbivory from ozone effects, while the relationship between treatments and metabolic profiles have been rendered as a network map.

Adsorption of volatiles can facilitate associational susceptibility

James Blande

University of Eastern Finland, Kuopio, 70211, Finland

Volatile organic compounds (VOCs) emitted by damaged plants play roles in a multitude of interactions between plants and surrounding community members. One such interaction is signaling between damaged plants and their undamaged neighbours, which purportedly prepares receiver plants for a better defense response upon subsequent attack. We used a system

comprising broccoli and the specialist herbivore *Plutella xylostella* to examine the effects of being exposed to damaged neighbours on the plant's susceptibility to subsequent herbivore oviposition. In choice tests, *Plutella xylostella* females oviposited significantly more on plants exposed to damaged neighbours than those with undamaged neighbours, indicating a volatile-mediated associational susceptibility. The mechanisms underlying plant-plant interactions are yet to be fully elucidated. However, evidence has accumulated to both highlight potential complexities in active signal processing and roles for chemical adsorption and desorption in near neighbours. We used priming of volatile emissions as a proxy for active plant responses and observed damage-receiver plants to have a stronger emission of green leaf volatiles when challenged by *P. xylostella*. In addition, we used artificial leaves to examine potential effects of chemical adsorption and noted a dramatic preference for *P. xylostella* to oviposit on artificial leaves exposed to damaged plants. We postulate that both active signaling and passive volatile adsorption can play roles in plant-plant interactions and the responses of the surrounding community. While the passive process is likely to play a key role in host-selection in the system studied, the active process is likely to provide a means for the more attractive plants to defend themselves more vigorously.

Isoprene and Co. - Biological and ecological functions in poplar and oaks

Jörg-Peter Schnitzler

Helmholtz Zentrum München, Research Unit Environmental Simulation, Neuherberg,

Plants synthesize and emit a large variety of volatile organic compounds (VOCs), with terpenes and fatty-acid derivatives being the dominant classes. Whereas some volatiles are probably common to almost all plants (e.g. C6 aldehydes, alcohols, and esters, as well as acetaldehyde or methanol), others are specific to only a few related taxa like isoprene that is predominately emitted by tree such as oaks and poplars. Isoprene is globally the most important volatile emitted by vegetation influencing atmospheric chemistry, stability of photosynthetic processes under thermal and oxidative stress as well as plant-insect interactions. Our current progress in understanding plant volatile functions is due to general advances in biochemical and molecular techniques and to the development of new instrumentation for the analysis of VOCs. The presentation will introduce some of these techniques and will give an overview on our actual knowledge on the biological and ecological function(s) of isoprene and stress-induced VOCs in poplar and oaks and will discuss the impact of plant-herbivore interactions.

Isoprene stimulates phenylpropanoid metabolism in drought stressed tobacco plants: an ABA affair?

Cecilia Brunetti

Recent findings support the idea that isoprene, a simple hydrocarbon produced by many plants, may serve multiple functions in response to drought stress. In addition to strength thylakoid membranes and scavenge reactive oxygen/nitrogen species, isoprene might regulate isoprenoid and phenylpropanoid pathways. This hypothesis was tested using transgenic isoprene emitting tobacco plants. We have found complex isoprene-related responses, which differ depending on drought severity. We confirm that isoprene emission is stimulated by mild/moderate drought stress, providing protection to thylakoid membranes, thus reducing photochemical damage. Under prolonged drought conditions, isoprene also triggers production of non-volatile isoprenoids, mostly ABA and carotenoids, and then up-regulates phenylpropanoid metabolism. Our data reveal previously undescribed ABA-mediated co-operation between unrelated metabolic pathways, in the enhanced protection of isoprene emitting leaves from severe drought stress. This work was funded by the European Science Foundation Eurocores programme "EuroVOL", project "Molecular and metabolic bases of isoprenoid emission in plants (MOMEVIP).

Back to the roots: Induction of belowground volatiles

Nicole Van Dam

Abstract not available

Isoprenoid emission in hygrophyte and xerophyte European woody flora: ecological and evolutionary implications

Silvia Fineschi, Francesco Loreto, Francesca Bagnoli, Carlo Calfapietra, Donata Cafasso, Manuela De Lillis, Goffredo Filibeck, Silvia Fineschi, Gabriele Guidolotti, Gábor Sramkó, Jácint Tökölyi and Carlo Ricotta.

The relationship between isoprenoid emission and hygrophily was investigated in woody plants of the Italian flora, which is representative of European diversity. Volatile isoprenoids (isoprene and monoterpenes) were measured, or data collected from the literature, for 154 species native or endemic to the Mediterranean. The Ellenberg indicator value for moisture (EIVM) was used to describe plant hygrophily. Phylogenetic analysis was carried out at a broader taxonomic scale on 128 species, and then refined on strong isoprene emitters (*Salix* and *Populus* species) based on isoprene synthase gene sequences (IspS). Isoprene emitters were significantly more common and isoprene emission was higher in hygrophilous EIVM classes, whereas monoterpene emitters were more widespread and monoterpene emission was higher in xeric classes. However, when controlling for phylogeny, isoprene emission was not associated with EIVM, possibly due to the large presence of *Salicaceae* among hygrophilous isoprene emitters. Moreover, the distribution of isoprene emitters among EIVM classes was not related to IspS-based phylogenesis in *Populus* and *Salix*, suggesting that the gene has not undergone evolution linked to ecological pressure. In contrast, the monoterpene emission pattern is independent of phylogeny, suggesting that the evolution of monoterpenes is associated with transitions to more xeric habitats.

Main conclusions Our results reveal an interesting ecological pattern linking isoprenoids and water availability. We suggest that isoprene is a trait that: (1) evolved in plants adapted to high water availability; (2) is replaced by more effective protection mechanisms, e.g. more stable isoprenoids, in plants adapting to more xeric environments; and (3) being strongly constrained by phylogeny, persists in *Salicaceae* adapted to more xeric environments.

This work was funded by the European Science Foundation Eurocores programme “EuroVOL”, project “Molecular and metabolic bases of isoprenoid emission in plants” (MOMEVIP).

Volatile emission profile of *Brassica nigra* plants under ozone and herbivore stress: From laboratory to field conditions.

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Increasing concentrations of phytotoxic gaseous ozone in the lower atmosphere due to anthropogenic activities is of particular concern because climate change may exacerbate ozone formation (Fuhrer, 2009, The Royal Society, 2008). Environmental conditions favoring uptake of ozone such as long day-length, high humidity and long range windborne transport promote the phytotoxic impact of ozone (Karlsson et al., 2009). This also means that plants may suffer from ozone toxicity even in geographical regions of the World that do not exceed the ozone threshold concentration, which for European countries is a one-hour average of 180 µg/m³ (European Environmental Agency, 2013). Ozone due to its strong oxidizing potential reacts with any bio-macromolecule (Kelly et al., 1995). Plant responses to ozone and changes in plant chemistry thereafter may alter volatile emission profile and consequently affect the innate interactions between insects and their host plants. This study investigates the effects of multiple stresses (exposure to ozone and/or *Pieris brassicae* larvae feeding) on the BVOC emissions from *Brassica nigra* and subsequent innate interactions between *Pieris brassicae* (The large white butterfly) and their host plants *Brassica nigra* plants (Black mustard).

In the laboratory, *Brassica nigra* plants were fumigated with three different ozone concentrations (Ambient, 70 ppb and 120 ppb) in plant growth chambers (Weiss Bio 1300) to test the effects of combined stresses on BVOC emissions. *Brassica nigra* plants were exposed to ozone and herbivory by *Pieris brassicae* larvae in laboratory were collected through the dynamic headspace sampling technique (Tholl et al., 2006). The BVOCs were also collected in the field conditions

and BVOCs.). Ozone exposure in the field was conducted in the Free-Air Concentration Enrichment (FACE) facility based at the UEF Kuopio campus.

To investigate the effect of ozone exposure on *Pieris brassicae* performance and preferences, *Pieris* larvae were reared on *B. nigra* plants exposed to three different ozone concentrations (Ambient, 70ppb and 120ppb). The effects of ozone on *P. brassicae* performance were separated into whole system and indirect categories. Whole system effects were investigated by exposing the plant-herbivore complex to ozone throughout the experiments, whereas indirect effects were tested by exposing only plants to ozone with subsequent herbivore-feeding at ambient ozone conditions.

The BVOC emissions from *B. nigra* plants were significantly altered by exposure to elevated levels of ozone and herbivore feeding stresses. Emissions of compounds like 2-Butenenitrile, Allylisothiocyanate, (E)-DMNT appeared to be induced more in plants exposed to ozone as well as herbivore feeding. Indirect effects of the higher ozone concentrations included increased development time and reduced larval and pupal masses. Plant leaves fumigated with 120 ppb ozone having the largest leaf area removed. The change in behavior and performance of *P. brassicae* was associated with alterations in abundance of glucosinolate and phenolic plant compounds. In nature, exposure of wild host plants to increasing ozone levels may have profound negative effects on *P. brassicae* populations.

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The effect of rearing history on volatile-mediated foraging behavior of a parasitoid

Rita Gols

Spatial-temporal realism is often missing in many studies of multitrophic interactions, which are conducted at a single time frame and/or involving interactions between insects with a single species or genotype of a plant. This is also the case in studies investigating the response of insect natural enemies to herbivore induced plant volatiles (HIPVs). Here, insects are often reared on certain host plant species for many generations and insect responses are compared using model plant species without considering the natural host-plant range with which these insects are associated in the field. In this study, we compared the attractiveness of HIPV blends emitted by different food plant species to the larval endoparasitoid *Cotesia glomerata*, which attacks several caterpillar species in the Pierid family, such as the large cabbage white, *Pieris brassicae*. This multivoltine herbivore restricts its diet to brassicaceous plant species of which many are short-lived annuals. Consequently, different generations of the herbivore and its parasitoid have to locate and develop on a different host plant than their parents. Many studies have reported on the importance of HIPV in parasitoid foraging behaviour. The aim of this study was to investigate whether the food plant species on which the insects developed has an effect on HIPV preferences of *C. glomerata* when searching for a new host plant.

Caterpillar-induced plant volatiles remain a reliable signal for foraging wasps during dual attack

Camille Ponzio, Rieta Gols, Berhane T. Weldegergis, Marcel Dicke

Plants respond to herbivory via the emission of induced plant volatiles, which can be used by the herbivores' natural enemies to locate their hosts. In nature, plants are often simultaneously confronted by various insect herbivores and phytopathogens, potentially interfering with enemy attraction via modifications of the induced volatile blend. Here we investigated parasitoid (*Cotesia glomerata*) attraction to volatiles of plant challenged by different attackers, either alone or in combination with *Pieris brassicae* caterpillars, hosts of *C. glomerata*. We used a natural system

consisting of *Brassica nigra* plants, eggs and larvae of *P. brassicae*, *Brevicoryne brassicae* aphids and a bacterial phytopathogen (*Xanthomonas campestris* pv. *campestris*). In all cases parasitoids successfully located host-laden plants, and wasp foraging behavior was unaffected by the simultaneous presence of a non-host attacker. Analyses of the volatile emissions show that the volatile profiles of all caterpillar-infested treatments were different from those without caterpillars. Furthermore, dually attacked plants could not be separated from those with only caterpillars, regardless of the non-host's identity, supporting the behavioral data. Our results suggest that indirect plant defenses are more resistant to interference than is generally assumed, with the volatiles induced during multiple attack remaining reliable indicators of host presence for the parasitoids.

d) Assessment of the results and impact of the event on the EUROCORES programme.

The Gordon conference on plant volatiles put together most of the world-class experts in this field, and showing a variety of presentations funded by the EUROCORES attracted international attention on the aim, main objectives, and specificities of the program. In addition to drawing positive attention to EuroVol research, 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. We organized a **special EuroVol brainstorming meeting** (Thursday afternoon), where we discussed potential future collaborations and how to reach the final research and dissemination objectives on the EuroVol project in a near future.

e) List of speakers and participants

Family name	First name	EuroVOL affiliation	GRC
Turlings	Turlings	InvaVOL	Chairman
Dicke	Marcel	A-BIO-VOC	Chairman + Poster
Poelman	Erik	A-BIO-VOC	Chairman
van Dam	Nicole	invaVOL	Speaker
Schiestl	Florian	InvaVOL	Chairman
Hansel	Armin	MOMEVIP	Speaker
Loreto	Francesco	MOMEVIP	Chairman + poster
Schnitzler	Jörg-Peter	MOMEVIP	Speaker
Albrechtsen	Benedicte	A-BIO-VOC	Poster
Blande	James	A-BIO-VOC	Speaker + Poster
Khaling	Eliezer	A-BIO-VOC	Poster
Gols	Rieta	A-BIO-VOC	Poster
Fineschi	Silvia	InvaVOL & MOME-VIP	Poster
Brunetti	Cecilia	InvaVOL	Poster
Pollastri	Susanna	InvaVOL	Speaker + Poster
Gouinguéné	Sandrine	InvaVOL	Poster

Desurmont	Gaylord	InvaVOL	Poster
Daner	Holger	InvaVOL	Poster
Papazian	Stefano	A-BIO-VOC	Poster
Lucas-Barbosa	Dani	A-BIO-VOC	Speaker + Poster
Ponzio	Camille	A-BIO-VOC	Poster
Bouwmeester	Harro	InvaVOL	Speaker