TYPE Editorial
PUBLISHED 21 February 2023
DOI 10.3389/fevo.2023.1154019

OPEN ACCESS

EDITED AND REVIEWED BY
Mark A. Elgar,
The University of Melbourne, Australia

*CORRESPONDENCE
Stefano Colazza
stefano.colazza@unipa.it

SPECIALTY SECTION
This article was submitted to Chemical Ecology, a section of the journal Frontiers in Ecology and Evolution

RECEIVED 30 January 2023
ACCEPTED 07 February 2023
PUBLISHED 21 February 2023

CITATION
Colazza S and Rodriguez-Saona C (2023) Editorial: Insights in chemical ecology: 2022. *Front. Ecol. Evol.* 11:1154019. doi: 10.3389/fevo.2023.1154019

Editorial: Insights in chemical ecology: 2022

Stefano Colazza [1*] and Cesar Rodriguez-Saona [2]

[1]Department of Agricultural, Food and Forest Sciences, University of Palermo, Palermo, Italy, [2]Department of Entomology, Rutgers, The State University of New Jersey, New Brunswick, NJ, United States

KEYWORDS

semiochemicals, induced resistance, plant volatiles, cuticular hydrocarbons, nutrients

Editorial on the Research Topic
Insights in chemical ecology: 2022

Chemical ecology is a multi-disciplinary science that continues to expand into numerous different research fields on the chemicals that mediate ecological interactions among organisms. The goal of this Research Topic is to highlight recent accomplishments in the field of chemical ecology. It contains three articles that cover a wide range of current topics that provide new insights, novel developments, and future perspectives in chemical ecology such as induced plant resistance against herbivores, insect adaptations to climate change, and nutritional needs in social insects.

An exciting field of chemical ecology in the past 3–4 decades has been studies on the role of plant volatiles mediating interactions between insect herbivores and their natural enemies (i.e., tri-trophic level interactions). Plants are known to increase their defenses not only in response to feeding damage by insect herbivores but also to their oviposition (Meiners and Hilker, 2000; Bruce et al., 2010; Fatouros et al., 2012). In fact, oviposition by insect herbivores can induce direct defenses in plants that reduce the performance of the newly hatched neonates (Kim et al., 2012; Geiselhardt et al., 2013; Bandoly et al., 2015; Rondoni et al., 2018), and can induce plant volatiles that attract the natural enemies of the herbivores–an indirect mechanism of defense (Meiners and Hilker, 2000; Bruce et al., 2010). These direct and indirect defenses are often regulated by phytohormones such as jasmonic acid and salicylic acid (Meiners and Hilker, 2000; Mumm et al., 2003; Little et al., 2007; Bruessow et al., 2010). Most of this research comes from studies with annual plants; however, less is known on the mechanisms mediating oviposition-induced defenses in woody perennial plants. Dávila et al. studied the response of the willow *Salix babylonica* to oviposition by the specialist willow sawfly, *Nematus oligospilus*, and its impact on insect performance. Using gas chromatography coupled with mass spectrometry (GC-MS) and high-performance liquid chromatography coupled with mass spectrometry (HPLC-MS), they measured the effects of sawfly oviposition on volatile emissions and phytohormones, respectively. They found that oviposition reduces neonate larval growth and increased the proportion of prepupae, which extended the sawfly's developmental times. Oviposition increased jasmonic acid levels and changed the volatile profiles in willows by increasing emissions of (*E*/*E*)-α-farnesene and (*Z*)- and (*E*)-β-ocimene. This study provides new advances into oviposition-induced defense responses in woody perennial plants.

The impact of climate change on species interactions has received increasing attention from researchers in recent years. Climate change can affect biodiversity by changing species' spatial ranges, phenology, and their interactions (Bellard et al., 2012; Halsch et al., 2021), which are likely to manifest more strongly at higher than lower elevations (Pepin et al., 2015). These changes could affect pollinators such as bumble bees. In their article, Maihoff et al. investigated whether cuticular hydrocarbons (CHCs) of alpine bumble bees are linked to the species' elevational niches. For this, the authors used GC-MS to analyze interspecific and intraspecific variation in CHCs of bumble bees along an elevational gradient. They also conducted a field experiment to test whether CHCs of *Bombus lucorum* change when translocated from the foothill of a cool and wet mountain region to a higher elevation and a warm and dry region. The authors found distinctive, species-specific CHC profiles, as well as inter- and intraspecific variation in the CHC profiles of bumble bees; however, these profiles were not linked to the elevational distribution of species and individuals. Bumble bees translocated to a warm and dry region tended to express longer CHC chains than bumble bees translocated to cool and wet foothills, possibly due to acclimatization to regional climate; although this was not associated with elevation, indicating that temperature alone did not explain these results. The authors conclude that, although bumble bee species have specific CHC profiles, their function in response to climatic conditions remains elusive.

Optimal foraging theory predicts that insects should forage to maximize their rate of energy intake (Stephens and Krebs, 1986). For social insects, such as ants, foraging workers must meet not only their own nutritional needs but also those of their nestmates. Worker ants require primarily carbohydrates for energy, while the queen(s) and brood also require proteins for egg production and larval development, respectively (Markin, 1970; Sorensen and Vinson, 1981; Weeks et al., 2006). To achieve this, worker ants utilize a wide range of food sources, including sugary honeydew, insect prey, floral and extrafloral nectar, pollen, seeds, plant foliage to cultivate mutualistic fungi, animal excreta and carrion, among others, to meet their nutritional needs (Hölldobler and Wilson, 1990). However, little is known about the volatile cues used by foraging ants to locate food sources (Knaden and Graham, 2016). Renyard et al. used the Western carpenter ant, *Camponotus modoc*, to test whether food sources rich in carbohydrates (aphid honeydew, floral nectar) and in proteins (bird excreta, house mouse carrion, cow liver with or without fly maggot infestation) attract worker ants, and whether attraction of ants to plant inflorescences (i.e., fireweed, thimbleberry, hardhack) is mediated by shared floral odorants. In Y-tube olfactometer bioassays, ants were attracted to both carbohydrate (thimbleberry, fireweed) and protein sources (bird excreta). Headspace volatiles of these attractive sources were analyzed by GC-MS, and synthetic odor blends were tested in Y-tube olfactometer bioassays. Ants were attracted to the synthetic blends of thimbleberry and fireweed but not of bird excreta. This study shows that *C. modoc* worker ants use food odor profiles when foraging for carbohydrate and protein resources.

In conclusion, this Research Topic includes articles that apply chemical ecology to study insect-plant interactions, insect adaptation to climate change, and insect foraging behavior. These articles employ various analytical techniques, such as GC-MS and HPLC-MS, for the identification of volatiles emissions and to quantify phytohormone levels. These techniques together with experiments on insect performance and preference can be powerful tools for the study of chemically-mediated interactions between organisms and their environment. We hope these articles will inspire, inform, and provide direction and guidance for future studies in this multi-disciplinary field of research.

Author contributions

SC and CR-S contributed equally to organizing this Research Topic. CR-S wrote the first draft of this editorial based on the contributed articles. All authors contributed to the article and approved the submitted version.

Acknowledgments

We thank Yahel Ben-Zvi for comments on an earlier draft of the editorial article, the Frontiers in Ecology and Evolution Specialty Chief Editor for the opportunity to edit this Research Topic, and the Journal Specialist for her consistent technical support. We are also thankful to all the authors who contributed to this Research Topic and the reviewers for critically evaluating the manuscripts.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Bandoly, M., Hilker, M., and Steppuhn, A. (2015). Oviposition by *Spodoptera exigua* on *Nicotiana attenuata* primes induced plant defence against larval herbivory. *Plant J.* 83, 661–672. doi: 10.1111/tpj.12918

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., and Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecol. Lett.* 15, 365–377. doi: 10.1111/j.1461-0248.2011.01736.x

Bruce, T. J. A., Midega, C. A. O., Birkett, M. A., Pickett, J. A., and Khan, Z. R. (2010). Is quality more important than quantity? Insect behavioural responses to changes in a volatile blend after stemborer oviposition on an African grass. *Biol. Lett.* 6, 314–317. doi: 10.1098/rsbl.2009.0953

Bruessow, F., Gouhier-Darimont, C., Buchala, A., Metraux, J. P., and Reymond, P. (2010). Insect eggs suppress plant defence against chewing herbivores. *Plant J.* 62, 876–885. doi: 10.1111/j.1365-313X.2010.04200.x

Fatouros, N. E., Lucas-Barbosa, D., Weldegergis, B. T., Pashalidou, F. G., van Loon, J. J. A., Dicke, M., et al. (2012). Plant volatiles induced by herbivore egg deposition affect insects of different trophic levels. *PLoS ONE* 7, e43607. doi: 10.1371/journal.pone.0043607

Geiselhardt, S., Yoneya, K., Blenn, B., Drechsler, N., Gershenzon, J., Kunze, R., et al. (2013). Egg laying of cabbage white butterfly (*Pieris brassicae*) on *Arabidopsis thaliana* affects subsequent performance of the larvae. *PLoS ONE* 8, e59661. doi: 10.1371/journal.pone.0059661

Halsch, C. A., Shapiro, A. M., Fordyce, J. A., Nice, C. C., Thorne, J. H., Waetjen, D. P., et al. (2021). Insects and recent climate change. *Proc. Natl. Acad. Sci. U.S.A.* 118, e2002543117. doi: 10.1073/pnas.2002543117

Hölldobler, B., and Wilson, E. O. (1990). *The Ants*. Cambridge, MA: Harvard University Press.

Kim, J., Tooker, J. F., Luthe, D. S., De Moraes, C. M., and Felton, G. W. (2012). Insect eggs can enhance wound response in plants: a study system of tomato *Solanum lycopersicum* L. and *Helicoverpa zea* Boddie. *PLoS ONE* 7, e37420. doi: 10.1371/journal.pone.0037420

Knaden, M., and Graham, P. (2016). The sensory ecology of ant navigation: from natural environments to neural mechanisms. *Annu. Rev. Entomol.* 61, 63–76. doi: 10.1146/annurev-ento-010715-023703

Little, D., Gouhier-Darimont, C., Bruessow, F., and Reymond, P. (2007). Oviposition by pierid butterflies triggers defense responses in Arabidopsis. *Plant Physiol.* 143, 784–800. doi: 10.1104/pp.106.090837

Markin, G. P. (1970). Food distribution within laboratory colonies of the argentine ant, *Tridomyrmex humilis* (Mayr). *Insectes Soc.* 17, 127–157. doi: 10.1007/BF02223074

Meiners, T., and Hilker, M. (2000). Induction of plant synomones by oviposition of a phytophagous insect. *J. Chem. Ecol.* 26, 221–232. doi: 10.1023/A:1005453830961

Mumm, R., Schrank, K., Wegener, R., Schulz, S., and Hilker, M. (2003). Chemical analysis of volatiles emitted by *Pinus sylvestris* after induction by insect oviposition. *J. Chem. Ecol.* 29, 1235–1252. doi: 10.1023/A:1023841909199

Pepin, N., Bradley, R. S., Diaz, H. F., Baraer, M., Caceres, E. B., Forsythe, N., et al. (2015). Elevation-dependent warming in mountain regions of the world. *Nat. Clim. Change* 5, 424–430. doi: 10.1038/nclimate2563

Rondoni, G., Bertoldi, V., Malek, R., Djelouah, K., Moretti, C., Buonaurio, R., et al. (2018). *Vicia faba* plants respond to oviposition by invasive *Halyomorpha halys* activating direct defences against offspring. *J. Pest Sci.* 91, 671–679. doi: 10.1007/s10340-018-0955-3

Sorensen, A. A., and Vinson, S. B. (1981). Quantitative food distribution studies within laboratory colonies of the imported fire ant, *Solenopsis invicta* Buren. *Insectes Soc.* 28, 129–160. doi: 10.1007/BF02223701

Stephens, D. W., and Krebs, J. R. (1986). *Foraging Theory*. Princeton, NJ: Princeton University Press.

Weeks, R. D., Wilson, L. T., Vinson, S. B., and James, W. D. (2006). Flow of carbohydrates, lipids, and protein among colonies of polygyne red imported fire ants, *Solenopsis invicta* (Hymenoptera: Formicidae). *Ann. Entomol. Soc. Am.* 97, 105–110. doi: 10.1603/0013-8746(2004)0970105:foclap2.0.co;2