INSTITUT DE FRANCE
Académie des sciences

Comptes Rendus

Chimie

Anne-Geneviève Bagnères and Olivier P. Thomas

Foreword: chemical mediation in the environment – Chemical ecology and the French GDR MediatEC

Volume 26, Special Issue S2 (2023), p. 3-5

Online since: 19 November 2024
Issue date: 13 February 2025

Part of Special Issue: Chemical Ecology – Chemical Mediation in the Environment
Guest editors: Anne-Geneviève Bagnères (Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), Montpellier, France) and Olivier Thomas (University of Galway, Ireland)

https://doi.org/10.5802/crchim.354

CENTRE MERSENNE
The Comptes Rendus. Chimie *are a member of the Mersenne Center for open scientific publishing*
www.centre-mersenne.org — e-ISSN : 1878-1543

Comptes Rendus
Chimie
2023, Vol. 26, Special Issue S2, p. 3-5
https://doi.org/10.5802/crchim.354

Chemical Ecology – Chemical Mediation in the Environment

Foreword: chemical mediation in the environment – Chemical ecology and the French GDR MediatEC

Anne-Geneviève Bagnères [a] and Olivier P. Thomas [b]

[a] Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), CNRS – University of Montpellier - EPHE – IRD, 1919 route de Mende, 34293 Montpellier Cedex 5, France

[b] School of Biological and Chemical Sciences, Ryan Institute, University of Galway, H91TK33 Galway, Ireland

E-mail: ag.bagneres@cefe.cnrs.fr (A.-G. Bagnères)

Chemical mediation refers to the process by which chemicals, both natural and synthetic, influence the interactions and behaviours of living organisms within ecosystems. These molecules usually affect various biological processes, including growth, reproduction, communication, and defence mechanisms among plants, animals, and microorganisms. The concept is at the core of the scientific field of chemical ecology and it encompasses the study of how these chemicals are produced, released, transported, and transformed in the environment, as well as their ecological and health impacts.

Historically, chemical ecology has first focused on plants and their chemically mediated interactions, with other living organisms such as insects, microbes but also other plants and animals. Such chemical cues have been identified as end products of secondary or specialised metabolic pathways finely tuned through a long evolutionary history and leading to a structurally unique and inspiring chemical diversity of bioactive metabolites. With the expansion of microbiology, close associations between plants and microbes such as bacteria or fungi were also identified as being mediated by chemical cues. Then, plant–plant communication was also evidenced to be mediated by volatile metabolites through the concept of allelopathy. While plants remain a major subfield of chemical ecology, interactions between other living organisms soon became of huge interest for the broader community. With the discovery of additional sources of chemical diversity in the marine environment and in the microbial world, it soon became evident that chemical interactions are ubiquitous and would benefit from the creation of a scientific consortium. With the development of always greener practices, chemical ecology is now offering new opportunities in diverse fields, for example through the natural biocontrol for the proliferation of invasive species or pests.

By nature, chemical ecology is multi- and interdisciplinary and the endeavour to build a large research group around chemical ecology was mainly supported and funded by the CNRS in France. The GDR MediatEC (CNRS 3658) was launched in 2014 from the merger of two similar and previous actions centred on chemical ecology in the terrestrial environment and marine biologists and chemists. The benefits of positive interactions between these communities were evident very early and resulted in a long list of positive collaborations and interactions between scientists of different backgrounds and centres of interest. For instance, the natural product chemists with deep knowledge especially when working on complex marine natural products brought their expertise to the (micro)biologists working on terrestrial models. A key component of the success of the GDR MediatEC was the creation and optimal use of shared facilities and expensive equipment by both communities in the terrestrial and aquatic fields. In addition to the yearly friendly meetings of the GDR organised all across France since 2014, we must mention the financial support for attending conferences or projects and the publication of a special issue entitled Aquatic Chemical Ecology in the journal Aquatic Ecology [1] and also a co-authoring book on Chemical Ecology in 2016 [2] translated afterwards in French (2017) and Spanish (2020) languages. Based on all these successes of this programme that also helped to build an international recognition of the French community working in chemical ecology, this collaborative network was renewed in 2018 for an additional 4 years and was terminated in 2022. Further actions are ongoing to maintain links between all members of this community such as creating a Thematic network (CNRS-RT).

The main thematic areas of research supported during these 8 years were:

- Chemical ecology and evolution
- Chemical diversity and biosynthesis
- Chemical mediation
- Chemical ecology in a changing environment
- Applied chemical ecology

These research themes were led by two to three researchers from different institutions and background to foster positive interactions. They were supported by technological platforms and infrastructures dedicated to the study of chemical interactions including the development of new tools in metabolomics.

A diversity of authors forms different backgrounds and disciplines have contributed to this special issue as a reflection of the interdisciplinarity of the consortium. The erudite and fine analysis of Beniddir and Poupon [3] starts with a brief and meaningful history of natural product chemistry and its importance for pharmacy and drug discovery. The point-of-view article then gives some insights on the importance of synthetic biology and bioinformatics for the future development of the field of pharmacognosy and the positive inclusion of metabolites of diverse origin including the marine environment and microbes. As a confirmation that the marine environment is becoming of growing interest for the society, Rousseau et al. [4] present a review on the chemical interplay that takes place within the seaweed holobiont. This fundamental knowledge is bringing key contributions in the context of the "seaweed revolution" and the blue bioeconomy. The following article shows how dynamic the research on microbes of marine origin is in the French scientific community. Bertrand and coworkers [5] studied the change in metabolome and lipidome of a fungus of marine origin when grown in different conditions. This study highlights the importance of new tools developed in bioinformatics for the annotation of metabolites present in minute quantities. Allelopathy has been studied by Tison-Rosebery et al. [6] between a proliferative macrophyte in Aquitaine lakes and blooms of the cyanobacteria *Microcystis aeruginosa* using also a metabolomics approach by LC-HRMS. The presence of metabolites downregulating the growth of the cyanobacteria could help mitigating the negative effects of its blooms. As presented by Eparvier and coworkers [7], molecular networking using t-SNE available in the newly developed software MetGem has been used to annotate the antimicrobial and defence metabolites produced by a bacterial strain present in a termite. A subsequent study by Touboul and coworkers [8] applies similar bioinformatics tools to the GC-MS data obtained on the volatile organic compounds (VOCs) released by a South American plant in order to identify antifungal metabolites. The soil is an example of medium where complex interactions mediated by chemical cues between organisms take place. In the study by Chauvat and coworkers [9], the impact of the presence of an insect in the vicinity of plant roots induced a change in the metabolome of the soil. As nicely illustrated by Mondet et al. [10], pheromones are essential metabolites for insects and especially for honeybees. A seasonal change in the metabolome of the brood has been observed and needs now to be better analysed and understood. Plant–insect interactions are still full of surprises as exemplified by the identification by Gibernau et al. [11] of an unusual VOC from the Mediterranean plant *Arum pictum* that can play a role in the attraction of a diversity of insects. Chemical emissions of the almond tree were for the first time investigated under changing conditions by Leconte et al. [12]. Identification of some VOCs involved in the positive interaction with the almond wasp could serve as a natural biocontrol of its proliferation. As demonstrated by Richard and coworkers [13], the presence of endosymbionts in the male terrestrial isopode known as potato bug modifies the metabolome composition of its cuticle while becoming feminised. Despite this change in reproductive behaviour, these individuals remain less attractive to males, which could be linked to this change in the metabolomics profile. Insects continue to be an important source of chemical diversity as exemplified by the discovery of new alkaloids of the azamacrolide family found in several species of ladybirds by Magro et al. [14]. The presence of major families of specialised metabolites should be included into the integrative approaches used in phylogenetics studies of plants and animals. Contact and distance interactions are the two modes of actions of chemically mediated interactions and they are usually difficult to tell apart in chemical ecology. Menacer et al. [15] were able to show that, for the cabbage root fly, VOCs act mainly when in mixtures, and have effects either at distance or at contact, but not both. In a changing environment, trees represent nutritional resources for bumble bees and flowering species are crucial to sustain colony initiation through chemical mediation. Gekière et al. [16] showed that orchards are good candidates to offset the ongoing decline of early flowering willows. Therefore, conservation strategies should consider specialised metabolite profiles, especially flavonoids, when designing agri-environmental schemes to support wild bee. The identification of pheromones in invasive species of insects such as hornets in Europe is highly relevant for biocontrol. To this end, Darrouzet and coworkers [17] have characterised the chemical profiles of the putative pheromones contained in the venom glands of four types of female hornets.

Overall, this special issue presents a broad overview of the evolving field of chemical ecology in France developed through the GDR MediatEC, spanning from the historical plant–insect interaction to the more recent marine and microbial environments. It highlights how dynamic the field is through the different disciplines and environments involved, and the valuable inputs it gives to both basic and applied science especially in a time of drastic global change.

References

[1] O. P. Thomas, A.-G. Bagnères, *Aquat. Ecol.*, 2022, **56**, 337-338.

[2] A.-G. Bagnères, M. Hossaert-Mckey (eds.), *Chemical Ecology*, ISTE Ltd, London, 2016, ISBN: 978-1-84821-924-3.

[3] M. A. Beniddir, E. Poupon, *C. R. Chim.*, 2023, **26**, 7-21.

[4] C. Rousseau, G. Demoulinger, S. Rousvoal *et al.*, *C. R. Chim.*, 2023, **26**, 23-47.

[5] V.-T. Le, S. Bertrand, M. Brandolini-Bunlon *et al.*, *C. R. Chim.*, 2023, **26**, 49-66.

[6] J. Tison-Rosebery, S. Moreira, M. Eon *et al.*, *C. R. Chim.*, 2023, **26**, 67-81.

[7] D. Nguyen, M. Levasseur, J. Segret, J. Sorres, T. Hebra, D. Touboul, V. Eparvier, *C. R. Chim.*, 2023, **26**, 83-95.

[8] M. Levasseur, C. Santerre, J. Segret *et al.*, *C. R. Chim.*, 2023, **26**, 97-109.

[9] V. Bohm, T. Michel, E. Forey, V. Agasse, P. Cardinael, M. Chauvat, *C. R. Chim.*, 2023, **26**, 111-118.

[10] F. Mondet, D. Beslay, M. Cousin, Y. Le Conte, *C. R. Chim.*, 2023, **26**, 119-128.

[11] M. Gibernau, A. Amadori, A. Godschalx, J. Albre, F. Tomi, P. Marcia, E. Farris, *C. R. Chim.*, 2023, **26**, 129-138.

[12] A. Leconte, N. Barthes, B. Buatois, E. Coutagne, H. Duval, P. Lucas, M. Staudt, *C. R. Chim.*, 2023, **26**, 139-154.

[13] N. Mouret, V. Tolassy, F.-J. Richard, *C. R. Chim.*, 2023, **26**, 155-164.

[14] A. Magro, F. Ramon-Portugal, D. Touboul, I. Borges, J.-L. Hemptinne, *C. R. Chim.*, 2023, **26**, 165-176.

[15] K. Menacer, M. Hervé, B. Lapeyre, M. Vedrenne, A. M. Cortesero, *C. R. Chim.*, 2023, **26**, 177-187.

[16] A. Gekière, A. Michel, I. Semay, C. Tourbez, M. Begou, D. Michez, P. Gerbaux, M. Vanderplanck, *C. R. Chim.*, 2023, **26**, 189-203.

[17] L. Berville, C. Lucas, M. Haouzi, A. Khalil, J. Gévar, A.-G. Bagnères, E. Darrouzet, *C. R. Chim.*, 2023, **26**, 205-219.