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Olivier P Thomas, Anne-Geneviève Bagnères

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Preface: aquatic chemical ecology

Olivier P. Thomas · Anne-Genevieve Bagnères

Compared to its terrestrial counterpart, chemical ecology has only recently been applied to aquatic organisms. The delay in this area is mainly due to the difficulty in accessing marine or freshwater habitats. Indeed, the discovery of the biological diversity inhabiting our oceans associated with their chemical diversity only started in the late 1950s with the development of SCUBA diving. Just as the terrestrial plants, the first studied macroorganisms present in coastal waters were found to host an unexpected diversity of unique metabolites. As life first appeared in our oceans, the chemical structures of aquatic metabolites have been finely tuned to exert their ecological role along their evolutionary history. The highly polar and protic properties of the water molecule acting as the surrounding medium of aquatic organisms induced original chemical architectures for the aquatic chemical cues involved into contact and distance interactions. Where some level of similarities was found between aquatic and terrestrial metabolic pathways some are specific to aquatic environments leading for instance to a higher number of nitrogen and halogens. In more than 70 years, some progress has been made in the understanding of the chemically mediated interactions in the aquatic environment, but this field is still largely understudied. Some peculiarities are identified between freshwater and marine chemical mediators mainly because of the difference in salinity. More recently, some pioneering works were also undertaken to unravel the ecological roles of metabolites produced by aquatic microorganisms. This special issue highlights recent work in different aspects of aquatic chemical ecology covering a broad range of organisms from freshwater to marine environments applied to micro and macroorganisms. Investigations are also directed towards the effects of the changes of environmental parameters on chemically mediated interactions between aquatic species.

A comparative review is presented on the chemically mediated recruitment between marine and freshwater macroorganisms (Bilodeau, Hay 2021). The importance of the response of freshwater gastropods to different types of conspecific and heterospecific cues is stressed in a discussion article (Kirsch 2022). In the marine environment, some seaweeds and cyanobacteria such as *Dicyota* and *Lobophora* for the seaweeds *Dichothrix* for the cyanobacteria were found to be deterrent to the long spined sea urchin *Diadema antillarum* commonly found in the Caribbean sea (Spiers, Harrison, Deutsch, Garg, Paul 2021). A review is focused on the lipidic metabolites produced by the common microscopic diatoms commonly found in aquatic ecosystems, their biosynthesis and their infochemical roles (Orefice, Di Dato, Sardo, Lauritano, Romano 2022). Cyanobacteria are a rich source of metabolites in tropical waters of the Pacific Ocean and the effect is not only defensive. A beneficial interaction was evidenced between the filamentous cyanobacterium *Moorena bouillonii* and the snapping shrimp *Alpheus frontalis* (Leber, Reyes, Biggs, Gerwick 2021). The predation rate of the freshwater glassworm *Chaoborus* towards the model planktonic crustacean *Daphnia* sp. was found to be affected by the level of bacterial degradation of the kairomone (Klintworth, von Elert 2021). Still in freshwater environments, differential allelopathic effects were identified from different planktonic groups towards the life history variables of zooplanktonic rotifers (López-Rocha, Sarma, Nandini 2022).

Climate change is likely to have a strong effect on the chemical mediation in aquatic environments and especially in the marine environment through the acidification of our oceans. The effect of pH was demonstrated for the shore crab *Carcinus maenas* in the detection and response to prey cues (Richardson, Martin, Bartels-Hardege, Fletcher, Hardege 2021). A sex pheromone bouquet was found to be composed of nucleotides for this shore crab (Fletcher, Terschak, Bartels-Hardege, Bublitz, Schirmacher, Hardege 2021). Changes of physico-chemical parameters also affect freshwater organisms. A review on the effects of different physical parameters on physiological

responses of three subgenera of *Sphagnum* mosses in freshwater systems is presented (Chiapusio, Binet, Bertheau, Priault 2022). Potentially associated with climate change, the proliferations of some species have a strong impact on local aquatic ecosystems based on modified chemical interactions. In the Mediterranean sea, a variety of the invasive green alga *Caulerpa taxifolia* was found to have a different chemical composition than the well-known species which will certainly induce adverse effects to the local ecosystems (Defranoux, Noè, Cutignano, Casapullo, Ciavatta, Carbone, Mollo et al. 2021). Blooms of toxic cyanobacteria are also becoming more frequent in freshwater environment. Allelopathic effects of portoamides produced by the cyanobacterium *Phormidium* sp. were evidenced towards competitive cyanobacteria (Monteiro, Cuaresma, Vasconcelos, Barreiro 2021). In a similar approach allelopathic effects of the toxic dinoflagellate blooming in the Mediterranean sea *Ostreopsis* cf. *ovata* were studied towards competitive benthic microalgal species (Ternon, Pavoux, Peltekis, Gemin, Jauzein, Bailleul, Lemée et al. 2022).

The widespread occurrence of contaminants in the aquatic environments does also induce modifications in the chemical mediations of aquatic organisms also called infodisruption (Gross 2022). Chemical ecology should therefore be considered when addressing ecotoxicology in aquatic ecosystems.

This special issue points out the need for a better understanding of chemical interactions in aquatic ecosystems both at micro and macro level. A key limitation is associated with the identification of the chemical cues responsible for the effects. Where some progress has been made in the planktonic phase a lot remains to be done for macroorganisms. The special issue also highlights the importance of global change, the proliferation of species and the impact of humans on the chemical interactions between aquatic organisms and therefore the biodiversity change of our fragile aquatic ecosystems. Approaches in chemical ecology are largely encouraged for a better comprehension and protection of our endangered aquatic environment.

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O.P. Thomas
Marine Biodiscovery, School of Chemistry and Ryan
Institute, National University of Ireland Galway, University
Road, Galway, Ireland

A.-G. Bagnères
CEFE UMR 5175, CNRS – Université de Montpellier –
EPHE - IRD 1919 route de Mende F-34293,
Montpellier Cedex 5, France

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