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Editorial: Recent advances in the chemical ecology of parasitic Hymenoptera

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Editorial on the Research Topic
Recent advances in the chemical ecology of parasitic Hymenoptera

The Hymenoptera order is considered one of, if not the most diverse taxon of animals on Earth, largely due to the hyperdiverse parasitic wasps, countless of which still await discovery and scientific description (Forbes et al., 2018). Parasitic wasps share a common way of life in that they develop in or on other arthropods and kill their host no later than the end of their development. Therefore, they play a key role in ecosystem functioning by controlling arthropod populations (Quicke, 1997). Due to their lifestyle, parasitic wasps are also suitable for selective and environmentally friendly control of insect pests. The effective use as biocontrol agents requires knowledge about all aspects influencing the reproductive success of parasitic wasps. This has led to a large community of researchers worldwide dedicated to the study of parasitic hymenopterans. However, it is not only application-related aspects that make parasitic wasps valuable research objects; some species such as the pteromalid wasp *Nasonia vitripennis* have achieved the status of model organisms suitable to answer fundamental questions in biology (Werren and Loehlin, 2009; Werren et al., 2010).

The genus *Nasonia* consists of four species, the cosmopolitan *N. vitripennis* and the North American species *N. giraulti*, *N. longicornis* and *N. oneida*. Mate finding in *Nasonia* species is mediated by male-derived sex pheromones. All species share the pheromone components (4*R*, 5*S*)-5-hydroxy-4-decanolide and 4-methylquinazoline while only males of *N. vitripennis* produce significant amounts of the additional component (4*R*, 5*R*)-5-hydroxy-4-decanolide (Niehuis et al., 2013). Kurtanovic et al. report in this Research Topic that *N. longicornis* females respond specifically to the conspecific male sex pheromone and discriminate against the pheromone of the sympatric species *N. vitripennis* by using (4*R*, 5*R*)-5-hydroxy-4-decanolide, the pheromone component newly evolved in *N. vitripennis*. Interspecific courtship and mating, as being common in the genus *Nasonia*, are usually associated with evolutionary costs for female insects. The study shows that females can avoid costly sexual interactions with males of a closely related sympatric species by discriminating against a pheromone component that evolved in the interacting species.

Apart from mate finding, the ability to locate suitable hosts is another factor that influences the reproductive success of parasitic wasps. Also for this process, females use chemical information emitted by the host or host-associated materials. A recent study (Malec et al., 2021) has demonstrated for a German *Nasonia vitripennis* population the existence of two ecotypes one of which parasitizing fly pupae mainly in bird nests, while the other occurs near carcasses where host species are also abundant. Accordingly, females of the two ecotypes preferred the odors of the respective habitats. Additionally, females from the carcass-ecotype had a higher parasitization rate on carrion flies and microsatellite analyses supported a subpopulation structure. Using a different approach, Buellesbach et al. did not find any differences in the CHC-profiles of wasps from bird nests and carcasses in a *N. vitripennis* population from the Netherlands. Also, microsatellite analyses did not reveal any subpopulation structure suggesting the absence of ecotypes in the Dutch *N. vitripennis* population. Now, it will be interesting to investigate how this population performs with respect to the other parameters investigated in the previous study.

Plants that are eaten by herbivores, or even just carry herbivore eggs, are induced to synthesize volatiles that attract parasitic wasps, helping the plants get rid of the attacker (Hilker and Fatouros, 2015; Turlings and Erb, 2018). These findings have initiated tremendous research activities in the past decades, which continue to produce new insights into various aspects of this fascinating phenomenon. Ross et al. demonstrate in their study that the odor of intact maize plants interferes with the landing response of the braconid wasp *Cotesia kariyai* on neighboring herbivore-infested plants. The authors were able to isolate the responsible compounds by dynamic headspace sampling, opening the door for the identification of the compounds modifying the parasitoids' behavior. Chierici et al. demonstrate that not only the presence of intact plants but also the host species a parasitoid developed in may influence its response to induced plant volatiles. In their study, the authors investigated the response of the egg parasitoid *Trissolcus japonicus*, a promising biocontrol agent of the invasive brown marmorated stink bug (BMSB), *Halyomorpha halys*, to oviposition-induced bean plants. *T. japonicus* may use eggs of other stink bugs as alternative hosts. Females developing in the preferred host BMSB specifically preferred the volatiles released by the *Vicia faba*/BMSB plant-herbivore complex whereas wasps originating from sub-optimal alternative hosts neither preferred *Vicia faba*/BMSB volatiles nor the odor of the plant-herbivore complex they originated from. These results are of great importance for optimizing biocontrol of BMSB by *T. japanicus*. They suggest that the use of readily available alternative hosts for rearing parasitic wasps may reduce their efficacy as biocontrol agents when the target pest is a different species. Bogka et al. investigated the olfactory response of the braconid wasp *Psyttalia concolor*, a natural enemy of the olive fly, *Bactrocera olae.* Both olive fruits infested by olive fly larvae and female olive fly-derived compounds attracted female *P. concolor* in bioassays. Mere oviposition, albeit changing the volatile profile of infested olive fruits, did not influence the behavior of the parasitoid. Chemical analyses revealed some promising candidate chemicals for further bioassay testing and application to increase the efficacy of *P. concolor* in olive fly control.

Parasitoids have also been used successfully to control stored product pest (Schöller et al., 2018). The bethylid wasp *Holepyris sylvanidis* is a larval parasitoid of different stored product infesting beetles including the confused flour beetle (CFB), *Tribolium confusum*. Awater-Salendo et al. demonstrate that females respond in a dose-sensitive manner to a two-component synthetic kairomone identified previously in the larval feces of the host. In microcosm experiments, it was shown that the presence of this kairomone increased the efficacy of the parasitoid against CFB. Interestingly, the offspring sex ratio was skewed towards males when the kairomone was present which is likely to impede the desired biocontrol effect in the next generation. This emphasizes that semiochemicals have the potential to augment biocontrol by parasitic wasps but there might be adverse side effects that need to be considered.

We hope readers enjoy this compilation of cutting-edge research papers on the fascinating biology of parasitic wasps.

Author contributions

JR: Writing – original draft. TS: Writing – review & editing. JS: Writing – review & editing.

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.

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