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Editorial: Chemosensory receptor systems of invertebrates, from expression to function: protein targeting, interactions with ligands, pharmacology, and pest management strategies

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Editorial on the Research Topic

[Chemosensory receptor systems of invertebrates, from expression to function: protein targeting, interactions with ligands, pharmacology, and pest management strategies](#)

The concept of chemical sensing by organisms describes the process of multiple mechanisms based on the binomial compound-receptor interaction, involved in complex interconnections: from the opening of ligand-gated ion channels to triggering molecular signaling on the plasma membrane and the cytoplasm. Among the protostome invertebrates, it is still common to distinguish taste from olfaction; however, in reality, it is more appropriate to break this distinction considering various lines of evidence for adaptation of the receptors involved in these “two senses” from more-primitive chemical sensors. Despite that some protostomes are bigger and others smaller, they are all complex chemosensory entities: the given abundance and variability among the classes of protostomes’ chemoreceptors make these invertebrates outstanding models to advance evolutionary, physiological and molecular discoveries, to shed light on various functional mechanisms of chemical sensing.

In this Research Topic, we intended to challenge the binomial distinction of “taste” and “olfaction” by proposing a broader “vision” of the chemosensory modalities of the invertebrates, seeking to explore cytological and physiological mechanisms associated

with the expression of both odorant and taste chemoreceptors, independent from their expression or interaction with the external environment.

Regarding methods, Tom et al. used the NanoString digital platform for gene expression to investigate genes from three chemosensory receptor families (GRs, ORs, and IRs) in different chemosensory organs of the Hawkmoth *Maduca sexta*, and to compare gene expression between males and females, pre- and post-mating. By this approach, the authors provided an extensive dataset of the expression pattern of a repertoire of 149 chemosensory receptor genes across nine peripheral chemosensory tissues and both sexes in different mating states in adults of the hawkmoth, suggesting that all peripheral tissues under investigation are potentially multimodal, having both olfactory and gustatory functions.

Using HiSeq Illumina sequencing, Venthur et al. aimed to explore chemoreceptors and chemosensory proteins present in the rostrum of male and female adults of the red palm weevil *Rhynchophorus ferrugineus*. The rostrum is a snout-like projection key for pheromone emission and dispersion. Comparing rostrum transcriptomes from insects collected in the field or reared in lab conditions, the authors pinpointed key olfactory proteins involved in pheromone or plant-volatile detection. From these transcriptomes, the authors identified 93 proteins related to olfaction, supporting an olfactory role of the rostrum. Among these, proteins for odorant transport appeared highly abundant, with one sharing the same evolutionary origin as a known pheromone transport protein. Differentially expressed genes between females and males were also found, as well as up-regulated and male/female-biased transcripts from weevils reared in laboratory conditions compared with those collected from the fields.

With similar methods, Johny et al. performed an antennal transcriptome analysis for the identification of the main olfactory sensory genes of three species of termite workers, covering the phylogenetic diversity of Isoptera, characterized by different levels of social complexity: from the relatively basal Kalotermitid *Neotermes cubanus*, the authors investigated the modern lineage of Termitids *Inquilinitermes inquilinus*, and the Rhinotermitid representative *Prorhinotermes simplex*, being situated mid-way between *N. cubanus* and *I. inquilinus*. The authors found comparatively large repertoires of chemosensory genes among ORs, GRs, IRs, SNMPs, OBPs and CSPs, revealing Isoptera-specific expansions with 1:1 orthologous patterns, indicating the existence of conserved chemosensory functions within this wide insect family.

In their mini review, Smith et al. conducted a critical bibliographic investigation on ant gustation, by analyzing diet preferences and cellular mechanisms, evolution and phylogenetic analysis of insect GR, OR and IR chemoreceptors and with respect to insect's social dimensions behind these receptors' activation. The

authors claimed to shed light on how gustation varies intra- and interspecifically for ants, on how the molecular mechanisms of gustation evolve when ants change diet, on how this has impacts on sociality for ants and how taste may influence species diversification. The authors conclude that the chemical sensing of gustation influences species biodiversity, evolving as a mechanism for food choice and dietary optimization, in which evolutionary changes in receptor alleles enabled the assessment of new food sources, driving selection for adaptive chemoreception. The remarkable dietary and species diversity of ants presents an outstanding opportunity to explore the evolution and mechanisms of gustation in eusocial species that make individual- and colony-level decisions based on taste.

In another contribution, Smith et al. combined transcriptomic analysis, with behavioral measurements of exudation to investigate CO₂ and weak acid detection in the European Nightcrawler annelid *Dendrobaena veneta*. The authors unveiled a complex asset of carbonic anhydrases (CAs), acid-sensing ion channels (ASICs), guanylate cyclases (GCs), otopetrin (OTOP) channels, transient receptor potential ankyrin 1 (TRPA1) channels, glutamate receptors (kainate, delta and NMDA) and the ionotropic co-receptor IR25a. When the authors tested earthworms by exudate assays, these animals excreted significantly more exudate in response to CO₂ and weak acids in a dosage-dependent manner, and such responses were muted when the authors combined inhibitors of carbonic anhydrase and blockers of calcium channels, sodium channels and acid-sensing ion channels, demonstrating the role of carbonic anhydrases and epithelial sodium channels in earthworm CO₂ detection, unveiling evidence of high tolerance of these animals to CO₂.

Generating transgenic *Drosophila melanogaster*, Jain et al. tested neuronal fluorescence from homozygous strains expressing, via *pUAS/Gal4*, an N-terminal GFP-fused Orco protein (*Homo*), that they compared with their parental heterozygous provided with only one copy, either of both the *pUAS-GFP-Orco* and the *pOrco-Gal4* cassettes (*Hetero 1*), or only one copy of either the *pUAS-GFP-Orco* cassette (*Hetero 2*) or the *pOrco-Gal4* cassette (*Hetero 3*). The authors found that fluorescent intensity was the highest in *Homo* flies. As Orco is known to guide OR_X proteins to the OSN dendrites, the authors checked whether the fusion of GFP to the Orco N-terminus may affect such trafficking and thereby OR function: their study shows that GFP insertion at the N-terminal region of Orco does not affect the localization of OR proteins in the dendritic OSN membrane and that physiological olfactory functions are maintained after this manipulation.

Collectively, these studies provide perspectives for the further exploration of chemosensory interactions of protostomes and display advances to improve future studies, both with a wider ecological interest, as well as practical targets for sustainable pest management strategies.

Author contributions

AC: Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. WW: Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – review & editing.

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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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