Editorial

Wilhelm Boland*

The chemistry of social insects

https://doi.org/10.1515/znc-2019-0139

In 1959 Adolph Butenandt published his fundamental discovery of bombykol as the sexual pheromone of the silk worm moth. Only 6 years later, E.O. Wilson published a review (*Science* 1965, 149, 1064–1071) on “Chemical Communication in the Social insects.” This demonstrated the enormous fascination of the just emerging research topic on “behavior controlling compounds” in social insects. In the early days, chemists and biologists together isolated and characterized numerous structures and begun to reveal behavioral patterns controlled by them. It became rapidly evident that in social insects most communications appeared to be chemical. The compounds were often produced in exocrine glands and released into the environment. Unlike hormones, these compounds exhibit a certain degree of species specificity. There exist fast-acting signal pheromones (releaser effect) and orally effective primer pheromones which can induce changes in the hormonal balance or in the nervous system of the insects, finally resulting in a modified behavior. With increasing social complexity, insects developed a greater diversity of messages with more sophisticated patterns and blends to coordinate division of labor, group cohesion and concerted actions. Since the early 1990s, from the rapidly increasing number of identified structures, biosynthetic patterns and pathways emerged and biochemical aspects gained more and more attention. With the advent of efficient silencing technologies of modern molecular biology also applicable to non-model insects, the scientific focus shifted to more basic questions addressing the raison d’être, development and evolution of communication systems.

The three contributions to the “chemistry of social insects” with special emphasis on “queen pheromones” illustrates the current view onto the field. The contribution of Abraham Hefetz (Tel Aviv University, Israel) critically summarizes our knowledge on primer pheromones which coordinate colony behavior “resulting from the behavior of individuals that is based on their perception of local information.” In this context, the importance of blends and their chemical uniqueness as well as their concentration in queens and workers are carefully outlined. In recent years, besides the classical queen pheromone [9-oxo-2*E*-decenoid acid (9-ODA)], particularly the cuticular hydrocarbons (CHCs) have been recognized as a conserved class of queen pheromones. A brief discussion of the biosynthesis of the honeybee queen mandibular pheromone (9-ODA and four other compounds) illustrates the tight regulation of the biosynthesis of such compounds by different enzymes and by a caste-specific expression. Noteworthy are Hefetz’s remarks on the still open questions regarding this elaborated communication system and how genomics may contribute to the identification of still unknown pheromones in the future.

A review on bumblebee male pheromones is provided by Irena Valterova et al. (Academy of Sciences, Prague, Czech Republic). Scent marking and patrol flying belong to the premating behavior of the bumblebee species. Often, the compounds originate from the cephalic labial gland (CLG), but besides the chemistry, the behavior of the insects might be even more important; long-range attraction of gynes to the male labial gland secretion in the field has been never demonstrated. The chemistry of these secretions has been extensively studied and comprises aliphatic compounds (alcohols, aldehydes and fatty acids), including hydrocarbons and terpenoids, summarized in a comprehensive table. Localization and mode of biosynthesis are discussed. The authors outline the difficulty of correlating CLG composition with phylogeny in general. Patterns have been found in several subgenera, but they never reflected wider relationships. The contribution gives a good impression on the enormous diversity of the chemistry in the CLGs and other glands contributing to the control of behavior in bumblebees.

The chemistry of “queen-specific volatiles” in termites is addressed by Jana Havlickova et al. (Academy of Sciences, Prague, Czech Republic). In termites, the queen-produced primer pheromones may be linked to CHCs as well, but also other compounds, especially terpenoids, may serve the same purpose. A queen-specific volatile present in hexane body washes was identified as (3*R*,6*E*)-nerolidol. Visualization techniques by mass spectrometry showed the compound homogenously distributed on the surface of the abdomen and thorax in four

***Corresponding author: Wilhelm Boland,** Max-Planck-Institut fuer Chemische Oekologie, Hans-Knoell-Strasse 8, D-07745 Jena, Germany, Phone: +49-(0)3641-572700, E-mail: Boland@ice.mpg.de

different genera; electroantennogram analyses revealed a preferential response of workers to the 3*R* enantiomer. However, a convincing evidence for the role for this compound as a primer pheromone in termites is still missing. This type of a holistic approach to describe a biological problem, addressing compounds, their biosynthesis, regulation and local distribution along with information on the origin and evolution of the genetic background has become a hallmark of current research in pheromone chemistry and beyond.