# Olfactory Concepts of Insect Control - Alternative to Insecticides

Jean-François Picimbon
Editor

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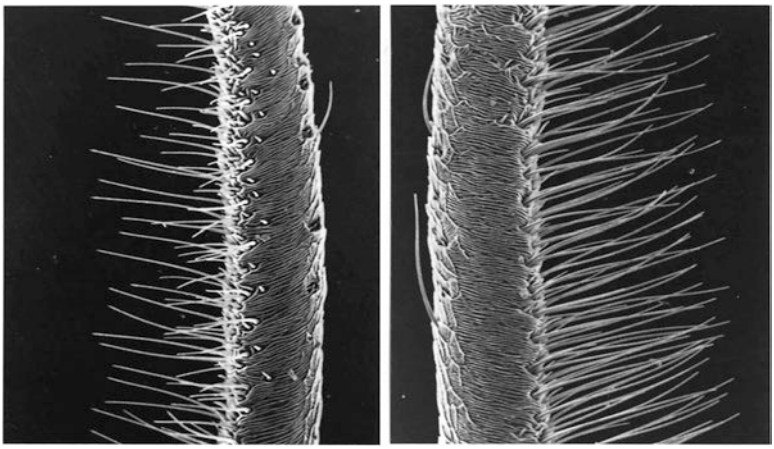

Scanning electron micrograph (SEM) of isolated branches of a male (right) and a female antenna (left) of the silk moth *Bombyx mori*. The olfactory hairs (sensilla trichodea) of the male antenna are about 100-µm long and house two neurons each, one responding to the pheromone component bombykol, the other to bombykal. The female hairs are shorter; their two neurons strongly respond to linalool and benzoic acid. In addition, the antennae of both sexes carry smaller hairs (sensilla basiconica) and very small hairs (<10 µm) located in pits (sensilla coeloconica) responding to other odorants (KE Kaissling)

# Foreword

Olfaction is the chemical sense that evolved to extract adaptive information from the environment. Sensitivity and selectivity are the two most salient features that characterize olfactory systems. An estimated half a million odorants are estimated to occur in nature. These compounds exhibit a wide variety of chemical structures and are produced in varying amounts ranging from minute quantities to large amounts. Faced with the challenge of steering in aerodynamic and complex chemical environments, insects are able to track trace amounts of semiochemicals (e.g., pheromones) with a high probability of detection and a seemingly low error rate. A striking example of such feat is represented by how male giant silk moths can locate calling female over distances reaching up to 4.5 km (Fig. 1).

In insects, the interface between odorants and behavioral responses is constituted by a complex network of morphological, physiological, molecular, and neural adaptations. This book draws examples from moths, the vinegar fly *Drosophila*, and other insects to provide an overview of the peripheral and central olfactory systems (Fig. 2). Some chapters address the chemical nature of pheromones and plant

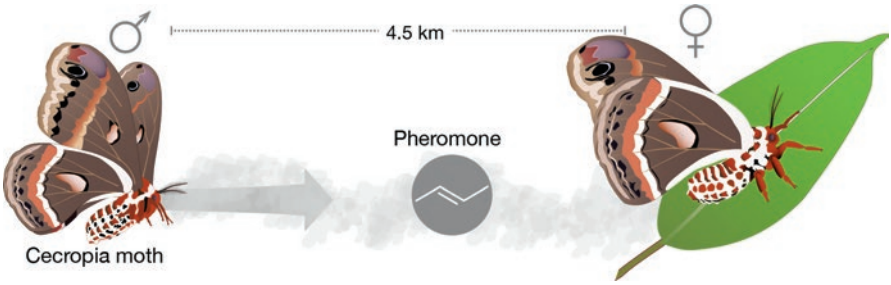


**Fig. 1** The male cecropia giant silk moth (*Hyalophora cecropia*) flies upwind long distances to the pheromone source, a calling female moth. The caterpillar feeds on mapple, apple, cherry, and birch trees but is not considered a serious pest. Due to its impressive size (up to 15 cm wingspan) and beautiful appearance, this moth has become a favorite of collectors. This insect has been used extensively in physiological research and in early studies on pheromone-mediated sexual communication

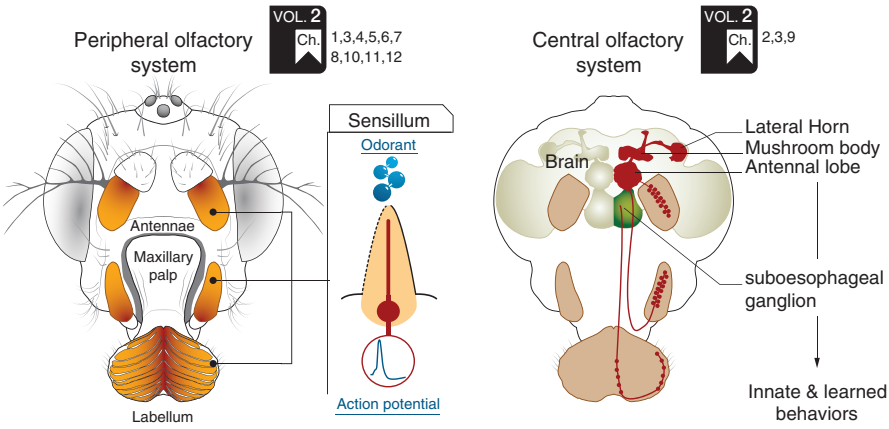


**Fig. 2** The vinegar fly, *Drosophila melanogaster*, is a useful genetic model insect to study how olfactory information is acquired by the peripheral olfactory system, which is constituted of chemosensory sensilla. These small sensory organs are responsible for converting chemical signals (e.g., odorants) into electrical signals (action potentials), which are interpreted by higher brain centers ultimately leading to behaviors. Chapters (Ch.) addressing these topics are indicated by the bookmark symbol

volatiles. Other chapters review how (the mechanisms) this information is obtained and processed through the subjacent neural substrate. Finally, the last chapters explore how this knowledge can be used for the development of new synthetic drugs or natural chemistries affecting these processes.

From this overview emerges a model whereby odorants are converted into action potentials (nerve signals) in the peripheral olfactory system. This neural information is then distributed to a first relay center, such as the antennal lobe, and projected to higher brain centers, such as the mushroom body and lateral horn in the deutocerebrum, which generate innate and learned behaviors.

This knowledge is not only important from a basic research standpoint but a necessary requirement for the generation of innovative ideas and to develop new technologies that will interfere with olfactory-mediated behaviors of specific insect pests whose impact on food production or human health is incommensurable.

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# Book Abstract

Flies, locusts, mosquitoes, moths, and most other insect species respond to odor messages they exchange consciously. This is due to the existence of thousands of olfactory sensilla covering the antennal branches and thousands of nerve cells that will transmit the odor signal toward specific parts of the insect brain. Pheromones, pheromone regulatory pathways, pheromone-sensitive nerve cells, pheromone receptors, and pheromone-binding proteins appear in this book as a prerequisite not only for fundamental knowledge but also for applied research and insect control. The pheromone or olfactory concepts, exposed here in nocturnal species of moths, mainly deal with the phenomenal expansion of some specific insects, invasive pest species that have severe impacts on agriculture or human health. However, the olfactory concepts exposed in this book must be brought further, before the shrinkage of some other more beneficial species such as the honeybees. Like many other species (butterflies, crickets, ladybugs, and other flying insects), the bees are disappearing or show signs of a fast and significant decline in hive population, as an example of the serious decline of flora and fauna due to our industrialized agriculture. New concepts of pest control may help to stop the serious general disappearing of insects that are pollinators of flowers but also important ecological factors (e.g., as food sources or material converters). This is very alarming for a nature at risk of losing a biodiversity and the ecological equilibrium that it has taken so long to build.

# Contents

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# About the Editor

**Jean-François Picimbon** Dr. Picimbon completed his doctorate in Neurosciences-Neurobiology at the University of Provence (Aix Marseille I) in 1995 after he graduated in Physiology-Neurophysiology at St Jérôme (Aix Marseille III) in France. His original work dealt with pheromone identification, regulation, and perception in moths (CNRS-INRA French Ministry of Research MRE#92114-9210 MR/MFP 907). After further behavioral, chemical, molecular, and physiological study of insect pheromones in Canada, Japan, and USA, he joined the Institute of Physiology in Hohenheim University as Alexander von Humboldt fellow (molecular basis of insect olfaction) before to be appointed "Forskarassistent" (Assistant Professor) at the Department of Ecology from Lund University in Sweden (ranked first). In 2001, his work on insect chemosensory proteins (CSPs) was honored as *"one of the top ten most talented international young scientists"* (14th NAITO Conference, Bioactive Natural Products and their Mode of Action, Kanagawa, Japan). In Lund, he led research on termite caste-specific genes, ECB moth male pheromone identification, endocrine regulation of pheromones, evolution of noctuid pheromone binding protein genes, and resolution of functional CSP structure with connection to CTBA-France (Bordeaux), INRA (Angers), School of Functional Genomics and Bioinformatics (Göteborg), National Centre for Biomolecular Research at Mazaryk University (Brno), Department of Biochemistry and Structural Biology (Lund), and various academic exchange/research programs from Belgium, Czech

Republic, France, Lithuania, and Sweden (Crafoordska Stiftelsen, Lund-Erasmus/Socrates grant programme, Swedish Research Council, and Swedish Institute in Stockholm). He moved to China in 2006 in the frame of UK-China Laboratory of Insect Biology (Nanyang, Henan Province). Following the award of Taishan Scholar and Outstanding Scientist from Abroad (2009), he is now a Distinguished Professor at the School of Bioengineering at QILU University of Technology (QLUT) and the Director of the Institute of Agricultural Microbiology in Jinan (Shandong Province, P.R. China), where he directs researches toward understanding of RNA mutations and development of new bio-natural microbial medicine and pheromone tools (eco-drug ORSA) for insect control, human health, and environment protection. He pioneered moths, chemosensory proteins, pheromone systems, and RNA editing. It is expected that the discovery of RNA editing in the silkworm moth *Bombyx mori* chemosensory gene family will pave way to key post-translational mechanisms underlying not only pheromone and olfaction in insects but also stem cell development in human. This discovery in insects may have profound impact in tissue repair and regenerative medicine, and cancer research. This research is the basis for teaching in Course 1/Ecological systems and evolution, path to biotechnology; Course 2/Sensory basis of food, wine, and juice to the path of simple enjoyment; International Course/Bioinformatics, phylogenomics and genetic tech. His thought is for teaching and education before research and innovation. His motto is, fundamental science and general knowledge should be the subject matter for applied or biotech concepts. He is also involved in developing French (Francophone) Language and Culture Education Course in support of Alliance Française in Jinan. He also helps internationalization of higher education in China through teaching "Advanced Scientific English-Science" and "Frontiers of Science": Evolution & Ecology, Animal Interactions, Pheromones, Neurobiology of Olfaction and Taste, at academic and public audience. He serves as Associate Editor of *Gene*, *Agri-Gene*, *International Journal of Bioorganic Chemistry and Molecular Biology*, *Journal of Clinical & Experimental Pathology*, *Journal of Clinical Pathology & Laboratory Medicine,*

*International Journal of Proteomics & Genomics*, and *SOJ Microbiology and Functional Diseases*. He is the Editor-in-Chief of *Gene & Translational Bioinformatics* (Smart Science & Technology, Houston, USA) and *International Journal of Genetic Science* (Symbiosis, Bloomington, USA).

He is matter of several biographical records including *Prabook* and "*Who is Who in Science and Bioengineering*" (insect pheromones and chemosensory proteins). He is also a recipient of Publons Peer Review Award (USA) and Insect Science Most Cited Paper Award of 2017. Besides science, he is a member of dozen international societies and governmental institutions, before all France's permanent representative to Shandong Province as ilot.SD@pekin-phedre.org in East Peninsula, North Yellow Sea, P.R. China. http://prabook.com/web/person-view.html?profileId=756595

# Conference, Scientific Seminar, and Public Audience to Science

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