Preface

Aphids, commonly known as plant lice, are important agricultural pests in temperate regions, causing both direct damage to crops as phloem feeders, and indirect yield losses by the transmission of plant pathogens. However, aphids are also fascinating model organisms in evolutionary biology and ecology, because they have evolved complex life cycles encompassing sexual and asexual reproduction as well as the development of multiple distinct phenotypes. The formation of one of several distinct phenotypes defined by the same genotype (polyphenism) is triggered by environmental stimuli and reflects adaptations to ecological challenges. Another prominent feature of aphids is their association with obligate and facultative microbial symbionts, which allow them to feed exclusively on phloem sap and which provide ecological benefits such as resistance to pathogens, parasites or environmental stress. The rapidly expanding scientific literature focusing on the biology and ecology of aphids calls for a textbook that summarizes the recent progress of research in this field, particularly for students in biology, ecology and the agricultural sciences. Accordingly, this volume offers a collection of chapters, written by experts, focusing on recent advances in distinct aspects of aphid biology and ecology.

Aphids belong to the superfamily Aphidoidea (~4400 species) which is part of the insect order Hemiptera representing a large taxon of hemimetabolous insects. The first chapter, entitled "Phylogeny of the aphids", summarizes current opinion concerning the placement of aphids in the tree of life. The reconstruction of the phylogenetic relationship among aphids and their hemipteran relatives has been supported recently by the rapidly increasing availability of transcriptome datasets and complete genome sequences, particularly the genome of the pea aphid *Acyrthosiphon pisum*.

The second chapter, entitled "The Ontogenesis of the Pea Aphid *Acyrthosiphon pisum*", focuses on the developmental biology of aphids and provides an illustrated guidance summary of oogenesis, embryogenesis, viviparous development and the complex life cycle of aphids. We are convinced that a text book for students should include such a chapter summarizing the basic processes of aphid development. The illustrations were drafted by Dr. Henrike Schmidtberg for teaching purposes in our agricultural biotechnology Master's programs at the Justus-Liebig University of Giessen in Germany.

The third chapter, entitled "Functional and Evolutionary Genomics in Aphids", highlights the rapidly developing field of aphid genome biology. The first completely sequenced genome of a hemipteran species was that of the pea aphid *Acyrthosiphon pisum*. Denis Tagu and his colleagues describe the background of this

pioneering project and have extracted the most important information for analysis in this chapter. They also consider potential future developments in aphid genome biology.

Chapter 4, entitled "Epigenetic Control of Polyphenism in Aphids", summarizes recent insights into the development of distinct morphological phenotypes of aphids in response to environmental stimuli. Epigenetics is a rapidly expanding research discipline addressing hereditary mechanisms that are not mediated by changes in the DNA sequence but which instead involve environmental mechanisms that reprogram transcriptional responses. Although the translation of environmental stimuli into particular aphid phenotypes is not fully understood, the current body of evidence suggests that epigenetic mechanisms participate in the regulation of aphid polyphenism.

The role of "Bacterial Symbionts of Aphids" is discussed in Chapter 5. The coevolution of obligate and facultative aphid symbionts along with their hosts can be thought of as a holobiont which fills an ecological niche as a highly-adapted phloem feeder. Phloem sap is rich in sugars, but lacks a balanced mixture of amino acids. The dependency of aphids on their microbial symbionts, which compensate for their unbalanced diet, is reflected by striking adaptations of their immune system, as highlighted in Chapter 6, entitled "Aphid immunity". In Chapter 7, Laramy Enders and Nicholas Miller provide a complementary analysis of "Aphid Molecular Stress Biology". Aphids must cope with environmental stressors such as heat, starvation and plant-derived secondary metabolites, and the corresponding adaptations are regulated by molecular mechanisms which now form an exciting research area.

The ecology of aphids is also determined by their host plants, which can be used for overwintering or reproduction. Chapter 8, entitled "The Effect of Plant Within-Species Variation on Aphid Ecology", by Sharon Zytynska and Wolfgang Weisser, introduces the reader to community genetics and multitrophic interactions. Communication among aphids, or between aphids and host plants or aphidophagous insects, is mediated by infochemicals known as semiochemicals or pheromones. The corresponding research field, the "Chemical Ecology of Aphids", is discussed by Antoine Boullis and François Verheggen in Chapter 9. A key feature of aphids is their ability to produce honeydew. This excretion product was originally considered as a waste product, but current insights suggest that honeydew not only removes surplus sugars from the diet but also plays a role in the chemical ecology of aphids. Klaus Hoffmann summarizes the state of the art in this area in Chapter 10, entitled "Aphid Honeydew: Rubbish or Signaler". Another key trait of aphids is their ability to produce saliva that facilitates their adaptation as phloem sap feeders. Recent biochemical and physiological studies have revealed a number of constituents and their functions, which are explained and discussed in Chapter 11, entitled "Function of Aphid Saliva in Aphid-Plant Interaction".

Aphids rapidly develop resistance against insecticides. Consequently, there is a pressing demand for sustainable control measures that benefit the environment and consumers. The development of such "Biotechnological Approaches to Aphid Management" is subject of Chapter 12 contributed by Benjamin Deist and Bryony Bonning. The final chapter, entitled "Aphid Techniques", focuses on the description of methods and technologies which are widely used in aphid research, such as the electrical penetration graph technique, styloctomy and artificial feeding.

Although a single book is not sufficient to provide exhaustive coverage of the burgeoning research on aphids, this volume covers an unprecedented spectrum of basic knowledge and recent research developments. I am convinced that this book will be a valuable source of information for researchers working with aphids and for students in biology, ecology and agriculture.

Autumn 2015

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