

Preface

Plant parasitism is a fascinating phenomenon of extreme intimate plant-to-plant interactions. The world of parasitic plants includes around 20 families, but the Orobanchaceae are the leading models for research. This is not only because some members of the family are parasitic weeds of great economic importance, but also because this family includes the whole trophic spectrum from non-parasitic autotrophs to obligate holoparasites. Many of these species are relatively amenable to laboratory and field experimentation. Research on the Orobanchaceae has yet to peak, but only recently has there been a surge in research with significant achievements particularly in the understanding of the mechanisms of parasitism, which justifies the publication of a new book on parasitic plants.

The evolutionary origin of plant parasitism is associated with regulatory changes in genes that usually fulfil non-parasitic functions. The specific functions of parasitism evolved following the duplication of genes or genomes and by ectopic expression of genes (see Sect. 4.5). In this way parasitic plants acquired features that are common to many non-parasitic plants, but their mode of expression, the extent to which these features have developed and the combination of the different features are unique. These unique features make fascinating scientific research that is aimed at understanding the parasitic plants at the most basic level. These findings can also be exploited at the applied level in designing sophisticated tools for the control of species that cause damage to agricultural crops.

The most recent example of parasitic plant research that significantly contributed to understanding the physiology of plants is the discovery of a novel family of plant hormones, the strigolactones, which was first identified as a group of germination stimulants for the holoparasites *Striga* and *Orobanche*. The detailed knowledge of the Orobanchaceae, presented in this book, should therefore not only reflect on the understanding of parasitic plants belonging to other families, for which little physiological and molecular information is available, but particularly contribute to understanding many features of plants in general.

The main objective of the book is to provide a comprehensive account of the current knowledge on all aspects of the parasitic syndrome within the Orobanchaceae. For this sake, internationally recognized leading scientists were invited as chapter

authors. The organization of the book is modular so that each chapter covering a given topic is self-contained while being indexed and fully cross-referenced to related chapters.

The book includes two parts. The first presents the cutting-edge knowledge of all key aspects of parasitism, and the second part is dedicated to the weedy species and their management, presenting and discussing strategies for parasitic weed control. Aspects of the Orobanchaceae that are not related to the parasitic habit are not presented. The diversity of parasitic families within the plant kingdom is briefly covered in Chap. 1, in order to clarify the position of the Orobanchaceae within the world of parasitic plants.

The core of parasitism is a special organ—the haustorium, a unique plant organ that is homologous to roots and physically connects the parasites to their hosts, allowing the physiological bridging between them. The structure of the haustorium, the signalling mechanisms for triggering its initiation and the manner it invades the host tissues are described and dealt with in Chaps. 2–5.

Following the establishment of the physical connection between the parasite and the host, the coordination between them is facilitated by specific chemical and hormonal signalling, allowing the parasite to act as an effective compatible sink in the overall host plant metabolism. While nutrient transfer and other physiological interactions between the parasite and its compatible hosts are discussed in Chap. 6, the host responses to the parasite are discussed in Chap. 7, including a detailed account of host resistance mechanisms.

Unlike the facultative hemiparasitic Orobanchaceae, the obligate parasites can only germinate in the vicinity of host roots. The unique structure of their seeds, the signalling mechanisms behind the ability of the seeds to identify host roots and the physiological aspects of their germination are dealt with in Chaps. 8–12. The strigolactones, a group of chemicals that are exuded by plant roots and serve as germination stimulants for many obligate parasites, are a major focus of Chaps. 10 and 12. The chemical and genetic aspects of strigolactones activity and the biochemical aspects of their biosynthesis are currently on the cutting edge of plant research.

Many Orobanchaceae species are adapted to parasitize specific hosts, a phenomenon that is particularly evident in the weedy species. Nonetheless, the mechanisms behind the adaptation of these species to changes in the availability of hosts are hardly understood. Given the increasing interest in epigenetics, a speculative chapter (Chap. 13) discusses, for the first time, the possibility that epigenetics is involved in determining host specificity.

The Orobanchaceae is a highly diverse plant family with many genera that have previously been included in other families. Recent molecular studies clearly show the phylogenetic relations between the different genera, on which the taxonomy of the Orobanchaceae is currently based. These phylogenetic relations and evolutionary trends are presented in Chap. 14, together with much taxonomic information regarding the current status of ‘problematic’ genera. Chapter 15 further presents aspects of the genomic evolution of the Orobanchaceae that appears to be extraordinarily dynamic and includes, between others, the reductive evolution of the plastid chromosome following the loss of photosynthesis.

Most Orobanchaceae species are not dominant in their habitat and may easily be ignored in the field because they look like ‘ordinary’ plants, though some have showy flowers or lack chlorophyll; nonetheless, certain species are keystone species in their plant ecosystems. The ecological aspects of parasitic Orobanchaceae have mainly been studied with some hemiparasitic model plants, particularly species of *Rhinanthus*. The interaction between parasitic plants and their hosts at the plant community level is presented in Chap. 16, with analysis of the impacts of these interactions on the dynamic structure of plant communities and on the interaction between the plant community and other organisms. The potential role of some hemiparasites as a tool in promoting floristic biodiversity by selectively parasitizing species that are too dominant in these habitats is also discussed in this chapter.

Plant parasitism is not only a case of extreme plant-to-plant interactions that can be useful as a tool in scientific research and in the management of certain habitats. It is also a significant threat to agriculture. Some parasitic species are weedy and damage major agricultural crops, leading to heavy economic losses worldwide and threatening food security, especially in poor countries. Potentially climate change may expand the distribution of the weedy species to geographical areas that are currently un-infested, and some non-weedy species may penetrate cultivated areas and become weedy. An updated description of the species that parasitize agricultural crops is presented in Chaps. 18–26, where the current knowledge on all aspects of parasitic weed management is discussed. These chapters are more fully introduced in Chap. 17.

The book is intended for all people who are interested in this remarkable family of parasitic plants, including students, university lecturers, plant scientists, as well as agronomists and weed specialists, breeders and farmers, extension personnel and experts in tropical and subtropical agriculture. The book is suitable for use in various university and college courses, not only in general plant biology, parasitic plants, plant physiology and plant evolution, but also in weed science, plant protection and host–parasite interaction.

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