Dharam P. Abrol

Pollination Biology

Biodiversity Conservation and Agricultural Production

Springer

Pollination Biology

Dharam P. Abrol

Pollination Biology

Biodiversity Conservation and Agricultural Production

Springer

Dharam P. Abrol
Division of Entomology
Faculty of Agriculture
Sher-e-Kashmir University of Agricultural
Sciences and Technology
Main Campus Chatha
Jammu 180009
India
dharam_abrol@rediffmail.com

ISBN 978-94-007-1941-5 e-ISBN 978-94-007-1942-2
DOI 10.1007/978-94-007-1942-2
Springer Dordrecht Heidelberg London New York

Library of Congress Control Number: 2011935032

Foreword

We dwell in the midst of yet another world food shortage that exacerbated by escalating prices the world over. Coupled to the apparent instability of climate cycles in recent years, one-fourth of our growing human population is fast approaching famine. Concomitantly, this situation includes rampant declines in honeybee populations across three continents, for as yet incompletely resolved reasons, and with no remedy or end in sight. These problems have been further aided and abetted by a lack of prophylactic progress in the conservation of biodiversity and increased agricultural production.

The above notwithstanding, there has been no shortage of interest in studies on honeybees in relation to pollination. Indeed, a brief perusal of this subject at the website Google scholar shows that during the last century the publication of research papers in this area has grown exponentially, and in just the last decade, some 15,000 items have appeared. In the event, it is both fair and pertinent to ask: "Is there actually need for yet another work on pollination biology, the conservation of biodiversity, and agricultural production"?

The answer depends on whether we are after the analysis, perhaps in great detail, of a particular aspect of a system; or seek a holistic treatise concerned with complete systems within a social human context. For the former, there are several excellent, scholarly works available. Works of the latter kind are few and far between. The present tome "Pollination biology – Biodiversity conservation and agricultural production" is of the latter kind. This work originates in the Himalayan region where agriculturalists have pioneered practical studies in pollination that combine basic ideas rooted in three facets: biological conservation, rural development and increased agricultural production and the role of pollination in improving food security and livelihoods.

Professor Abrol develops the theme that pollination is basic to agricultural and natural productivity and that this is an ancient co-evolved and intricate process involving animals and plants in mutualisms. The value of pollination to agriculture is of great and inestimable value in the global economy of *Nature*. Indeed, pollination is essential for sexual reproduction in plants and their seed and fruit sets.

These can be increased considerably in areas where there is a dearth of natural pollinators by introducing pollinators, a practice that has yielded excellent results.

The value of bees in pollination is undisputed. Nonetheless, Abrol evaluates systems for maintaining honeybees on crops that are insect- pollinated. Factors that attract honeybees to flowers, floral competition, and methods for increasing numbers of pollen and nectar foragers as well as techniques for attracting honey bees to, and retaining them on, target crops are fully probed. Wild bees provide pollination services that often go unnoticed, yet are critical to the success of some forms of agriculture. The impact that bees have on our food production systems should serve as a reminder to our dependence, in general, on the ecosystems around us.

Against this, on the one hand the use of pesticides for pest control and the role of honeybees for crop pollination on the other have become essential components of modern agriculture and without either global food production would be seriously impaired. Unfortunately, these two practices are not always compatible, as honeybees are susceptible to many commonly used chemicals for the control of insect pests. The major constraint confronting pollinator-plant interactions is the indiscriminate and excessive use of pesticides for controlling insect pests. Moreover, reduction in the population of these beneficial insects due to insecticides incurs significant environmental, ecological and economic costs.

The energetics of these systems is rather interesting. Pollinators are highly selective in their floral visits and choose those flowers which best meet their energetic needs. The energy needs and foraging dynamics of pollinators are dependent upon prevailing weather conditions which regulate the schedule of activities thus influencing the energy budget. Much of Professor Abrol's own research has been on the role of energetics in pollinator-plant interactions and indicates directions for future lines of research for the enhanced understanding of pollination biology. Energetic costs of pollination have been ameliorated by the *Evolution* of plant volatile production in pollination ecology and in pollinator-plant relationships are reviewed here. This interrelationship between the two is governed by biochemical factors such as scent, colour and nutritional value of nectar and pollen.

Pollinators and pollination are crucial in the functioning of almost all terrestrial ecosystems including those dominated by agriculture because they are in the front line of sustainable productivity through plant reproduction. But, any programmes specifically focused on pollination require formal education at all levels as well as informal capacity building amongst farmers, land managers, policy makers and other target groups, including the public as a whole. This is, indeed, an awesome task and we must congratulate Professor Abrol for this uncommon blend of pure and applied science placed in the broader human social context.

Grahamstown, South Africa Randall Hepburn

Preface

Pollen, the small spore, plays an important role in the sexual reproduction of angiosperms as does the sperm in the animals. However, the pollen grains are non-motile requiring some foreign agent for their carry over to the female counter part. Wind, water and gravity are some of the abiotic agents, but through them the pollen carryover is undirected and very large number of pollen has to be produced to ensure successful pollination. Still the effectivity of pollination by these agents is low. On the other hand in a large number of plant species, pollination is effected by the bioagents. This is especially true in plants exhibiting self-incompatibility, protandry or protogyny. Pollination by bees and birds is of special importance. Efficiency of pollination by bioagents is the direct measure of mutualism specialization which is reflected in terms of success of reproduction as evidenced by quality and quantity of produced seeds/fruits. Higher the degree of mutualism, specialization more should be interdependence between the two participating organism – the plants and the pollinators. The extermination of one would adversely affect the survival and/or propagation of the other. In other words, loss of pollinators should mean decline in the reproductive propagation of several cross-pollinated plant species including reduction in crop seed production. Conversely, conservation of several plant species and increase in seed production of cross-pollinated crops could be ensured by the conservation of natural pollinators and vice-versa.

During the past four decades, human population has increased more than two folds exerting a tremendous pressure on the natural resources and the land especially for food, fuel and timber. As a consequence, vast forests have been converted into agricultural land and mountains have become barren due to ruthless cuttings and grazing, thus extensively destroying the food and habitat of several pollinators species. Along with these, use of chemicals, too, have greatly wiped out the population of natural pollinators, thus resulting in failure of reproduction in several cross-pollinated plant species including the agricultural crops. This book on pollination biology addresses two basics questions. How the pollination can be utilized in the (1) conservation of plant species and (2) for crop seed/fruit production. The various aspects related to pollination, plant reproduction, pollinators behaviour, ecology and management and their safety are discussed to serve as guide to evolve future strategies for sustainable agriculture without disturbing the environment and the natural balance.

The land resources are being limited and increased agricultural production is to be obtained through intensive farming i.e. higher cropping intensity, better seed and greater use of fertilizers. New cropping patterns are likely to create new problems, new pests may appear or pests now considered minor may become major. In some crops, any amount of fertilizer, irrigation or pesticide use may not even yield a fraction of yield unless pollinated by bees. Honeybees play an important role in the pollination of large portion of the angiosperms of the world and maintain natural vegetation needed for survival of the ecosystems and the world as whole. The magnitude and direction of all manner of anthropogenic global environmental change have lately come to dominate the conversation at national/international levels and the debate is raging over the validity of various projections of consequences and diverse proposals for remediation. Of the multitude of ways humans could be harming the planet, however, one that has largely been ignored is the "pollinator crisis" – the perceived global decline in the number and viability of animal species that facilitate reproduction of flowering plants, the overwhelming majority of plants in terrestrial communities. In her hugely influential book *Silent Spring* published more than 50 years ago, Rachel Carson recognized the central role of pollinators. They are the proverbial birds and the bees, along with many other insect species and even a handful of mammals that maintain human health and terrestrial biodiversity. Carson painted a bleak picture of a world with "fruitless falls". In the intervening decades, reports have quietly accumulated from virtually every continent of shortages or extinction of pollinators of various descriptions. Ironically, despite its apparent lack of marquee appeal, pollinator decline is one form of global change that actually does have credible potential to alter the shape and structure of the terrestrial world. Over the past decade, the public has begun to take notice and ask whether a pollinator crisis is brewing and, if so, what can be done to avert it.

The book emphasizes conserving and culturing honey bees, non-Apis bees and pollinators other than bees. It also addresses the biology of pollination and managing bees for optimum crop pollination. Individual pollination requirements and recommendations for some of the most important crops are discussed. The book has a unique blend of basic and applied science to understand the pollination biology in a much wider context.

The writing of this book has been possible with the active help and support of a wide spectrum of people has helped in one way or the other. This book is outcome of my personal experiences and the contributions of several workers which have been incorporated. I express my humble and profound thank to all of them whose hard work has enabled me to compile the suitable information in a such a manner that it would be useful to those interested in basic and applied aspects of pollination biology. The illustrations and figures are either original or redrawn from other sources which have been cited individually in the figure legends. All the authors whose work has been used/refereed deserve special appreciation and heartiest acknowledgments.

I am particularly indebted to Professor Dr. Raghavendra Gadagkar, Centre for Ecological Sciences, Indian Institute of Sciences Bangalore for his help, guidance and encouragement. I also thank my university authorities for the excellent working atmosphere and needed encouragement for compiling such a voluminous book.

I am also extremely thankful to Springer who took great pains and keen interest in publication of this book in a very impressive way.

I am highly indebted to Professor Randall Hepburn, Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa who has been very kind to write the foreword of this book. I also thank Dr. Uma Shankar, Debjyoti Isha and Sandeep for their help and support. Last but not the least my sincere thanks are due to my wife Professor Dr. Asha Abrol, son Er. Rajat and daughter Er.Vitasta for their endurance and help during writing of this book.

Jammu Dharam P. Abrol

Contents