

Preface to the Second Edition

Since the publication of the first edition of our book on seeds in 1998, we have continued to learn about seed germination ecology, and new information has come from many sources. In an attempt to help fill a void in *Seeds* with respect to information on tropical montane species, we have studied about 50 species from Hawaii (USA). This work was made possible in large part thanks to the great efforts of Alvin Yoshinaga (Lyon Arboretum, University of Hawaii) who collected seeds of many species and helped us in many ways. Graduate students (Christopher Adams, Nalin Gama-Arachchige, Tracy Hawkins, Siti Nur Hidayati, Gehan Jayasuriya, Xiaojie Li, Xiaoxia Qu, Adriana Sautu and Jeffrey Walck) in our lab during the post-*Seeds* period have done detailed studies on germination of various species. It has been our privilege to host visitors in our lab from China, Spain and Taiwan and to collaborate with seed scientists in Australia, Belgium, China, England, Germany, India, Iran, Israel, Japan, Mexico, Spain, Sweden, Sri Lanka and Taiwan on studies on many interesting species. Also, we have visited seed scientists in Australia, China, England, Greece, India, Israel, Japan, Malaysia, Mexico, New Caledonia, Panama, Sweden, Sri Lanka and Taiwan. We have learned much from many people and appreciate all the help.

Since publication of *Seeds* in 1998, we have visited mainland China 11 times and established ongoing collaborative projects with Professor Dun-Yan Tan and Dr. Juan-Juan Lu at Xinjiang Agricultural University in Ürümqi, Xinjiang Province, on species of cold deserts. We also have greatly enjoyed working with and interacting with many people in China, including Professors Min Cao, Xishuangbanna Tropical Botanical Garden, Yunnan Province; Guo-Zhen Du, Lanzhou University, Gansu Province; Yan-Rong Wang, Lanzhou University, Gansu Province; and Zhen-Ying Huang, Chinese Academy of Science, Beijing, and their many talented students.

Another source of new information has been through email contacts with other people. From 2000 to 2005, we exchanged a number of emails with the late M. G. Nikolaeva and greatly enjoyed learning her opinions on small embryos in Martin's dwarf seeds and on our placement of her "mechanical dormancy" and her "chemical dormancy" under

physiological dormancy, with which she did agree. We exchanged books with her and still have the gift copy of her book titled *Reference Book on Dormant Seed Germination* (published in Russian in 1985). If you use Nikolaeva's formula system for seed dormancy classification, this book has a wealth of information about dormancy, especially for species from Russia and northern Europe. We also have benefited greatly from meetings of the International Seed Science Society (ISSS) and in particular the International Seed Ecology meetings, which were cosponsored by ISSS.

A major source of new information has been from the published literature on seeds. Thanks to increased use of the web and computers, it has become much easier to find new information about seeds, i.e., no more looking through massive hardbound volumes of *Biological Abstracts* because abstracts are available on-line via the library. Also, it is much easier to obtain copies (or pdf files) of papers than it was in the 1970s, 1980s and early 1990s when you ordered a reprint by writing the author a letter or postcard and waited up to many weeks for it to arrive. Further, being able to access a large number of journals from South America, in particular Brazil, and other parts of the world on the computer/web is a modern-day miracle. Also, it is now relatively easy to have a good understanding of the seed germination literature from China. Most papers being published in Chinese now have an English abstract, and tables and figures are in English. Furthermore, many studies done on seeds in China also are being published in English.

The result of all the new contacts and collaborations with other seed scientists and the increased easiness with which papers on seeds could be obtained led to a massive accumulation of literature in our lab. Finally, in autumn 2005 we decided that the time had come to sort, synthesize and then to greatly expand and in some cases rewrite large portions of *Seeds* in an effort to accommodate the new information. However, the goal for the second edition is the same as it was for the first edition: that is, we want to provide the reader with a comprehensive overview of the ecology, biogeography and evolution of seed dormancy and germination. Working on the revision of *Seeds* has been challenging but informative and

enjoyable, and we hope readers also will be eager to learn more about this remarkable stage in the life cycle of seed plants.

After the manuscript for a book has been submitted to the publisher, a huge amount of work must still be done, and our book would never have been completed without

the great efforts of Patricia Gonzalez, Melissa Read, Carol Lewis, Susan Stuart, Liz MacSween, Glynys Norquay and other Elsevier staff. We are grateful for their careful, patient and highly competent attention to the fine details and for their good cheer throughout the whole process.

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Introduction

Our involvement in seed germination began in spring 1966, when, as graduate students at Vanderbilt University in Nashville, Tennessee (USA), we took a course in plant autecology under Professor Elsie Quarterman. She came to class one day with a list of research projects and went around the room assigning one of them to every two students. We happened to be sitting next to each other, and thus were given the same project: germination studies on caryopses of the two summer annual grasses, *Sporobolus vaginiflorus* and *Aristida longespica*.

The plant autecology course gave us an awareness of the general ecological question: Why do plants grow where they do? Further, it was clear that a knowledge of seed dormancy and germination requirements could be an important part of the answer to this question. We were intrigued by studies on seeds of desert plants by F. W. Went in southwestern USA and by M. Evenari, D. Koller and others in Israel. Equally interesting were the results from studies by B. Quinlivan on legume seeds in Australia and those of D. Ratcliffe and of E. Newman on winter annuals in England. In all these studies, seed and environmental factors interacted to control the timing of germination in nature.

Our excitement about seeds was stimulated further by Dr. Lela V. Barton who came to Vanderbilt University for a visit. She patiently answered questions and told us fascinating things about seeds, such as the different dormancy-breaking/germination requirements of ray and disk achenes in some Asteraceae and double dormancy in seeds of *Trillium*. A tremendous stimulus to our interest in the different kinds of seed dormancy and how these are broken in nature was provided by the publication of the English translation of Dr. M. G. Nikolaeva's (1967) book *Physiology of Deep Dormancy in Seeds* in 1969.

Over the years, it has been our pleasure to study the seed germination ecology of numerous species. We have concentrated on herbaceous species but occasionally have investigated shrubs. These studies have included nonnative (weeds) and native geographically widespread, as well as narrowly restricted (endemic), species. Most seeds have come from eastern USA, and they have been collected from plants growing in arable fields, lawns, pastures, roadsides, forests, prairies, rock outcrops and mudflats and other

wetlands. However, some seeds have come from species of deserts (New Mexico and Arizona), mountains (Colorado and Utah) and semi-arid habitats (Texas and Utah) in western USA. To expand our knowledge of the field, we have made great efforts over the years to become familiar with, and collect copies of, the past and current literature on seed germination ecology.

In autumn 1989, we started writing a book on seed dormancy and germination from an ecological, biogeographical and evolutionary perspective. To our surprise, we discovered that many articles that had been published on these aspects of seed biology were not in our files; thus, much time has been devoted to obtaining copies of them. As we wrote this book, new papers were appearing in the literature almost continuously, and at times it has felt like we were on a fast-paced treadmill, i.e., new information was being published faster than it could be incorporated into the manuscript. However, the quantity and quality of new material being published on seed dormancy and germination is very exciting, and it testifies to the interest in this subject of scientists all over the world.

Work has been cited only if we have examined a copy of it. It should be made clear, however, that not every publication on seed germination ecology has been (could be) included in this book. Some omissions are due to our ignorance, and for that we apologize in advance to the authors and hope they will send us copies of (or references to) their work. Other studies may not have been mentioned because (1) they were very similar to representative ones already cited, or (2) the methods were not clearly stated and thus the meaning of the results was unclear. We would like to thank the librarians at the University of Kentucky for all their help in finding and/or obtaining copies of references. Special thanks are due to Bradley O. Grissom, Biology Librarian, and to various people in the Interlibrary Loan Department.

We hope that this book will (1) provide people who are just beginning to learn about seed germination a comprehensive overview of seed germination ecology, biogeography and evolution, and (2) give active researchers in the field a sense of what we know and do not know about these aspects of seed biology, and thus what research needs to be done on them in the future.