

Preface

The richness and diversity of biological systems in general, and ecological systems in particular, are a source for both inspiration and frustration among scientists. It is an inspiration to search for general principles and processes that underlie the complexity of ecological systems. Yet, frustration may develop, because at times that search seems to advance at such a slow pace. Both our research careers have largely focused on an area of ecological complexity that most ecologists have ignored or avoided: the implications of intraspecific size variation owing to ontogenetic development on population and community processes. Moving into this research area has undoubtedly been a major endeavor for us. The changes in size and morphology of individuals over ontogeny translate into changes in the type and intensity of interactions among them and thus increase the complexity of the interaction network that forms the backbone of an ecological system. Even among unicellular organisms like phytoplankton and bacteria, individual organisms undergo significant changes in size (growth over the cell cycle). Actually, we can think of no organism on earth in which the individual, be it a single cell or a multicellular organism, starts to reproduce directly after birth. Because of this total ubiquity of ontogenetic development among organisms, we considered it a fundamental and also unavoidable question for ecology as a discipline to investigate the effects that ontogenetic development may have on ecological processes.

The fact that inclusion of ontogenetic development in the study of population and community processes undoubtedly increases complexity made the search for generality a challenging task. Still, it relatively soon became clear to us that general patterns and principles regarding the dynamics of size-structured populations were present, despite the added complexities in both model and empirical developments and analyses. In particular, we found that the scaling of three basic individual ecological traits—search rate, maximum food intake, and metabolism—was a major determinant of consumer-resource dynamics. The population dynamics of size-structured consumer-resource systems turned out to be possible to understand (and predict) based on how the resource density necessary for maintenance (the critical resource density) scaled with body size.

The finding that a complex, fully size-structured model can be stringently reduced to a two-stage (juvenile-adult) model under equilibrium conditions represented a major theoretical breakthrough in our studies of the community dynamics of size/stage-structured communities. This substantially simpler two-stage model also turned out to preserve the major mechanisms by which ontogenetic development affects community dynamics. At a more fundamental level, this two-stage approach allowed us to transparently show how the balance of two rates—population maturation and population reproduction—determines how ontogenetic variation affects both population and community dynamics. Furthermore, it made clear to us exactly how limited the set of conditions is that unstructured ecological theory applies to. This set of conditions forms only a borderline case, in which mass-specific rates of new biomass production through somatic growth and reproduction and biomass loss through mortality are independent of the individual's body mass. It separates two broad domains of conditions, in which either juveniles or adults are energetically superior. We had already in previous papers advocated that unstructured ecological theory represents a special case of a more general and richer theory. Still, it was only during the course of writing this book that we have started to grasp the full implications of this idea for the discipline of ecology as a whole.

Our research on size-structured interactions has naturally not occurred in isolation. For the development of the mathematical framework of physiologically structured population models, which we use in our analysis, we owe a lot to the work of Odo Diekmann, Mats Gyllenberg, and Hans Metz. Odo Diekmann and Hans Metz are the main architects of this framework and in addition inspired and supervised one of us (A.M.dR.) during the early stages of his career. Without the tools and techniques they developed (albeit only in theory), this book could not have been written. Discussions and collaboration with Mats Gyllenberg on the first discrete-continuous consumer-resource model were quite important in taking our work on consumer-resource dynamics further. A major source of inspiration for us has always been the pioneering conceptual and experimental work by Earl Werner and his students on the dynamics of size-structured communities. For many years, one of us (A.M.dR.) was deeply involved in a research collaboration with Bill Gurney, Ed McCauley, Bill Murdoch, and Roger Nisbet on consumer-resource dynamics, particularly targeted at the dynamics of the water flea *Daphnia pulex*. To understand and quantitatively predict the dynamics of this model organism turned out to be much tougher than anticipated, but the endeavor itself was hugely inspiring and a great deal was learned from it, both theoretically and experimentally. Among many other scientists involved in our work, we want to thank especially Kjell Leonardsson and Gary Mittelbach.

Most important have been the stimulating interactions with PhD students and postdocs in everyday discussions and at the frequent workshops that we have organized over the years from the area of Abisko, in northern Sweden, to the North Sea coast of the Netherlands (for some reason we never considered places south of the Netherlands). The work carried out by PhD students and postdocs also constitutes a major contribution to the development of the research field of size-structured dynamics. Our thanks go to Jens Andersson, David Boukal, Pär Byström, Bent Christensen, David Claessen, Vincent Hin, Joakim Hjelm, Magnus Huss, Sido Mylius, Karin Nilsson, Tim Schellekens, Arne Schröder, Karen van de Wolfshaar, Tobias van Kooten, and Anieke van Leeuwen.

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A substantial part of the work of finalizing the different chapters of this book was carried out in the countryside at Kussjön in the inlands of Västerbotten, Sweden. Kussjön has for many years served as a retreat for writing papers and for numerous discussions on both scientific as well as nonscientific topics. Many ideas ultimately originated during long walks in the silent setting of this beautiful place. Last but not least, A.M.d.R. wants to thank Mirjam for the years of love and family life with their three wonderful sons, Joshua, Daniel, and Kristian, and thanks Liliana for the love during the last years, in which this monograph was written. Similarly, L.P. wants to thank Ingrid for many years of love and for many discussions on the philosophy and theory of science in general.