Preface

This book is dedicated to the understanding of small mammals, of their fascinating adaptations that enhance survival in many different environments. I have written this book to appeal to a broad readership, including nature lovers, wildlife professionals, and students of science. I have attempted to elucidate the great diversity of morphological, physiological, and behavioral adaptations that enable small mammals to cope with the many selection pressures present in their environments. While I discuss a broad range of small mammals, from shrews to carnivores, this book is by no means comprehensive. Rather, I highlight those species and adaptations I personally have found most interesting and enjoyable to learn, teach, and write about.

Adaptations are indicative of how animals make a living and are crucial in tailoring an individual for survival and enhancing its ability to reproduce. The diversity of adaptations exhibited in small mammals is tremendous and spans taxonomic borders. Adaptations range from the brown adipose tissue of masked shrews, used as a crucial heat-producing source in the cold, to the sanguinivorous (blood-eating) and piscivorous (fish-eating) behavior exhibited by vampire bats and bulldog bats, the bizarre acrobatic maneuvers of eastern spotted skunks, and monogamy and housekeeping in sengis.

Formalized by Charles Darwin in 1859, the term **adaptation** is a central concept in biology and has attracted a great deal of controversy. A discussion of this controversy is well beyond the scope of this book. I refer the interested reader to the thorough accounts of the history and meaning of "adaptation" provided by R. W. Hill and Wyse (1989) and Willmer, Stone, and Johnston (2000). I use the term here to describe any anatomical, physiological, or behavioral trait or character (or suite of characters) that results from natural selection and enhances the survivorship and reproductive ca-

pacity of a given species in its natural environment. I focus on delineating survival mechanisms with an emphasis on form and function and the adaptive significance of unique characters; however, it is noteworthy that some species show fascinating morphologies with no adaptive purpose that we know of.

I begin by answering the question, what is a small mammal? The majority of extant species of mammals are indeed small, measuring less than a meter and ranging in size from the diminutive Kitti's hog-nosed bat and Etruscan shrew, weighing less than 2 g (0.07 oz), to the familiar woodchuck weighing in at about 5 kg (11 lb)—this is where I draw the line. In Chapter 1, I trace the history of the definition of "small mammal" and discuss the advantages and disadvantages of being small. I then endeavor to define the protagonists: the small mammals. This is a formidable task and one that is subject to many interpretations and disagreements—all debated with good humor. To set the stage for the book, I present an overview of the cast of characters organized by order. I have organized the volume into three parts: Modes of Feeding, Environmental Adaptations, and Reproduction. Some species are given a bit more attention than others, and I highlight some such groups in Case Studies. My unequal allocation of attention among groups is simply due to my curiosity and interest in particular species, as well as my hope that the reader will share in this fascination.

Chapters 2 through 5 are dedicated to a discussion of modes of feeding. I review the great variation in feeding designs of small mammals, including insectivory, herbivory, carnivory, and omnivory. Foraging techniques reflect dietary opportunities and, as one would expect, these chapters have many players, and there are, of course, many more than can be included here. I hope I have covered most of the foraging strategies but realize that I have only scratched the surface in terms of practitioners. As case studies, I include (in Chapter 3) the fascinating "rock badgers" of Africa with their bizarre elastic foot pads and a one-of-a-kind digestive system and (in Chapter 5) brief discussions of dietary nonconformists such as the insect-eating bat-eared foxes and the most carnivorous North American mouse, the grasshopper mouse. And (also in chapter 5) I could not forget to discuss the hero shrew, or armored shrew, of Africa, that mysterious insectivore with its bizarre, fortified backbone for which we have difficulty ascribing any functional significance. I also take time to discuss the different foraging strategies of some of the familiar and not-so-familiar species of bats.

In Chapters 6 through 10, I discuss environmental adaptations, speci-

fically the many physiological, morphological, and behavioral mechanisms adaptive in coping with the rigors of cold and hot environments. I survey the diverse mechanisms that small mammals employ to avoid and resist cold and heat and aridity. Avoidance techniques include the long, thinly furred ears of African fennecs, huddling thermogenesis in muskrats, and torpidity in Etruscan shrews. Resistance strategies include the role of brown adipose tissue in shrews, bats, and voles. In the case studies (Chapter 10), I discuss how some small mammals, such as the secretive southern flying squirrels, are especially adept at using group nesting for conserving heat in winter, and how hedgehogs employ hibernation to cope with the cold.

In Chapters 11 and 12, I discuss the reproductive patterns of small mammals, ranging from delayed development in New World fruit bats and delayed implantation in weasels to embryonic diapause in the smallest gliding mammals, the feather-tailed gliders of Australia. I also discuss the adaptive significance of the fastidious road maintenance and mate guarding of the monogamous African sengis, the absentee maternal care of treeshrews, the role of lek behavior in those "flying loudspeakers," the hammer-headed fruit bats of Africa, and the natural history of the only eusocial mammal, the African mole-rat. A fitting conclusion to this discussion of reproduction, and to the book, is Chapter 13, dedicated to a discussion (albeit far too brief) of the long-term research on the population cycles of lemmings and snowshoe hares.

As I mentioned earlier, I have written this book to appeal to a broad readership, including amateur naturalists, students of science, and wildlife professionals. I use scientific vocabulary throughout the book. Technical terms are shown in boldface type when they are first introduced in a chapter, and those terms are defined in the text and in the glossary. I provide up-to-date, as well as some historically interesting, reference sources throughout the chapters. General information on mammalian ordinal characteristics is derived from Feldhamer et al.'s *Mammalogy: Adaptation, Diversity, Ecology* (2007). The reader is referred to that volume for a more detailed description of taxa and characteristics of mammals. To further assist the reader in understanding the lives of small mammals and tracking mammalogy in general, the appendix includes a list of useful web sites.