Preface

The present volume results from a Zoological Society of London symposium on 'miniature vertebrates: the implications of small size', held on 11 and 12 November 1994. It is probably the first book to be dedicated to the biology of small body size across the entire vertebrate spectrum from fishes to mammals, with problems and advantages being considered from the major aspects of functional allometry and ecological role in the natural world.

The size of objects in relation to our own physique is a primary factor in human perception and assessment of our surroundings. Depending on their dimensions, other vertebrates may prompt in our subconscious one of three possible responses: feeding, associating, or fleeing. Human interest in the vertebrates considered in the present volume might derive essentially from the first of these instincts. With *Homo sapiens* essentially a strolling omnivorous primate, gathering small food items, perhaps it is not surprising that most of the vertebrates regarded as small for the present academic survey also fall into the category of having a girth less than the diameter of the average human mouth and a mass no greater than that of a typical brown rat. However, given this as a practical guide, inclusion as a miniature vertebrate can also follow a more flexible definition of miniature as 'representation on a small scale', in either absolute or relative terms. The recognition of finer size categories within the overall situation of being small and the possibility of defining 'miniature' on the basis of radical genomic, developmental or ecological shifts are ongoing lines of research. Some of the conventional vertebrate classes such as the amphibians, reptiles, and birds (with notable extant exceptions like crocodiles and ostriches) comprise species which are virtually all small by the present concept. Within these classes, attention in the symposium has tended to concentrate on the very smallest forms. In fish and mammals, discussion has included relatively small representatives but not exclusively the tiniest; in these groups, despite many familiar large representatives, the majority of species are also appreciably smaller than humans.

Our biological knowledge of vertebrates at the lower end of the size range is inevitably polarized into a great deal for some species and very little, at best, for the majority. A limited number of small vertebrates, such as the house mouse and the three-spined stickleback, have been intensively investigated, because their physiological resilience and small size permit the maintenance of large numbers under laboratory conditions and often a rapid succession of generations gives the opportunity to follow genetic change. Abundant and accessible populations of other species in the wild have also yielded much information. However, many other small vertebrates are more difficult to find and investigate, especially in contrast to popular larger species, simply because a small size lends itself to concealment or precise habitat requirements are difficult to reproduce under

experimentation. For such species, for example caecilian amphibians, most information is limited to systematics and morphology.

Scientific study of the phenomenon of being small (miniaturism) and the evolutionary processes (miniaturization) behind this condition can be seen to address two main topics. These are essentially functional and ecological: the implications of small size for fitness—physical or Darwinian—with respect to functional limitations and ecological opportunity. The very smallest species raise intriguing questions of how the basic complexity of a vertebrate body can operate and have evolutionary success within a framework less than that of the largest beetle.

For the physiology of scaling effects on small vertebrate function, the symposium provides an overview of potential constraints, followed by more detailed discussion of interface problems in water, competence in cephalization, and, for homeotherms, the functional complications of seasonality on land, taking to the air and locating an aerial food resource in the dark. The topics of function and ecological interaction are linked by the developmental genetics of size reduction and the role of size in species diversification which concluded the first day of the symposium.

Scaling down has permitted great extension of the limits of adaptive radiation among the vertebrates, opening up new resources in what becomes a vastly expanded world. Whatever functional burdens may be identified, above limiting sizes within the classes, small vertebrates can achieve impressive ecological success in terms of abundance and exploitation of specialized ecological niches only available for the tiny – scuttling over sea fans, living in a termite colony, hunting spiders under the snow, or rearing their young in bromeliad reservoirs.

In the second part of the symposium, discussion of the ecology of small vertebrates is taken further with a consideration of whether functional allometries might be expected to exert a strong influence on the temporal pattern of energy expenditure over life in an ecosystem, but a survey of life-history features in mammals shows a range in adaptive response little constrained by size. Other contributions deal with the occurrence and ecology of small species within the teleost fishes, the amphibians, and the reptilian sauropsids, culminating in the hummingbirds, exemplifying a radiation in adaptation and co-evolution linked with small body size. Apart from the many species which are small in absolute terms, size reduction in phylogeny has occurred in a number of situations to produce forms which are relatively dwarfed by comparison to ancestral stock. This phenomenon is discussed here in the context of 'miniature' deer, elephants, and mammoths.

Small vertebrates interact with mankind in a number of ways, usually complex and economically advantageous or deleterious. The tropical fish trade may be compared with the depredations of rats and mice. Another relationship is an emotional one and the psychology of associations with small vertebrates for the pleasure of companionship, rather than intellectual satisfaction, is a suitable conclusion to the present volume.

Big game and large objects attract more human attention than the small, but diminutive size obviously has selective advantage in a variety of natural situations.

Other than in global catastrophe, the expanded world of small vertebrates offers many more niches for survival and evolutionary persistence than those in which African elephants or Indian tigers might find comparable security. After all, miniature mammals came through when Cretaceous giants failed.

Finally, my thanks go to all contributors and participants in the symposium and to the Zoological Society of London, for supporting this review of miniature vertebrates. In particular, I must thank Ms Unity McDonnell for all her organizational and editorial work.

Bristol P. J. M.
September 1995