# Book Reviews

## Planktonic Dynamics

**Evolution and Ecology of Zooplankton Communities.** Papers from a symposium, Hanover, N.H., Aug. 1978. W. CHARLES KERFOOT, Ed. University Press of New England, Hanover, N.H., 1980. xxiv, 794 pp., illus. $45. Special Symposium Volume 3, American Society of Limnology and Oceanography.

Because of their moderately small size most zooplankton live in a paradoxical world; their food items occur in a viscous environment, but their predators, especially fish, live in a turbulent one. To feed and grow, herbivorous zooplankton must contend with the honey-like viscosity of water, but to survive they must evade predation, which is usually based at far greater sizes. In this strange (from a human-centered viewpoint) world lives a variety of small invertebrates, including cladocerans, water mites, copepods, rotifers, and insects (many more taxa occur in the sea), that are the subject of this large and varied book, containing 66 papers by 91 authors.

Bringing some kind of organizational sense out of a mass of experimental results liberally seeded with speculative ideas has been a major test for the editor. The papers are grouped into ten sections of uneven length; intellectually they fall into fewer categories, which I will consider in more detail later. Section 1 contains papers dealing with the viscous environment, the behavior of animals in response to mates or light, and the strategies employed in finding food. Vertical migration, a subject that has preoccupied zooplankton specialists for decades, is considered next in nine papers aimed mainly at examining the adaptive significance of this enigmatic pattern of behavior. A short third section deals with the biology of rotifers, particularly feeding and population dynamics. Section 4 brings together a variety of new or newly reviewed observations on filter-feeding, also the mechanics of feeding by processes less easy to characterize. This is followed by a varied group of seven papers dealing mostly with cladocerans; the subjects include nutrient release, the shapes of feeding curves, effects of food quality (toxic chemicals, spines, gelatinous sheaths), and the control of algal species composition by grazers.

Ten papers have been grouped under the heading Genetics, Demographics, and Life Histories of Zooplankton. Of these, two deal specifically with the genetics of rotifers and cladocerans and the rest with reproductive strategies (including diapause), the evolution of life histories, estimation of life-history parameters, and the effect of age-specific predation on estimates of population growth. They are followed in section 7 by five papers discussing cyclomorphosis, especially its definition, cellular control, the effects of food and predators, ecological genetics, and graphical representation.

A long section (a further ten papers) contains reports on varied approaches to predation by and on zooplankton. The nature of the prey—its size, texture, shape, and kind of motion—affects its susceptibility to predators; thus predation (whether by rotifers, carnivorous copepods, insect larvae, or fish) can control the species composition and ecological structure of the zooplankton community, sometimes in the "keystone predator" style that has been described for communities in the intertidal of rocky shores.

Section 9 is devoted to community structure from a descriptive viewpoint and to the biogeography of zooplankton communities. Predators are invoked again, both on small and major geographic scales, to account for the vertical and horizontal distribution of prey species. One paper contains the intriguing idea that zooplankton size structure on both local and larger scales is the outcome of predation (or its absence) and, more subtly, of the trophic status of the lake, which governs transfer efficiencies throughout the community. Another shows that the theory of island biogeography applies to phytoplankton in Ecuadorian lakes (including some of the Galápagos Islands) but that there is a "paradox of the zooplankton," namely that fewer species of zooplankton are found than would be expected on the basis of lake size and the complexity of the phytoplankton. This should bring a bemused response from many ecologists who, like me, were raised on G. E. Hutchinson's paradox of the plankton, the problem that many co-occurring species of phytoplankton are found in seemingly structureless environments, or those who realize the importance of environmental size spectra in governing species diversity.

In the short concluding section two papers discuss experimental work on community structure. A further two papers examine some implications of body size. One, using marine copepods as examples, shows that there are large species-specific differences in filtration rate, ingestion rate, speed of development, and growth rate that are not predictable from body size alone. This conclusion is a slightly sour aperitif to the 66th contribution, a theoretical one, describing energy flow through pelagic communities in terms of a "master equation" governed mainly by body size and the rough equivalence of volumes within discrete ranges across a broad spectrum of plant and animal sizes.

Because this book is long and complex I have not tried to give the full flavor of the facts, speculations, and controversies it includes. Part of the flavor can be obtained by examining the program of the meeting it stems from, which is included as an appendix. The participants appear to have eaten and slept as an afterthought; the program was crowded with papers, demonstrations, movies, and, I suspect, protracted debate in every corner. Vitality bursts forth from the program and from the book that has resulted from it. Zooplankton research is in a healthy state, burgeoning, incorporating new techniques, absorbing useful approaches from genetics, functional morphology, population biology, and fluid mechanics. But some highly conservative elements are also evident in this volume. This is clearest in the papers that deal with vertical migration and with predator-prey relations. Let me consider vertical migration first. In 1963 I. A. McLaren presented the hypothesis that vertical migration conferred metabolic advantage if a migratory crustacean fed near the surface and then grew at depth at a lower temperature. Metabolic advantage was then converted to demographic advantage because of direct relationships between the size of crustaceans and their fecundity. Later (1974), finding this model too complex and misleading, McLaren replaced it with a purely demographic formulation based on laboratory experiments relating realized fecundity to growth and vertical migration. It is evident from reading the papers on vertical migration in *Evolution*

*and Ecology of Zooplankton Communities* that the old metabolic model lives on, like Mr. Hyde transcending his creator's hopes and expectations. Despite this, very little new is contributed to solving the problems of vertical migration. Yes, vertical migration is consistent with metabolic advantage—also with escape from predators, with maximum exploitation of phytoplankton growth, and with maximum reproductive output. But the difficulty of testing each relationship, so that we are left with one general, unifying unfalsifiable hypothesis, is very great. Such a chimera-like problem suffers from too much truth and frustrating ungraspability. This results in recourse to probabilistic "best guess" verification, as is evident in this book. I am interested in the remarkable paradigmatic quality of McLaren's first paper, which is still generating more research and rhetoric than the one intended to replace it, the more intellectually demanding paper on demography.

The other major paradigm (dare I repeat Kuhnian terminology?) dominating this book is the Brooks-Dodson hypothesis of 1965. Their claim that the size structure of zooplankton communities is the result of fish selecting large prey or that it results from competition for food among grazing zooplankton when large predators are absent has also had a remarkably stimulating effect on research. This volume summarizes well, albeit in piecemeal fashion, the complexities of competition and size-selective predation in freshwater plankton communities, showing, in particular, the intricacies of predation by invertebrates and prey responses to them, factors not included in the original model. By contrast, work on vertical migration has bogged down in hazy ideas and apparently untestable hypotheses.

The problem of filter-feeding is also a major presence in this volume. For years we assumed, on the basis of a few observations, that grazing zooplankton fed mechanically by pumping water through a screen of fixed size that could be combed by limbs passing food to the mouth. A great deal of experimental work in the 1960's and 1970's enabled feeding rates to be quantified, on the hypothesis that water was pumped mechanically through a filter and that the structural properties of the filter could account for the sizes of the particles captured, in particular the fact that zooplankters appeared to "select" particles of slightly larger than average size. Recently we have seen that copepods show highly varied feeding responses based on the abundance, size, texture, and chemical composition of their food particles. It seems likely that copepods detect particles before direct contact is made, that some particles may be rejected once captured, and that the panoply of feeding responses is mediated by chemo- and mechanoreceptors all over the anterior part of the body. As the five papers in this volume indicate directly or through references to recent work, if the idea of passive filter-feeding is not dead, reports of its demise are not greatly exaggerated.

*Evolution and Ecology of Zooplankton Communities* is a valuable contribution to the literature of aquatic biology. Though it slights the marine environment, good problems in ecology are not directly related to salinity. This book reviews large amounts of earlier literature, presents new data and experimental work, and makes available in one sourcebook many advances in plankton research. In general the contributions are well written and well illustrated. The editing is excellent. I spotted no more than a dozen very small typographical errors, surely a proud accomplishment in so long a book. Its general format is that of *Limnology and Oceanography*, but because speculation, controversy, and theory have been the heart of the symposium the outcome is far more vivid and interesting than the average contents of that austere journal. Those exciting little aquatic animals living at low Reynolds numbers deserve no less.

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## Atmospheric Phenomena

**Ball Lightning and Bead Lightning.** Extreme Forms of Atmospheric Electricity. JAMES DALE BARRY. Plenum, New York, 1980. x, 298 pp., illus. $29.50.

This most recent addition to the literature on lightning reviews the known physical aspects of two unusual forms of atmospheric luminous phenomena. Through an analysis of the available literature, Barry summarizes the characteristics of ball and bead lightning and encourages the reader to improve his or her understanding of these phenomena. The book includes a large collection of photographs of bead and ball lightning.

Although we are assured at the outset that "lightning terms such as stroke, stepped leaders, dart leaders, and ionization channels will be used in subsequent chapters," Barry does not always follow this rule. Instead he introduces new terms such as secondary discharge, main discharge, and discharge velocity (p. 119), dart stroke (p. 122), and flashless discharges (p. 196). The continuity of his discussion would have been enhanced if he had followed the definitions he presents in the introductory chapter and used standard scientific terminology.

Bead and ball lightning are not treated equally in the book. Only chapter 2, 17 pages long, deals with bead lightning; the remainder of the book covers ball lightning—its characteristics, photographic evidence of it, skepticism concerning it, and its simulation in the laboratory. The short treatment of bead lightning is justified, however. I have seen bead lightning every three or four years during a series of summer thunderstorm studies that now span 20 years. In addition, my colleagues have photographed bead lightning several times, and reliable theories explaining the observed phenomenon have been published in the reviewed literature. Barry suggests correctly in the preface to the book that bead lightning is apparently an accepted scientific fact. Ball lightning is another matter and deserves the attention he devotes to it.

The characteristics of ball lightning are presented in an interesting way—by analyzing 13 cases reported in the literature. One result of this analysis is table 4.1, which is a compilation of the data available on the energy density of ball lightning. It is a useful table for comparisons. I had not realized, for example, that the energy estimates range over ten orders of magnitude with a mean roughly centered on 1 joule per cubic centimeter. Barry concludes that ball lightning is a "single form" having the possibility of either silent or explosive decay.

Several other tables will be useful to researchers of ball lightning. Table 5.1 contains references to all discussions of ball lightning that include photographs, and tables 6.2 and 6.3 contain references to photographs of what has been thought to be natural ball lightning and photographs of artificially produced ball lightning. The latter resulted from laboratory studies, some by Barry, that demonstrated the formation of a luminous ball in an enriched mixture of hydrocarbons. We are led to the reasonable conclusion that a hydrocarbon gas oxidation mechanism could be responsible for one type of ball lightning.

The possibility of obtaining a photograph of ball lightning is an intriguing one, attracting wide interest among researchers. Barry presents approximately 24 "ball lightning photographs" and labels most of them false. Three photo-