BOOK REVIEWS

A fluid dynamicist and a biologist were asked, separately, to review the following book.—ED.

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ALEYEV, Yu. G. 1977. **Nekton.** Dr. W. Junk, The Hague. vi + 435 p. f.120.

As briefly explained on the coverjacket of the book, "The word 'nekton' (derived from the Greek word for 'swimming') is used to describe all swimming animals that are able to go where they wish, contrary to planktonic animals that cannot resist a strong current and, therefore, are moved by this current." Thus the distinction between plankton and nekton depends on current velocity and swimming speed of the animal, and is resolved by the author on a biohydromechanical basis in terms of the slenderness ratio of the body shape and the characteristic Reynolds number of swimming motion. This definition is further clarifed in the Introduction and Part 1, where the history of nektonology is also given. Within the refined classification, ranging from euplankton to eunekton through several variations in ecomorphological types of aquatic animals, the main scope of interest seems to be focused on the biohydromechanics of different species of fishes and cetaceans, although swimming of squid by hydrojet, flapping and paddling propulsion of waterfowl and mammals such as seals in submersion, flight of airborne flying fish, and even tactile locomotion on solid surfaces are also treated.

Studies of the general subject are currently being undertaken in many institutions, along various directions, to emerge as an active multidisciplinary endeavor. Thus, all factors involved in aquatic locomotion are examined, including metabolic rate and the underlying biochemical processes, respiration, cardiovascular function, musculature, skeletal strength, physiology, thermoregulation, and hydrodynamics and energetics. Of these wide-ranging areas this book elects to concentrate on two tasks, one being the development and adaptation of nekton analyzed from the points of view of both ontogeny and phylogeny, the other being hydrobionic studies associated with nekton with a functional morphological analysis, while the well known zoological material is curtailed as much as possible.

Chapters I and II give a detailed classification of nekton and its geographic range and distribution. Part 2 of the book, consisting of six chapters, III to VIII, is addressed to the major interest in "Fundamental nektonic adaptations." Chapter III discusses the primary problem of equilibrium between buoyancy and hydrodynamic forces that can be maintained by various means, ranging from the hydrostatic control by air sac, gas bladder, and body fat in nektonic animals to the use of extended pectoral fins and (dorsoventrally) asymmetric undulations of an asymmetric caudal fin for generating lift forces. Extensive data collected from a large number of species are presented in terms of certain characteristic parameters. Chapter IV is devoted to the main problem of generation of propulsive force in nektonic animals using aquatic, aerial, and tactile propulsors. The ecomorphological study is developed using several basic parameters which are adapted as necessary for characterizing the undulatory swimming movement. These parameters seem to be largely devised by the author and, while they can serve to explain the qualitative features of various observed results, they could be more refined in the course of further studies. For instance, the index C_n of the distribution of undulatory propulsive forces, as given by Eq. 21, is overly simplified; it can be improved by taking advantage of the recent advances in hydromechanics theory which accounts for not only the reactive forces due to the virtual masses of the surrounding fluid but also the effects of vortex sheets shed from various appended fins (some references to be cited later). A few of the quantities are not precisely specified. For instance, it is not clear if the total energy expended by the organism given in Eq. 9 is meant to be referred to the metabolic level or the mechanical level, as their distinction will require a thorough exposition of the muscle efficiency, which is lacking here. In spite of these drawbacks, the abundant data will be of value to those interested in pursuing new studies on related problems. It may be found, for example, that the observation on the caudal fin flow contains interesting information and new ideas to allow further exploration. The quite unusual feature that in tunas the body core temperature may be considerably higher than that of the ambient water (p. 114) is of interest since the underlying thermoregulatory mechanism for transporting excessive heat may have a hydrodynamic importance. This contention coincides with some current work being carried out elsewhere.

From the hydromechanical and physiological standpoint, Chapter V on "Reducing resistance to movement" is perhaps the most interesting treatment in this book. It follows a balanced approach to deal with the three principal components of the total resistance, namely the form drag, frictional drag, and induced drag, as well as the tradeoffs arising when only one or two of them are overly reduced. It also points out possible pitfalls of drawing conclusions based on data obtained under experimental conditions that do not approach the natural ones. The point is well made (p. 210) that a crucial feature of the flow over nektonic animals is its unsteadiness. This significant point is not further elaborated, however, aside from a brief discussion on comparison of the thickness of the boundary layers on the leading and trailing sides of a laterally moving body segment. It is quite obvious that our knowledge about this particular aspect is still very weak. On several occasions the author gives readers the impression that a thickening of the turbulent

boundary layer would result in a lower tangential stress of friction—a concept which is at variance with known hydrodynamic results. A correct argument is immediately reached upon noting the significance of the eddy-viscosity coefficient. Further, a thickening of the boundary layer is generally associated with an increase in form drag. These misinterpretations notwithstanding, this chapter is still dotted with some sparkling ideas. The discussions of the microstructure and hydrodynamic functions of fish scales are very illuminating. The many flow-visualization pictures presented here can serve well to provide valuable information for future investigators. The book proceeds on with discussions of maneuvering, camouflage, other adaptations, and ecological divergence of nekton in subsequent chapters.

In summary, this book draws on the contributions from an extensive Russian literature and introduces many fresh new ideas to be tested. It may be said that the best approach to this multidisciplinary subject is by collaborative effort from all the disciplines involved. In the areas covered, the book offers many original thoughts and evaluations in its own right and expertise, and in this respect it will serve as a useful reference source. Readers interested in other aspects not covered may benefit from reading several recent publications such as *Swimming and flying in nature* (2 vol., T. Y. Wu et al., eds., 1975: Plenum), *Mathematical biofluiddynamics* (J. Lighthill, 1975: SIAM), *Hydrodynamics and energetics of fish propulsion* (P. W. Webb, 1975: Bull. 190, Dep. Environ., Ottawa), *Scale effects in animal locomotions* (T. J. Pedley, ed., 1977: Academic), and *Bewegungs-physiologie-Biomechanik* (W. Nachtigall, eds., 1977: Fischer).

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ALEYEV, Yu. G. 1977. **Nekton.** Dr. W. Junk, The Hague. vi + 435 p. f.120.

The table of contents of this attractively presented English translation from the Russian suggests exciting reading for the oceanic biologist. Nekton are to be treated systematically, functionally, ecologically, and evolutionarily. However a closer look reveals that treatment is uneven. Of 373 pages of text, 227 deal with the biohydromechanics of swimming. For the nonspecialist in the fluid dynamics of swimming, this extensive section is nevertheless interesting, filled with richness of example and synthesis of literature. Each section begins with a simple verbal description of the problem to be discussed. This is followed with examples illustrated with high-quality photographs, diagrams, drawings, and figures, then with a series of references to particular nektonic species that exemplify the point under consideration. Finally the results of the comparative analysis are tabulated, sequentially ranking many different species according to given factors. The extensive use of comparative information is impressive and reflects a bibliography of over 1,000 references that leans heavily on the Russian but that also cites extensively the contributions of western investigators. This, coupled with the clear hydrodynamic descriptions and beautiful illustrations of the mechanical action of adaptations associated with rapid swimming, makes *Nekton* a most useful addition to the personal library.

Each chapter is cleanly presented, easy to read, and carefully documented, but some sections were more fun than others for me. For example, in the section on boundary-layer laminarization, a spectrum of skin adaptations to control boundary-layer flow by damping turbulent pulsations is discussed. The subject is illustrated with high quality photos and a series of experiments on nektonic porpoises and nekkid leddies (ages 17–30) that indicate visually the beauty and excitement of experimentation. Aleyev evaluates these experiments against other observations in the literature and concludes that flabby folds of flesh are really not a useful adaptation for rapid forward movement through a viscous medium. Each chapter, therefore, has a nice admixture of patterns of presentation, diversity of data, and probing experiments.

Although the book is really about how fishes swim, Aleyev is also deeply concerned with the concept of "nekton." E. Haeckel in 1890 derived the term from a Greek word for swimming. Aleyev (p. 1) explains that Haeckel's nekton were ". . . 'free to choose their path', i.e. can resist a strong current of water and, distinct from planktonic animals, go where they wish." But Haeckel's definition (p. 1) ". . . no longer provides a sufficient basis for ecological and functional morphological investigations, since it affords no possibility of quantitatively assessing either the boundary between plankton and nekton or that between nekton and other ecomorphological types of biont." Aleyev points out the difficulty of sorting pelagic animals into these categories (p. 1):

> Parin (1968) believes that in the epipelagic zone of the ocean the minimum size of nektonic fishes with a well-developed capacity for active swimming may be between 15 and 30 cm, as fishes shorter than 15 cm are unable to counter oceanic currents. Meanwhile young *Leucaspius* (*Leucaspius delineatus*) only 1.5 cm long, observed by this writer in ponds near Moscow proved capable of active horizontal migrations across the entire body of water . . . .

Aleyev himself distinguishes between plankton and nekton by (p. 1) "the capacity of pelagic animals for active forward movement" and asserts that biohydromechanics and Reynolds number are the tools required to make the distinction. But Aleyev's definiton of "nekton" generates the two quite serious weaknesses of this book: inadequate appreciation of the biology of animals, and an almost total disregard of normal ecological interactions.