



# Physiological adaptations of animals in the aquatic environment

By Čedomil Lucu

(*Fiziologija prilagodbe životinja u vodenom okolišu*, in Croatian),

Profil International, 2012; 244 pages, 10 chapters and 107 illustrations

## Tvrtko Smital

Ruđer Bošković Institute  
Division for Marine and Environmental Research  
Zagreb, Croatia  
E-mail: [smital@irb.hr](mailto:smital@irb.hr)

Comprehensive books focused on numerous aspects of animal physiology are relatively rare and have always been in high demand for students from natural sciences and related fields all over the world. This is by no means surprising, however. First and foremost, it is an exceptionally complex and voluminous topic that requires different approach and is far more challenging than related titles in e.g., human physiology. Life in all complexity, from the simplest to the most complex forms, evolved with number of different adaptive solutions to survive in the fluctuating environmental conditions. Therefore, a truly impressive knowledge and experience is needed for a comprehensive and scientifically reliable textbook presentation of the complex world of physiological adaptations of animals. As a consequence, the number of authors who took that challenge is relatively small, and number of those who actually succeeded is even scarcer. Most importantly, however, textbook titles that offer this type of comparative and integrative knowledge on animal physiology are important for most naturalists, absolutely necessary for biologists, and often highly useful for scholars and researchers in the fields of e.g., veterinary science, aquaculture or fisheries. As was well pointed by **Knut Schmidt-Nielsen**, author of probably the most popular book on the subject (*Animal Physiology: Adaptation and Environment*; 5<sup>th</sup> edition, Cambridge University Press, 1997):

“This book is about animals and how they function in their world. First of all it is about problems and their solutions. There is no way to be a good physiologist, or a good biologist for that matter, without understanding how living organisms function in their environment.”

That is the main reason why the book *Physiological adaptations of animals to aquatic environment*, written by **Čedomil Lucu**, truly represents an important title for Croatian students, scholars and researchers from different disciplines, offering a concise and contemporary overview of truly amazing range of physiological adaptations of various animal taxa in aquatic environments. Saying this it has to be pointed out that this book is not composed or written as a substitute for the much more comprehensive textbooks which are offer expensive and very difficult to acquire for Croatian students. Apart from the title mentioned above, some of the most popular titles on the subject that should be high-

lighted include e.g., *Comparative Animal Biochemistry* by **Klaus Urich** (Springer Verlag, 2010), or *Comparative Animal Physiology, part 2 - Environmental and Metabolic Animal Physiology*, by **Clifford Ladd Prosser** (Ed.) (J Wiley & Sons, 1991), covering, apart from the aquatic environment, also physiology of animals living in terrestrial environments.

Furthermore, in spite of the well recognized significance of environmental animal physiology in the teaching programmes and courses at the most prestigious world universities, the topic is highly underrepresented at Croatian universities. Therefore, this first textbook on environmental physiology written in Croatian, can be of great help and encouragement to undergraduate and graduate students from biology, marine sciences, and other specialized studies in high demand to understand physiological functions and adaptive strategies of organisms living in the aquatic environment.

The book covers all basic physiological principles important for understanding the physiology of aquatic organisms. It deals with fundamental physiological subjects, i.e., osmoregulation, respiration, hormones, pigmentation, and bioluminescence in the selected aquatic invertebrates and fish species. The subjects are assembled in relation to major environmental fluctuations of oxygen, salinity (seawater), temperature and effects of stress. This book particularly describes physiological adaptations of marine organisms – fascinating adjustments of functions under amazing variety of environmental conditions. Studying physiological processes in model aquatic animals, readers actually learn how the same or similar processes take place in the human body.

During a long evolutionary history aquatic animals have survived in freshwaters, oceans and all transitional habitats. Water and ions are indispensable for all life metabolic reactions. Crustacean and fish osmoregulation processes are exemplified from the organismic to molecular level. It incorporates information on regulations of ion transport under variable conditions in freshwater, brackish and seawater environments. In the chapter covering respiration, various mechanisms developed in aquatic organisms to extract oxygen from their environments are explained. The respiratory functions of gills and basic description of structure and function of hemocyanin and hemoglobin, plus the link between oxygen and carbon dioxide transport, offers a fundamental knowledge how crustaceans and fish respire. The resistance of mussels, crustaceans and fish to low partial pressure of oxygen in their environment are explained on the basis of different strategies such as changing metabolic rate by their depression, switching on anaerobic metabolism and/or air breathing. Finally, due to the more recent anthropogenic effects of pollutants in coastal regions, aquatic organisms often live in oxygen depleted water (hypoxia and anoxia)

and limited physiological adaptive strategies of aquatic organisms to deal with these problems are summarized.

Chapter on hormones is written in the framework of hormonal regulation of critical physiological processes like osmoregulation, growth, gametogenesis, and spawning. In addition, as fish in captivity may not reproduce without injection of naturally occurring reproductive hormones or their synthetic analogs, the author briefly describes hormonal stimulation of the final oocyte maturation and ovulation as an important method in the effective reproduction of majority of economically important aquaculture species. Aquaculture is a rapidly growing industry which will represent important sources of protein in the future world food supply. Further research on growth hormones and identification and synthesis of more potent gonadotropins, along with the studies focused on reproductive dysfunctions, should enable further progress in maturation and ovulation of fish in aquaculture industry. Application of active analogs of hypothalamus and pituitary in induction of spawning was also described. Practical methods of injection and doses to stimulate spawning are exemplified as useful tools for those working in aquaculture.

Temperature is another crucial environmental factor in aquatic environment, playing pivotal role in development, growth and reproduction of aquatic organisms. The related chapter describes how thermal regime can affect physiological responses. Determination of the upper thermal tolerance limits of aquatic organisms can help in prediction of climate change effects in the marine environment. There is quite a large amount of information in this book on molecular chaperones including the heat stress proteins. They represent evolutionary conserved family of proteins whose expression is increased in response to environmental temperature and variety of different metabolic changes. Finally, the authors explain how many organisms living in cold environments can survive subzero temperatures by providing antifreeze proteins or antifreeze glycoproteins, and discuss possible adaptations of animals in polar regions that will experience the greatest overall temperature change caused by the global warming.

In the chapter Bioluminescence, the fascinating phenomenon of light production by a chemical reaction in variety of marine organisms is explained, along with the current understanding of the role of the phenomenon in camouflage, attraction, repulsion, communication and illumination of prey. The last chapter of the book deals with stress in the aquatic organisms. The stressful effects are caused by a wide spectrum of pollutants. Reactive oxygen species are responsible for variety of oxidative damage in aquatic organisms. Current knowledge and recent advances in the understanding of reactive oxygen species effects, and factors affecting storage and expression

of organic toxic substances in aquatic organisms, is well summarized in this chapter.

Besides carefully selected literature sources, mostly based on the internationally recognized authors, the contribution and competence of the author of this book in the field of environmental physiology is evident. All of the chapters are supplied with abstract and cited literature which will help interested readers to easily find related links and do more in depth research on the subject. Phys-

iological principles are clearly presented and illustrated with more than 100 illustrations. The figures are well arranged in the text, and many simple diagrams illustrate basic concepts and principles. The glossary provides brief description of scientific terms used throughout the book.

In conclusion, this textbook truly represents an excellent new learning tool for Croatian students, scholars, researchers and other readers interested in the complex subjects of aquatic environmental physiology.