

THE PHYSIOLOGY OF POLAR FISHES. Anthony P. Farrell and John F. Steffensen (Editors). 2005. Amsterdam: Elsevier Academic Press. xii + 396 p, illustrated, hard cover. ISBN 0-12-350446-5. £63.00; \$US99.95; EUR 91.95.
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The physiology of polar fishes aims to explore what is physiologically unusual about fishes living in polar waters, and to contrast adaptations in Arctic and Antarctic species. This book forms part of a long series of respected volumes that have reviewed many aspects of fish physiology, and provided an important resource for researchers since the late 1960s. Many researchers will feel this volume is long overdue. There is considerable current interest in the physiology of polar, and in particular Antarctic, fishes. Several books have previously reviewed progress in this field (di Prisco and others 1991, 1998; Kock 1992; Eastman 1993), but none within the last eight years. The composition of the Antarctic fish fauna, particularly in the high Antarctic, is unique, and unusually dominated by a single perciform family, the Nototheniidae. This family forms a rare example of a monophyletic radiation (Eastman 1993). Endemism is extremely high in the Antarctic, with 88% of species only found within Antarctic waters (Eastman 1993). In contrast, endemism in the Arctic is low, with many species also found at lower latitudes. Antarctic fishes show a range of highly specialised adaptations for living in cold water, but fewer adaptations have been found in Arctic species. However, this may be partly due to the fact that considerably less physiological research has been carried out in Arctic waters.

The first chapter in this book usefully examines how the differing Arctic and Antarctic physical environments have driven the evolution of physiological traits in fish species. The major physical and geographic characteristics of the Arctic and Antarctic are compared and contrasted. Physical differences in seawater temperature, density and viscosity, salinity, oxygen solubility, ice cover, light availability, and primary production are discussed in detail. Important differences in the geography of the two regions are also outlined. This chapter provides a valuable summary for researchers unfamiliar with the polar environs.

A taxonomic overview of both Arctic and Antarctic fishes is provided in Chapter 2, including a short section on the history of the classification of polar fish. Interestingly, similar numbers of fish species are found in the Arctic (289) and Antarctic (252), but only three species are found in both. The authors highlight the importance to comparative physiologists of understanding the underlying phylogeny of polar fishes, in particular when attempting to understand the evolution of specific cold-adaptations, such as anti-freeze proteins.

Chapter 3 reviews elements of physiological, biochemical and molecular, and temperature-dependent trade-offs in cold-adapted marine fish. It introduces the concept that polar fish have adopted a 'life in the slow lane'

strategy to life, with low standard metabolic rates, and growth rates at the lower end of those observed in temperate species. The inability of the ventilation and circulatory systems to deliver sufficient oxygen is highlighted as a major determinant of both lower and upper thermal limits of organisms. Specific adaptations are outlined, which have allowed polar fishes to achieve a high degree of physiological compensation at water temperatures near to the limits of life, including elevated mitochondrial densities, reduced proton leakage across membranes, increased membrane lipid saturation, increased muscle fibre size, up-regulation of aerobic enzyme capacities, structural modifications to proteins, and cold-compensated protein synthesis. The chapter clearly demonstrates the high level of physiological adaptation that has occurred over evolutionary time, in Antarctic fish species in particular. Differences in strategies adopted by Antarctic, Arctic, and cold-adapted temperate fishes are also highlighted.

Living in polar waters places fish under a considerable risk of freezing, as their bodies are hyposmotic to seawater. To live at these water temperatures, fish have two options: either migrate in winter to areas where water temperatures do not decrease to their freezing point, or evolve a strategy to cope. Chapter 4 examines the remarkable story of the evolution of groups of glycol-proteins and peptides that act as antifreezes, allowing fish to live at polar water temperatures. The authors of this chapter have produced much of our knowledge in this area, and are well qualified to write this review. It is thought that antifreeze glycol-proteins evolved in Antarctic fishes 7–15mya, at the same time as sea level glaciation. These various antifreeze molecules disrupt or arrest the growth of ice crystals in the animal's body and hence prevent freezing.

One of the most long-running and contentious issues in polar fish biology has been whether polar fish show metabolic cold-adaptation (MCA), a concept first proposed in the 1950s. MCA advocates suggest that metabolic rates in polar fishes are elevated above those seen in temperate and tropical species, even allowing for the effects of temperature. Arguments for and against the existence of MCA have raged since. Chapter 5 firstly examines the evidence for low temperature-induced morphological and morphometric adaptations of the respiratory systems in fish, and concludes, that as of yet, none have been found. The concept of MCA is then discussed in the light of recent data, with the author concluding that there is no evidence of elevated metabolic rates in fishes living at polar water temperatures.

Chapters 6 and 7 examine whether there are fundamental differences in the circulatory physiology, blood-gas transport, and haemoglobin function of polar and temperate fishes. Antarctic fish have to cope with a temperature-induced increase in blood viscosity at low temperatures. Blood viscosity is 40% higher at 0°C than at 10°C. In turn this would lead to a 40% higher cardiac workload if no adaptations existed. In fact, polar species have adopted several strategies to reduce this problem, including reducing the number of red blood cells by

about 50% in comparison to temperate species, and also having more deformable red blood cells so they can pass through blood vessels with greater ease. Icefish have evolved a strategy unique amongst vertebrates, with the complete loss of red blood cells and a great reduction in white blood cells, thereby greatly reducing their blood viscosity. In turn, icefish have had to adapt to relying on oxygen dissolved within their blood plasma, along with an 80% reduction in vascular resistance and a cardiac output that is 10 times higher than in red-blooded polar species.

A considerable amount of research has been carried out on swimming and muscle physiology of polar fish, and this is reviewed in Chapter 8. All Antarctic fish with the exception of one species are primarily labriform swimmers, only utilising sub-carangiform swimming for high-speed swimming. Both red and white muscle fibres are much larger in Antarctic fishes than temperate species, with red muscle fibres having a 40% larger diameter and white fibres up to 500%. Both red-blooded Antarctic fish species and the icefish also lack muscle myoglobin. A similar reduction or loss of myoglobin is also seen in Arctic fish species, suggesting this may be a general low-temperature adaptation. Very high mitochondrial densities have also been shown in Antarctic fish red muscle, up to 50% of the fibre volume, much higher than temperate fish.

Lastly, in Chapter 9 the nervous systems of polar fishes are discussed. Evidence is presented that cold adaptation of nerve conduction velocities has occurred with velocities in polar species higher than temperate species when tested at the same temperature. However, the net trade-off appears that the nerves of Antarctic fishes fail at lower maximal temperatures than temperate species.

The physiology of polar fishes provides an excellent overview of current research in polar fish physiology. The book covers the main areas of focus for polar fish research over recent decades. By necessity, areas in which only limited research has occurred are omitted. I have very few criticisms of the volume. The authors chosen are highly qualified to write the chapters, and the book has been generally well edited. My only minor criticisms are that it would have been nice to see a more standardised chapter format, in particular in the way individual chapters are summarised. Also there is some small overlap of information between chapters, in particular Chapters 6 and 7, which also contain minor contradictions. However, these are insignificant criticisms, and I am sure any researcher working in this area will find this book invaluable both now and for many years to come. (Keiron Fraser, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET.)

References

- di Prisco, G., B. Maresca, and B. Tota. 1991. *Biology of Antarctic fish*. Berlin: Springer Verlag.
- di Prisco, G., E. Pisano, and A. Clarke. 1998. *Fishes of Antarctica: a biological overview*. Milan: Springer-Verlag.

Eastman, J.T. 1993. *Antarctic fish biology: evolution in a unique environment*. New York: Academic Press.

Kock, K-H. 1992. *Antarctic fish and fisheries*. Cambridge: Cambridge University Press.

THE PHYSICAL GEOGRAPHY OF FENNOSCANDIA. Matti Seppälä (Editor). 2005. Oxford: Oxford University Press. xxxii + 432 p, illustrated, hard cover. ISBN 0-19-924590-8. £130.00. doi:10.1017/S003224740623599X

This new book, part of the Oxford Regional Environment series of texts on physical geography, explains the 'state of the art' knowledge of a rather peculiar region — Fennoscandia — consisting of Finland, Sweden, and Norway. The region has a long and interesting geological history. The Archaean bedrock currently exposed over large areas has at times been covered by sediments; remodelled by orogenies, volcanism, and erosion; and inundated by the Paleozoic ocean. Furthermore, Fennoscandia has endured erosional and depositional effects of multiple glaciations. The current landscapes were finally remodelled into their present forms during the last glaciation, which ended some 10,000 years ago. The isostatic adjustment of the crust changed the distribution of water and land and can still in some areas be observed as shoreline displacement, rerouting of rivers, etc.

The editor of this special volume, Professor Matti Seppälä, is a well-known and honoured Finnish scientist, with special interests in Arctic geomorphology. In the preface, he explains that this volume is logically limited in area to Finland, Sweden, and Norway, although both Denmark and Iceland are often mentioned as part of Scandinavia. An important reason is the fact that only the three countries are resting on an Archaean crystalline basement known as the Baltic Shield. Although the Shield does extend east into westernmost parts of Russia, where the geomorphology is similar to that of Finland, the Russian part was excluded because of difficulties in finding suitable contributors.

The physical geography of Fennoscandia is divided into three separate parts. Part I covers various aspects of the physical environment of the study area. The Fennoscandian setting is described in the chapter on landforms and bedrock by Karna Lidmar-Bergström and Jens-Ove Näslund. They give a concise description of the geology, including the crystalline basement, the sedimentary rocks, orogenic and tectonic processes, the various petrographic regions, and naturally how these have influenced the present-day landscape. Details that have not been covered in the text are well documented in the many references.

The second chapter, by Matti Eronen, deals with the isostatic uplift following the unloading of Fennoscandia due to the melting of the continental ice sheet that covered most of the region 15,000–20,000 years ago. The crustal rebound has slowed down considerably, although in the central parts of the area, around the Northern Quark and