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**The Diversity of Fishes: Biology, Evolution and Ecology. Second edition.** Gene F. Helfman, Bruce B. Collette, Douglas E. Facey, and Brian W. Bowen. 2009. Wiley-Blackwell. ISBN 978-1405124942. 736 p. \$129.95 (hard cover).— For the past 12 years, the first edition of *The Diversity of Fishes (DOF)* has been the world's most adopted ichthyology text and has provided foundational reading for a new generation of scientists, including the authors of this review. Given that the release of its first revision coincided with the onset of our new undergraduate teaching duties, we were excited to put the new text through its paces in our classrooms. Overall, we found the volume to be a remarkably comprehensive treatment of the biology of fishes written by four expert authors. Their work is an incredible reference and certainly a major update to what was already a very fine textbook. However, the volume's greatest strength—its remarkable level of detail—is also its greatest weakness at the undergraduate level, where its abundance of details seems to prove overwhelming. As in all courses employing a comprehensive textbook, the instructor will have to filter the information in *DOF* to best support his or her lesson priorities. Still, the text succeeds because its richness of content allows ichthyologists from varied backgrounds, teaching disparate courses that emphasize different information, to look to *DOF* as their singular reference.

We are co-writing this review because our individual perspectives on teaching span three very different undergraduate courses using *DOF* as the primary text. Between us, we used every chapter in the book. We both taught our courses for the first time in the fall of 2009, and used the updated version of the text just months after its printing as our primary source of course readings. Brian's Ichthyology course at Oregon State University (OSU) is a major part of

the undergraduate experience for more than 60 on-campus and 75 online students a year, mostly juniors and seniors majoring in Fisheries and Wildlife, Zoology, or Natural Resources. It is a lecture-only course (three hours a week) covering diversity, anatomy, physiology, reproduction, life history, behavior, ecology, biogeography, and conservation, all from an explicitly evolutionary perspective and in roughly that order. Brian also teaches a concurrent, lab-based course on the Systematics of Fishes to about 35 students yearly; this class used the text as a supplement to detailed examination of specimens from the OSU teaching collection. Prosanta's course at Louisiana State University (LSU) is a cross-listed class in Biology and Renewable Natural Resources taught once a year to roughly 15 upper division students. The LSU course focuses mainly on diversity of fishes and systematics during lectures (two hours a week) and anatomy and physiology during labs (up to six hours a week).

Perhaps most importantly, the second edition of *DOF* represents the most up-to-date general text on ichthyology currently available. This was the primary drive behind our adoption of the text, and should provide strong motivation for others to consider doing the same. All three authors of the previous edition have revised their earlier chapters and added a wealth of new citations, new examples, and new figures, and in some cases documenting substantial shifts in treatment. For example, the superb final chapter on conservation contains much-expanded passages on fishing pressure as an evolutionary force and on the ecological effects of the aquarium trade, two important topics that have received increased attention over the past decade (Law, 2000; Wood, 2001). While the examples in the conservation chapter stand out as particularly timely and are well tied to thematic and ecological concepts introduced in earlier chapters, examples throughout the entire volume are global in scope and current up to the year of printing. For example, a marvelous color photo of *Histiophryne psychedelica*, described from Indonesia (Pietsch et al., 2009) only months before publication of *DOF*, graces the opening to part IV of the text. The breadth of examples is particularly rich in the chapter on reproduction, in which virtually every major group of fishes receives at least a cameo, all bound together by cogent discussion of how variation in reproductive strategies among species, sexes, and individuals contributes to differential lifetime reproductive success.

The volume's treatment of ecological interactions among fishes and between fishes and their environment is particularly strong, as is the integration of evolutionary theory as an underlying explanatory force for the diversity of adaptations found in fishes. For example, Chapter 18 on special habitats is organized along the evolutionary principle of convergence in common environments, providing a logical framework for what would have otherwise been a collection of miscellaneous information about fishes that live in extreme habitats (deserts, the deep sea, caves, the open sea, polar regions, and swift currents). Sections on fishes as predators and prey (Chapters 19 and 20) are similarly well integrated with theory, with the authors always taking care to explain how individual behavioral or morphological features of fishes represent solutions to specific challenges, such as the use of spinning and knotting in eels, or dismemberment in barracudas as ways to overcome the problem of gape limitation.

Chapter 17 on fish genetics by Brian Bowen is entirely new, and like the rest of the text, is packed with excellent examples. It provides thorough coverage of the huge array of ichthyological questions that have been addressed with

molecular methods. Phylogenetics, phylogeography, pedigrees, population genetics, conservation genetics, and even mating systems find treatment here. Despite the general excellence of the genetic examples, we admit to finding it a bit odd that all are grouped here in a single chapter, rather than being distributed throughout the rest of the volume in the chapters on systematics, zoogeography, reproduction, and the like. Given that so much of the rest of the volume is organized along ecological or evolutionary principles, it seems artificial to have this section broken out along what amount to methodological lines. The fact that this chapter has a separate author goes a long way towards explaining the division, but we would love to see the genetic examples integrated more fully into the volume in an eventual third edition.

The most extensive revisions are found in the five chapters summarizing the diversity and relationships of major fish clades from jawless fishes to bony and cartilaginous fishes. Given the fast moving nature of systematics, the need for a major update here is not surprising, and the treatment of various fish groups in *DOF* is thorough and informative. However, a major flaw crops up in the organization of this diversity. Phylogenies, redrawn mainly from Nelson (2006) and other secondary sources, are sometimes awkward and not reflective of the relationships discussed in the text. For instance, hagfishes are considered part of Vertebrata in the very first phylogeny appearing in *DOF*, but this contradicts the text of chapter 13, which includes hagfishes as either part of the controversial "cyclostomes" or sister to all living vertebrates, but never as a vertebrate itself. The trees typically show safe pectinate versions of relationships, but in being safe they can be confusing when relationships among sister taxa discussed in the text are not illustrated on the phylogenies. In another example, the text strongly implies that Otocephala (Clupeomorpha + Ostariophysi) is a natural group, but this sister relationship is not depicted in any trees, and the group appears as paraphyletic in the main illustration of relationships of teleosts for this section (fig. 14.1). The mismatch between trees and text makes it difficult to follow *DOF* in presentations without heavily modifying the provided phylogenies.

Some of these internal inconsistencies stem from the fact that *The Diversity of Fishes* simultaneously adopts Nelson's (2006) revision of *Fishes of the World* (the only current text to do so fully) and tries to point out portions of the fish tree-of-life in which those relationships remain contentious. Any attempt to treat this topic will be controversial, but on the balance the text does a reasonable job of highlighting ambiguity while still providing a reasonable framework. Those students interested enough to know more about these relationships can always be pointed to the primary literature, as *DOF* sometimes does.

Despite our overall high esteem for *The Diversity of Fishes*, we both found that the text is written at a level too high for easy comprehension by the typical undergraduate junior or senior. The major problem appears to be information overload. The text is so full of examples, details, and technical terms that students new to the field end up with an experience akin to drinking from a firehose. One of us (BLS) specifically asked his students to evaluate the textbook at the end of the course and received a fairly high proportion of negative comments, mostly concerning the density and overwhelming level of detail, particularly in the chapters on anatomy and zoogeography. It seemed hard for students to know how to study such chapters, as they are largely presented as a list of information without sufficient

theoretical underpinning. Such student criticisms need to be taken with a grain of salt (and certainly some students praised the text, with several singling out the conservation chapter as being particularly excellent), but they do illustrate a strong need for the professor to filter, highlight, and contextualize the most important information, lest his or her students be left trying to absorb more detail than is feasible or practical. Integration of details across chapters provides one successful tactic. For example, both of us combined the presentation of examples from Chapters 3 (“Skeleton, skin and scales”) and 8 (“Functional morphology of locomotion and feeding”), thus providing a strong functional context to the teaching of anatomy.

Sometimes the need to mix chapters can be cumbersome. In particular, any attempt to teach the diversity sections (Chapters 11–15) in phylogenetic order will require a good deal of flipping between multiple chapters. The text separates out most of the information on extinct fishes into Chapter 11 (“A history of fishes”), but Chapter 13 on “Living representatives of primitive fishes” covers much of the same phylogenetic ground while skipping over the living chondrichthyans, which are discussed separately in Chapter 12. As a result, important information on bichirs, hagfish, sharks, and various other non-teleosts is scattered across multiple chapters. We would have preferred a presentation that more fully integrated the discussion of fossil and extant taxa in a single progression through the phylogeny of fishes.

Of course, for students of ichthyology at the graduate level and beyond, the level of detail throughout all the chapters is entirely appropriate. In fact, this extreme attention to detail and citation helps the volume double as a superb single-volume reference on the most important past and present papers in any subfield of ichthyology. We find ourselves pulling down the volume with some regularity in search of quality references, the proper spelling of obscure bits of anatomy, or a quick guide to a particular branch of the fish tree.

The authors of the text do appear to have been aware of the issue of information density, and they have clearly made some efforts to highlight the most important information in each section. The summaries at the end of each chapter are definitely helpful in this regard, as are the many boxed discussions, which frequently contain concise and highly cogent discussions of key examples such as the recent discovery of *Tiktaalik roseae* (Daeschler et al., 2006), the many ways that fishes use color to communicate, or the debate about whether farming salmon is ecologically sound.

The illustrations in the second edition of *DOF* are improved over those in the first, but there is still high variation in quality. Many of the newly added color plates are beautiful, and several figures have been redrawn and clarified from previous editions, such as figure 6.2 on mechanoreception, figure 8.3 on two competing models of shark locomotion (after Wilga and Lauder, 2002), and figure 18.3 on the remarkable feeding mechanism in *Chauliodus* (after Tchernavin, 1953). However, many other figures are taken directly from the primary literature and appear in black and white at a grainy resolution. Some such figures contain a confusing wealth of information that is somewhat extraneous to the text (e.g., figure 10.4 on mechanisms of sex determination, or the dauntingly labeled illustration of tuna osteology that confronts students at the beginning of chapter 3), while others are incompletely contextualized.

For example, figure 25.16, depicting a North American lake food web, contains several blotchy or faded pen-and-ink drawings of organisms that are insufficiently labeled; this could have benefitted greatly from judicious redrawing and the addition of color.

Despite the fact that there is a figure on about every other page, the addition of even more illustrations would have been welcome. Although all the figures and tables are available from the text through a useful website associated with the textbook (<http://blackwellpublishing.com/helfman/>), there are not nearly enough to fill a Powerpoint presentation. Supplemental images are of course easily available from the web, but additional visual materials would have improved students' experience with *DOF*.

Overall, the book is a very good text with a few flaws in the illustration and organization of information. Like health care reform or large family dinners, you can't please everyone, but *DOF* does an excellent job of being flexible enough to meet the needs of nearly everyone interested in the study of fishes. Given its extraordinary level of detail, it is particularly well suited to serve as a graduate-level text, but it can certainly be adapted for undergraduate use if the professor takes care to help the students prioritize the wealth of information that it contains. Overall, *The Diversity of Fishes* is, in our opinion, the best current single-volume resource for teaching students about fishes, and if we had to condense our ichthyological libraries to just one book, at the moment this would certainly be it. Within *The Diversity of Fishes* nearly every professor of ichthyology will find most of what he or she needs to prepare a master course on fishes.

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