

BOOK REVIEW

Ecology of Australian Freshwater Fishes. Edited by Paul Humphries and Keith Walker. CSIRO Publishing, Collingwood, Victoria, Australia. 2013. 423 pages. \$A130.00 (hardcover).

This book is a synthesis of fisheries biology and ecology. It applies Northern Hemisphere experiences to the unique Australian context of a fish fauna evolved in isolation on the driest and flattest continent on the Earth. The authorship includes 23 well-known aquatic biologists. Each of the 13 chapters is stand-alone, with approximately 2,088 references at the end of the book, the most recent of which are from 2012.

After paying homage to aquatic ecology pioneers Stephen Forbes, G. E. Hutchison, and Noel Hynes, the editors point out that only two Antipodean ecologists, R. M. McDowall (New Zealand) and J. Allen Keast (Australia) achieved much international recognition in the 20th century. This is offered as a motive for the book.

Fish ecology received a boost from the 1949 studies of Shelby Gerking, and the principles were codified by George Nikolsky. Important journals like the *Transactions of the American Fisheries Society* prospered, and classic works such as Matthew's 1998 *Patterns in Freshwater Fish Ecology* emerged. I recommend that Saunders (2013) be consulted for additional historical presentations.

After the stage is set, the origin of the Australian freshwater fish fauna is discussed. This fauna consists of about 256 species that are listed alphabetically by family in the appendix. Only three species of Gondwanan origins are present: one lungfish (*Neoceratodus*) and two osteoglossids (*Scleropages*). The scientific name of the Spotted Bonytongue, *S. leichardti*, is consistently misspelled throughout the book with "hh" as in Leichhardt's name (Berra 1989), although the correct spelling is used in the index. A review of Australian fish biology highlights the work of Gilbert Whitley, John Lake, and Gerry Allen.

Peter Unmack's review of Australian ichthyogeography points out that the fauna is dominated by acanthopterygians, not the ostariophysians that are so common on other continents. Only two native ostariophysian families (Ariidae and Plotosidae) and four endemic families (Neoceratodontidae, Lepidogalaxiidae, Melanotaenidae, and Pseudomugilidae) occur in the freshwaters of Australia and New Guinea (A–NG). Limited geological relief has allowed dispersal across low barriers. The fauna is about 91% endemic at the species level. More species remain to be described in the 36 families. Most of the freshwater fish species of A–NG have marine affinities, but not necessarily recent ones. The Spangled Perch *Leiopotherapon unicolor* is Australia's most widespread freshwater fish. Australia's

southwestern province is a hotbed of endemism for fishes as well as plants and other biota due to its prolonged isolation by arid regions, yet it shares some relatives with southeastern Australia. I wish, however, that the chapter had included the vicariance versus dispersal arguments of the 1970s that centered on Common Galaxias *Galaxias maculatus* (also known as Inanga) and so consumed graduate students of that era (Berra et al. 1996).

Chapter 3 is a primer on genetics for the fish ecologist, a topic that informs taxonomy, dispersal, management, and conservation. One of the most interesting and useful aspects of this chapter by Hammer, Adams, and Hughes is Table 3.2. It gives the relative expense and technical expertise required for obtaining data such as morphology, karyotypes, allozymes, amplified fragmented length polymorphisms, mtDNA, introns, exons, microsatellites, and single-nucleotide polymorphisms. A brief summary of each technique (including DNA bar coding and GENETAG) shows how and for what purpose each method can be used.

The chapter on habitats by Koehn and Kennard describes the diversity of Australia's freshwater environments from large rivers such as the Murray–Darling system to ephemeral streams. The demands of droughts and floods are embedded in the DNA of Australia's biota. This unpredictability has consequences for fish faunas throughout much of the continent. Tropical northern Australia, on the other hand, has predictable wet and dry seasons, which present a different set of circumstances. Natural lentic habitats are few and far between, except in Tasmania. There are no "Great Lakes" of Australia as in North America or Africa, but oxbow lakes (billabongs) are common. Reservoirs have been formed by impounding rivers with a loss of native fish habitat. Lake Eyre, a gigantic basin in arid northern South Australia, fills with water and fishes about every 50 years, but oddly it is not mentioned in this chapter or in the index. Hydrology, hydraulics, water quality, and physical structure are discussed, with many examples of how various species cope. For example, the iconic Murray Cod *Maccullochella peelii* and two of its congeners are consistently associated with woody debris.

Koehn and Crook present a master class on movements and migration in Chapter 5. We learn that Golden Perch *Macquaria ambigua* move up to 2,300 km through inland rivers. Such large-scale movement wholly within freshwater is termed potamodromy. Aboriginal people had knowledge of fish migrations and used stone fish traps to catch Golden Perch, Murray Cod, and the catadromous Southern Shortfin Eel *Anguilla australis* (also known as just the Shortfin Eel) for millennia. The authors provide a table of 16 terms to explain various fish movements.

The mechanics of swimming is discussed in detail. Home range and homing as well as diadromy, catadromy, and anadromy are illustrated by many Australian examples. Amphidromy (a type of diadromy between freshwater and the sea not for spawning) is illustrated by the Australian Grayling *Prototroctes maraena*. Both high- and low-tech methods of studying fish movements are summarized, including passive integrated transponder tags, telemetry, and otolith chemistry (whereby variations in the ratio of trace elements between the cores and edges of otoliths are thought to show movements between marine and freshwater environments). There is much to recommend this chapter to fish ecologists who are not experts in this subspecialty.

Stoffel's chapter on trophic ecology covers the ways in which fish sense and ingest prey and the bioenergetics and nutrition of various diets. Trophic guilds are discussed, and food webs are spun in an Australian context. This involves knowledge of the physics and chemistry of fish vision, mechanoreception, and chemoreception. A major contribution of this chapter is Figure 6.17, which shows 92 fish species arranged in six clades of piscivores, algivores–detritivores, surface carnivores, microcrustacivores, aquatic insectivores, and omnivores. At least one of the papers cited for this figure (Berra et al. 1987) is missing from the references, and another that could have been included is not (Berra and Wedd 2001).

Reproduction and early life history are expertly handled by King, Humphries, and McCasher in Chapter 7. *K*- and *r*-selection theory and semelparous versus iteroparous breeding strategies are explained with Australian examples. Of the 92 Australian freshwater fish species studied, about 35% show some form of parental care, which is almost always provided by the male. Australia's premier game fish, Barramundi *Lates calcarifer* (also known as Barramundi Perch), is a protandrous hermaphrodite that transitions from male to female at about 80–100 cm after spawning in brackish waters at 6–8 years old. Protogyny (female-to-male conversion) is the more usual pattern among hermaphroditic fishes, but this is rare in Australia. Figure 7.10 is an informative graphic representation of the spawning time, rainfall, and temperature patterns in five regions of Australia. One can see that many species spawn in the tropical Alligator Rivers of the Northern Territory from September to December on the buildup to the wet season. This can be compared with southwestern Australia or Tasmania, where rainfall and temperature patterns are very different. Table 7.3 shows the reproductive guilds of Australian freshwater fishes. Early life history stages are reviewed, along with anthropogenic disturbances.

Crook and Gillander do their best to make age and growth interesting in their comprehensive chapter. How old is a 30-kg Murray Cod? It could be 20–48 years old or more. This demonstrates the difficulty of pinning down a specific answer in animals with highly variable growth rates. Yet management and conservation decisions depend on having such answers. One of the geologically oldest fish species on the planet, the Australian Lungfish *Neoceratodus forsteri*, can live 65 years or

more and reach 1.4 m TL. In terms of approach, the authors round up the usual suspects, such as length-frequency analysis, scales, otoliths, and the venerable von Bertalanffy equation. Data on the validation of aging methods for many Australian species is lacking. Otoliths are especially useful since they grow continuously and their chemical structure is not remetabolized. As a general rule, small species mature in their first year and live 1–5 years, whereas large-bodied fishes mature later and live longer. As ectotherms, fish have very plastic growth rates and continue to grow throughout life. Environmental conditions play a large role in fish growth rates. Larger fishes tend to have great reproductive potential, and females usually are larger than males of the same species. To its credit, this chapter is strongly based on the fish physiology that explains the methods of the fisheries ecologist.

Population dynamics is the foundation upon which management decisions are made, and this is the subject of Chapter 9 by Harris, Bond, Closs, Gehrke, Nicol and Ye. Metapopulations (populations of populations), catch per unit effort, recruitment, and other subjects are explained. Table 9.1 is a compilation of demographic data (longevity, size, age at maturity, and fecundity) for 39 species. Such summary sources are reason enough to own this book. Desiccating Lake Eyre and the stranding of 40 million Bony Herring *Nematalosa erebi* and hardy-heads *Craterocephalus* spp. get a mention in this chapter. A boxed presentation of coldwater pollution from reservoirs shows how the warmwater Murray Cod has been adversely affected. Mitigation ideas are offered. Today, most commercial harvest in Australian freshwaters is for alien species. Recreational fishing is the dominant form of exploitation of native fishes. Australia ranked only 55th among nations in total fisheries production in 1989. Four native freshwater fishes are commercially exploited: Barramundi, Golden Perch, Longfin Eel *A. reinhardtii*, and Southern Shortfin Eel. Redfin Perch *Perca fluviatilis* (also known as Eurasian Perch) and Common Carp *Cyprinus carpio* are the two alien species that support commercial fishing. Three salmonids (Atlantic Salmon *Salmo salar*, Brown Trout *S. trutta*, and Rainbow Trout *Oncorhynchus mykiss*) are raised in aquaculture. Many other native species (including Murray Cod) were previously exploited commercially, but overfishing, habitat destruction, alien species, and other anthropogenic factors have had a deleterious impact on stocks. Australians are mad-keen anglers, and about 20% of the population over 5 years old fish annually and spend \$A1.8 billion doing so. About 20% of this effort is in freshwaters. Freshwater fishing is very important to the lives and cultural traditions of Aboriginal people, especially in the Northern Territory. The pros and cons of stocking programs are debated at the end of the chapter. There is a strong conservation ethic among most anglers and indigenous people. This chapter has much food for thought for the angler as well as the professional fisheries biologist.

A group of species that occur together in a single locality is considered an assemblage, and this is the topic of Chapter 10 by Arthington, Kennard, Pusey, and Balcombe. Abiotic

and biotic factors interact to structure assemblages, and it is necessary to understand these interactions to positively influence physical restoration efforts. Both geological and human history affect which species and how many will be available in the regional species pool, and then various abiotic and biotic filters determine the composition of the local assemblage. For example, Australia's aridity is a major filter and may yield depauperate assemblages. Lake Eyre, the world's 18th largest lake (when it is actually full), is discussed in more detail here, along with its rarely connecting stream (more often a string of water holes), Cooper Creek. Various assemblages, such as those of springs, coastal lakes, and rivers, and their filters and species are reviewed. Both species richness and piscivory increase downstream. A complex web of interacting abiotic factors is diagramed in Figure 10.3. Predation and competition are two important biotic filters. Local assemblages that include some dispersal and interaction between them constitute metacommunities.

John Harris is the author of the very important chapter entitled "Fishes from Elsewhere." This title applies to exotic, alien, and translocated native species—and even to different genetic stocks of native species. In this context, "exotic" species are defined as ones that do not exist in the wild but rather are held captive in aquaculture or aquariums. They are potential "alien" species, which are defined as "imported and established." Table 11.2 lists 43 such alien fishes. There are 18 cichlids, 8 cyprinids, 6 poeciliids, and 5 salmonids on the list. All are from west of Wallace's Line. The International Union for the Conservation of Nature considers five of these taxa to be among the 100 most invasive species in the world: Brown Trout, Common Carp, Redfin Perch, Eastern Gambusia *Gambusia holbrooki*, and Mozambique Tilapia *Oreochromis mossambicus*. Acclimatization societies brought in many European species for food and recreation in the 19th century. Some species escaped from the aquarium trade. Australia's northern waters are ideal for invasive tropical aliens. Since Australia has no major freshwater shipping ports, it has avoided ballast-water alien introductions as experienced in the North American Great Lakes. Murray Cod are highly prized, and there has been pressure to translocate them widely. This brings up the issue of hybridization of different genetic stocks of the same species. A total of 76 native species in 28 families have been translocated, mostly in eastern Australia. Salmonids are generally thought by most Australians to be a "good" introduction, but ecologists consider them to be detrimental to native coolwater species such as blackfish (Gadopsidae), Australian Grayling, Trout-Cod *Maccullochella macquariensis*, some galaxiids, and other fishes. Various eradication plans are in place, including the "daughterless carp" program that attempts to manipulate sex ratios to eliminate females. The characteristics of a successful invader and their impact on native species are discussed with real examples.

Conservation and management is tackled by Lintermans. Many Australian freshwater fish species are in decline, especially in the southern part of the continent where the population

and agricultural influences are greatest. Fish populations in the sparsely populated north are in better shape. Table 12.1 lists 49 taxa and their various categories, such as critically endangered, endangered, vulnerable, etc. Members of the Galaxiidae and Percichthyidae have the most problems. The Pedder Galaxias *Galaxias pedderensis*, a Tasmanian endemic, is extinct in the wild but survives in two translocated populations. All four species of cod (*Maccullochella*) are considered endangered or vulnerable and management plans are in place, but these plans may vary from state to state. Some threatened species may be captured and retained, whereas others must be released if caught. There are also some unknowns. Do hooked fish survive release? Can anglers differentiate closely related species? The principal threats to fish include habitat modification, altered flow, water quality, barriers, alien species, translocation and stocking, and overfishing. These threats are explored with specific examples and management responses. The Murray–Darling basin provides world-class examples of fishway solutions along the 2,225 km from the mouth of the Murray River to Hume Dam. Since 2000, more than 79 million fish of 15 species have been stocked in New South Wales and Victoria. About half of these were salmonids and half were natives, with Golden Perch and Murray Cod predominant among the natives. The freshwater fish harvest consists mainly of Common Carp, Redfin Perch, Golden Perch, salmonids, Australian Bass *Perca latipes novemaculata*, Barramundi, and Murray Cod.

The final chapter by the editors reflects on where Australian freshwater fish ecology has been and where it needs to go. A scenario for 2050 is proposed in which "we must prepare for change, rather than resist it." After all, isn't this what the Australian freshwater fishes have done through their life history strategies? It is called evolution.

My quibbles with the book, already mentioned and otherwise, are minor. For example, in Figure 1.1 (an Aboriginal rock painting) an eeltail catfish (Plotosidae) is clearly shown, but it is identified as a fork-tailed catfish (Ariidae). On page 5, the American Society of Ichthyologists and Herpetologists is misnamed, and the correct date of its founding is 1913 rather than 1914 (Berra 1984).

I really enjoyed this book. It made me homesick for all the people, places, and species I've encountered in a 45-year career devoted to studying weird Australian fishes. Anyone interested enough to read this review and the journal it is published in will benefit from owning this book.

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