

BOOK REVIEW

Malformed Frogs: The Collapse of Aquatic Ecosystems. 2008. Michael Lannoo. University of California Press, Berkeley, California. \$65.00, hardcover; 270 pages + photographs. ISBN 978-0-520-25588-3.

Michael Lannoo's *Malformed Frogs* is a well-written scientific review of the likely causes of the malformed frog phenomenon and the practical approaches to resolving it. Lannoo is engaging, entertaining, and scientifically rigorous in presenting his 10 years of chronicling, surveying, and compiling 2377 radiograph images of malformed amphibians. Lannoo is a professor at the Indiana University School of Medicine and editor of *Amphibian Declines: The Conservation Status of United States Species* and *Status and Conservation of Midwest Amphibians*.

This book appeals to a wide audience, from citizen scientists to graduate students and environmental professionals. Its extensive review of existing literature pertinent to amphibian malformations, complete with endnotes, makes this work applicable and accessible to readers with varying levels of interest and background in environmental science and ecology. Graduate students and researchers in the field will find this book to be an excellent reference text.

Lannoo begins with a definition of amphibian malformation. Color plates illustrate several genetic mutations, and Lannoo discusses trauma-induced and epigenetic malformations. Lannoo includes an overview of normal frog development and metamorphoses. This provides the unfamiliar reader with a physiological background sufficient to understand the timeframe of normal amphibian development, especially eye, jaw, and limb development.

Lannoo presents the existing classification scheme and definitions of frog malformations. The book includes dozens of radiograph images of frog skeletons, portraying each malformation type, and it includes field notes on where the frogs were collected. The array of information on skeletal abnormalities can be

dismal and dry, but Lannoo's writing style keeps the reader engaged with anecdotes and discussion of the broader ecological framework.

Lannoo gives an overview of frog "hotspots," which are known sites with high rates of malformed frogs. The Minnesota Pollution Control Agency defines a hotspot as a site with an occurrence of >5% of amphibian malformations. Hotspots are nearly equally split between natural and man-made wetlands; however, Lannoo discusses that all sites are impacted by housing development or agriculture to varying degrees. He provides a brief list of all natural and man-made causes of amphibian malformations, with references to other chapters for further discussion. Lannoo also discusses the challenges of determining causal factors of frog malformations and the challenges of linking morphological signatures to malformation types.

Lannoo tackles the question humans have when responding to the gross abnormalities of frog malformations: do humans have the same risks as amphibians to developmental deformities? He reviews the wide array of known types and causes of human malformations and discusses the broader societal context and implications of frog malformation. As he succinctly states, the malformed frog dilemma represents a "societal meltdown." He asserts that remediation of former hotspots has been effective without managers knowing the exact causes of frog malformation and that extrapolating the causes beyond the local or regional scale is often problematic given the site-specific nature of the conditions. He argues that many former hotspots of frog malformations have been remediated and healthy frog populations have been restored by effectively reducing run-off to reduce nutrient, pesticide, and chemical loads to water bodies. However, he also argues that the solution is independent of the cause.

The book examines the human side of science and some of the pitfalls in solving the problem of frog malformation. Throughout the book, Lannoo is quick to identify sources of biases—both his own and those of other researchers. Often these biases are unavoidable

at a practical level, as in field sampling methods. For example, one would expect sampling with dip-nets to favor sampling frogs with compromised locomotion over healthy specimens. Lannoo discusses how some researchers have relied on type thinking versus variation thinking and he makes the following profound observation: “[Malformed] types are convenient, especially as bookkeeping devices, but human convenience does not always translate into biological reality.” Given the wide variation in types of frog malformation and the developmental variability in response to known causes of malformation, Lannoo urges researchers to expand their environmental studies. He carefully presents the major hypotheses of frog malformations (predation, UV-B, chemicals, retinoic acid and chromosomal damage, and trematode parasites) along with relevant literature.

This book is a well-crafted and occasionally entertaining read. Lannoo does an excellent job of summarizing and critiquing the literature and placing it in real-world context while acknowledging the limits of field work and nonbiased sampling. Lannoo takes great care to examine all sides of the debate and thoroughly discuss the merits of various theories related to the decline of amphibian populations. With the experience of 10+ years of meticulous research, his conclusion is encouraging: the causes of frog malformations are complex, but the remedy is not. Aside from background mal-

formations attributable to chromosomal errors, most frog malformations are traceable to environmental degradation.

The summary list of known North American species with malformations and their malformation types with references would be a great asset to those conducting research in this area. Those involved in researching environmental causes of amphibian decline and those charged with protection and remediation of wetlands would gain the most from reading *Malformed Frogs*.

Unfortunately, the higher-than-expected list price of \$65.00 may be cost prohibitive even for the most motivated readers, not to mention those merely curious about the subject. On the positive side, book royalties benefit the Dan Sutherland Memorial Scholarship fund.

The dust jacket and layout are attractive and well-designed, and the detailed general index makes it easy to locate subjects of interest. I highly recommend this book to anyone interested in the malformed frog phenomenon and the health of aquatic ecosystems. Lannoo’s thorough review of relevant literature, careful evaluation of the existing science, and accessible writing style make this book a worthwhile contribution to its field.

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