

Ecology, 98(12), 2017, pp. 3231–3232
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Monarchs and milkweed: An epic tale and royal controversy

Agrawal, Anurag. 2017. **Monarchs and milkweed: a migrating butterfly, a poisonous plant, and their remarkable story of coevolution.** Princeton University Press, Princeton, New Jersey. ix + 283 p. \$29.95 (cloth), ISBN: 978-0-691-16635-3 (acid-free paper); \$16.17 (e-book), ISBN: 978-1-400-884766.

Key words: coevolution; milkweed; milkweed limitation hypothesis; monarchs.

At a time when monarchs (*Danaus plexippus*) have gone from a ubiquitous, iconic insect to a species now in need of conservation, Agrawal's latest book comes at a critical moment. His book is an engaging and accessible synthesis of the biology of monarchs and their milkweed (primarily *Asclepias* spp.) community, and has the potential to transform interested parties into informed and engaged citizens.

The book reads like a novel at times, with Agrawal acting as a storyteller and weaving together his extensive knowledge of monarchs and milkweed, as well as the people behind various related scientific discoveries. Agrawal's style of writing is humorous, insightful, and most importantly, accessible. *Monarchs and milkweed* starts out with a dramatic flair, detailing the "handsome and heroic migrator" and its "evolutionary battle" with the milkweed plant. The first two chapters delve into background on monarchs, milkweed, and the author's journey to working on these two organisms. While Agrawal doesn't assume any monarch-specific background knowledge, he is adept at briefly providing relevant information and then presenting complex concepts in very understandable ways for a reader with even a basic level of scientific understanding. Chapter 3 details the chemistry of milkweeds, where Agrawal deftly explains milkweed cardenolides, from their molecular structure to their historical use as medicines, and the ability of monarchs to withstand these toxins.

A majority of the book is devoted to the monarch's annual cycle, including the parts of the year when monarchs are not using milkweed. Agrawal covers everything from autumn migration to survival at overwintering sites, with a primary focus on eastern North American monarchs (the most-well studied population with the longest migration). In examining the breeding season, the book returns to the relationship between

monarchs and milkweed, including a discussion on the ways monarchs have adapted to the many milkweed defenses, including trichomes and latex. There is also a chapter on the milkweed community, detailing the fascinating world of milkweed specialists that live alongside monarchs (and how these species relate to monarchs). While I wasn't expecting an entire chapter to be spent on this topic, it added context to the monarch and milkweed narrative and showcases the breadth of Agrawal's milkweed community knowledge.

The first eight chapters provide a compelling look inside the life history of monarchs, their relationship with milkweed and the milkweed community, and their impressive annual migration. Chapter 9 has a different feel, as this addresses an ongoing area of research, and one in which Agrawal diverges from many within the monarch scientific community: what is causing the monarch population decline? There is no doubt that monarchs rely on milkweed, and that milkweed has decreased in recent years. This massive loss of milkweed has been implicated in the decline (Pleasants and Oberhauser 2013) and is the focus of many conservation efforts. However, Agrawal's work has recently posited that the decline of monarchs is occurring during parts of the annual life cycle where monarchs do not rely on milkweed, and thus milkweed is not the limiting factor (Inamine et al. 2016).

Agrawal provides evidence for his hypothesis, but the focus on one side of this story could be detrimental to monarch conservation. Even though many scientists have evidence indicating that milkweed limitation is strongly linked to the decline, a layperson reading this chapter may come away believing that the science is settled and milkweed is not limiting. I did appreciate the disclaimer Agrawal gave about his work and the current scientific disagreement. It will be very interesting to see what this chapter looks like in the second edition of the book. I expect that with continued research, the entire monarch scientific community and conservationists throughout the monarchs' range will excitedly greet new information on population-limiting factors.

As for the design of the book, Agrawal has teamed up with a talented group of visual artists, resulting in stunningly beautiful representations of monarch biology. The care and detail displayed in the images greatly enhances the overall message of the book. Agrawal could have easily gone with stock photos to illustrate the many concepts he covers, but instead utilizes impeccable illustrations and unique photos to exemplify concepts, such as the different ways that birds consume monarchs at the

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overwintering grounds or the phenology of different insects that feed on common milkweed (*A. syriaca*). In addition to the new photography and artwork, Agrawal has clearly dug deep into the archives to find notable historical observations of monarchs in major newspapers and rare photos of monarch scientists and their work.

My only qualm with the setup of the book itself is a minor one. The book was made highly readable by not having citations throughout, but rather 22 pages of notes at the end. However, while these notes do provide many sources and supplemental information, there were also many times throughout the book when I read an interesting fact or a reference to a piece of research that had no follow up citation in the notes section.

A book like this is long overdue, and the time and effort that went into making this volume are apparent. *Monarchs and milkweed* will serve as a valuable reference, both for the amateur monarch enthusiast and the seasoned lepidopterist. Agrawal is also good about pointing out places where further research is needed, which would make this a particularly good reference for an undergraduate or new graduate student. This book is a stand-

alone tome on monarchs, but could easily be used as a case study in an ecology classroom. This book's appeal to both the general public and the scientific community is a testament to Agrawal's skill at presenting such breadth and depth of content, as well as to the charisma of the monarch itself.

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Ecology, 98(12), 2017, pp. 3232
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