REPTILES & AMPHIBIANS

BOOK REVIEW

Lizards of the World

Lizards of the World. Natural History and Taxon Accounts. 2020. Gordon H. Rodda. Johns Hopkins University Press, Baltimore, Maryland, USA. x + 801 pp. ISBN 9781421438238 (hardcover). ISBN 9781421438245 (ebook). $150.00.

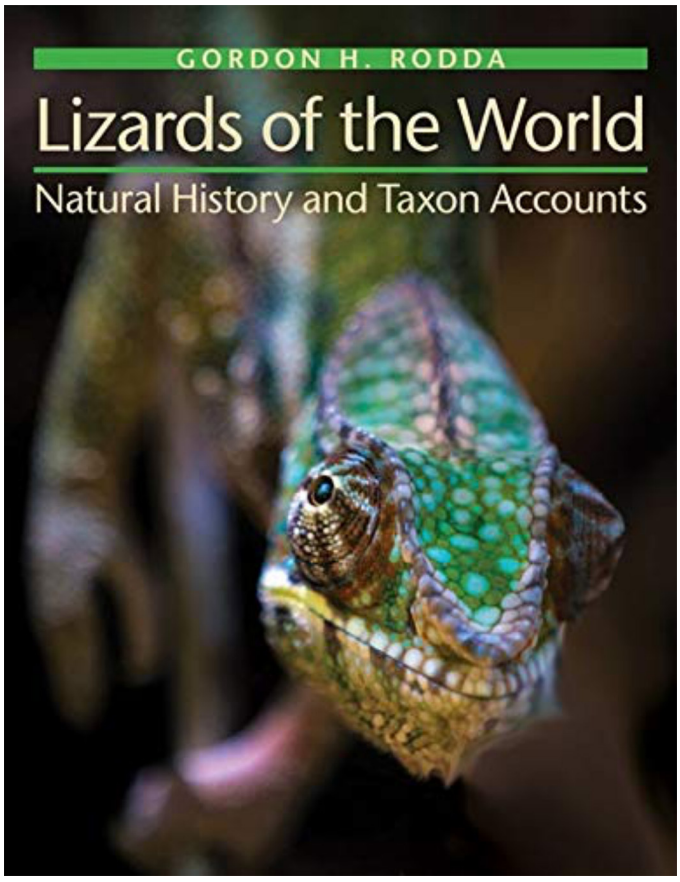
Gordon Rodda assembled this massive tome just for me. Not really — but he might have. I have been enamored by lizards since I took a herpetology class as an undergraduate. Bob Henderson, a good friend, once described our professional relationship by noting that I studied lizards and he studied the snakes that eat them. More than the general topic, however, this book also goes to the heart of my interest by focusing on natural history, the composite of all features and strategies that define how organisms make a living, reproduce, and interact with their environment. In short, I was thrilled by this book before I got past the cover.

After a dedication to Stan Rand, to which I will return later, the first chapter deals with methods, the second with defining a lizard, the third and fourth with linkages and "business models" (more on these below), followed by taxon accounts (which comprise the bulk of the book), acknowledgments, appendices, literature cited, and an index.

In the introductory chapter on methods, Rodda describes natural history as "a specialization that collects and tabulates … observations from nature and thereby provides the fodder for the discovery of causation." Once used to describe what we today call biology, natural history has in recent years taken a backseat to more specialized pursuits "because it only initiates the multidisciplinary inference of causation." Rather than jump on the bandwagon of more fashionable sources of acquiring knowledge, I laud Rodda for embracing natural history as fundamental to all we know about the organisms that occupy our world.

Rodda devoted eight years to compiling a massive dataset based on more than 140,000 citations from 5,045 unique sources to identify "the 170 most important natural history attributes" of lizards (more on these below). He closed that dataset to new species descriptions in May 2017, at which time 6,528 species of lizards were recognized ("about twice as many as in the year 2000"), a number that has grown to 6,905 species as of August 2020 (Uetz et al. 2020).

In developing his synthesis, Rodda described the primary purpose of this work as the description of lizards in relation to both "their taxonomic lineage[s] and their ecological associations," asking "to what extent is an individual lizard species' natural history a product of its phylogeny versus its ecological situation?" He follows this with a bulleted list of a few of the conceptual obstacles to answering that question: (1) Disentangling the end result of millions of interactions over millions of years between genotype and environment is very difficult; (2) uncertainties regarding the higher-level phylogeny of lizards are not resolved; (3) simplifying assumptions of evolutionary genetics, especially for the deepest and most ancient taxonomic divisions, is tenuous, particularly for highly labile traits such as many behaviors; (4) the web of more than 1,400 statistically significant correlations between



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natural history traits is so tangled that phylogenetically correct methods have difficulty analyzing them concurrently (and single-trait analyses are distorted by correlated factors omitted from those analyses); and (5) we lack critical information on the natural history of most lizards — and much of what we have is erroneous. Consequently, Rodda's suggestions of plausible patterns "should be viewed as first-approximation hypotheses that are only partially tested, completely untested, or novel."

In the second chapter, in which he defines lizards both taxonomically and ecologically, the latter entailing the "business models" that are addressed in greater detail in chapter 4. The factors that influence both taxonomy and ecology include morphology (size, shape, voice, tails, color, color change, blue tails), sexually differing traits (size, color, structures), geography (environment, habitat), activity (inactivity, activity, foraging movements, social structuring of spacing and movements, sex-based spacing), reproduction (parental care, timing, incubation, longevity, clutch/litter attributes, relative clutch mass ratio), diet, and populations. Rodda also looked at conservation status and introductions.

The third chapter focuses on linkages (i.e., correlations) between traits. Examples given by Rodda include the field "diel activity," which involves four mutually exclusive choices (diurnal, crepuscular, cathemeral, or nocturnal), and scansorial versus arboreal, which are correlated but not equivalent (all arboreal lizards are scansorial but not all scansorial lizards are arboreal). Noting that knowing relationships among traits is useful in understanding an individual species, Rodda addresses the question of why *Anolis cristatellus* possesses crests. Possession of crests is strongly correlated with lizards that are arboreal, sit-and-wait foragers, males larger than females, diurnal, ant eating (but not necessarily ant specialists), characterized by high population density, and sexual dichromatism. In this case, the example (*A. cristatellus*) is all of those things, raising the question "of why crests are so useful for species that are arboreal, sit-and-wait foragers, males larger than females, ant eating, and so forth." The bulk of this chapter is devoted to a series of tables listing significant correlates of various characters, after which, however, Rodda notes that these hypothesized linkages were not used in attempts to ascertain which factors were causes and which were effects.

In the fourth chapter, Rodda describes the ecological "business models" he uses in an "attempt to distill the patterns present in the database's array of natural history traits." He notes that these are similar to the concepts of a functional niche, a guild (albeit with less emphasis on feeding specialization), and ecomorphs, differing from the latter in generality (i.e., they "can be applied to all species of lizards in all localities, but as yet they lack the precise morphological correlates identified for anole ecomorphs"). For each of the 14 models (crack hermit, diurnal canopy walker, ground-foraging tree lizard, giant herbivore, glider, immobility expert, litter cryptozoid, nocturnal canopy walker, refugia-anchored diurnal ground lizard, subterranean forager, sand shark, trunk/wall lizard, and wide-ranging chemosensor), he provides a definition, implications, examples (with color and black-and-white plates illustrating selected species that exemplify a particular model), similar business models, and touchstones from the database (highest proportion of species exhibiting certain traits) supplemented by a multi-page table showing the mean values of 76 selected traits for each model. In the overview that ends this chapter, Rodda likens the search for structure in natural history traits organized by the tabulation of benefits (survival, growth, reproduction) and risks (mortality) to the benefit-cost analyses in business financial reports, suggesting that over time, "life histories consistently 'in the black' will diversify and those routinely 'in the red' will disappear." He also states that he believes that understanding the connections and independences of natural history traits is the "essence of knowledge, even if some species are exceptions." Additional benefits that accrue from applying these models are that "having convenient terms to summarize complex interrelations expedites the dialogue that will eventually uncover causation," "probing the correlations between traits is … useful for suggesting hypotheses about the ecology and behavior of species known only from the morphology of their fossil remains," and that the "models reflect behavioral and ecological biodiversity." The last two sentences in the chapter say it all: "Spending the time to watch how lizards forage and escape predation broadens our understanding of biodiversity conservation in a fundamental way. Moreover, it's fun."

Arranged alphabetically by generic name (with families interspersed), the taxon accounts, which occupy 578 pages, provide a general description of the species in each genus accompanied by a table with an English common name and core range for each species that also lists activity, diet, size (both length and mass), and the business model. The accounts of families list the species in that family and provide an overview of features and business models employed.

The appendices include: (A) database fields and comments on their tabulation, (B) methods for quantifying lizard sizes, and (C) standards for qualification of absolute population densities. The literature cited is largely restricted to "regional and monographic taxonomic works and the targeted natural history studies cited therein." To access the actual database and the full list of citations, one must go to the publisher's website (https://jhupbooks.press.jhu.edu/lizards-world-supplemental-materials), which provides free downloads. The index includes extensively used terms and common English names.

Did I love this book? Yes. Gordon Rodda has provided a wealth of information synthesized into a valuable and readily adaptable format that will provide a basis for further synthe-

ses of what we know (and don't know) about lizard natural history. However, several relatively minor tweaks would have made it far more easily used. Embedding the familial accounts among those organized by genus is counterproductive. Since the generic accounts are listed alphabetically rather than arranged into familial groups, having the familial accounts with the lists of genera in each family at the beginning rather than at the end would have been very helpful. The most frustrating aspect of the book, however, is that the index uses only common English names instead of the far more readily recognizable binomial nomenclature. English names have never been standardized beyond some regional lists (e.g., Crother 2017; Hedges et al. 2019) and those do not always coincide. Consequently, relying on common names renders the index essentially worthless and makes finding species-specific information difficult at best.

Staying on top of ever-changing taxonomies is difficult at best. To evaluate the currency and accuracy of the taxon accounts, I looked at the genus *Pholidoscelis*, a group with which I have been working. Despite the fact that Tucker et al. (2016) explained why the name *Pholidoscelis* must be treated as masculine, many of the specific names retain the feminine endings appropriate to *Ameiva*, the genus to which these species were previously assigned. Although not recognized at this time by the Reptile Database (Uetz et al. 2020), *P. alboguttatus* and *P. desechensis* are generally recognized as species distinct from *P. exsul* (Goicoechea et al. 2016; Tucker et al. 2016). Similarly, although *P. umbratilis* is still included in the Reptile Database (Uetz et al. 2020), based on the findings of Gifford et al. (2004) and their own results, Tucker et al. (2016) placed that taxon (which had been elevated by Goicoechea et al. 2016) in the synonymy of *P. chrysolaemus*, in which it still is recognized as a subspecies. The name *P. maynardii* is listed without the second terminal i, reflecting an unjustified emendation initially by Barbour (1914) and used by many others but first corrected by Buckner et al. (2017). Finally, the omission of *P. turukaeraensis* occurred simply because the formal description of this species (Bochatan et al. 2017) followed the May 2017 cut-off date for descriptions of new species. I suspect that this perhaps unfairly chosen example does not reflect the accuracy of other accounts but instead is attributable to a reliance on the Reptile Database (which is a trusted institution and usually very current) and a concentration on the natural history rather than the systematic literature. However, readers should be wary of relying on the taxonomy in the book without checking the most recent literature.

The scope and enormity of effort that Rodda invested in compiling and analyzing a vast amount of data have produced a valuable contribution that is well worth the rather hefty price and which should be on the bookshelves of every lizard biologist. Except for the concerns expressed in the previous paragraphs, the production quality is first rate and the plates are well executed (although for a book selling at this price, one wishes all of the plates had been in color — even professional herpetologists enjoy photographs). However, what I liked most was the consistent recognition, first expressed in the dedication to Stan Rand, that, despite the magnitude of information used to construct this synthesis of what we know about lizard natural history, we have much left to learn.

To the memory of Stan Rand,
A profoundly wise lizard ecologist, who listened intently to nature rather than asking it to conform to theory, promoted the discoveries of his students and colleagues in place of his own, and embraced the depth of our ignorance regarding the complexities of nature rather than trumpeting the small successes we have had in unraveling them.

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