Trends in
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Book Review

One Species at a Time: Cataloguing the Natural History of the Global Lizard Fauna

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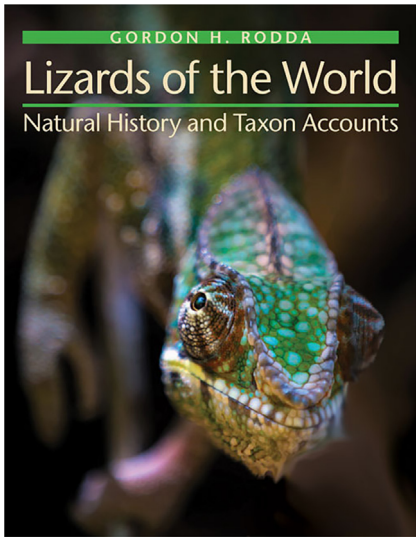

This book starts with possibly the most ambitious opening sentence I have ever read, 'I wish to describe for you the natural histories of all lizards'. I had to read it a few times to process that. Bear in mind, there are currently 6972 species of lizards globally (http://www.reptile-database.org). (Rodda covered 6528 at his cutoff). Rodda then explains how he focused on the 170 most important natural history attributes of a lizard, consisting of approximately 310 character states or conditions. This generated a data matrix of 1 109 760 cells, of which he had data for 27%, amounting to 299 635 cells. To say that this book represents a project of epic proportions is a vast understatement. I was surprised when he said he spent 8 years collecting the data. I thought it would take longer!

You might think, based on the title of this book, that a review is unlikely to be featured in a journal such as *TREE*. However, what makes this book different from similar taxon-based books is first that it covers the entire world's currently known lizard fauna, and second, in putting this book together, Gordon Rodda assembled a massive database of character traits around which the book centres and which he used to identify character syndromes in lizards. These traits include morphological characteristics, abundance, reproductive strategies, diet, and other life history and social attributes. What is the goal of this endeavour? Rodda explains that he wishes to improve our understanding of the deep structure of natural history traits. By simplifying highly complex relationships, we can facilitate discussion about patterns we see in nature and make connections a little more easily. Importantly, this approach can go a long way in helping us understand causation and to formulate new hypotheses in the process. It is worth noting that a similar, albeit smaller, database was published by Shai Meiri [1] for 6657 species and largely focused on lizard life history traits, including thermal and conservation data. One advantage of Meiri's dataset is that it is anchored to a centroid set of coordinates, which allows for spatial analysis (Rodda did not do this for reasons he explains). Meiri's dataset has already been used in multiple studies, highlighting the importance of large comparative datasets.

The book is 801 pages and consists of only five chapters because chapter 5 consists of species accounts for the global lizard fauna and may set a record length for a single chapter (578 pages!). Chapters 1–3 and three appendices detail the methods used to assemble the database, what characterises lizards, the properties that emerge from seeking correlations among traits, and an enormous reference list (>140 000 citations). In Chapter 3, where Rodda seeks 'linkages' between traits, he provides 15 tables examining correlations among traits and a series of 'conditions'. For example, one table examines five categories of diet (carnivore, herbivore, invertebrate eater, ant specialist, and omnivore) and whether they correlate with any of 53 conditions [e.g., sit-and-wait forager, cruise forager, active forager, longevity, introduced, International Union for Conservation of Nature (IUCN) listed, etc.]. An overwhelming number of relationships are dealt with here. As you would expect from an exercise of this nature, a large number of correlations emerge, and Rodda has to sometimes dig deep to provide a possible explanation. There is an inordinate amount of information packed into this chapter that could be useful for anyone embarking on a new research program or that wants a fresh look at an old problem.

Chapter 4 culminates in the overarching aim of the book, to distil this wealth of natural history into 'business models', the rough equivalent of a functional niche [2] or a guild [3] but without the emphasis on diet. The question being, do patterns in natural history traits cluster in a way that allows for the discrimination of an 'ecotype' (i.e., business model) of sorts? The system that comes to mind is the anoles. Anole ecomorphs are defined by well-established links between habitat and morphology [4]. However, Rodda's aim is to apply a model to 'all species of lizards in all localities', and, to accomplish this, he sets aside morphology and instead focuses on microhabitat use, foraging behaviour, and social/territorial interactions (eight traits in total). In any large-scale, big picture endeavour, we are ultimately constrained by gaps in data. In this case, although we know lots about lizard habitat use and where lizards are found, there are few data on where lizards actually forage. This made unequivocally assigning lizards to business models challenging; only 13% of lizard species have behavioural observations that allowed for this.

How do Rodda's business models compare with past efforts to understand lizard ecology (e.g., [5–7])? Historically, one of the major goals of lizard ecologists was to

understand how species coexist [8,9]. To do this, they sought to understand the role of competition and how that was ameliorated through resource partitioning, especially in diet [10]. Other approaches include incorporating phylogeny or deep history [6] and niche differentiation using >50 variables for five major niche dimensions (habitat, diet, life history, metabolism, and defence) [7]. These studies are important classical ecological approaches. Rodda takes a fresh approach in order to understand how lizards balance predation risk against food intake, and this is the basis for a 'business model' in much the same way a business plan balances costs against benefits. In this case, the cost is any exposure to predation risk, such as movements for foraging or mating benefits. It is therefore not the classic energetic approach taken by physiological ecologists. Taking this approach, Rodda is able to build 14 business models in which various combinations of risk and food intake allow for a scoresheet in the 'black' (i.e., benefits offset risks over a lifetime).

Examples of these business models include the 'sand shark', so named because it spends most of its time below ground in sand or loose soil but captures prey at the surface. Only 1.9% of species fitted this category, which had the third lowest number of species after 'glider' (1.2%) and 'giant herbivore' (1.6%). The largest number of species (24.5%) were allocated to 'refuge-anchored diurnal ground lizard', with the second most speciose category being 'trunk/wall' (13%). The message here is that besides refuge-anchored diurnal ground lizard, there are no categories that are particularly speciose. My only quibble with the names of business models (and they do very effectively capture the lizards' biology) is that the word 'lizard' was used in four cases. Every business model describes a group of lizards, so either use lizard in every case or not at all. Having allocated lizards to business models, Rodda provides a definition for each business model, a description (termed implications), examples, similar business models, and traits that best define the business model (touchstones from the database). Rodda then presents tables relating many of the morphological, life history, and behavioural traits in his database to each business model.

How robust are the business models? Species that are diurnal and terrestrial can potentially be allocated to seven different models. Rodda also notes that his focus is adult lizards, but juveniles may fall into a different model than adults. Mistakes will no doubt occur given the uncertainty behind allocating poorly known species and because there is overlap between categories. Rodda does point out that these business models should be regarded as hypotheses. Although he uses empirical data to create these models, he is not using any type of sophisticated statistical modelling to verify or test them. There is no question that any such analysis would be very challenging given the nature of these data. For example, predation risk is largely categorised based on intuition. Rodda subjectively allocates each business model to one of seven categories of 'relative predation risk per hour foraging', ranging from extremely low to extremely high. With the age of reproducibility upon us, we do need to carefully consider how we curate data, consider uncertainty, and track any changes to dynamic databases (e.g., using version control software). In the case of both Rodda's and Meiri's datasets, two highly accomplished biologists have used their many years of experience and a deep knowledge of their study organisms to sometimes make decisions about allocation or inclusion. This exercise, by its very nature, may not be clear, thereby making it inherently difficult for others to replicate. With time, hopefully the database will expand, gaps will be filled, and the next generation of lizard biologists will apply sophisticated analyses to test these hypotheses while considering uncertainty. In the meantime, Rodda has given us a new framework for thinking about lizard natural history, and he has built an incredible database that is a rich resource that can be mined for years to come, although common fields should be reconciled with that of [1]. Any scholar of lizard biology or natural history should think of adding this book to their library. It will be a wonderful resource for years to come.

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Declaration of Interests

No interests are declared.

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