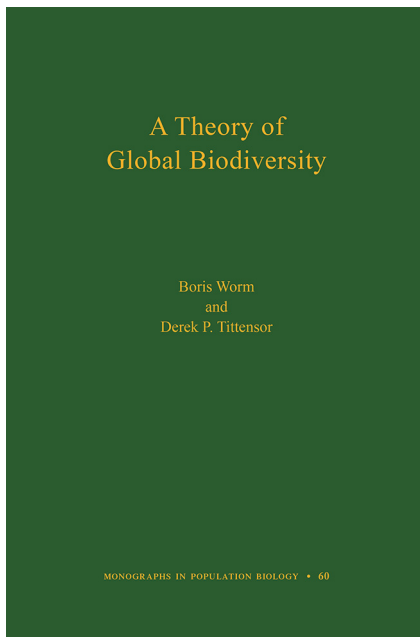


Book Review

What Explains
Latitudinal Diversity
Gradients?Matthew W. Pennell^{1,*}

The latitudinal diversity gradient (LDG) is the most pernicious of problems. The fact that it is so obvious and so general – the overabundance of species in the tropics was recognized long before there were even ecologists around to describe it – strongly suggests that the explanation should be a simple one; yet distinguishing between alternative simple explanations has proven, well, complicated. However, as Worm and Tittensor (hereafter W&T) remind us in their new book *A Theory of Global Biodiversity* [1], there is not one, but many LDGs: different environments and different taxa show a variety of patterns, both today and throughout geological history; of course for many taxa, diversity is highest at low latitudes, but

there is considerable variation around both the mean and variance of these distributions. This diversity of diversity gradients may provide biologists with the clues and statistical power to tease apart the influence of various causes.

In their book, W&T curate an incredibly vast dataset of species richness by site and walk the reader through many taxon-specific diversity gradients in four broad types of ecosystems. One of these four is terrestrial and the other three – coastal, pelagic, and the deep sea – are marine. This whole earth catalog is delightful reading even without the theoretical context; I learned a tremendous amount about what lives where and was also taken aback by just how little we know about a large portion of our planet (surveys of deep sea diversity are particularly sparse; we are just starting to uncover major new biodiversity patterns [2]). With this distributional information in hand, W&T comb through the literature and evaluate global associations between diversity and environmental correlates; this is also a valuable synthesis of a dizzying array of data and hypotheses. Through all of this, they identify three drivers of diversity that appear over and over again in many groups and environments: temperature, area, and productivity.

So how does one take this information and formulate an explanation for diversity gradients? W&T's approach is to construct a novel simulation model containing a minimal set of parameters that tie into each of the drivers they have identified and then try to recapitulate (relative) biodiversity patterns by running this model across a geographical landscape modeled after the real world (see [3] for a review and discussion of similar simulation models).

Where things get tricky is that, as W&T repeatedly acknowledge, an apparent driver, such as temperature may be

underlain by a variety of mechanisms. In their model, speciation happens faster at higher temperatures and this scaling relationship, along with allowing larger and more productive areas to contain more individuals is sufficient to 'generat[e] fits to empirical data that are within the range of statistical non-mechanistic models' (p. 146). This is certainly an intriguing result, but in my view, W&T overinterpret this as evidence that temperature influences diversity patterns via diversification rates; there are likely many ways that the model could be formulated such that areas of high temperature also harbor high diversity and these alternative formulations might be more consistent with other lines of theory and evidence. Support for the hypothesis that temperature is causally linked to higher rates of molecular evolution or diversification rates [4] is mixed at best [5]; in fact, a number of recent studies have shown that at least the latter may be faster in temperate regions [6,7]. Endotherms, and terrestrial endotherms in particular, are the rule that prove my exception. Unlike with ectotherms, there is not even a theoretical expectation that environmental temperature should influence molecular rates. However, since including this is necessary to make their model fit the data for these groups, W&T are forced into the awkward position of speculating that there might be 'an unexplained mechanism that links temperature to evolutionary rates in endotherms' (p. 142). To me, a better path forward would be to consider alternative ways that temperature and diversity could be linked beyond a direct link to speciation rates.

But overall, while I quibble with some of details of this particular model, I love the idea and ambition behind it. As the title modestly implies, this is a theory of global biodiversity and not the theory. I can imagine – and hope for – many other possible models of global biodiversity;

each one containing a different set of processes and held together by a different set of assumptions. Once synthesized, results from these alternative constructs will hopefully help us gain a deeper understanding of the ecological and evolutionary processes that have generated the large-scale patterns which have enthralled us for so long.

A Theory of Global Biodiversity (MPB-60) by Boris Worm and Derek P. Tittensor, Princeton University Press, 2018. 978-0-691-15483-1, US\$49.95/£40.00

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