

## Book Review

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**Systema Naturae 250—The Linnaean Ark.**—Andrew Polaszek, editor. Boca Raton, FL: CRC Press, 2010. xvi+276 pp. ISBN 978-1-4200-9501-2. \$99.95, £63.99 (hardcover).

Taxonomists (myself included) have a reputation for whining (Smith 2008; Wheeler 2008). It was therefore with some trepidation that I approached *Systema Naturae 250—The Linnaean Ark*, a series of essays exploring the history and future of zoological nomenclature. This book was born from a symposium of the same name held in 2008 to celebrate 250 years since the publication of the 10th edition of Linnaeus' *Systema Naturae*. Edited by Andrew Polaszek, in his then capacity as Executive Secretary to the International Commission on Zoological Nomenclature (ICZN), this new volume charts the birth of modern nomenclature, from Linnaeus, through his contemporaries like Charles Davies Sherbon, up to present day nomenclatural issues relevant to initiatives like DNA barcoding, the Encyclopedia of Life (EOL), and the future of web-based taxonomy.

Polaszek introduces the volume as a 'Linnaean Smörgåsbord,' held together under the unifying theme of celebrating a quarter millennium of naming animals. His analogy is particularly apt since *Systema Naturae 250* has several characteristics in common with a buffet-style Scandinavian meal. The topics of its 17 chapters have little thematic arrangement, are written in a range of literary styles and, although they are mostly quite digestible, include a few pickled herrings for those with more acquired tastes. The subjects cover social and scientific history, informatics, publishing, funding practices, digitization, taxonomic workflows, and conservation biology, to name but a few. Eighteenth century history abuts contemporary taxonomic theory; speculative ramblings are sandwiched between reasoned judgments. Despite this assortment, the arrangement does not detract. I suspect that few people read edited volumes cover to cover, and those who do are sufficiently engaged with the subject not to care. The variety of topics illustrates the reach of zoological nomenclature as a foundation for understanding biological diversity. To this end, this topical diversity is fully justified, even if a little more thematic arrangement would not have gone amiss.

For a scientific method that had endured for more than 250 years, it is only fitting that there is a heavy dose of historical narrative in this collection. David Quammen kicks this off with an evocative chapter on the early history of Carl von Linné. Written as a coming of age story, Quammen's short chapter is packed

with expressive details of Linnaeus' early life, hinting of a future that was to mark Linnaeus out by something greater than was suggested by his early career as a botanist. Linnaeus became a global encyclopedist of flora and fauna, but this was only possible thanks to a network of scholars supplying him with specimens. Chief among these were his 17 "apostles." Linnaeus furnished his students with the means to collect material on his behalf, but most never lived up to his expectations. In fact, 7 barely lived at all, dying before they returned from their expeditions.

A particular disappointment was Daniel Rolander, who returned with a substantial collection of plants and insects but never gave any to Linnaeus. In a separate chapter, James Dobreff attempts to rehabilitate Rolander's reputation in a biography that builds on several years of historical detective work, translating Rolander's original journals and rediscovering his specimens. Dobreff presents a convincing case that Linnaeus unjustly maligned Rolander. His extensive work ably demonstrates Rolander's skills as a naturalist and author. Linnaeus effectively blackballed Rolander, his anger so great that at one point, during a fit of rage, Linnaeus broke in to Rolander's home to steal the disputed specimens. Rolander was unable to gain an academic position and did not publish his findings, gradually drifting into obscurity and poverty. Through Dobreff's efforts, Rolander's reputation is being restored.

Unquestionably, the most substantial historical tome in this volume is the chapter by Benoît Dayrat. In more than 50 pages, this tour de force gives a detailed historical account of the debates on zoological nomenclature that define current taxonomic thinking. Linnaeus is famed for establishing the principles of nomenclature that promote stability of taxonomic names. But Dayrat dispels the perception that these principles are static by charting the contentious, and often vitriolic, debates that have helped to shape zoological nomenclatural rules. Throughout the past 250 years, even sacred cows like the Linnaean binominal form of species name remain deeply divisive. Notwithstanding recent developments like the Phylocode, daring proposals for new forms of species name occurred in the 1950s and 1960s, when numerical taxonomy was the cause of intense debates in systematics. Various systems of "nomenclature" were proposed (e.g., Hull 1966; Michener 1963), some of which encoded systematic, hierarchical, and phenetic characteristics into uninominal species names. This work echoes some attempts during the late 18th century to encode morphological characteristics

of organism into unusual (and quite unpronounceable) names, in an effort to promote nomenclatural stability (e.g., Bergeret 1783–1785). Although the intensity of these debates may be sociologically regrettable, challenging scientific discussions should not be viewed as a bad thing. Many of the nomenclatural codes charted by Dayrat share important goals, and even now one should not exclude that they could potentially be reconciled or, more likely, coexist to influence each other. The first president of the ICZN made this clear when he wrote “the code that seems to us to appropriately answer our current concerns will be regarded as inadequate by our successors. Science moves forward: it asks new questions, for which new solutions must be found” (Blanchard in ICZN 1905, p. 11).

Blanchard’s concern is perfectly illustrated by Schindel and Miller, who bring the issues up to date in their examination of the nomenclatural challenges presented by DNA barcoding. The scale of collection efforts being undertaken by barcoding projects (approximately 900,000 specimens for 72,000 formally described species), and the lack of trained taxonomists capable of sorting and identifying this material (approximately 6000 professionals worldwide; Wilson 2004), is creating a perfect storm for traditional zoological nomenclature. Browse the pages of this and similar journals and it is clear that an increasing number of “operational taxonomic units” are identified by nothing more than a specimen or voucher number and perhaps a generic name. Despite the protestations of many (e.g., Wheeler 2008), this is the likely shape of things to come. As Schindel and Miller note, formal taxonomic names that comply with nomenclatural codes are not the only medium for information exchange. Other forms of labels can not only convey the results of different forms of biological research, but can also dramatically accelerate the progress of describing and documenting taxonomic biodiversity. To achieve these ends, these labels need to be unique, stable, and (in my view) independent of the formal systematic concepts that they might otherwise convey. Only this way will they be able to provide a precise, stable, and enduring meaning. Such thoughts may be heretical to some, but this need not be the death knell for taxonomy. These labels could sit harmlessly alongside our traditional nomenclatural schemes while they prove their worth. Arguably they already exist in the form of GenBank accession numbers.

One potential vehicle for delivering changes to the nomenclatural codes is ZooBank, the ICZN’s official registry of zoological names. Two chapters are devoted to this Web database. Polaszek and Michel (past and present ICZN Executive Secretaries) chart the road to ZooBank, whereas Pyle and Michel review the first year of operation. The fundamental concept behind ZooBank as a register of animal names is so simple that the uninformed might scarcely believe it has not already been done. But as Pyle and Michel note, the detailed implementation of ZooBank raises many issues. Indeed, inadequacies of related initiatives (Species2000,

Integrated Taxonomic Information System, and the Zoological Record, to name but a few) highlight the enormous sociological challenge and effort needed to make ZooBank a success. Polaszek and Michel draw on historical comparisons with efforts to build indices of animal names. Examples include completely independent efforts of Schulze and Neave to provide precisely the same list of all animal genera (a lesson in duplication that some current initiatives could do to learn) and Sherborn’s (1902–1933) monumental efforts to write his *Index Animalium*.

The chapter by Pyle and Michel details the more practical minutiae of building ZooBank. Issues include the precise form of unique taxon identifiers, the definition of “registration” and the scope of what should be registered. A quick look at the current ZooBank Web site (<http://www.zoobank.org/>) suggests that some of these issues have at least been partially addressed since the publication of these chapters. Nearly 73,000 nomenclatural acts have been registered in ZooBank since 2008, although all but a fraction are retrospective registrations that predate ZooBank’s inception. With 16–24,000 nomenclatural acts published annually (some estimates put this figure as high as 30,000; see Polaszek and Michel 2010), it is hard to see how the manual processes of entering records can keep pace with the volume of new names. Mandatory registration might be enforced by the ICZN as a condition of formalizing a nomenclatural act. However, this risks testing the authority of ICZN at a time when ZooBank is in its infancy. To greater effect, publishers need to integrate their activities with ZooBank, such that registration is a service provided to the author as part of the publication process. There are signs that this is already happening among publishers who have a deep and vested interest in this area. Pyle and Michel report that the publishers of *Zootaxa* and *Zookeys* are actively engaged in the development of ZooBank; and I know from recent personal correspondence with Pensoft (publisher of *Zookeys*) that prospective ZooBank registration is likely to become obligatory for nomenclatural acts published in their journals in the near future.

How electronic publication might interface with registration of names is an issue touched on in one of two chapters on taxonomic publishing. Sandy Knapp and Debbie Wright pose the question “e-Publish or Perish?” in their chapter that examines the main issues besetting the acceptance of electronic publication for nomenclatural acts. As our published world has become increasingly digital, taxonomists have been left behind by ICZN and International Code of Botanical Nomenclature (ICBN) rules that effectively dictate “ink on paper” as the only acceptable medium of publication. Knapp and Wright examine issues concerning archiving, accessibility, the date of publication, and the type of electronic medium in taxonomic publishing. Despite their optimism that these issues can be resolved, they are decidedly reluctant to suggest that taxonomic publications are currently ready to exist in a wholly digital

medium. Instead, they pose a series of challenges that must be addressed, before this transition can take place. To my mind, initiatives like ZooBank are made to take on these challenges, and it therefore seems unfortunate that ZooBank, publishers, and ICZN are not closer to solving these problems. In some quarters, I am not even certain that ZooBank is recognized as a possible solution. At first sight, recent events such as Knapp's publication of 4 new plant species in an e-only journal, *PLoS One* (Knapp 2010), appear to bring us one step forward, until you read the footnotes to discover that Knapp had to print out and send paper copies of these articles to 10 major libraries on the day of publication to remain compliant with the ICBN codes. This is hardly a scalable solution to the problem of accepting electronically published nomenclatural acts; surely stakeholders can do better than this?

Without question, one indisputable publishing success in the field of zoological nomenclature is the taxonomic mega-journal *Zootaxa*. In a chapter by Zhi-Qiang Zhang, *Zootaxa*'s chief editor and founder describes how this publishing sensation has come from nowhere in 2001 to dominate the taxonomic publishing landscape as the world's largest taxonomic journal. *Zootaxa* by 2007 accounted for 14% of all new taxa indexed in the *Zoological Record*, represented 12.5% of all papers in the Zoology category of ISI's Science Citation Index, and accepted more than 1000 taxonomic papers. To put this into perspective, *Zootaxa*'s closest rival (*Journal of Natural History*) currently accounts for just 1.6% of all described species (Thomson Reuters 2010). *Zootaxa* was founded because it was becoming increasingly difficult for taxonomists to publish purely taxonomic works in mainstream biological journals. Coupled with this, most taxonomic publishers were providing poor levels of service. It was not uncommon for authors to wait a year or more before taxonomic manuscripts came to print, and publishers were doing little to promote these journals that were often very expensive for libraries to purchase. *Zootaxa* addressed these issues by embracing the web and thus reducing publication costs; speeding up the publication rate by building an extensive network of editors to manage review, and streamlining publication in small issues after acceptance; keeping a low cost base such that there are no page charges or a small fee to support open access; and crucially offering the flexibility to publish manuscripts of any length, so long as they pass peer review. This allows *Zootaxa* to publish specialist monographs that might not otherwise have been printed due to the recent decline in institutional monograph series. In effect, *Zootaxa* has helped defragment the publishing landscape for zoological taxonomy, making taxonomy findable, and enabling the discipline to benefit from the network effects of increased collaboration.

Despite the success of *Zootaxa* and new comparable journals like *Zookeys*, online versions of taxonomic publications are for the most part still presented as static PDF documents, with the Internet used primarily as a convenient distribution medium for the text. In fact,

very few publishers have embraced the radically different forms of publishing afforded by new and increasingly web-based technologies. In a chapter on new tools to accelerate the taxonomic process, Johnson challenges this model, highlighting a series of databases that have been integrated into the workflow of platygastrid wasp taxonomists, enabling researchers to rapidly conduct taxonomic revisions and simultaneously generate taxonomic treatments for publication. The principles behind this are not new. Initiatives like DELTA (DEscription Language for TAXonomy) have supported the automated compilation of taxonomic keys and revisionary publications from databases for some time (Dallwitz 1980). What has changed are two things. First, software tools have become easier to use, offering an integrated experience for the taxonomist that supports the entire taxonomic workflow from project inception to publication. Second, these tools are on the Web, supporting more collaborative efforts in generating and publishing taxonomy. The taxonomic process becomes streamlined through efficient reuse of data (e.g., previously published literature and specimen-level documentation) supporting the production of new revisions. Whether the tools Johnson and his colleagues are building scale to the whole of the taxonomic community is a matter of some debate. As a general rule, it takes 10 times as much effort and funding to build robust scaleable software as it does to demonstrate a principle (Atkins et al. 2010). Also, hymenopterists have a long tradition of databasing their work with sufficient structure that it can be efficiently reused. Nevertheless, Johnson and his colleagues are treading new ground as they show that the components of taxonomic publications can be implemented as collaborative database applications.

From Johnson's approach to publication, it is a short conceptual step to entirely electronic, dynamic taxonomic publications. The mode by which papers might be consumed includes not only human readable text, but automated extraction through data mining and semantic enrichment. These can support new aggregations of data (mashups), reusing and synthesizing information on demand in ways that are not possible by using the traditional concept of fixed, static publications. This vision (or at least part of this vision) is the subject of several chapters that examine the future of taxonomy. Wheeler makes a passionate case for embracing new technologies that address the scale of the challenge facing taxonomists. But for all his passion, there is little practical advice in his text. Hanken fares a little better with his description of the Encyclopedia of Life, especially with respect to their scanning and digitization work under the banner of the Biodiversity Heritage Library. However, I am justified in saying that the current EOL experience is underwhelming for both taxonomists and the general public. Patterson provides a beautifully articulate précis of the problems of taxonomy, but argues that these can be solved through better modeling and "unionizing" taxonomic names. The details of this approach might generously be described

as “fuzzy.” Likewise, Remsen argues that we should start by indexing all genera, but for reasons that escape me.

Overall, the smörgåsbord of *Systema Naturae 250* is a fitting tribute to the past 250 years of zoological nomenclature. This book justly celebrates the enormous accomplishments of the taxonomic community in cataloging almost 1.5 million animal species, and a method of scientific inquiry that has endured for more than a quarter of a millennium. This is illustrated in the book’s final chapter, in which Fredrik Ronquist reminds us that the birthplace of Linnaeus still has an active role in modern taxonomy through the work of the Swedish Taxonomy Initiative. The positive outlook presented by Polaszek and colleagues is especially encouraging from a discipline that at times has an unfortunate tendency to focus more on what it has not done, than on what it has achieved.

Most of all, *Systema Naturae 250* reminds us that taxonomy is an information science, drawing on an enormous and diverse collection of data to build a coherent picture of the extent and trajectory of life on earth. Taxonomists are beginning to face up to the magnitude of this task with technical approaches that scale to the challenge; they are addressing the fragmentation of their output by redefining what it means to publish; and it is doing this with less, not more. Fewer researchers, less funds but greater efficiency. Like Linnaeus, the next generation of taxonomists will still be the synthesizers—people able to put together the right information at the right time to document the natural world. What has changed is the scale, speed, and mode of disseminating this work. Through these endeavors, taxonomy has the chance of reaching a new audience. It is this new

audience that will likely dictate whether taxonomy survives the next quarter millennium.

#### REFERENCES

- Atkins D., Borgman C., Bindoff N., Ellisman M., Feldman S., Foster I., Heck A., Heermann D., Lane J., Milanesi L., Paraki J., Szalay A., Tackley P., von Rden W., Wensink H., Ynnerman A. 2010. Building a UK Foundation for the Transformative Enhancement of Research and Innovation. Report of the International Panel for the 2009 Review of the UK Research Councils e-Science Programme. Research Councils UK, p. 69.
- Bergeret J.P. 1783–1785. *Phytonomatotechnie Universelle*. Paris (France): Chez l’ auteur, Didot le jeune, Poisson.
- Dallwitz M.J. 1980. A general system for coding taxonomic descriptions. *Taxon*. 29:41–46.
- Hull D.L. 1966. Phylogenetic numericulture. *Syst. Zool.* 15:14–17.
- ICZN. 1905. *Règles internationales de la nomenclature zoologique*. Paris (France): F.R. de Rudeval.
- Knapp S. 2010. Four new vining species of *Solanum* (Dulcamaroid clade) from montane habitats in tropical America. *PLoS ONE* 5:e10502. doi:10.1371/journal.pone.0010502.
- Michener C.D. 1963. Some future developments in taxonomy. *Syst. Zool.* 12:151–172.
- Polaszek A., Michel E. 2010. Linnaeus-Sherborn-Zoobank. In: Polaszek A., editor. *Systema naturae 250—the Linnaean ark*. Boca Raton (FL): CRC Press. p. 163–172.
- Sherborn C.D. 1902–1933. *Index animalium* (8 volumes). London: C.J. Clay & Sons.
- Smith V.S. 2008. A review of “The New Taxonomy”. *Syst. Biol.* 57:660–663.
- Thomson Reuters. 2010. Thomson Reuters’ Zoological Record metrics. New York (NY): Thomson Reuters. Available from: [<http://www.organismnames.com/metrics.htm?page=tsj>].
- Wheeler Q.D. 2008. Taxonomic shock and awe. In: Wheeler Q.D., editor. *The new taxonomy*. Boca Raton (FL): CRC Press. p. 211–226.
- Wilson E.O. 2004. Taxonomy as a fundamental discipline. *Philos. Trans. R. Soc. Lond. B.* 359:739.
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