2014-09

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http://hdl.handle.net/10026.1/12067

10.1080/00219266.2014.926653
JOURNAL OF BIOLOGICAL EDUCATION
Informa UK Limited

What's in a name? – What have taxonomy and systematics ever done for us?

There is increasingly little doubt that we are in the midst of an anthropogenically driven extinction event which may end up rivalling the mass extinctions of the geological past (Barnosky *et al*., 2011). Increasingly the world's natural and semi-natural habitats are being irreversibly transformed by human populations, meaning that much of global biodiversity is under threat (see Caro *et al*., 2011 on remaining intact ecosystems). Given this "biodiversity crisis" and the fact that biodiversity is ultimately essential to human survival on this planet (e.g. Juniper, 2013) one might expect that the basic science underpinning the study of biodiversity would be a priority worldwide. Unfortunately, with a few exceptions, one would be wrong – and indeed a so-called "Taxonomic Impediment" has been recognized as a major obstacle to biodiversity research for over two decades (Wilson, 1988; Riedel et al., 2013). The fact remains that despite much time devoted to discussing the problem and its possible solutions (e.g. House of Lords Science and Technology Committee 1992, 2008; Deans *et al*., 2011) we are still not training enough people in taxonomy, nor are we employing enough taxonomically-orientated biologists in universities. Some of the educational consequences of this have been discussed before, including in the pages of this journal. Leather and Quicke (2009) point out how a limited study of organismal biology in many modern university curricula translates through to a lack of natural history knowledge in schoolchildren, as it results in biology teachers with limited knowledge of the wider diversity of life. Here, rather than revisiting these arguments I instead focus on some of the perhaps lesser-known academic, educational and societal benefits of systematic biology, as well as highlighting what I believe is the major remaining obstacle to taxonomy and systematics, and their benefits, being better embedded in the modern biology curriculum. It is important to remember that taxonomy is about more than simply giving a name to an organism, and adding this name to a list. Species names are hypotheses, these hypotheses forming the basic currency of comparative biology, a science which allows us to better understand the natural world, and our place in it.

If taxonomy is the science of describing and naming organisms, then systematics studies their inter-relationships. In practice, the divide between these two disciplines is largely artificial (Enghoff, 2009); most taxonomic treatments combining descriptions with discussions of phylogeny, and these now routinely relying on both morphological and molecular data in the case of living taxa. Scan some papers in a leading taxonomic journal such as *Zootaxa* or *Phytotaxa*, and you'll see that these are anything but dry, dusty works listing species names. Instead most treatments are truly integrative, combining systematics with other aspects of an organism's biology, biogeography and natural history – vitally important in its own right, and just the stuff which is required for any further serious scientific study, or evaluation of conservation status for example.

As well as sometimes being misconceived as boring (e.g. Leather and Quick, 2009), taxonomy and systematics are frequently dismissed as unscientific; more akin to stamp collecting than science (e.g. Godfray, 2002). Such a view couldn't be further from the truth (Wheeler, 2004; Sluys, 2013). Species and other taxa are from their outset *hypotheses* about natural entities and their interrelationships, which are tested with evidence. In addition, taxonomy *integrates* evidence from numerous sub-disciplines and levels of organisation within biology. As a result, many of the best taxonomists are well-versed in the modern 'omic' approaches, and in addition have to be well-read scientists. In an intellectual and educational sense, such integrative taxonomy forces the student to evaluate multiple lines of evidence, and make sense of conflict and incongruity between them, such as is often found between molecules and morphology when delineating species (see Monaghan *et al*., 2006 for an excellent example). In a wider sense, the demarcation of species provides a challenge which can be traced back to the earliest origins of modern philosophy (Wilkins, 2009). Are species real or a human construct – an attempt to simplify and pigeonhole the world? If species do exist as discrete entities, what maintains them, and are such processes the same across organisms as diverse in their biology and reproductive mode as cyanobacteria and seabirds? Such questions go to the heart of biology, and indeed the way in which we, as humans, see with the world, as well as clearly meeting many of the higher-level descriptors required for a good university education.

A sound taxonomy, based on evolutionary reality, also tells us something about ourselves – the fact that we are classified in the Hominidae, together with other great apes, informs us on the identity of our closest ancestors. A wider appreciation of where we sit within the species diversity of the Animalia gives us a clear sense of our place in nature – one small branch on the evolutionary tree, and one which has sprouted from a small shrub, overshadowed by a forest of insects (Grimaldi and Engel, 2005). Teaching biological classification in a way which is based on evolution may present challenges for teachers, such as which particular view is the most 'correct' (Reiss and Tunnicliffe, 2001) – largely an issue about the extent to which the curriculum should keep up with research developments in the post genomic era - but use of such a scheme uniquely allows the learner to appreciate where they fit into the natural world. Too much school biology is, like the UK National Curriculum (https://www.gov.uk/government/collections/national-curriculum#curriculum-by-key-stages) dominated by consideration of a handful of species, mostly vertebrates and flowering plants. The same has become true of many university courses, reinforcing the situation (see Wilson, 2000; McGlynn, 2008). Part of this shift away from organisms results from recent technological paradigm shifts in biology, and the desire of university educators to embed these in their degree courses. It leads to a focus on sub-organismal processes, typically studied in a handful of model species. Not everything in biology can be learned from the study of a limited number of such model species, however (see Bennett, 2003), and an appreciation of biodiversity and our place in it has wider societal benefits, including helping people reconnect with nature.

We are, apparently, spending less time in nature in many of today's societies. Studies in the USA and Japan have, for example, identified a significant shift away from nature-based recreation in the last 20 years (Pergams and Zaradic, 2008). As Arnold (2012) points out, from 1997 to 2003 the amount of time American children aged 9 – 12 spent on outdoor activities dropped by 50%. Member of this so-called 'Net Generation' who are now filling university classrooms, are increasingly disconnected from nature (Arnold, 2012), this disconnect posing a number of potential dangers. In addition to the physical value of nature-based recreation, spending time with nature can apparently reduce the severity of attention-deficit hyperactivity disorder symptoms (Kuo and Faber Taylor, 2004), increase self-esteem (Pretty *et al*., 2005) and reduce stress (Wells and Evans, 2003). According to an increasing number of people, most famously the author Richard Louv (2005, 2011), these things are part of a broader phenomenon which has been termed Nature Deficit Disorder. An understanding of where we fit in the natural world, together with the natural history study which goes alongside taxonomy and systematics, can serve to increase our connection with wild organisms and places, something which is increasingly difficult in urbanised societies. Study of the diversity of life, including organisms which do things quite differently from ourselves, has the potential to add 'the strange and the beautiful' to the biology curriculum (Rowland, 2007), and if children are exposed to this early on they often remain hooked. Simple exercises such as the use of nature tables (Tunnicliffe, 2006), or projects which focus on familiar wild species (e.g. Hawkey, 2001; Huxham *et al*., 2006) can readily introduce more contact with nature into schools, exercises which can have significant educational benefits, since students often learn abstract processes and concepts better if these are grounded in real organisms (Magntorn and Helldén, 2007).

If taxonomy and systematics have a range of educational benefits, why have they been squeezed from university curricula in many countries, including the UK? Thirty years ago, most first year biology undergraduates would have been able to identify a range of common animals and plants, skills which their degree courses would expand on. Nowadays this is typically no longer the case, many courses failing to develop identification skills, despite their continued requirement in a range of professions, including environmental consultancy. Some of the reason behind this shift is the fact that fewer staff with a research interest in systematic biology have been recruited to university positions in recent decades, something which at least partly results from the increased use of citation metrics such as journal impact factors to evaluate science quality. Since impact factors reflect the number of workers citing a paper, they are much higher in fields with large numbers of active researchers. With such a scheme a 'top' taxonomic journal, of the kind which actually includes species descriptions, might have an impact factor of 3, whilst in cell biology, for example, a similarly prestigious journal may have to score 10 or above.

Since impact factors form a key component of exercises to assess university research, such as the UK Research Excellence Framework (http://www.ref.ac.uk/), they inevitably influence hiring and funding decisions. Taxonomy loses out in this process, and indeed the citation index has been identified as an impediment to the description of the world's biodiversity (Valdecasas *et al.*, 2000). A simple step towards a solution, which makes use of citation metrics, is obvious here – and that is that whenever a species name is used in the scientific literature, the author(s) of that name are included, and reference made to the work in which the name was first published (Wägele *et al*., 2011). Taxa are hypotheses, after all, and in what other branch of scholarship would one fail to cite the originator of an idea? Bad referencing is something we frequently bemoan of our students, so perhaps it's time for the rest of us to tighten up?

Arnold G (2012) Enhancing college students' environmental sensibilities through online nature journaling. *Environmental Education Research*, 18, 133-150.

Barnosky A D, Matzke N, Tomiya S, *et al*. (2011) Has the Earth's sixth mass extinction already arrived? *Nature*, 471, 51-57.

Bennett A F (2003) Experimental evolution and the Krogh Principle: generating biological novelty for functional and genetic analyses. *Physiological and Biochemical Zoology*, 76, 1–11.

Caro T, Darwin J, Forrester T *et al*. (2011) Conservation in the anthropocene. *Conservation Biology*, 26, 185-188.

Deans A R, Yoder M J and Balhoff J P (2011) Time to change how we describe biodiversity. *Trends in ecology and Evolution*, 27, 78-84.

Enghoff H (2009) 'What is taxonomy? - An overview with myriapodological examples. *Soil Organisms*, 81, 441-451.

Godfray H C J (2002) Challenges for taxonomy. *Nature*, 417, 17-19.

Grimaldi D and Engel M S (2005) *Evolution of the Insects*. Cambridge University Press, Cambridge, UK.

Hawkey R. (2001) Walking with woodlice: an experiment in biodiversity education. *Journal of Biological Education*, 36, 11-15.

House of Lords Science and Technology Committee (1992) *Systematic Biology Research* House of Lords Paper 22.

House of Lords Science and Technology Committee (2008) *Systematics and Taxonomy: Follow-up.* House of Lords Paper 162.

Huxham M, Welsh A, Berry A and Templeton S (2006) Factors influencing primary school children's knowledge of wildlife. *Journal of Biological Education*, 41, 9-12.

Juniper T (2013) *What has Nature Ever Done for Us? How Money Really Does Grow on Trees.* Profile Books, London.

Kuo E and Faber Taylor A (2004) A potential natural treatment for ADHD? Evidence from a national study. *American Journal of Public Health*, 94, 1580-1586.

Leather S R and Quicke D J L (2009) Where would Darwin have been without taxonomy? *Journal of Biological Education*, 43, 51-52.

Louv R (2005) *Last Child in the Woods: Saving Our Children from nature Deficit Disorder.* Algonquin Books, Chapel Hill, NC.

Louv R (2011) *The Nature Principle: Human Restoration and the End of Nature Deficit Disorder*. Algonquin Books, Chapel Hill, NC.

Magntorn O and Helldén G (2007) Reading nature from a 'bottom-up' perspective. *Journal of Biological Education*, 41, 68-75.

McGlynn T P (2008) Natural history education for students heading into the century of biology. *American Biology Teacher*, 70, 109-111.

Monaghan M T, Balke M, Pons J and Vogler A P (2006) Beyond barcodes: complex DNA taxonomy of a South Pacific Island radiation. *Proceedings of the Royal Society of London Series B*, 273, 887-893.

Pergams O R W and Zaradic P A (2008) Evidence for a fundamental and pervasive shift away from nature-based recreation. *Proceedings of the National Academy of Sciences, USA*, 105, 2295-2300.

Pretty J, Peacock J, Sellens M and Griffin M (2005) The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, 15, 319-337.

Reidel A, Sagata K, Suhardjono Y R, Tänzler R and Balke M (2013) Integrative taxonomy on the fast track – towards more sustainability in biodiversity research. *Frontiers in Zoology*, 10, 15.

Reiss M J and Tunnicliffe S D (2001) What sort of worlds do we live in nowadays? Teaching biology in a post-modern age. *Journal of Biological Education*, 35, 125-129.

Rowland G (2007) Towards a new biology curriculum. *Journal of Biological Education*, 40, 99-101.

Sluys R (2013) The unappreciated, fundamentally analytical nature of taxonomy and the implications for the inventory of biodiversity. *Biodiversity Conservation*, 22, 1095-1105.

Tunnicliffe S D (2006) The importance of research to biological education. *Journal of Biological Education*, 40, 99-100.

Valdecasas A G, Castroviejo S and Marcus, L F (2000) Reliance on the citation index undermines the study of biodiversity. *Nature*, 403, 698.

Wägele H, Klussman-Kolb A, Haszprunar G *et al*. (2011) The taxonomist – an endangered race. A practical proposal for its survival. *Frontiers in Zoology*, 8, 25.

Wells N and Evans G (2003) Nearby nature: A buffer of life stress among rural children. *Environment and Behavior*, 35, 311-330.

Wheeler Q D (2004) Taxonomic triage and the poverty of phylogeny. *Philosophical Transactions of the Royal Society of London Series B*, 359, 571–583.

Wilkins J S (2009) *Species: a History of the Idea.* University of California Press, Berkely and Los Angeles.

Wilson E O (Ed) (1988) *Biodiversity*. National Academy Press, Washington DC.

Wilson E O (2000) On the future of conservation biology. *Conservation Biology*, 14, 1-3.