

EDITORIAL

Positioning taxonomic research for the future

Why do taxonomists matter?

The work of taxonomists is often understated if not completely misunderstood. Without taxonomists, organisms cannot be accurately identified, neither can these organisms be given universally accepted names, and reliably positioned in the phylogenetic tree of life. Thanks to the work of taxonomists over the last 269 years since Carl Linnaeus established the binomial system, we can now measure the health and wealth of our biodiversity in a refined, science-based inventory prescribed by stringent nomenclatural rules.

The centrality of taxonomy buttressing other branches of biology and applied sciences is also not fully appreciated. The names associated with organisms described and defined by taxonomists serve as a precise communication tool for scientists and officials working on agriculture, animal husbandry, bioprospecting, conservation biology, ecology, food sciences, forestry, horticulture, pharmacy, physiology, pest control, and customs and quarantine services. Taxonomic research underpins the work by decision-makers in governments and practitioners in non-government organizations in combating invasive species, zoonotic diseases, in managing reforestation and other nature-based solutions, and above all, in saving our planet threatened by unprecedented habitat and biodiversity losses.

At a time when we are facing a “planetary emergency” (WWF, 2019), we cannot protect what we do not know. And there are still tens of thousands if not millions of species in the national parks and nature reserves in numerous countries around the world that have yet to be discovered or described. In China alone, more than 45 million specimens have been collected and preserved in various depositories over the last century, but at least 40% of them have remained unidentified.

Is taxonomy threatened?

Concerns that taxonomy is under threat have been articulated within the scientific community for close to two decades (Rodman & Cody, 2003; Agnarsson & Kuntner, 2007; Wägele *et al.*, 2011; Wheeler, 2014, 2020, Jaeger *et al.*, 2021).

By 2020, government signatories of the Convention of Biological Diversity (CBD) have collectively acknowledged that there is indeed a “taxonomic impediment” to the sound management of biodiversity (CBD, 2020). Some taxonomists fear that many species will become extinct before they are found, and some even fear that they themselves can become an “endangered species” before long (Platnick & Raven, 2013; Verbeke, 2017; Hong *et al.*, 2022). There are two simple reasons for this concern.

First, with the focus of biological research increasingly shifting to the applied, experimental, and molecular modes, funding for the traditional, collection-based, taxonomic research is correspondingly diminished, with its attendant negative spillover on career opportunities for the taxonomists (Agnarsson & Kuntner, 2007). There is an obvious irony in the situation: while financial support is increasingly being channeled to recognize and reward those who have scored successes in applied and experimental biological research, those engaging in the equally empirical and intellectually rigorous and challenging “basic” research that laid the foundation of such successes are left high and dry.

Second, the value of taxonomic research is grossly underestimated in an assessment system that places undue primacy on readership, citations, societal impact, and economic benefits (including potential appeals to donors and funding sources). Prestigious “high-impact” journals have developed a resistance to publish highly specialized and purely descriptive taxonomic research. The problem is exacerbated as bibliometrics measuring scientific work almost always ignore the authorship citation when the name of a species is invoked in a non-taxonomic study (Wägele *et al.*, 2011).

It is therefore not surprising that many young and promising taxonomists are forced to migrate to jobs with better prospects for funding support, career advancement, and tenure security. In China, over 80% of post-graduate taxonomists

groomed under state-funded programmes do not remain in the field. The continued brain drain raises a worrisome question: will there be enough successors to take over the indispensable and uncompleted mission of documenting China's biota when the present cohort of experienced taxonomists with a track record of high accomplishments retire in five to ten years' time?

What can we do about it?

The picture today is not entirely gloomy. Some exemplary initiatives have been launched at both the international and national levels to alleviate the threat. As a response to the "taxonomy impediment", the CBD has come up with a Global Taxonomy Initiative (Shimura & Hiraki, 2006; CBD, 2020). Many advanced countries have also developed national programmes to overcome this deficiency. In Sweden, the government has launched a "Swedish Taxonomy Initiative" to build taxonomic capacity, enhance public outreach, and chart a national inventory of its fauna and flora (Sjödén Skarp, 2019). In Germany, the problem is addressed by the "Taxon-Onics Initiative" funded by the German Research Council (Begerow, 2022).

As early as 2002, the National Natural Science Foundation of China established a "Classical Taxonomy Fund" that played a pivotal role in sustaining and bolstering the core of taxonomic scientists in China. At present, Chinese taxonomic depositories and natural history museums coming under the ambit of the "National Science & Technology Resources Service Platform" have become new launching pads of a national undertaking for scientific advancement and technological innovations.

More countries can follow suit, devising their own national programmes tailored to their local conditions. Synergy from PPP partnerships (among the public, private and people sectors) and international collaboration can multiple the benefits many folds over. Even for countries (such as China) that have enshrined biodiversity protection in their respective national agendas, more can be done to bend the curve. Here, we offer five recommendations:

First, a national taxonomic manpower infrastructure may be established, under-pinned by the intellectual and scholastic processes unique to taxonomy. Building from its pinnacle, premier positions can be designed based on national needs, and deserving candidates may then be recruited. In the case of China, we recommend that new posts be established for senior taxonomists within the framework of the "National Science & Technology Resources Service Platform", so that sustained backing may be extended to a core of world-class scientists engaging in classical, collection-based, taxonomic research.

Second, the key performance indicators (KPI) may be revised so that taxonomists can be evaluated more fairly and objectively. They may be evaluated by subject specialists, based on verifiable professional competencies, significance of discoveries, quality of analytical interpretation, degree of innovative breakthroughs, and potential environmental or socio-economic impact. Instead of measuring taxonomists solely with citation rate or impact factor, they may be assessed by a codified set of KPI within a human resource management system with transparent career advancement pathways for deserving and promising scientists.

Third, given the fact that taxonomy is an accumulative science with diminishing scope for new discoveries within a confined faunistic territory, a special fund may be set aside to incentivize and sponsor classical taxonomic work, especially in revisionary research across national boundaries, advisedly in collaboration with their foreign counterparts.

Fourth, taxonomists themselves may reshape taxonomy. They should quickly internalize emerging taxonomic theories and embrace evolving methodologies such as DNA barcoding, 3-D imaging, artificial intelligence image recognition, machine learning, and automated classification. They can shift the paradigm and transform taxonomy into a sophisticated and dynamic inter-disciplinary scholastic endeavor, thus opening new windows for career advancement on par with those trained in other fields.

Fifth, educators, education authorities and academic institutions can turn taxonomy into a more robust science going beyond teaching the tradecraft of species identification and description. They can enrich the taxonomy curriculum and fortify taxonomic textbooks by broadening the scope to include ecology, histology, and related sciences, while adding new dimensions such as genomics, informatics, and molecular biology. With such training, the budding taxonomist will become an all-rounder who will be in a better position to compete in an increasingly challenging job market.

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