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Assessing Biotic Diversity: The glorious past, present, and the uncertain future

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ABSTRACT. The recent biodiversity crisis, primarily due to economic models and human population pressure, is paralleled by a taxonomic crisis. The main responsibility for the crisis in taxonomy is the evaluation of the discipline in the sciences. Other factors impeding work in taxonomy derive from practices concerning grants, paradigms in museums shifting away from collection-based studies, biodiversity studies with diminishing effort to adequately identify samples, methods of global diversity assessments, and bureaucratic restrictions regulating field work.

KEY WORDS. Biodiversity, taxonomy, paradigms, impediments.

Pre-modern taxonomy

In Europe, religion had turned away from nature that has been linked to morality and mythology. By the start of the 18th century the study of animals and plants became an obsession in the wealthy class and by mid-century this interest spread to other classes throughout Western culture. Establishing collections became commonplace and the interest for natural history became highly appreciated and almost a necessity in educated circles. Some examples: in 1775, American warships were instructed by Benjamin Franklin not to interfere with Captain James Cook returning on the Resolution from his second discovery voyage; Thomas Jefferson was not only president of the United States but also president of the American Philosophical Society; while in battle in Spain, Napoleon's General Comte Pierre F.M.A. Dejean collected a beetle (d'Aguilar, 2008), listed later as *Cebrio ustulatus*.

Many nations supported natural history museums to preserve and display results of their expeditions, often as an activity alongside imperialist expansion. The introduction of binominal nomenclature by Carolus Linnaeus in his *Systema naturae* (from 1748 on) enabled the proper naming and cataloguing of new discoveries. It is difficult to imagine the sustained progress of natural history without his approach to naming and classifying species. At that time (as it should be now) to be a naturalist was to participate in building a great and important body of knowledge. The passions for nature studies had its material base in collections, and collections required taxonomy, well before Augustin Pyramus de Candolle coined the term. Taxonomists were considered with respect, and their work was adequately supported for about two centuries. Many achieved leading positions in universities, museums and other research institutes. As result of their efforts, we have a language upon which to base our knowledge of living organisms, and all other facets of biology.

Present taxonomy

Maintaining and measuring biotic diversity (or biodiversity, a term coined by Edward Wilson in 1988), has become a major, global concern, yet taxonomists, who provide the baseline data for biodiversity studies claim decreasing support and a potentially bleak future. Though only a fraction of life forms is known fully and can be identified, comprehensive reports on expedition results seem

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to be relegated to the past, with most of the European-style faunal series being abandoned; many present-day projects are accomplished privately while the number of curators of biotic collections is being reduced, regardless of a continuous flow of new material to be added. Here are some trends, based also on somewhat older data:

- In USA, the percentage of systematic biologists younger than 36 years declined from 24% in 1980 to 8% in 1990, and it was concluded that if the trend in entomology continues unabated the last student of insect systematic would graduate in 2017 and the field would be essentially dead in the United States (Wheeler, 1995).
- Within the past 40 years the median number of courses on natural history required for a bachelor's degree in the USA dropped from 2 to 0 (Dijkstra, 2016).
- In the U.K., between 1980 and 1990, the number of systematic biologists in higher education declined from 268 to 209 (Wheeler, 1995).

Wheeler (2014) witnessed three decades of haemorrhage in the funding of taxonomy. Though the discipline is the foundation of biodiversity research (Fisher, 2016) and irrespective of new tools and methods, the field has become less of an academic priority, even, surprisingly, in museums that were built as monuments to the discovered and catalogued species. Discovery of life forms is considered inferior to the study of other biotic disciplines, and the great effort needed to be trained to become a qualified expert in taxonomy is considered unproductive and a waste of time. This cultural phenomenon by itself suggests that the word "biodiversity" is hardly more than a buzzword in the mind of many people. An objective measure of taxonomic impediment seems to be the time-gap between the discovery and the published descriptions of new species. It was stated to be 21 years (Fontaine *et al*., 2012), but according to my own experiences it may be significantly longer. Therefore, it seems useful to question the roots of these regressive trends.

Taxonomic wrong-headedness

Several blows affected or still affect work in taxonomy, some of which are the shift, often by taxonomists, toward population research of species boundaries; numerical taxonomists disregarding homologies; development of the phylocode that abandons classic naming criteria and classification; and bar-coding that identifies species based only on a single strand of nucleotides and disregards false shortcuts (Audisio, 2017). In addition, there are some doubtful practises such as establishing new species without voucher specimens (see Amorim *et al*., 2016; Santos *et al*., 2016), i.e. accepting methodology that provides statements that cannot be disproved, and the erroneous ideas about the term "type" (and its derivates) used to designate name-bearing specimens, or taxa. Non-practising taxonomists overlook the polysemy and believe the term applies to concepts based on observed features, while in reality the "types" are not correlated with "typical" (or "untypical") features of organisms and do not delimit species nor any other taxa. These mistaken ideas and methods impact on inadequately informed decision-makers and the public. Sometimes, agenda driven revisionists are particularly aggressive, for example phylocodists that have called taxonomists essentialists and creationists (e.g. Pleigel, 2000). Their criticism of typology (essentialism) in modern taxonomy (see Sluys *et al*., 2004; Dubois, 2008) is based on semantic similarities and thus not better founded than, for example, criticism of evolution.

Scientific work is usually perpetual if accomplished by a community of an adequate number of researchers. This is often not the case in taxonomy dealing with megadiverse groups of organisms. Academically employed experts of groups that contain thousands of species have sometimes been replaced decades after their retirement, or not at all. Information needed on these groups can only be accessed via archived publications. Since 2012, electronic-only publications became admitted for taxonomic work. According to the Amendment of the International Code of Zoological Nomenclature (ICZN, 2012, Art. 8.5.3.1.), such works must be archived by the publisher and "give the name of an organization … that is intended to permanently archive the work …". Many private organisations publish electronic scientific journals, but their life-time and the life-time of their archives, are unpredictable. Thus, unlike printed information, a long-term sustainability of only electronic taxonomic information appears uncertain.

Another assault on taxonomy comes from efforts to relegate its usefulness to a simple identification service to other disciplines, such as ecology, applied biology, and conservation. Significantly, Garnett & Christidis (2017) proposed outside authority of legislators (to parallel inadvertently situations common several centuries ago) in cases when research leads to changes in taxonomy that affect names of taxa – a proposal that undermines basic research that provides information on phylogenetic relationships and valid species status. Taxonomy, and morphology by extension, became considered to be subservient disciplines as if knowledge of interactions of organisms would be more important than knowledge of organisms, as if once established names of species should fix research, or as if knowledge would be justified only by its potential applications.

Granting practice

Efficient taxonomic work on poorly known or hyper-diverse groups requires long periods of familiarization. It is necessary to assess previously published data, revise vouchers of inadequately described taxa, verify the usefulness of characters, and check collections scattered in many countries. But once being an expert, one can often easily recognize new taxa or identify many of the described ones. In addition, experts are aware of gaps in taxonomic knowledge and of the most efficient means to fill them. The fashionable practice of short-term grants does not necessarily meet the more important requirements of modern taxonomy, such as revisions or monographs of species-rich groups. At best, this practice leads to the study of restricted numbers of taxa, or only the reconstruction of phylogenetic relationships (often with an evolutionary question to address) that do not necessitate taxonomic skills. The system prevents the training of future experts, unless exceptionally endowed students are involved. It leads also to a loss of research time by chasing grants and responding to administrative requirements, and to the establishments of agencies that consume resources supposed to support research.

Granting is part of a system based on the belief that peer assessment enhances efficient research. In addition to the above-mentioned impacts, Vaesen & Katzan (2017) provide data showing that the system is not cheaper than the partnership facilitated by the sharing of funds among qualified researchers. Following are some data providing insights to costs and time investments (not reflecting the successful grants nor the resulting research):

- In 2014, the US National Science Foundation received a total of 48,051 proposals, 96% of which were evaluated by reviewers as well as by the Foundation's staff (Anonymous, 2015).
- Researchers in 2012 lost about 400 years of research time in writing unsuccessful proposals for the Australian National Health and Medical Research Council (Herbert *et al*., 2013).
- In the period 2005/06, reviewers for the UK Research Councils can be estimated to have spent 192 years on assessing applications (Anonymous, 2006).

Museums

With scientific competition increasing for over a half a century the idea of old-fashioned museums lacking social and scientific benefits slowly became widespread. Museums tried to compensate for decreasing revenue and financial support by increasing their emphasis on non-research initiatives, drawing a larger number of visitors, and having their scientific staff focused on popular questions; all this resulted in a net reduction of collections-based research. The management teams of museums are progressively driven to emphasise possession and protection, rather than to use the collections to improve knowledge (Mound, 2012).

This shift away from collection-based research is correlated with increasing bureaucracy and less funding. Scientists become subservient to administrations and loose research time in addressing non-scientific issues (e.g. according to Nelson (2016) in New Zealand 77% of the 97 taxonomists surveyed had only 25% of their work on taxonomy and, in addition, only 16% of the workforce is in the 20-40 age bracket). A dilemma derives also from the fact that the value of fungi, plants and animals in collections is correlated with the technical and scientific expertise present at the institution, and as their numbers dwindle, so does the stewardship of the holding, while collections of artefacts retain their intrinsic value. This fact is self-evident for biologists but poorly understood by administrators.

The negative impact is amplified by an opinion that collections are not necessarily relevant for understanding life. The fact that we know anything objectively about a given species is because there are specimens in collections (Davis, 1996), and this seems to be ignored by decision-makers. As result, the shrinking of Earth's biodiversity is at present correlated with the shrinking number of curators: The Field Museum of Natural History (Chicago) has lost 18 of its 39 curators since 2001, and the US National Museum of Natural History (Washington) has lost 41 curators since 1993 (Kemp, 2015). Similar reductions are seen in many countries. Even if the number of curators remains unchanged in some museums, their ratio to the number of curated taxa and specimens is inadequate.

Global diversity assessment

In 1982 Terry Erwin estimated the number of tropical arthropods species to be 30 million, a number exceeding 10 times the number of species currently believed to be correct (e.g. May, 1986). His estimate was based on the canopy fauna knocked down from a single tree species, *Luehea seemannii*. Nevertheless, Erwin's two-page paper had a shocking effect. First, it planted the idea that building complete collections is an illusion. Secondly, it inspired a shift of resources to studies expected to provide more and more accurate estimates of global biodiversity. The issue was and still is considered important with respect to the rate of on-going extinctions. As community-level biodiversity studies operate often only with numbers they may lack adequate involvement or the skill necessary to identify samples to species level and may deem such identifications as unnecessary. In this way, resources are shifted from taxonomy and the fact that many insect studies lack information essential for testing identification (Packer *et al*., 2018) seems to be symptomatic of the modern trends. An outcome is the use of "morphospecies" or "Operational Taxonomic Units" ("OTU's"), which may result in incorrect assessments of taxa if based strictly on phenotypes and render studies irreproducible, especially if based on haplotypes. Another recent idea is the assertion that "naming species" is the goal of taxonomy (e.g. Costello *et al*., 2013), though names are nothing but labels. An additional problem occurs when non-taxonomists work on biodiversity issues, without an adequate knowledge of natural history or having no taxonomic collaborators. One such case is a study in the Danum Valley, Sabah (Ji Yinqiu *et al*., 2013): coprophagous scarabs were trapped and considered to be indicators of presence of mammals, though human and animal droppings were not discriminated in the field.

Web monitoring biodiversity

Taxa are concepts that depend on available information and on tools used for analyses. Consequently, taxa are frequently modified, resulting in changes in rank, validity, or placement. Quite often, different and distinctive concepts are applied for the same taxon. The need to compile basic taxonomic data was already recognized in the 19th century (e.g. Dejean, 1821; Stephens, 1829) and is ongoing, usually in the form of catalogues. To be useful, a catalogue must be as complete as possible, provide the essential information, and respect nomenclatural rules. The WEB allows the dispersal of such information globally. According to the WEB page of the Catalogue of Life:

"The Catalogue of Life is the most comprehensive and authoritative global index of species currently available. It consists of a single integrated species checklist and taxonomic hierarchy. ... The Catalogue of Life (CoL) is the nearest thing to a comprehensive catalogue of all known species of organisms on Earth" (accessed January 2, 2018) and "… *Species 2000 and ITIS teams peer review databases, …"*. I have checked several sections of this Catalogue and found many of them misleading and blatantly incorrect. Moreover, publishing partial information in catalogues or check-lists is counter-productive, leading to errors. Here are some examples:

The insect genus *Scaphidium* (Coleoptera, Staphylinidae) comprises 344 species recognized as valid, only one of them is listed in the *Catalogue of Life* (with an incorrect author's name!). The related genus *Scaphisoma* comprises 721 valid species, again with only one of them listed in the *Catalogue of Life*. The genus *Cerapeplus*, one of the distinctive beetle taxa, comprises only two species. One is in that Catalogue, but with 15 **non-existing** names listed as synonyms (accessed January 2, 2018).

Misinformation results in other issues. For example, three out of eight species currently placed in *Derolathrus* (Coleoptera, Jacobsoniidae) were originally published in *Gomya* (see Löbl & Burckhardt, 1988), and their species epithets were consequently feminine in gender. The *Catalogue of Life* under *Derolathrus parvulus* (Rücker, 1983) gives "*Derolathrus parvula* (Rücker, 1983)" as a synonym. This is nonsense (the species was described as "*Gomya parvula*") and in addition there is no consistency for the entries of its two congeners. An ignorance of elementary nomenclatural rules may be seen in the *Catalogue of Life* quite often, e.g. the cerambycid beetle "*Coptosia* (*Barbarina*) *annularis* Löbl & Smetana, 2010" listed as a synonym of "*Conizonia* (*Conizonoides*) *annularis* (Holzschuh, 1984)". Holzschuh described the species *annularis* in the genus *Conizonia*, so his name is not to be given in parentheses; Löbl & Smetana have edited a work (Löbl & Smetana, 2010) in which G. Sama transferred to his new subgenus *Barbarina* the species *annularis*; the authors of transfers are not to be listed as authors of animal taxa, and the editors of works are not to be confused with the authors of names of taxa.

Never published binomina in the *Catalogue of Life* are quite a common feature (e.g. in the staphylinid genus *Baeocera*), and as other errors, such as grossly incomplete information (e.g. not even 10% of the species of the megadiverse insect genus *Stenus* are listed), leads to misconceptions due to the absence of reviewing and incompetence. Another site, the *Global Names Index* contains more names ("17,275,522 names strings total" - accessed December 20, 2017) but is hardly useful as a source of information. Here, the Nearctic staphylinid *Baeocera apicalis* is listed five times, once misspelled "*apicaliis*", once with the incorrect author's name "Leclerc", once without author's name, and finally with and without a comma between the correct author's name and the year of publication. The *Global Biodiversity Information Facility* (GBIF) provides partial information submitted from some of the specimen repositories, while the *Encyclopedia of Life* (EOL), is also grossly incomplete, and lists names of fungal species within lists of animals (e.g. in *Scaphidium*). While these initiatives assert collaboration, their respective data exhibit discrepancy.

It is particularly worrisome when the extensive data provided by these on-line initiatives have been sourced for meta-analyses (e.g. Costello *et al*., 2012; Mora *et al*., 2013), also providing a skewed view of diversity and of where to focus taxonomic effort.

Conservation issues

The conservation of life existing naturally is a major challenge and much has been advocated by legislators who have introduced regulations that are believed to enhance the conservation of threatened species and ecosystems. Though positive in many ways the system has now resulted in a bias against any collecting of organisms with an increase in bureaucracy. Fundamental differences between small, rapidly reproducing and large-sized, slowly reproducing organisms are ignored via some legislation, making it impossible to collect or even study many animals and plants. Such bureaucracy has led to a number of absurd situations.

Populations are controlled by many factors, and one is predation. A single average-size colony of the *Myotis myotis* bat consumes annually 2,250,000 to 2,800,000 ground beetles in Switzerland and the cumulative effect of 130 colonies kill about 100 to 300 million ground beetles in a year; compared to such losses, two centuries of collecting have resulted in less than one million ground beetles being preserved in collections in Switzerland (Carbonnel & Moeschler, 2001; Löbl, 2017). At the arthropod level, spiders kill 400 to 800 million tons of insects and springtails yearly (Nyffeler & Birkhofer, 2017). Assuming an average weight of the prey to be 0.2 g, 2 to 4 x 10^{15} individuals are killed annually by spiders.

Natural predation rates pale to the apocalyptic situations occurring daily by habitat destruction ranging from small-scale parking lots to the removal of rainforests for pasturing. Glitzer *et al*. (1999) have pointed to the multiple effects of cars on the fauna in Austria, where in the 1970s cars killed annually 14×10^{15} insects (Gepp, 1973). Thus, cars have killed in a single country and in a single year at least one million times more animals than all those preserved in collections worldwide, assembled since the 18th century (estimated by Kemp, 2015 to be 3 billion specimens).

These astronomical numbers of killed animals are insignificant compared to effects of habitat loss and pollution. Indeed, even classified (i.e. "protected") sites may be threatened by human activity (personal observation). Lambertini (2016) notes a reduction of freshwater populations to a fifth of the state existing 40 years ago. About 25% of all tropical forests have been cleared since the 1992 adoption of the Convention on Biological Diversity, and the pace of destruction is increasing year by year. When a tropical rainforest is cleared, perhaps 19 out of 20 species in it will be unknown. In Indonesia, from 2000 to 2012, 6.02 Mha primary forests was lost, i.e. 0.84 Mha per year, in Brazil 0.46 Mha per year is lost. In 2009, the primary forests of Sabah covered only 8% of the surface, and in Sarawak only 3% (Bryan et al., 2013). In a protected area in Germany, the populations of flying insects are now reduced to 25% of the percentage in 1989 (Sorg *et al*., 2013; Hallmann *et al*., 2017).

The short-sighted and absurd bureaucratic-legislative conservation efforts for insects is demonstrated by the protection of the wide-spread European long-horn species *Rosalia alpina*. Its populations have dwindled in some parts of its range while in other areas, such as in the Slovak Carpathians, the species is common and may be a pest (Jendek & Jendek, 2006). Nevertheless, it is "globally" protected (IUCN, 1996), while its habitat, dead piles of logs that attract females of *Rosalia alpina* and other protected longhorn beetles, are destroyed or removed to make parklands clean-looking.

Conservation of green or natural areas are unbalanced with an emphasis on reserves for human recreation, wilderness, or emblematic species. As a result, the fragmented reserve system that is presently in place cannot conserve continental biodiversity (Rechner, 2013). Similarly, Floren (2017) points to isolated tropical forest fragments that remain species-poor over long time spans.

Thus, recently introduced restrictions on collecting *all organisms equally* limit the advance of knowledge and are counter-productive as far as conservation issues are concerned. The over-legislation of collecting may annihilate opportunities for natural history studies by impeding the interests of young people, by shifting students away from a holistic view of organisms and by discouraging faunal studies of poorly known groups or areas but does not hinder pollution and destruction of habitats. In subtropical and tropical areas, where the highest number of undescribed species occur, this process of limiting research and collecting combined with a lack of local taxonomists and adequate infrastructure, does not bode well for increasing the knowledge of global biodiversity. The world-wide net of restrictions results in higher rates of species threatened by extinction that go unnoticed to science (Dubois, 2003).

Unfortunately, the true reasons of the biodiversity disaster, primarily derived from economic myopia and population pressure, and paralleled by widespread wishful thinking overriding obvious facts, seem to be disregarded. Meanwhile, taxonomists are used as lightning rods, and the restrictions serve as an alibi.

Means of evaluation in sciences

Sciences, like other human endeavours, are competitive and competition requires evaluation. Since 1960, when Eugene Garfield established the Science Citation Index for many scientific periodicals, his Impact Factor has been used as a tool for selecting and evaluating journals. In the 1970s, by a strange short cut, the Impact Factor (IF) (and later other metric tools) started to be used to evaluate journal articles and authors. The citation numbers (= the Impact Factor), as measures of research quality has been adopted as a universal tool by most institutions to evaluate their staff's productivity and to offer rewards, and are used by funding organizations to assess grants. This agenda has perverse effects as many taxonomic journals recognized by the Zoological Record (Boero, 2010) were not included in the Garfield's Citation Index. As a result, taxonomy is further marginalized by the following:

- Major, long-term work being disadvantaged.
- Shift from taxonomic revisions toward phylogenies and question-driven research.
- Faunistic studies disadvantaged.
- Work in fields with few researchers disadvantaged due to decreasing citation rate.
- Taxonomic works published in journals ranked in categories other than "Systematic and Biodiversity" have a higher IF (Shubert, 2012), inducing difficulties in survival for many specialized journals.

- Stimulating increase in the number of short papers and of co-authors (Bebber *et al*., 2014), partly due to a myth of superiority of teamwork. Examples of such newly established species are "*Leonhardia jajcensis* S. & T. Rada & B. Ćurčić in S.B. Ćurčić, T. Rada, Mulaomerović, Vrbca, Antić, Tomić, B. Ćurčić & B. Rada, 2014" or "*Winklerites serbicus* S. Ćurčić, Antić, Rađa, S. Makarov, B. Ćurčić, N. Ćurčić, Lučić & Vrbica, 2013".

However, more important are the general effects of metrics:

- The evaluation of works is correlated with the metrics of journals, not with the results of the studies. There is no correlation between publishing in a "high impact" journal and the citation of an article (Shubert, 2012). In practice, an erroneous study in such journals may provide more score to an author that a correct study published in poorly evaluated or unevaluated journals.
- Research programs are shifted to the production of papers in high IF journals.

An unforeseen side effect of metrics is its interference with academic liberty. Ranking schemes that lead people to obtain good scores rather than just good science create a clash of values and are a concern (Calver, 2013). Ignorance can be turned into bliss if the outcome is a publication in a higher impact journal (Lawrence, 2007). The San Francisco Declaration on Research Assessment (DORA) demonstrates the situation is widespread and occurs in unrelated fields, such as mathematics, geology, and linguistics (see the DORA WEB-page), a reward system that seems to be based on the belief that quality can be measured by simple metric means alone. According to Seglen (1997) "as long as there are people out there who judge science by its wrapping rather than by its contents, we cannot afford to take any chance". To me, it is strange to see a scientific community supposed to be built on rational behaviour aware of problems and still accepting the perversity of metrics (the one that is promoted is an independent system of administrators and decision-makers). As a result, ethics are compromised to support ideologies that ensure gain for publishers of profit-based journals that possess a high IF, helping authors to not only achieve esteem by publishing in these journals but also advancement of careers based on a business model.

Solutions

With temperature rising and fragmentation or destruction of habitats on the increase in our age of the Anthropocene, it is urgent to find possible solutions to the present state of taxonomy in this "Dark Age of Modernity" (Rose, 2013), in which natural history research is being marginalized by profit making initiatives and myths. While most of the planet's species might disappear before they have been studied (Dubois, 2003), a common effort of taxonomists and conservationists is needed. Naturally, we should continue efforts to assess faunal, fungal and floral richness and continue to advance these studies by having institutions as repositories of vouchered material. Also, we should prioritize sites for more and urgent conservation, a process that must engage scientists and legislators alike. But we should also minimize profit-based research that seeks only to publish in journals with a high Impact Factor: we could have a set of publishing criteria as well as special funding for natural history research, as we should for the humanities, mathematics, and other less profitable areas of research; in that way careers in all academic facets are somehow preserved.

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REFERENCES

Amorim, D.S., Santos, C.M.D., Krell, F.-T., Dubois, A., Nihei, S.S., Oliveira, O.M.P., Pont, A., Song, H., Verdade, V.K., Fachin, D.A., Klassa, B., Lamas, C.J.E., Oliveira, S.S., de Carvalho, C.J.B., Mello-Patiu, C.A., Hajdu, E., Couri, M.S., Silva, V.C., Capellari, R.S., Falaschi, R.L., Feitosa, R.M., Prendini, L., Pombal, J.P. Jr., Fernández, F., Rocha, R.M., Lattke, J.E., Caramaschi, U., Duarte, M., Marques, A.C., Reis, R.E., Kurina, O., Takiya, D.M., Tavares, M., Silva Fernandes, D., Franco, F.L., Cuezzo, F., Paulson, D., Guénard, B., Schlick-Steiner, B.C., Arthofer, W., Steiner, F.M., Fisher, B.L., Johnson, R.A., Delsinne, T.D., Donoso, D.A., Mulieri, P.R., Patitucci, L.D., Carpenter, J.M., Herman, L. & Grimaldi, D. (2016) Timeless standards for species delimitation. *Zootaxa*, 4137(1): 121–128.

Anonymous (2006) *Report of the Research Councils UK Efficiency and Effectiveness of Peer Review Project*. Research councils UK, 76 pp.

Anonymous (2015) *Report to the National Science Board on the National Science foundation's Merit Review Process FY 2014*. National Science Foundation.

Audisio, P. (2017) Insect taxonomy, biodiversity research and the new taxonomic impediment. *Fragmenta entomologica*, 49(2): 121–124.

Bebber, D.P., Wood, J.R.I., Barker, C. & Scotland, R.W. (2014) Author inflation masks global capacity for species discovery in flowering plants. *New Phytologist*, 201: 700–706.

Boero, F. (2010) The study of species in the era of biodiversity: a tale of stupidity. *Diversity*, 2(2): 115-126 [Doi: 10.3390/d2010115].

Bryan, J.E., Sherman, P.L., Asner, G.P., Knapp, D.E., Aoro, G. & Lokes B. (2013) Extreme differences in forest degradation in Borneo: Comparing practises in Sarawak, Sabah, and Brunei. *PloS One*, 8:c69679.

Calver, M.C. (2013) RAM the PI.BETA, C3PO – what the H-Star happened to my promotion application? Or: The pros and cons of bibliometric evaluations of researchers (Pp. 106–121). In: Lunney, D., Hutching, P. & Rechner, H.F.[eds.] *Grumpy scientists: the ecological conscience of a nation*. Royal Zoological Society of New South Wales, Mosman.

Carbonnel, J.-P. & Moeschler, P. (2001) Petite contribution au problème de la protection de l'entomofaune. *Le Coléoptériste*, 42: 91–94.

Costello, M.J., Wilson, S. & Houlding, B. (2012) Predicting global species richness using rates of species description and estimates of taxonomic effort. *Systematic Biology*, 61: 871–883.

Costello, M.J., May R.M. & Stork N.E. (2013) Can we name Earth's species before they go extinct? *Science*, 339: 413–416.

D'Aguilar, J. (2008) Dejean, une légende entomologique. *Insectes*, 17(149): 2–3.

Davis, G.M. (1996) Collections of biological specimens essential for science and society. *Newsletter, Association of systematics collections*, 24(6): 77–90.

Dejean, P.F.M.A. (1821) *Catalogue de la collections de coléoptères de M. le Baron Dejean.* Crevot, Paris, viii + 136 + [2] pp.

Dijkstra, K.-D.B. (2016) Restore our sense of species. *Nature*, 533: 172–174.

Dubois, A. (2003) The relationships between taxonomy and conservation biology in the century of extinctions. *Comptes Rendus Biologies*, 326 (Suppl. 1): 9–21.

Dubois, A. (2008) Phylogenetic hypotheses, taxa and nomina in zoology (Pp. 51–86). *In*: Minelli, A., Bonato, L. & Fusco, G. [eds.] Updating the Linnaean Heritage names as Tools for Thinking about Animals and Plants. *Zootaxa*, 1950: 1–163.

Fisher, B.J. (2016) Descriptive taxonomy: a golden or gold-plated age? *Ecology*, 97(5): 1366–1367.

Floren, A. (2017) Gefährdete Vielfalt: Käfer in Baumkronen SE-Asiatischer Regenwälder. *Nachrichenblatt bayerischen Entomologen*, 66(3/4): 109–110.

Fontaine, B., Perrard, A. & Bouchet, P. (2012) 21 years of shelf life between discovery and description of new species. *Current Biology*, 22: 943–944.

Garnett, S.T. & Christidis, L. (2017) Taxonomy anarchy hampers conservation. *Nature*, 546 (7656): 25–27.

Gepp, J. (1973) Kraftfahrzeugverkehr und fliegende Insekten. *Natur und Landschaft*, 59: 127–129.

Glitzer, I., Beyerlein, P., Brugger, C., Egermann, F., Paill, W., Schlögel, B. & Tataruch, F. (1999) *Literaturstudie zu anlage- und betriebsbedingten Asuswirkungen von Strassen auf die Tierwelt. Endbericht. Erstellt im Auftrag des Magistrates der Stadt Wien*. Abteilung 22 – Umweltschutz. «G5» - Game-Management, Gratz, 175 + 59 pp.

Hallmann, C.A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D. & de Kroon, H. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS ONE*, 12(10): e0185809. Doi.org/10.1371/journal.pone.0185809.

Herbert, D.L., Bamelt, A.G., Graves, N. (2013) Australia's grant system wastes time. *Nature*, 495: 314 Doi: 10.1038/495314d.

ICZN (2012) Amendment of Articles 8, 9, 10, 21 and 78 of the International Code of Zoological nomenclature to expand and refine methods of publication. *ZooKeys*, 219: 1–10.

IUCN: *1996 IUCN red list of threatened animals*. IUCN, Gland, 368 pp.

Jendek, B. & Jendek, E. (2006) Analýza druhovej ochrany coleoptera na Slovensku na základe modelovej skupiny fuzáče (Coleoptera, Cerambycidae). *Folia faunistika slovaca*, 11(4): 15–28.

Ji Yinqiu Ashton, L., Pedley, S.M., Edwards, D.P., Tang Yong, Nakamura, A., Kitching, R., Dolman, P.M., Woodcock, P., Edwards, F.A., Larsen, T.H., Hsu Wayne, H., Benedick, S., Hamer, K.C., Wilcove, D.S. Bruce, C., Wang Xiaoyang, Levi, T., Lott, M., Emerson, B.C. & Yu Douglas, W. (2013) Reliable, verifiable and efficient monitoring biodiversity via metabarcoding. *Ecology Letters*, 16(10): 1245–1257. [Doi: 10.1111/ele.12162].

Kemp, C. 2015: The endangered dead. *Nature*, 518: 292–294.

Lambertini, M. (2016) Rapport Planète Vivante 2014. Syntèse. WWF Suisse – Rapport. WWW. WWF.CH.

Lawrence, P.A. (2007) The mismeasurements of science. *Current Biology*, 17(15): 583–585.

Löbl, I. (2017) Beschreibungen neuer Arten ohne materielle Belege – die International Regeln der Zoologischen Nomenklatur bedrohen Taxonomie und Museen. *Entomologia Austriaca*, 24: 159–170.

Löbl, I. & Burckhard, D. (1988) Revision der Gattung *Sarothrias* mit Bemerkungen zur Familie Jacobsoniidae (Coleoptera). *Stuttgarter Beiträge zur Naturkunde Serie A*, 422: 1–22.

Löbl, I. & Smetana, A. (2010) *Catalogue of Palaearctic Coleoptera. Volume 6 Chrysomeloidea*. Apollo Books, Stenstrup, 924 pp.

May, R. M. (1986) How many species are there? *Nature*, 324: 514–515.

Mora, C., Rollo, A. & Tittersor, D.P. (2013) Comment on "Can we name earth's species before they go extinct?" *Science*, 341: 237.

Mound, L.A. (2012) The Natural History Museum re-visited. *Antenna*, 36(3): 195–200.

Nelson, W. (2016) Taxonomic research, collections and associated databases – and the changing science scene in New Zealand. *New Zealand Science Review*, 73: 79–82.

NYFFELER, M. & BIRKHOFER, K. (2017) An estimated 400-800 million tons of prey are annually killed by the global spider community. *The Science of Nature*, 104: 30 [Doi: 10.1007/s00114-o17-1440-1].

PACKER, L., MONCKTON, S.K., ONUFERKO, T.M. & FERRARI, R.F. (2018) Validating taxonomic identifications in entomological research. *Insect Conservation and Diversity*, 11: 1–12.

PLEIGEL, F. (2000) Nomenclature linnéenne et nomenclature phylogénétique. *Bulletin de la Société Française de Systématique*, 24: 25–28.

RECHNER, H.F. (2013) What makes this old science grumpy (Pp. 1–8). In: LUNNEY, D., HUTCHING, P. & RECHNER, H.F. [eds.] *Grumpy scientists: the ecological conscience of a nation*. Royal Zoological Society of New South Wales, Mosman.

ROSE, D. (2013) Grumpy about this dark age of modernity (Pp. 88–94). In: LUNNEY, D., HUTCHING, P. & RECHNER, H.F. [eds.] *Grumpy scientists: the ecological conscience of a nation*. Royal Zoological Society of New South Wales, Mosman.

SANTOS, C.M.D., AMORIM, D.S., KLASSA, B., FACHIN, D.A., MIHEI, S.S., DE CARVALHO, C.J.B., FALASCHI , R.L., MELLO-PATIU, C.A., COURI, M.S., OLIVIERA, S.S., SILVA, V.C., RIBEIRO, G.C., CAPELLARI, R.S. & LAMAS, C.J. (2016) On typeless species and the perils of fast taxonomy. *Systematic Entomology*, 41(3): 511–515 [Doi: 10.1111/syen.12180].

SORG, M., SCHWAN, H., STENMANS, W. & MÜLLER, A. (2013) Ermittlung der Biomassen flugaktiver Insekten im Naturschutzgebiet Orbroicher Bruch mit Malaise Fallen in den Jahren 1989 und 2013. *Mitteilungen aus dem Entomologischen Verein Krefeld*, 1: 1–5.

SEGLEN, P.O. (1997) Why the impact factor of journals should not be used for evaluating research. *The BMJ*, 314: 497–508.

SHUBERT, E. (2012) Use and misuse of the Impact Factor. *Systematics and Biodiversity*, 10(4): 391–394 [Doi 10.1080/1477200.2012.753716].

SLUYS, R., MARTENS, K. & SCHRAM, F.R. (2004) The PhyloCode: naming of biodiversity at a crossroads. *Trends in Ecology and Evolution*, 19(6): 280–281.

STEPHENS, J.F. (1829) *A systematic catalogue of British insects: being an attempt to arrange all the hitherto discovered indigenous insects in accordance with their natural affinities. Containing also the references to every English writer on entomology, and to the principal foreign authors. With all the published British genera to the present time.* Baldwin & Cradock, London, xxxiv + [1] + 416 + 388 pp.

VAESEN, K. & KATZAV, J. (2017) How much would each researcher receive if competitive government research funding were distributed equally among researchers? *PloS One*, 12(9): e0183967.

WHEELER, Q.D. (1995) The “Old Systematics”: classification and phylogeny (Pp. 31–62). In: PAKALUK, J. & ŚLIPIŃSKI, S.A. [eds.] *Biology, Phylogeny, and Classification of Coleoptera: Papers celebrating the 80th Birthday of Roy A. Crowson. Volume one*. Muzeum i Instytut Zoologii, Warszawa, xii + 558 pp.

WHEELER, Q.D. (2014) Are reports of the death of taxonomy an exaggeration? *New Phytologist*, 201: 370–371.