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Funding, training, permits—the three big challenges of taxonomy

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Taxonomy is "the scientific discipline that explores, discovers, interprets, represents, names, and organizes organic beings" (Ebach *et al*. 2011: 550). It is one of the oldest biological disciplines.

A decrease in the number of taxonomists, and the lack of sufficient funding for taxonomy, caused by the lack of appreciation for this area of research, have been mentioned as some of the major factors impacting taxonomic research and impeding its progress (e.g. Dubois 2003; Carvalho *et al*. 2007; Ebach *et al*. 2011, but see Tancoigne & Dubois 2013 for an alternative view). Currently *ca*. 1.6 million species are known scientifically, but estimates about the true diversity of life on our planet range from several million (Costello *et al*. 2012) to 2 billion species once bacteria are included (Larsen *et al*. 2017). With habitat loss at an unprecedented scale and speed, and other anthropogenic negative influences, the discovery and scientific documentation of biodiversity, in the form of species descriptions, is felt by many taxonomists as a race against time. Only species bearing a scientific name are entities recognized by society and politics for conservation, often with a strong bias towards the larger and charismatic species.

Various attempts to stem the tide of losing species before they are even discovered by the dwindling number of taxonomists globally have included various initiatives, of which the most prominent were the NSF-funded Planetary Biodiversity Inventories (PBI) and Partnerships for Enhancing Expertise in Taxonomy (PEET), the first directed at monographically covering an entire taxonomic group globally and the second at training the next generation of taxonomists. An international, cross-institutional spot-focus on biodiverse areas, or the fast publication of large numbers of species by standardized workflows have also been identified as ways to tackle the taxonomy crisis. DNA taxonomy and DNA barcoding have been hailed more than 15 years ago as the new approaches that would overcome the taxonomic impediment (Godfray 2002; Hebert *et al*. 2003, 2004; Tautz *et al*. 2003), but studies like that of Bebber *et al*. (2013) seem to indicate that this has not happened. While DNA taxonomy was intentioned by its protagonists to replace traditional taxonomy, many taxonomic papers rather now include DNA barcodes and other DNA information alongside morphological characters—without DNA taxonomy having replaced traditional taxonomy. We predict that in the genomic era additional genetic marker systems will enter taxonomic descriptions, without changing the forever integrative character of this discipline. This can be taken as evidence for the continued primacy of a morphological and an organismic view in taxonomy over the reductionist DNA-only approach. Genetic approaches have certainly helped highlight taxa with underappreciated species level diversity, and have speeded up the step of species discovery, particularly in morphologically challenging and hyperdiverse groups. Yet, they have not helped to speed up species descriptions—it can even be argued they have sometimes slowed down the process, but without doubt have increased its scientific thoroughness (when well-done; see for a recent example Srivathsan *et al*. 2019).

Species descriptions still rely on the expertise of a practicing taxonomist to provide the important step of scientifically defining, and diagnosing, a new species including the nomenclatural act that makes a name available under the Code of Zoological Nomenclature or the Code of Nomenclature for Algae, Fungi, and Plants. Even the recently propagated approach of 'turbo-taxonomy', which has been highly successful to tackle hyperdiverse taxa (e.g. Butcher *et al*. 2012; Riedel *et al*. 2013; Riedel & Narakusumo 2019), still must employ the expertise of a trained taxonomist to reach its goal, bringing us back to one of the continuing challenges, the decreasing number of practicing taxonomists in general. A recent example for this bottleneck is the study by Srivathsan *et al*. (2019) that identified more than 650 phorid fly species. Yet, only a single species was described as new to science.

The training and recruitment of the next-generation taxonomists gets increasingly difficult with university

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education globally facing a significant decrease in both organismic focus and taxonomy in the respective curricula. Without counteracting here, taxonomy -and our society in general- will undoubtedly lose the battle of inventorying the diversity of life. This situation is further exacerbated by a change in research directions in those institutions that were considered the last remaining bastions of taxonomic research, the natural history museums with their vast collections. Many of the globally major natural history museums have increasingly moved away from their unique organismic and specimen-focused profile and engage in research fields decoupled from collections and specimens. We do not dispute achieved scientific quality in this process, but maintain that this type of research does not need to be performed in natural history museums.

We therefore feel that two of the biggest challenges taxonomy is facing are the same as during the last twenty-five years since the biodiversity crisis moved to the center of attention: (1) inadequate funding combined with (2) the lack of succession planning, training and recruitment into permanent positions of competent taxonomists.

These two interconnected issues have in the past few decades impeded taxonomic progress and had a negative impact on the academic education of the next generation of methodologically broadly trained, yet still taxonomically competent, new researchers. Application of the cut-throat criteria of amount of external funding and publication impact factors to measure scientific success have left taxonomy in a disadvantaged state. Taxonomic research does not need the same high level of external funding as, for instance, medical research or developmental genetic research and the impact factor system is not applicable as a quality measure to taxonomic research (Krell 2000).

With taxonomy and systematics being marginalized in many university curricula, the number of available competent next-generation taxonomists is expected to dwindle. This will aggravate the situation with an increasing number of taxonomists retiring, and we predict that broad-scale expertise in many organismal groups will be completely lost. Counteracting requires the re-introduction of taxonomy and systematics into university curricula on a broad scale and capitalizing on the remaining taxon expertise left in natural history museums by integrating these institutions into the university education. Faculties need to shift their focus towards hiring already rare taxonomic experts as academic staff and to appreciate their expertise in organismic biology, rather than applying simple metrics, like h-indices or the number of citations, when recruiting new permanent staff.

Another significant issue, to us the third big challenge for taxonomy, is represented by the increasingly difficult and complex legislative side of biodiversity research. The increasing burden when obtaining permits for field-work and for the scientific use of the collected samples, often within the framework of recently developed and well-intentioned Access and Benefit Sharing regulations, effectively hinders or even prevents taxonomic research in many fields (Neumann *et al*. 2018; Prathapan *et al*. 2018), especially when studying taxa with large distributions across political borders. Recent research has provided ample evidence that many wide-ranging taxa are much more diverse than thought before and represent several species or diverse species complexes (e.g., Hebert *et al*. 2003, 2004; see also Ceballos & Ehrlich 2009 for a review of mammal species and Bickford *et al*. 2006 for a general review). Such studies on wide-ranging taxa that led to the description of new species or the revalidation of previously synonymized species include for instance Korn & Hundsdoerfer (2016) for tadpole shrimps; Mutanen *et al*. (2013) and Kaila (2015) for a complex of presumably well-known moths; Adamson *et al*. (2019) for Asian bullseye snakehead fish; or Ihlow *et al*. (2016) and Petzold *et al*. (2014) for Southeast Asian and African turtles. Many of these works would have either taken much longer to complete or would have been impossible to tackle if the strict rules posed by the Nagoya Protocol had been in effect a few years earlier. Its negative impact is also felt in other areas of basic biodiversity-related research, like biological control, with attempts to argue for "tailored access and benefit-sharing legal frameworks" (Silvestri *et al*. 2019), an approach that could also be applied to taxonomic research to overcome this obstacle.

Having originally started with good intentions to safeguard the biodiversity of many developing countries from exploitation by developed countries, the Nagoya treaty has already started to stifle and strangle taxonomic research, a discipline without a strong international lobby. Rather than comprehending biodiversity as a global good and a global challenge when trying to preserve it, international biodiversity legislation has led to 'biodiversity nationalism', which often makes it extremely difficult to near impossible to work in some countries on biodiversity exploration. Some have highlighted the importance of training taxonomists from developing countries with high levels of unexplored biodiversity in developed countries that hold large collections and still have the respective expertise (Rodrigues *et al*. 2010), an initiative that appears to have worked in other, biodiversity related disciplines (Wemmer *et al*. 1993). This important step of capacity building to perform taxonomic research locally in developing countries may well be a solution for a number of areas in the world with high levels of biodiversity. A training and capacity building initiative for biodiverse developing countries may also help locally to alleviate what we described above as the second challenge for taxonomy, the training and recruitment into permanent positions of competent taxonomists. However, we are not optimistic that such initiatives will resolve the problems

associated with obtaining permits of widely distributed species that occur across many political borders. Under the current legislative situation, the taxonomic and phylogeographic study of many widely distributed taxa has become virtually impossible, for researchers from developed countries and from developing countries. It is obvious that this results in many cases in the continuation of an outdated classification that lumps together distinct species and counteracts the protection of unrecognized and overlooked taxa.

We live in a time of pressing environmental issues and large-scale environmental destruction. This, combined with a globally changing climate and an ever increasing demand for space and food by the growing human population, are the main drivers for the current biodiversity crisis, but not the collection of scientific specimens or genetic samples. It feels as if the scientific documentation of the diversity of life, which should be an international endeavor of utmost urgency, is currently being sacrificed in a process that seems to mask some of the most pressing issues for mankind.

References

Adamson, E.A.S., Britz, R. & Lieng, S. (2019) *Channa auroflammea*, a new species of snakehead fish of the Marulius group from the Mekong River in Laos and Cambodia (Teleostei: Channidae). *Zootaxa*, 4571, 398–408. http://dx.doi.org/10.11646/zootaxa.4571.3.7

Bebber, D.P., Wood, J.R.I., Barker, C. & Scotland, R.W. (2013) Author inflation masks global capacity for species discovery in flowering plants. *New Phytologist*, 201, 700–706. https://doi.org/10.1111/nph.12522

Bickford, D., Lohman, D.J., Sodhi, N.S., Ng, P.K.L., Meier, R., Winker, K., Ingram, K.K. & Das, I. (2006) Cryptic species as a window on diversity and conservation. *Trends in Ecology and Evolution*, 22, 148–155. https://doi.org/10.1016/j.tree.2006.11.004

Butcher, B.A., Smith, M.A., Sharkey, M.J. & Quicke, D.L.I. (2012) A turbo-taxonomic study of Thai *Aleiodes* (*Aleiodes*) and *Aleiodes* (*Arcaleiodes*) (Hymenoptera: Braconidae: Rogadinae) based largely on COI barcoded specimens, with rapid descriptions of 179 new species. *Zootaxa*, 3457, 1–232. http://dx.doi.org/10.11646/zootaxa.3457.1.1

de Carvalho, M.R., Bockmann, F.A., Amorim, D.S., de Vivo, M., de Toledo-Piza, M., Menezes, N.A., de Figueiredo, J.L., Castro, R.M.C., Gill, A.C., McEachran, J.D., Compagno, L.J.V., Schelly, R.C., Britz, R., Lundberg, J.G., Vari, R.P. & Nelson, G. (2005) Revisiting the taxonomic impediment. *Science*, 307, 353. https://doi.org/10.1126/science.307.5708.353b

Ceballos, G. & Ehrlich, P.R. (2009) Discoveries of new mammal species and their implications for conservation and ecosystem services. *Proceedings of the National Academy of Sciences of the USA*, 106, 3841–3846. https://doi.org/10.1073/pnas.0812419106

Costello, M.J., Wilson, S.P. & Houlding, B. (2012) Predicting total global species richness using rates of species description and estimates of taxonomic effort. *Systematic Biology*, 61, 871–883. https://doi.org/10.1093/sysbio/syr080

Dubois, A. (2003) The relationships between taxonomy and conservation biology in the century of extinctions. *Comptes Rendus Biologies*, 326, S9–S21. https://doi.org/10.1093/sysbio/syr080

Ebach, M.C., Valdecasas, A.G. & Wheeler, Q.D. (2011) Impediments to taxonomy and users of taxonomy: accessibility and impact evaluation. *Cladistics*, 27, 550–557. https://doi.org/10.1111/j.1096-0031.2011.00348.x

Godfray, H.C.J. (2002) Challenges for taxonomy. *Nature*, 417, 17–19. https://doi.org/10.1038/417017a

Hebert, P.D.N., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003) Biological identifications through DNA barcodes. *Proceedings of the Royal Society B*, 270, 313–322. https://doi.org/10.1098/rspb.2002.2218

Hebert, P.D.N., Ratnasingham, S. & deWaard, J.R. (2004) Barcoding animal life: cytochrome *c* oxidase subunit 1 divergences among closely related species. *Proceedings of the Royal Society London B*, 270 (Supplement 1), S96–S99. https://doi.org/10.1098/rsbl.2003.0025

Ihlow, F., Vamberger, M., Flecks, M., Hartmann, T., Cota, M., Makchai, S., Meewattana, P., Dawson, J.E., Kheng, L., Rödder, D. & Fritz, U. (2016) Integrative taxonomy of Southeast Asian snail-eating turtles (Geoemydidae: *Malayemys*) reveals a new species and mitochondrial introgression. *PLoS ONE*, 11, e0153108. https://doi.org/10.1371/journal.pone.0153108

Kaila, L. (2015) New Palearctic species of the *Elachista bifasciella* group (Lepidoptera: Gelechioidea, Elachistidae). *Shilap*, 43, 385–423.

Korn, M., & Hundsdoerfer, A.K. (2016) Molecular phylogeny, morphology and taxonomy of Moroccan *Triops granarius* (Lucas, 1864) (Crustacea: Notostraca), with the description of two new species. *Zootaxa*, 4178, 328–346. http://dx.doi.org/10.11646/zootaxa.4178.3.2

Krell, F. (2000) Impact factors aren't relevant to taxonomy. *Nature*, 405, 507–508. http://dx.doi.org/10.1038/35014664

Larsen, B.B., Miller, E.C., Rhodes, M.K. & Wiens, J.J. (2017) Inordinate fondness multiplied and redistributed: the number of species on earth and the new pie of life. *The Quarterly Review of Biology*, 92, 229–265. https://doi.org/10.1086/693564

Mutanen, M., Kaila, L. & Tabell, J. (2013) Wide-ranging barcoding aids discovery of one-third increase of species richness in presumably well-investigated moths. *Scientific Reports*, 3, 2901. https://doi.org/10.1038/srep02901

Neumann, D., Borisenko, A.V., Coddington, J.A., Häuser, C.L., Butler, C.R., Casino, A., Vogel, J.C., Haszprunar, G. & Giere, P. (2018) Global biodiversity research tied up by juridical interpretations of access and benefit sharing. *Organisms, Diversity & Evolution*, 18, 1–18. https://doi.org/10.1007/s13127-017-0347-1

Petzold, A., Vargas-Ramírez, M., Kehlmaier, C., Vamberger, M., Branch, W.R., Du Preez, L., Hofmeyr, M.D., Meyer, L., Schleicher, A., Široký, P. & Fritz, U. (2014) A revision of African helmeted terrapins (Testudines: Pelomedusidae: *Pelomedusa*), with descriptions of six new species. *Zootaxa*, 3795 (5), 523–548.

https://doi.org/10.11646/zootaxa.3795.5.2

Prathapan, K.D., Pethiyagoda, R., Bawa, K.S., Raven, P.H., Rajan, P.D., Acosta, L.E., Adams, B., Adl, S., Ahyong, S.T., Anderson, R., Arango, C.P., Arnedo, M.A., Armbruster, J.W., Avila, L.J., Azevedo, C.O., Baldo, D., Barclay, M.V.L., Baron-Szabo, R., Bauer, A.M., Bentlage, B., Bezdek, A., Bird, G., Blagoderov, V., Bocak, L., Bonaldo, A., Bond, J.E., Borkent, C.J., Branham, M.A., Carranza, S., Carreno, R., de Carvalho, M.R., Castroviejo-Fisher, S., Chiba, H., Ciampor, F., Clarke, D.J., Collins, A.G., Constantino, R., Crespo, F.A., Daly, M., Dominiak, P., Dronen, N., Dubois, A., Duda, T.F., Eleaume, M., Erlacher, S., Estrela, P.C., Evenhuis, N., Fehlauer-Ale, K.H., Fery, H., Fritz, U., Gaimari, S.D., Garrison, R., Gaubert, P., Geiger, D.L., Gill, A.C., Gimmel, M.L., Goldschmidt, T., Goswami, R., Gonzalez, A.P., Gonzalez, V.H., Gordon, D., Gower, D.J., Greenslade, P., Gusarov, V.I., Hajdu, E., Harms, D., Heinicke, M.P., Hilton, E.J., Hodgson, C.J., Hormiga, G., Hughes, L.E., Hutchings, P., Jäger, P., Jennings, J.T., Kadej, M., Kaila, L., Kaminski, M.J., Karaman, G.S., Karanovic, T., Kathirithamby, J., Kerr, P.H., Kirkendall, L.R., Kitahara, M.V., Klautau, M., Kondratieff, B.C., Kroh, A., Labarque, F.M., Leavengood, J.M., Letardi, A., Liang, A.-P., Lima, F.C.T., Liu, Z., Löbl, I., Lohrmann, V., Malchus, N., Malipatil, M.B., Marques, A.C., Matzke-Karasz, R., Mayer, G., Mayoral, J.G., McInnes, S.J., Minelli, A., Moir, M.L., Monks, S., Morrone, J.J., Muster, C., Nagy, Z.T., Narayanan, K.S., Nearns, E.H., Nekola, J., Nihei, S.S., Nutzel, A., Ohler, A., Orrico, V.G.D., Padial, J.M., Page, L.M., Passos, P., Paulson, D., Perkins, P.D., Pfingstl, T., Prieto, C., Pinheiro, L.R., Pinto-da-Rocha, R., Prendini, L., Price, B., Prins, J.D., Ramirez, M., Rasmussen, C., Rasmussen, P., Redei, D., Ribera, I., Ricarte, A., Rivera, J., Rix, M.G., Rossaro, B., Roy, A.D., Ruiz, G.R.S., Salles, F.F., Sanborn, A.F., Sartori, M., Scholler, M., Schmelz, R.M., Schrödl, M., Segniagbeto, G.H., Serrano, J., Shimano, S., Shin, M.K., Sidorchuk, E., Siler, C.D., Sket, B., Smith, A.D., Smith, A.B.T., Smith, R., Smith-Pardo, A.H., Sparks, J., Sterrer, W.E., Stroinski, A., Svavarsson, J., Toledo, M., Twomey, E., Vasudevan, K., Vences, M., de Voogd, N., Wang, Q., Watson, G.W., Weiner, W.M., Weksler, M., Wesener, T., Whitmore, D., Wiklund, H., Williams, P.H., Winterton, S.L., Wood, T.S., Yen, S.-H., Zaher, H., Zhang, Z.-Q. & Zhou, H.-Z. (2018) When the cure kills—CBD limits biodiversity research. *Science*, 360, 1405–1406. https://doi.org/10.1126/science.aat9844

Riedel, A. & Narakusumo, R.P. (2019) One hundred and three new species of *Trigonopterus* weevils from Sulawesi. *ZooKeys,* 828, 1–153. https://doi.org/10.3897/zookeys.828.32200

Riedel, A., Sagata, K., Suhardjono, Y.R., Tänzler, R. & Balke, M. (2013) Integrative taxonomy on the fast track – towards more sustainability in biodiversity research. *Frontiers in Zoology*, 10, 15. https://doi.org/10.1186/1742-9994-10-15

Rodrigues, A.S.L., Gray, C.L., Crowter, B.J., Ewers, R.M., Stuart, S.N., Whitten, T. & Manica, A. (2010) A global assessment of amphibian taxonomic effort and expertise. *BioScience*, 60, 798–806. https://doi.org/10.1525/bio.2010.60.10.6

Silvestri, L., Sosa, A., McKay, F., Diniz Vitorino, M., Hill, M., Zachariades, C., Hight, S., Weyl, P., Smith, D., Djeddour, D. & Mason, P.G. (2019) Implementation of access and benefit-sharing measures has consequences for classical biological control of weeds. *BioControl*, in press. https://doi.org/10.1007/s10526-019-09988-4

Srivathsan, A., Hartop, E., Puniamorrthy, J., Lee, W.T., Kutty, S.N., Kurina, O. & Meier, R. (2019) Rapid, large-scale species discovery in hyperdiverse taxa using 1D MinION sequencing. *BMC Biology*, 17, 96. https://doi.org/10.1186/s12915-019-0706-9

Tancoigne, E. & Dubois, A. (2013) Taxonomy: no decline, but inertia. *Cladistics*, 29, 567–570. https://doi.org/10.1111/cla.12019

Tautz, D., Arctander, P., Minelli, A., Thomas, R.H. & Vogler, A.P. (2003) A plea for DNA taxonomy. *Trends in Ecology and Evolution*, 18, 70–74. https://doi.org/10.1016/S0169-5347(02)00041-1

Wemmer, C., Dallmeier, F. & Wilson, D.D. (1993) Training developing-country nationals is the critcal ingredient to conserving global biodiversity. *BioScience*, 43, 762–767. https://doi.org/10.2307/1312320