

Editorial**Insect taxonomy, biodiversity research and the new taxonomic impediments**

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It is a well-known matter-of-fact that a huge number of animal diversity on Earth, estimated by most zoologists around 3 to 5 million species at least, still needs to be discovered, studied by specialists, and described. This picture of ignorance becomes even worse if we also consider that our knowledge (e.g., about ecology, distribution, genetics, life history, conservation status) of the living animal species thus far described (less than 2 millions) is still very poor and dramatically incomplete, especially for most invertebrates. The worrying rate of habitat loss, fragmentation and simplification due to the human never-ending activities renders the overall scenario particularly dark, pressing the international community of scientists and taxonomists to urgently fill this enormous taxonomic gap (Dubois 2011), also known as “Linnaean shortfall” (Brito 2010).

In entomology, where basic systematic work involves, probably more than in other animal groups, both professional and amateur taxonomists, the synergy between these two partially overlapping communities is a backbone of the primary research on biodiversity. Integration among professional and amateur taxonomists was called for by several authors (e.g., Fontaine et al. 2012), and the need for a common scientific path is also supported by the recent increasing developments of Citizen Science (Bonney et al. 2009; Campanaro et al. 2017; Zapponi et al. 2017).

In this general scenario, several authors recently discussed appropriately about the so-called Taxonomic Impediment, i.e., the lack or the marked shortage, in several countries, of qualified professionals or amateur taxonomists and of financial resources in the field of alpha-taxonomy, the necessary first-level approach to every biodiversity study (Giangrande 2003, Wheeler et al. 2004; De Carvalho et al. 2007; Wheeler 2008; Ebach et al. 2011). This is certainly true, although (in some more countries at least) both the overall number of taxonomists and the public financial resources available to them have shown a slight increase in the last few years, due to the growing demand of knowledge on management of biodiver-

sity resources and their conservation (Boero 2001; Rodman et al. 2003; Agnarsson & Kuntner 2007). For example, remarkable recent efforts have been done in Brazil, with good results, to greatly improve the number and the skills of local researchers on taxonomy and systematics, although the combined excess of local “protectionist approach” risks to exclude the international community from a freely shared access to basic taxonomic data and material (discussed below).

Currently, however, some new, additional important impediments are growing on a World scale, progressively threatening the existence, the freedom and, let me say, the serenity of taxonomic research on biodiversity.

Bureaucratic Moloch and Biodiversity research

The first new impediment is certainly the increasing bureaucracy’s weight concerning field research permissions, damaging basic scientific research in several countries in Europe, as well as in Africa, Asia, USA, Australia and South America. To these problems must be added the combined increasing difficulties to move entomological and zoological material throughout airports, customs, postal services, etc. Most of the bureaucratic technicalities causing this situation were originally imagined to protect biodiversity from commercial exploitation by ruthless traders or to prevent diffusion and introduction of alien species, but, in fact, the most serious effects involve now researchers and scientists which in some cases can no longer investigate certain local faunas. The most emblematic case in this scenario is probably India, where several decades of demonization of the biodiversity research by foreign scientists (chiefly after the promulgation of the Biological Diversity Act in 2002: <http://nbaindia.org/text/12//TheBiologicalDiversityAct2002.html>) caused the present-day knowledge on Indian fauna to be very poor for several groups of invertebrates, despite India’s recognized status of megadiversity country. Although some virtual

proclaims tried to demonstrate the contrary (e.g., Pushpangadan & Narayanan Nair 2001), probably only a small portion of the present-day taxonomic gap of Indian entomological biodiversity has the potential to be filled in by local scientists alone (most of them being oriented towards applied biology). Generally speaking, it is, in fact, evident that in modern systematic research all kinds of politically-imposed autarchic solutions are always wrong and simply out of time. It seems that some countries unfortunately confused the basic information on taxonomy and biodiversity, which should be acknowledged as an internationally shared scientific heritage, with the management of local biodiversity resources of potential additional values in terms of economic exploitation (an obviously inviolable right of each country). However, happily some other countries recently applied a much wiser policy, like China, where official cooperation between local taxonomists and foreign scientists was on the contrary greatly promoted and granted, and addressed to cover most taxonomic groups, with excellent results in terms of both quick increasing knowledge of local biodiversity, and quick improvement of the number and skill of Chinese taxonomists.

Also some recent decisions such as those associated with the adoption of the Nagoya Protocol [*Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity*; <https://www.cbd.int/abs/about/>], if applied according to a strict bureaucratic approach, seriously risk to render field research and data collection much more problematic even in some European countries. In this kind of processes the involvement of the scientific community of taxonomists is frequently inadequate or even zero; this rather anomalous procedure paradoxically produces the most negative effects in many aspects of the basic scientific research on biodiversity.

Another seriously negative aspect of our Bureaucratic Moloch involves the ever-growing power of bibliometric parameters in most evaluation processes aimed to select professionals in the field of biology and nature sciences, and to assign financial resources to competing research projects. Such procedures obviously strongly discriminate taxonomists, due to the simple fact that most journals dealing with taxonomy and systematics have low IF, or don't have any at all (Krell 2000), while more generalist journals usually refuse to host taxonomic publications. These are, in fact, unlikely to be cited, thus lowering the journal's overall impact factor. This argument has been amply discussed elsewhere (e.g., Valdecasas et al. 2000; Agnarsson & Kuntner 2007), in some countries it has been at least partially overcome, but in others (e.g. in Italy) the situation is becoming worse and worse. The main effect of this process in several countries is a never-ending marginalization of taxonomists within Universities, Research Centers, and even some Natural History Museums. As appropriately pointed out by Agnarsson & Kuntner (2007), "*To over-*

come the taxonomic impediment one important step is to start treating taxonomic hypotheses with the respect they deserve and realize their true scientific impact".

It is probably time that a best practice policy be introduced at international level, in order to more wisely combine conservation biology, national policies on biodiversity management, international scientific research on systematics and taxonomy, and preservation and improving of public Zoological Collections (Entomological Society of America 2017). The creation of some kind of International Agency specifically devoted to assist, supervise, and control the research activities in the field of basic biodiversity description worldwide would be essential to enforce a homogeneous and wise policy in this field. An international Board could be organized, involving, e.g., managers of GIBF, ICZN & ZooBank, IUCN, the Society for Conservation Biology, representatives of the main Natural History Museums, of University zoological Museums, and of local agencies of Nature Conservation and Biodiversity management. Such a reference organism could greatly help the national authorities to correctly regulate field research activities; simultaneously improving and sustaining the level of local and global taxonomic knowledge, the skill of local researchers, and the efficiency of international cooperation, especially in emergent, species-rich but faunistically poorly known countries (see, e.g., D'Alessandro et al. 2016).

It would be highly desirable also to establish an international official list of researchers and specialists (both professional and internationally recognized amateur taxonomists), formally and officially qualified to carry out field research for merely scientific purposes, as well as a common protocol to apply for permissions to collect scientific material during field work. The same is true for rules on type material repository, commitments in preparation of common scientific articles, mandatory cooperation with local scientists and local research centers, and ethics on data collection and data management. To cite Wheeler et al. (2004) and Godfray (2002), respectively, "*Taxonomy is planetary-scale science and deserves planetary-scale tools*", and "*for taxonomy to flourish now and in the future, it has to move from the first to the second model: from having a distributed to a unitary organization*".

DNA life barcoding, Environmental Barcoding, and false shortcuts

The recent explosive developments of DNA barcoding initiatives (Hebert et al. 2003, 2004; Hajibabaei et al. 2007) and of the New Generation Sequencing tools (Hajibabaei et al. 2011) highly promoted and enhanced, on one side, the available information on animal phylogeny and genetics, producing strongly positive effects also in the field of the integrative animal taxonomy, and markedly reducing the average costs of molecular phylogenetic analyses.

But the apparent ease to obtain data on species identification and on overall biodiversity measurement using molecular tools, recently generated also the misinterpreted illusion in the public opinion, in some ecologists and molecular biologists, as well as in several policy makers, that “traditional” taxonomy could be almost completely overcome and put apart by the use of these new revolutionary tools, even completely bypassing the need of “tedious” skills such as those of morphologically-based taxonomists and entomologists (Wheeler et al. 2004; Ebach et al. 2011).

The risk is therefore to allocate most (if not all) available financial resources of several countries in national and international programs on biodiversity based on merely molecular or bioinformatics approaches, considered a more economic, “scientific” and “modern” way to face the demand of biodiversity information (Godfray 2007). In the most recent years we are, in fact, witnessing to the creation of a plethora of national and international databases, where distributional data, molecular characterizations, ecological and model-oriented information are in most cases based on a derisory number of publically available row data (originated by “traditional” taxonomists), especially for the invertebrates. The obvious risk is therefore the building up of virtually large but empty boxes, ever increasing in number, formally smart but substantially useless, that risk even to replace the real data over time.

It should also be stressed that the frequently proclaimed ability of molecular tools to correctly detect cryptic biodiversity (Hebert et al. 2004), in comparison with traditional morphological (and ecological) taxonomy, was greatly overestimated, as several recent comparative analyses have convincingly demonstrated (e.g., Trizzino et al. 2011; De Biase et al. 2012; McClure & Elias 2017). This evidence is clear especially for recently evolved taxa, which may not have had the requisite evolutionary time necessary for reciprocal genetic monophyly to be achieved following speciation (despite even marked levels of accumulated morphological and ecological differentiation: De Biase et al. 2012).

Molecular tools and model-based ecological analyses risk therefore to represent stimulating and appealing proxy of the basic biodiversity information, erroneously considered by policy-makers and funding providers to be useful shortcuts to get sound biodiversity information. The international community of taxonomists and systematics needs therefore to make her voice heard as soon as possible, to avoid this novel kind of further marginalization.

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