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Advances on Dipterology in the 21st century and extinction rates

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ABSTRACT

At least one million extant insect species have been described on Earth, of which 150,000 belong to the megadiverse order Diptera. We here synthesize data from the last 15 years of taxonomic work in Diptera, mapping the world taxonomic productivity in the order. Our data shows an increasing importance of China and Brazil in taxonomic production, along with other traditional centres such as the USA and Europe. We correlate our database with estimates of extinction rates to determine the amount of basic taxonomic research still necessary to have the description of the fly diversity before extinction. Due to the growing recent extinction rates, it is unlikely that we will be able to entirely describe unknown fly diversity before their demise. Even considering that is still a constant and increasing speed of new species description, raising the number of active dipterists in the world is an urgent priority and the only real solution.

Key-Words: Biodiversity; Diptera; Entomology; Extinction rates; Systematics.

INTRODUCTION

Earth biodiversity remains poorly known. Estimates of the number of extant species have varied between two and 100 million species (González-Oreja, 2008; Costello *et al.,* 2013). We will certainly never know the actual number of extant and extinct species that have existed since the origin of life – some information is simply lost. Nevertheless, it has been argued that around 100 extinct species have existed for each extant species (Dawkins, 1995).

Popularly known as true flies, gnats, midges or mosquitoes, Diptera has a rich evolutionary and taxonomic history. Such richness has demanded a great and diverse academic community dedicated to the study of the diversity of this order throughout the world. This has not been able to accomplish the task and considerable work is still necessary to fulfill the gaps in taxonomic knowledge for most groups of dipterans. However, this need should not be taken as justification for prioritizing volume over quality (Carvalho *et al.,* 2014; Amorim *et al.,* 2016).

There is not enough awareness of the centrality of taxonomy (Santos *et al.,* 2016). Being a quite old science or using often low-technology to compile information, the entire communication on biological taxa or biological features is strictly dependent on the correct use of the same names for the same

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groups. Budget cuts and reduction in technical staff in natural history museums may be partially the result of a general reduction of interest in basic research – that particularly affects taxonomy (Amorim *et al.,* 2016). Economic restraints could be argued as limiting factors as well. Whatever the causes of budget reduction, funding for taxonomy becomes even more critical at times of growing rates of extinction (Scheffers *et al.,* 2012; Costello *et al.,* 2013; Ceballos *et al.,* 2015) due to direct anthropic activities and to global changes (Joppa *et al.,* 2016; Waters *et al.,* 2016). Time is against taxonomists: it is unlikely that we will be able to describe the entire extant biodiversity, Diptera included, before species threatened with extinction finally perish. Actually, extinction of species still unknown is already occurring. González-Oreja (2008) provided estimates suggesting that a considerable number of taxonomists will be needed to describe all species on Earth in a time span above 100 years. During this period, an important amount of this biodiversity will have disappeared.

In fact, the challenge for any biodiversity survey seems an open-ended question – maybe there is no way to describe all species of Diptera in the world (Bickel, 2009). Even though, as pointed by Hochkirch (2016), we must support global programs to explore and preserve biodiversity. It is indeed possible to preserve what is unknown – a national park established on the basis of vertebrates, vascular plants and scenery, for example, will allow conservation of a huge number of small organisms that may remain forever undescribed. But knowing the biological diversity is not a simple luxury of scientific vanity. The lack of taxonomic knowledge – especially through the destruction of natural environments and insufficient investment in the study of biodiversity – diminishes the possibilities of properly comprehending evolutionary and biogeographic history and, in the long run, of loss of profit. Secondarily, this has negative consequences on the understanding and characterizing ecosystems and, hence, initiatives for biological conservation. There is impact on water supplies and on the very sources of biotechnology.

A central issue, hence, concerns how much we already know. To assess recent effort in the study of undescribed biological diversity, the information on the last 15 years of taxonomic research in Diptera was synthesized in a database compiling number of species descriptions and redescriptions published in peer-reviewed journals, which is compared to the development of the international dipteran community throughout the years. With this, we have a twofold goal: to map the world scientific production in Diptera from 2000 to 2015 and correlate our database with three different assumed extinction rates – thus estimating the amount of necessary basic taxonomic research for knowing the entire biodiversity of Diptera.

MATERIAL AND METHODS

We compiled species descriptions and name changes in Diptera published in peer-reviewed journals between 2001 and 2015 based on papers indexed in the Web of Science platform. During the searches, we used 92 different combinations (*e.g.,* n. ssp., subsp. nov., new subspecies, spec. nov., sp. nov., sp. n., new species etc.) to cover the maximum information on new species, new genera, synonyms and any other changes in the taxonomic status of a given name.

Information was gathered in a database including the species name (or its synonym), author(s), year of publication, journal name and country of authors. We organized the information of the published papers into ten categories to classify the total number of species studied per year. This includes the number of new species, modified species (*i.e.,* taxonomic acts modifying species status such as synonyms, new generic combinations and replacement names), papers written in collaboration, international collaborations, number of new and modified species per author, new genera, new subgenera, published papers, species by paper, and total authors by paper. Table 1 summarizes our numerical data.

RESULTS

We were able to identify the top-10 most productive countries regarding taxonomy in Diptera from 2001 to 2015 (Fig. 1) and the number of new species and taxonomic changes of flies published during the same period (Fig. 2). The relative number of collaborations (both same-country and different countries researchers) is shown in Fig. 3. The number of papers on any taxonomic aspects of Diptera published in the top-10 journals from 2001-2015 is presented in Fig. 4. The total number of species changes of Diptera (*i.e.,* new species, redescriptions and species status changes) and the number of new species of the order published in the last 15 years considering the top-10 most productive countries of the period are shown respectively in Figs. 5 and 6. Considering a constant increasing of new species for Diptera based on the data from the last 15 years, we project how many years would be necessary to describe the

TABLE 1: Data on the increase in taxonomical knowledge in Diptera from 2001 to 2015 gathered from the Web of Science platform, divided into categories.

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Total species number	701	545	903	1062	1312	1079	981	1165	1442	1284	1543	1445	1325	1187	1256
New species	572	420	632	858	911	875	828	924	1057	908	910	1160	1021	911	1055
Modified species	129	125	271	204	401	204	153	241	385	376	633	285	304	276	201
Collaboration	53%	56%	67%	63%	71%	66%	67%	71%	75%	73%	69%	73%	73%	80%	82%
International collaboration	34%	16%	24%	28%	30%	34%	26%	26%	28%	24%	33%	25%	35%	36%	40%
Species/author	3.13	2.06	2.27	2.20	2.44	2.01	1.70	1.96	1.79	1.99	2.06	1.92	1.89	1.57	1.51
New genera	39	21	38	27	64	52	48	69	33	45	40	47	50	44	66
New subgenera	4	2	10	2	5	0	2	5	2	3	4	3	2	0	1
Papers	131	148	194	254	262	263	275	282	343	285	342	338	289	304	299
Species/paper	5.35	3.68	4.65	4.18	5.01	4.10	3.57	4.13	4.20	4.51	4.51	4.28	4.59	3.91	4.20
Authors/paper	1.71	1.78	2.05	1.90	2.05	2.04	2.10	2.10	2.35	2.26	2.19	2.23	2.43	2.49	2.78

presumed diversity of the order according to Scheffers *et al.* (2012) and Brown (2005), and taken three different extinction rates (Figs. 7 and 8).

DISCUSSION

Worldwide distribution of effort on Diptera taxonomic knowledge and journal destination

It is commonly suggested that the productivity of the global taxonomists and systematists – those mainly responsible for species descriptions – is declining (Hopkins & Freckleton, 2002; Carvalho *et al.,* 2005; Marques & Lamas, 2006; Carbayo & Marques, 2011; Joppa *et al.,* 2011, Tancoigne & Dubois, 2013). This is not supported by our data (Table 1), that shows a different scenario: the number of world dipterists is rising globally, particularly in countries such as China and Brazil, remaining quite stable in centres (USA and Europe) more traditionally involved with taxonomical research. In the words of Bacher (2012: 65), nevertheless, "even after more than 250 years of taxonomic study, the increasing number of taxonomists is not enough to allow estimation of how many species there are still left to be discovered in speciose but less-well studied taxa".

Describing biodiversity is a resource demanding activity, frequently based on focus and determination. Carbayo & Marques (2011) estimate that around US$ 250 billion and almost 400 years of work would be necessary to describe the entire animal kingdom, a gigantic task. Although money itself would not guarantee qualified taxonomic work, "governments, science funders and environmental agencies need to invest" (Hochkirch, 2016, p. 141). The decline of funding from governmental and private agencies, and the tendency of students moving towards more in vogue and fancy areas of scientific investigation jeopardize the ability of the area to accomplish its goals and the urgent need of development (Lajus *et al.,* 2015). The 'taxonomic impediment' – *i.e.,* the small and inadequate number of proficient taxonomists, and the consequential lack of keys and other resources for accurate identification – is a reality (Carvalho *et al.,* 2005; Evenhuis, 2007) and may affect entomologists in general and dipterists in particular. At least one million insect species already have been described (Grimaldi & Engel, 2005; Scheffers *et al.,* 2012), but the number of species awaiting for formal description, including their supraspecific taxa in the biological system, may still be up to millions, especially in the five megadiverse orders (Coleoptera, Lepidoptera, Hymenoptera, Hemiptera, and Diptera) (Scheffers *et al.,* 2012; Hebert *et al.,* 2016).

During the last 15 years, there is a strong trend indicating China, Brazil, and USA as the leading countries authoring taxonomic papers in Diptera. From 2001 to 2015, China has been the main source of new papers with species descriptions, redescriptions, taxonomic revisions and notes (Fig. 1). Out of 4,009 total papers published from 2001 to 2015, 2,198 has at least one Chinese co-author, with an astonishing average of 146.5 papers/year. For the same period Brazil comes second, with 1,153 papers having at least one Brazilian co-author (76.8 papers/year) (Table 1, Fig. 1). The remaining eight top-10 countries include USA, Japan, United Kingdom, Russia, Canada, Argentina, Australia, and Poland – somewhat constant from 2001 to 2015.

The absolute number of published papers is not the most important metric: the number of new species described (Fig. 2) and the quality of the descriptions should be analyzed *in tandem* with increases or decreases in number of published papers. Emphasizing only the number of papers somehow may reinforce the academic frenzy for fast and numerous publications, potentially damaging to the biological system, under the pression over the area since the last quarter of the 20th century (Amorim *et al.*, 2016; Santos *et al.*, 2016). Although statistics are often the main concern of research funding agencies – generally, more published papers mean more money to keep working at the same (or faster) pace –, they should not be the main priority for taxonomists. It is better to describe vast number of new species in a single revisionary paper or monograph than to divide it into numerous non-contextualized papers, with no comments on ecology, biogeography, phylogeny etc. This sort of *szalámitaktika* – a Hungarian term coined in the

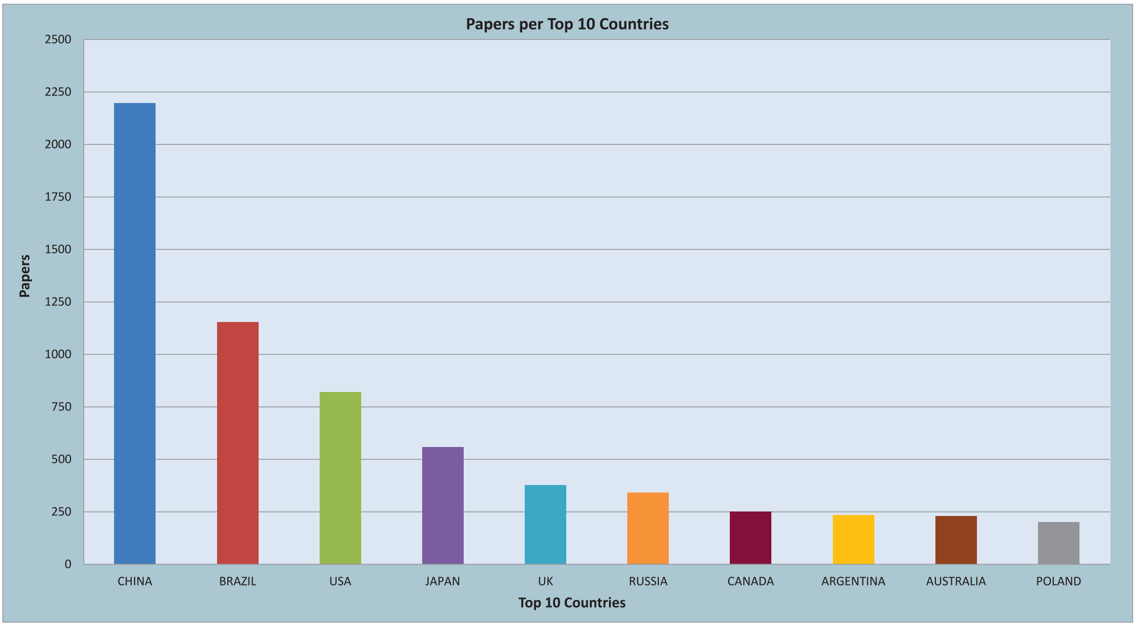

FIGURE 1: Total number of published papers (in journals indexed to Web of Search) dealing with taxonomy of Diptera among the top-10 most productive countries from 2001 to 2015.

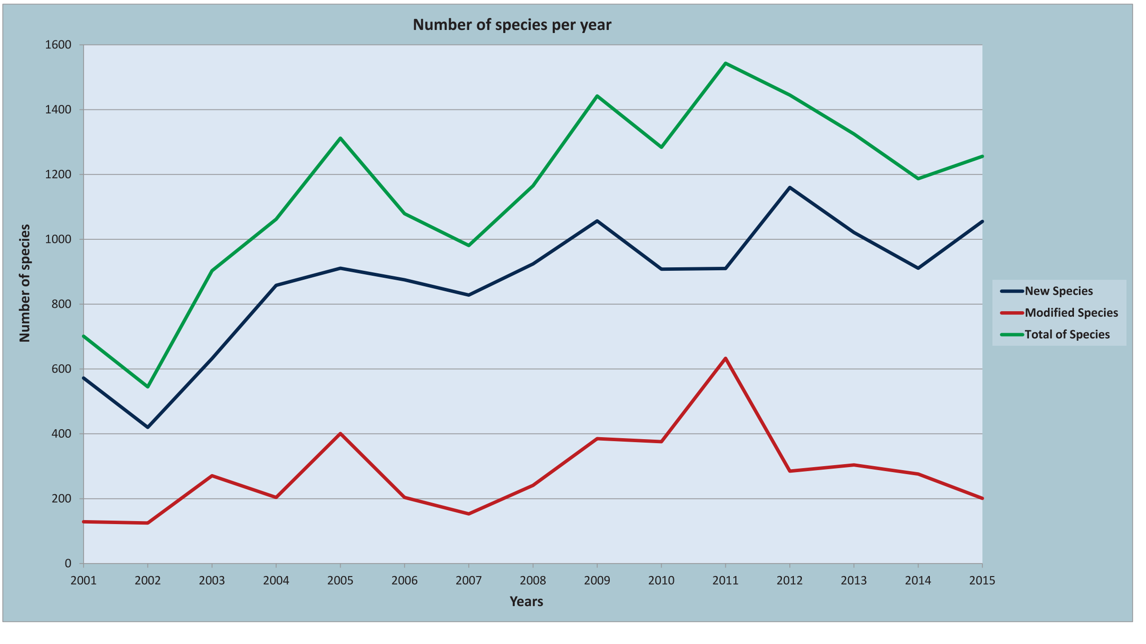

FIGURE 2: Blue: number of new species of Diptera published from 2000-2015. Red: modified species status (taxonomic acts modifying species status such as synonyms, new combinations and replacement names) in fly species in the period. Green: total number of new species and species changes.

late 1940s that means "salami-slice strategy" – is often prejudicial to science, to taxonomy, and to conservation, turning the field into an unnecessary competition for growing number of papers and citations.

According to Costello *et al.* (2013), the number of taxonomists, including dipterists, is decreasing in some of the countries that formerly led the field – *e.g.*, the USA and UK –, but is growing in South America and Asia. At least for Brazil, the reasons are diverse. This includes increased funding from governmental agencies, such as the Coordination for the Improvement of Higher Education Personnel (CAPES, in the

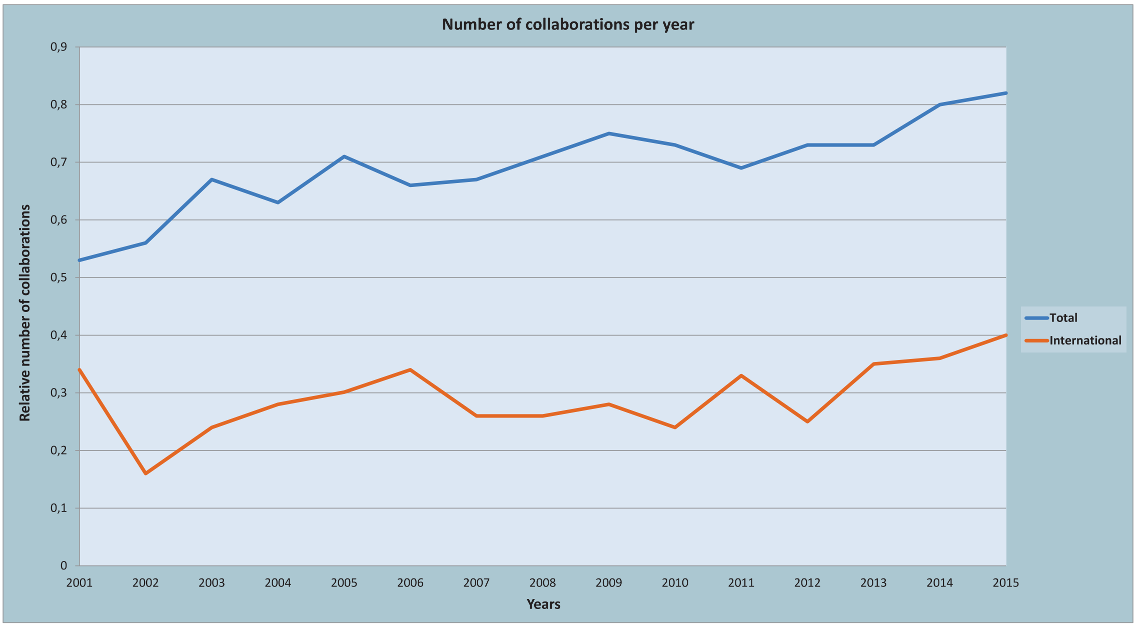

FIGURE 3: Relative number of total (blue) and international (orange) collaborations (*i.e.,* multi-author papers) in taxonomy of Diptera from 2001 to 2015. A collaboration is considered international when there are at least two authors from different countries per paper.

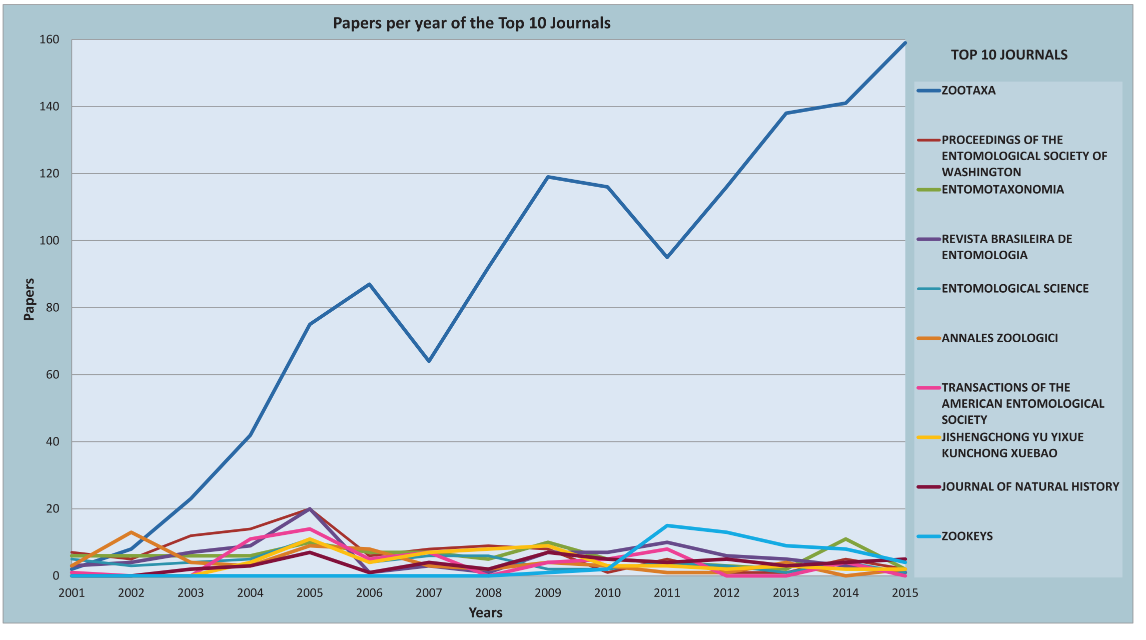

FIGURE 4: Published papers per year in taxonomy of Diptera in the top-10 journals from 2001 to 2015. In absolute numbers: Zootaxa: 1,277; Proceedings of the Entomological Society of Washington: 104; Entomotaxonomia: 90; Revista Brasileira de Entomologia: 87; Entomological Science: 61; Annales Zoologici: 60; Transactions of the American Entomological Society: 59; Jishengchong Yu Yixue Kunchong Xuebao: 58; Journal of Natural History: 52; and Zookeys: 52.

Portuguese acronym) for Grad students, and the National Council for Scientific and Technological Development (CNPq) and the São Paulo Research Foundation (FAPESP) for research; collaborative projects including large numbers of dipterists (*e.g.,* the FAPESP Research Program on Biodiversity Characterization, Conservation, Restoration and Sustainable Use, known as BIOTA-FAPESP); the sustained expansion of Federal Universities from 2002 to 2015, consequently engaging a large number of taxonomists and systematists in their teaching pools; and support from experienced taxonomists in North America and Europe to young dipterists. Unfortunately, the growth of Brazilian basic science after 15 years of rapid expansion may be in serious danger of retraction to levels seen two or three decades ago (Gibney, 2015; Angelo, 2016).

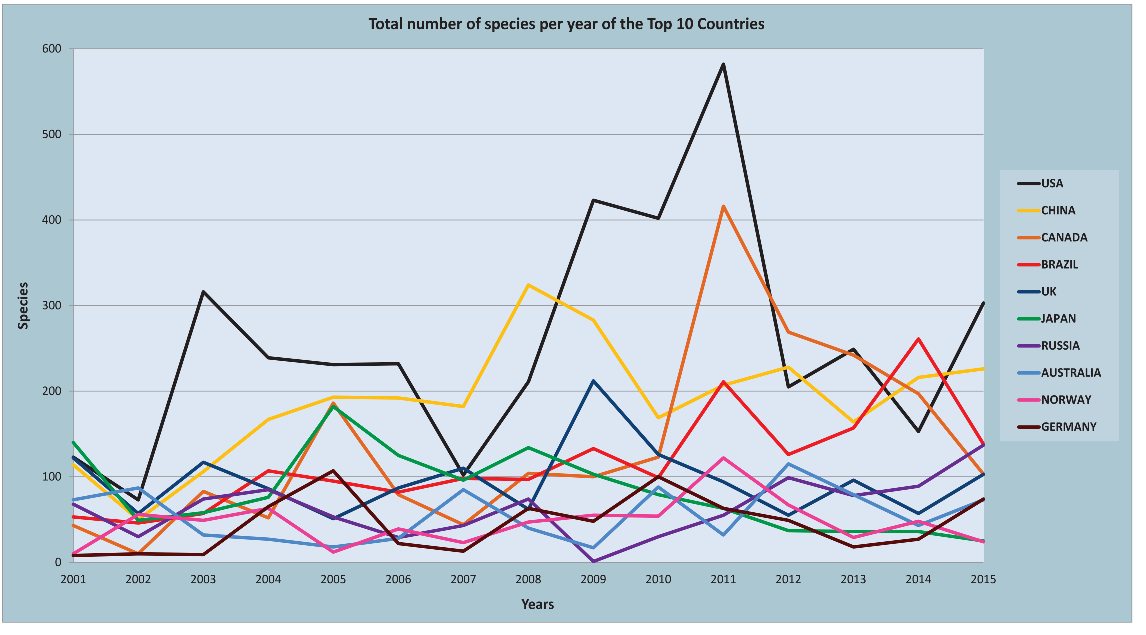

FIGURE 5: Total number of species changes of Diptera – new species, redescriptions and species status changes – published in the last 15 years among the top-10 most productive countries.

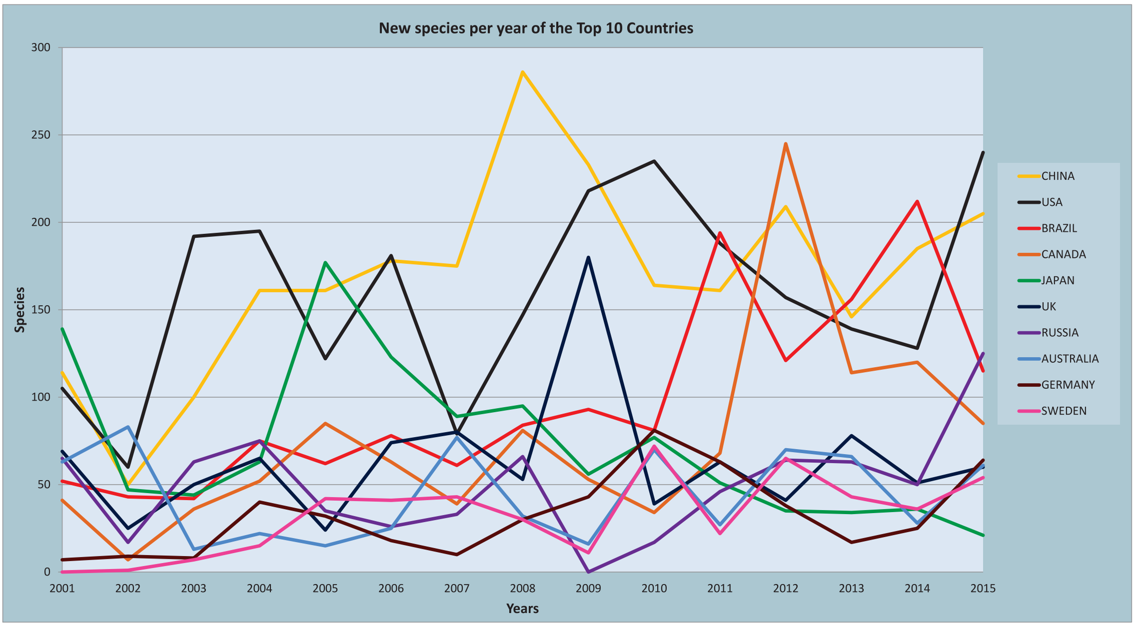

FIGURE 6: Number of new species of Diptera published in the last 15 years among the top-10 most productive countries.

There is a clear tendency towards increasing number of collaborations per paper: in 2001, 53% of the publications concerning Diptera had more than one author; this rate was 82% in 2015 (Fig. 3). These numbers indicate a qualitative sort of change in taxonomic research, from solo research (Charles Paul Alexander and his nearly one thousand single-authored publications on Tipulomorpha, for example) to a collaborative, multi-author effort. The percentage of international collaborations has been growing at least since 2012 (Fig. 3); currently *ca.* 40% of taxonomic papers in Diptera have authors from at

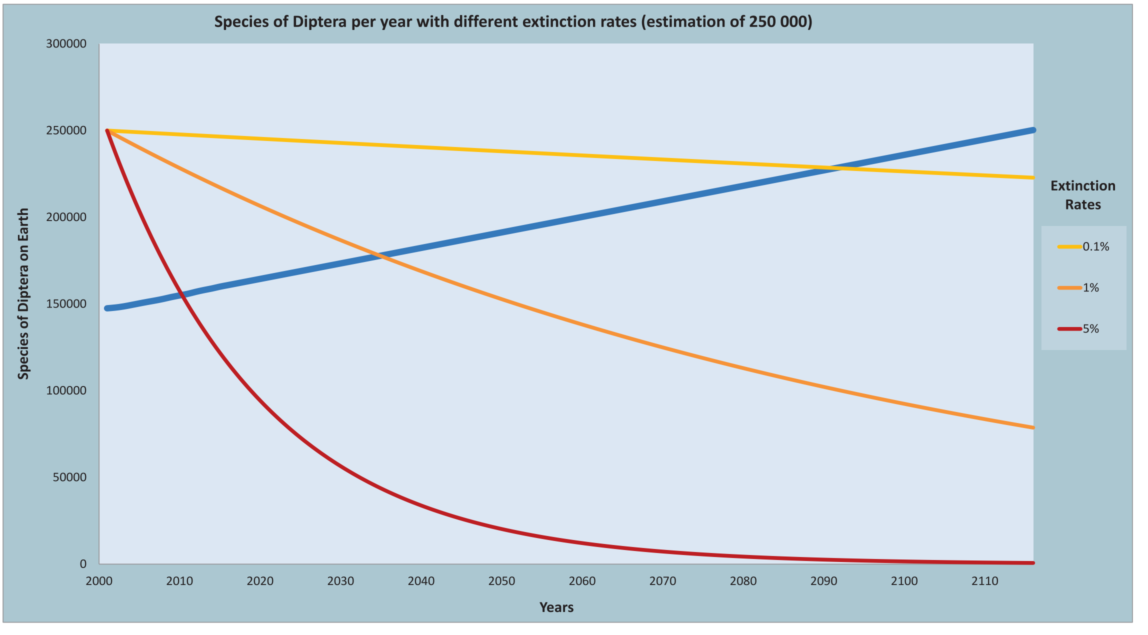

FIGURE 7: Extinction rates (*cf.,* Scheffers *et al.,* 2012) plotted against the projection of the number of new species descriptions based on the current rate herein diagnosed. Blue: estimate showing we will reach 250,000 described species in Diptera a hundred years from now. Red: curve considering a 5% extinction rate. Orange: 1% extinction rate. Yellow: 0.1% extinction rate.

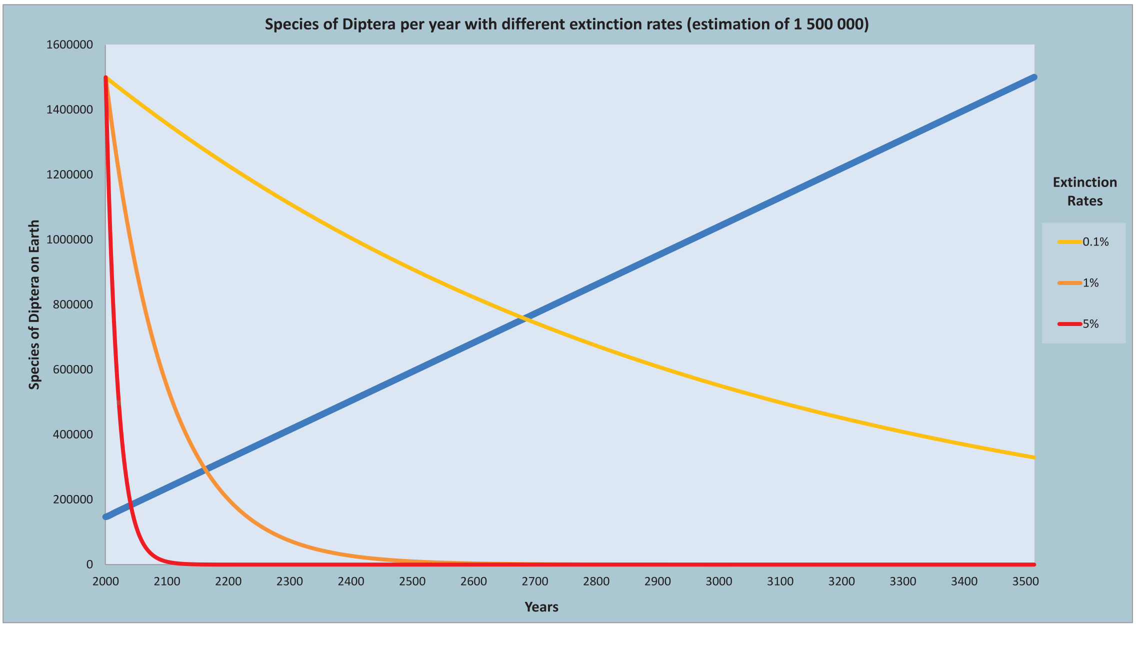

FIGURE 8: Extinction rates (*cf.,* Brown, 2005) plotted against a projection of the number of new species descriptions based on the current rate herein diagnosed. Blue: estimate showing that we will reach 1,5 million described species in Diptera a hundred years from now. Red: curve considering a 5% extinction rate. Orange: 1% extinction rate. Yellow: 0.1% extinction rate.

least two countries. In this context, it is undeniable the massive output of researchers from countries once considered peripheral in science such as China and Brazil (the impact of the heavy use of internet-based communication in taxonomy should be considered). The continuous increase of active taxonomists has affected the number of authors: from *ca.* 1.5 in 2001 to almost 3 authors per paper fifteen years later. However, the benefits of this tendency of team work are not that clear: Alexander's papers remain highly regarded by current tipuloid workers (*e.g.,* Ribeiro, 2009; Podenas *et al.,* 2014; Young, 2014), but it is unpredictable if the same would be valid for recent papers with multiple authors.

According to Evenhuis (2007, p. 3), "Despite over 10 years of recognizing the problem (…) we still lack the taxonomic expertise to effectively describe the remaining biodiversity on Earth". The good news is that Diptera seems to be an attractive taxon to newcomers. In the last 15 years, there is a perceptible increase in the number of dipterists publishing taxonomic papers, as mentioned especially from Asia and South America. The numbers from Brazil show that a relevant amount of graduate students that began their careers publishing in taxonomy remain working in the area as professional researchers, especially if they obtain a position in universities. In the long run, however, it is necessary constant training and funding at both, undergraduate and graduate levels, as well as maintaining conditions for their work as regular professional taxonomists throughout their careers.

Network initiatives of species-level inventories have been seen among the world community of dipterists, including actively employed, retired, graduate students and independent systematists. The Manual of Central American Diptera (Brown *et al.,* 2009), the Atlantic Forest BIOTA-Diptera project (Amorim *et al.,* 2010), the SISBIOTA-DIPTERA project (Lamas *et al.,* 2015), the Zurqui All-Diptera Biodiversity Inventory (ZADBI) (Borkent & Brown, 2015), and the forthcoming Manual of Afrotropical Diptera and Manual of South American Diptera are excellent examples of ways of multilateral efficient teamwork in dipterology. In times of budget cuts in science projects and global economic crisis, the value of collaboration needs to be reinforced.

The journal Zootaxa gained prominence in the development of taxonomy, dipterology included, along the period covered in this paper (Fig. 4). From two papers on taxonomy of Diptera published in 2001, Zootaxa went to 159 papers in 2015. Zootaxa was responsible, from 2001 onwards, for more than 50% of the entire taxonomic production in Diptera worldwide. The journal presented 1,277 (of a total of 4,009) papers, while the sum of all the other top-10 journals totalized 623 papers in dipterology. The average number of taxonomic papers on Diptera in the remaining journals was constantly below 15 papers/year from 2000-2015, without much variation.

It is worth noting the increasing number of papers on taxonomy of Diptera per year in the period (Fig. 4). Whereas 131 papers were published in 2001, from 2009 onwards the average number of papers per year was almost 315. This increased taxonomic productivity may be related to the consolidation of Zootaxa as an important peer-reviewed journal in taxonomy, especially concerning Diptera. Furthermore, the rapid process of evaluation and publication is an obvious attraction to dipterists all over the world, as well as the possibility to submit manuscripts of any length. On the one hand, as a web-based medium of transmitting information, this new model has transformed taxonomic publishing, accelerating biodiversity descriptions, and, in the vast majority of times, preserving quality and trustworthiness of the published material (Zhang, 2006, 2011, 2014). On the other hand, many traditional taxonomic print journals are dying or have ceased publication.

Species descriptions and extinction rates

Scheffers *et al.* (2012) presented a conservative number of total extant dipteran species in the world. According to them, there are *ca.* 100,000 species of flies still unknown, which would result in a total of 250,000 extant species for the entire order Diptera, given that about 150,000 species had been described until 2015. Counting species with DNA barcodes, Hebert *et al.* (2016) suggest the presence of *ca.* 5 million fly species worldwide, with about 1.8 million of these taxa within the Cecidomyiidae. Brown (2005) suggested a very different estimate (*ca.* 1.5 million fly species) based on a survey in the Neotropics. Although not every region in the world has such high diversity as the Neotropics, there is still much to be known about the diversity of Diptera in world, perhaps making the task for describing the total number of fly species almost impossible to achieve (Bickel, 2009).

From 2001 to 2015, 13,042 new species of Diptera were described and published in peer-reviewed journals registered in the Web-of-Sciences platform (Fig. 2), an average of almost 870 new species per year. There were also 683 new genera proposed, and a few new subgenera (Table 1). This represents an enormous effort, viz., almost 9% of the whole known diversity of Diptera was described in the last 15 years. In the same period, more than 4,000 redescriptions and other taxonomic changes (such as designating synonyms) appeared in the literature. Considering solely the taxonomic work on Diptera made in the 21st century, which is the scope of the present paper, we notice an remarkable increase of new species per year in the early 2000s. The number remained constant after 2008 (around 900-1,000 new dipteran species per annum) (Fig. 2).

On average, each article deals with 4 to 5 species (including new ones and revisions). This number has been decreasing slightly since 2001, pointing to a preference for small sized taxonomic works, although most journals, including Zootaxa, prefer large papers such as monographs and revisions. Considering both new species, redescriptions and changes in species status, USA and China are the leading countries during the last 15 years (Fig. 5). From 2010 onwards Brazil had a slight increase in its numbers (Canada had a peak of productivity around 2010-2011). When it comes to new species, China surpasses USA and Brazil rises to third position. Comparing Fig. 5 and Fig. 6, it seems clear that countries like USA, Canada, UK, Russia, Australia and Germany have a balanced number of new and altered species. On the other hand, Brazilian and Chinese dipterists have favored the description of new species, which may indicate low concern on major taxonomic revisions (since most papers deals with few species).

Assuming the conservative position of Scheffers *et al.* (2012), if the current rate of dipteran species description per year were to be maintained, we would reach 250,000 described species in 2115. Even if this number of species is underestimated – which may be the case considering the estimates made, *e.g.,* by Brown (2005), Bickel (2009) and Hebert *et al.* (2016) –, there is need for more than a century of collecting and describing species, especially in less known areas such as the tropics. However, the Anthropocene Epoch is strongly characterized by negative human influences on natural areas, leading to adverse environmental impacts and increased extinction rates (Ceballos *et al.,* 2015; Waters *et al.,* 2016). This blurs the future of dipterology.

It is obviously difficult to estimate the loss of biodiversity in the next years and decades. Costello *et al.* (2013) presented three different scenarios: 0.1%, 1% and 5% of species extinction (Figs. 7 and 8). Taking into account Scheffers *et al.* (2012) underestimation of 250,000 extant species of Diptera, the last scenario seems too extreme: if the number of known Diptera in the beginning of the 21st century was something around 150,000 species, all then unknown species would be definitely extinct by now. The two other less extreme estimates are not as exaggerated and fit best with the data herein presented (Fig. 7).

Considering an extinction rate of 1% and an average number of 870 new described species of Diptera per year (Fig. 2), at current rates we would have around 20 years of taxonomic work to do before every remaining unknown fly species goes extinct. These rates evidently discount the many collected but still undescribed species that are deposited in museums and collections worldwide. According to the estimate aforementioned, in the year 2035 we would have reached something like 178,000 described species for Diptera. Alternatively, considering a 0.1% extinction rate, the picture is less dramatic. In this scenario, by the year 2090 dipterists would be able to describe around 229,000 species, a number much closer to the 250,000 scenario proposed by Scheffers *et al.* (2012) as the whole diversity of extant Diptera (Fig. 7).

Such scenarios should be considered when we discuss the need for an increased taxonomic effort in order to describe the planet's biodiversity. Even in the less alarming situation, the current rate of species description is insufficient to describe every unnamed species of Diptera in the world.

If we assume Brown's (2005) estimate of 1,5 million extant species of Diptera, a 5% extinction rate would imply that in 2041 we would have reached *ca.* 180,000 described species for the order, and that all the remaining unknown species still not collected would be extinct (Fig. 8). Considering a 1% extinction rate and an average number of 870 new species of Diptera described per year (Fig. 2), in 2162 we would have reached around 300,000 described species for the order. Alternatively, with a 0.1% extinction rate, in the year 2680, we would have described half the total species of extant Diptera according to Brown's (2005) projection of the world fly diversity. Obviously, such long-term projections are just illustrations to reiterate a main concern for 21st dipterology: the need for increasing human resources and tools in taxonomy and for funding for projects dealing with taxonomic and biodiversity surveys.

In any scenario considering Brown's (2005) estimation (1,5 million extant species of Diptera), the taxonomists' mission of describing the whole diversity of the order would not be accomplished – indeed, "(…) the fact that [large-open ended taxa] can never be individually named is not the issue" (Bickel, 2009: 297). The issue here is to promote taxonomy and dipterology. Even in the less dramatic case of a 0.1% extinction rate and considering Brown's (2005) estimate, only half of the fly species would be described before their ultimate disappearance in nature.

The uncertain estimates of Diptera biodiversity clearly affect the predictive power of our scenarios, which aim to quantify the number of fly species that can be described before extinction in coming decades. Even with these uncertainties, we need to overcome the taxonomic impediment, striving to increase the number and quality of professional taxonomists and reinforcing the notion that taxonomy is a relevant branch of science, very far from obsolescence (Amorim *et al.,* 2016). Thus, the enthusiasm for knowing the diversity of Diptera, and the implications of that knowledge for systematics, evolution, ecology, biogeography and biological conservation, needs to be constantly fed.

CONCLUSIONS

Taxonomy remains a valid and needed science, and we need to promote public and academic interest in naming and describing biodiversity. Costello *et al.* (2013) lists a series of actions aimed at increasing the species description rate and taxonomic efficiency in modern times: enhancing the publication process by reducing the time between submission, peer-review, editing and publication while keeping high quality standards; emphasizing open-access online databases; global coordination among scientific communities; and financial support from governmental and non-governmental sources. Although being urgent, the loss of biodiversity and the taxonomic impediment should not seduce dipterists (or any other zoologist or botanist for that matter), or journal editors, into accepting careless approaches to species description based on poor data.

It is true that solely naming species will not prevent their extinction. The history of life is far older than the history of biological systematics: taxa have existed for millions of years without human names. Even species names are not end products themselves: they are "essential to phylogenetic and biogeographic studies which (…) underlie any real understanding of biodiversity, evolution, and their causes. It is such integrative knowledge that is indispensable to other areas of biology as well as for conservation" (Carvalho *et al.,* 2007, p. 141). Without knowing – and naming – it is virtually impossible to conserve. Thus, describing species makes us a step closer to understanding the world we live in.

We reiterate Amorim *et al.* (2016) and Santos *et al.* (2016): modern taxonomy can improve species descriptions through collection and organization of geo-referenced records, as well as using DNA sequences, high-resolution digital images and ecological data records, without abandoning traditional practices. We also endorse the teaching and practice of taxonomy in graduate projects and courses. Although the increase of taxonomic productivity is imperative, the key for revealing Earth's biodiversity is quality of information. We taxonomists should not be competing to know who the fastest researcher is or who can describe the largest number of species per year.

The trends indicated by our analysis of taxonomic productivity in Diptera reveal that the community of dipterists is doing its best to fulfill current gaps in the knowledge of dipteran biodiversity, but the challenges are enormous and some regions of the world are still scarcely documented. An huge amount of taxonomic work is currently needed. Despite the intense production of species descriptions and taxonomic revisions in the last 15 years, there is still plenty of room for new taxonomists. Thousands of new fly species await discovery and description.

RESUMO

Pelo menos um milhão de espécies de insetos foram descritas na Terra, das quais 150,000 pertencem à ordem megadiversa Diptera. Aqui nós sintetizamos os dados dos últimos 15 anos de trabalho taxonômico em Diptera, mapeando a produtividade global da ordem. Nossos dados apresentam um aumento na importância da China e Brasil junto com outros centros tradicionais como Estados Unidos e Europa. Nós também correlacionamos nosso banco de dados com estimativas de taxas de extinção para determinar a quantidade de pesquisa básica ainda necessária. Devido ao crescimento da taxa de extinção no Antropoceno, é improvável que conseguiremos descrever todos os Diptera desconhecidos até sua extinção. Mesmo considerando o aumento constante de novas espécies descritas todo ano, aumentar o número de dipteristas ativos no mundo é uma prioridade urgente.

Palavras-Chave: Biodiversidade; Diptera; Entomologia; Taxas de extinção; Sistemática.

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