*Zootaxa* 4979 (1): 155–165
https://www.mapress.com/j/zt/


**Review**

ISSN 1175-5326 (print edition)
**ZOOTAXA**
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4979.1.16
http://zoobank.org/urn:lsid:zoobank.org:pub:381CE15E-C556-4443-A1CF-0E239561D595

# Twenty years for *Zootaxa* and ten years for Afromoths (Lepidoptera): a taxonomic interaction between the journal and an online relational database

JURATE DE PRINS
*Royal Belgian Society of Entomology, Vautier street 29, 1000 Brussels, Belgium;*
*jdeprins@naturalsciences.be; https://orcid.org/0000-0001-7637-5755*

## Abstract

After twenty years of publishing the taxonomic journal *Zootaxa*, it is now the right time to synthesize its achievements and its contribution to the taxonomic knowledge of the Afrotropical Lepidoptera taxa. These contributions were made thanks to the exploration of natural habitats, museum collections, historic libraries, private holdings and phylogenetic investigations by many professional and amateur lepidopterists throughout the world. *Zootaxa* was introduced as a novel publication model with its innovative, community-based, and democratic approach to speed up the process of taxonomic publications. The fast-developing technology and especially the accessibility of digital taxonomic tools prepared the basis for novel links and inter-relationships. The global digital revolution and especially the overwhelming embrace of digital technology in Africa made an essential switch in the way we work: it became possible to present taxonomic information in a way that is searchable, consultable, illustrative, updatable, correctable and, most importantly—open and accessible to everyone. In this article, the trends of an increase in Afrotropical moth biodiversity knowledge published in *Zootaxa* and other journals are shortly discussed. Data are retrieved from the online taxonomic relational database Afromoths (www.afromoths.net).

**Key words**: Afrotropical, checklists, distribution, species assessment, taxonomy

## Introduction

The twenty-first century brought many changes to most classical biological sciences, including taxonomy, systematics, species diversity and distribution, faunistic data and other museum-based disciplines (Heberling *et al*. 2021). It is thus essential to re-estimate what we know, what we have, how we work and how we proceed further. Moths (Lepidoptera) in many biodiversity surveys are often seen as the most interesting and charismatic insects (BID 2021). Until 2007, the approximate number of species of moths in Africa was absolutely unknown, with many lepidopterists expressing concern that the knowledge of African biodiversity is a black hole (Jallon *et al*. 2009). In 2007, for the first time during the Zoological Congress in Paris and the official celebration of the 250th anniversary of Linnaeus' *Systema naturae*, the question was raised sharply about the role of the internet in taxonomic research and taxonomic publications (Pearson 2003; Zhang 2008, 2011).

It became clear that the internet is a powerful medium to present taxonomic knowledge on Afrotropical moth species, to democratize the process of data gathering and data presentation and to reach any user globally (De Prins 2016). The first issue that urgently had to be answered was how many species of moths are in the Afrotropical region. Previous estimates were purely speculative, ranging from 20,000 to 50,000 species-group names of Lepidoptera based on incomplete catalogues, guides and species diversity books on Afrotropical butterflies and moths. The completion of a full inventory of **all** species-group names of moths occurring in the Afrotropical region, with accompanying country distribution records, host plants and parasitoids, became a goal that was challenging, inspiring but nevertheless it seemed to be achievable in a reasonable time scale (De Prins & De Prins 2011–2021).

The need of species inventories not only in Africa, but in many biodiversity-rich countries, became an official supporting policy to slow down the undergoing massive extinction process before many moth species became extinct (BID 2021; CBD 2021). Species inventories are vital resources for protection of threatened species and moth

*Accepted by Z.-Q. Zhang: 11 May 2021; published: 28 May 2021*

diversity in general as well as to understand the complexity of inter-organism relationships (Garwood *et al*. 2019; Stockdale *et al*. 2019; Graeff *et al*. 2020).

The purposes of this article are 1) to explain the approach taken by the author to present taxonomic issues of Afrotropical moths as an online, community based, and continuously updatable endeavour; 2) to demonstrate some trends obtained while studying the statistics of the taxonomic publications in *Zootaxa* and other journals.

## Material and methods

### Publications

The publication data on Afrotropical moths were obtained from major libraries of the world, mainly:

- Library of Dutch Entomological Society (Amsterdam, Leiden, the Netherlands);
- Library of the Royal Museum for Central Africa (Tervuren, Belgium);
- Library of the Biodiversity Center Naturalis (Leiden, the Netherlands);
- Library of Royal Belgian Society of Entomology (Brussels, Belgium);
- Library of Royal Belgian Institute of Natural Sciences (Brussels, Belgium);
- Library of Willy and Jurate De Prins (Leefdaal, Belgium);
- Library of the Smithsonian Institution (Washington DC, USA);
- Library of Ditsong Museum (Pretoria, South Africa);
- Library of Albert Legrain (Hermalle-sous-Argenteau, Belgium);
- Libraries of colleague-lepidopterists (see Acknowledgements http://www.afromoths.net/species/about)

Zootaxa issues dealing with Afrotropical moths were kindly presented by the publishing team of Magnolia Press.

### Afrotropical Region

The biogeographic area (Afrotropical Region) can be defined as the African continent south of the Sahara (i.e. excluding Morocco, Algeria, Tunisia, Libya and Egypt), nearby islands in the Atlantic Ocean: Amsterdam Island, Ascension, Cape Verde Archipelago, Inaccessible Island, St. Helena, São Tomé and Principe, Tristan da Cunha, and nearby islands in the Indian Ocean: Comoros (Anjouan, Grande Comore, Mayotte, Mohéli), Madagascar, Mascarene Islands (La Réunion, Mauritius, Rodrigues), Seychelles (Félicité, Mahé, Praslin, Silhouette, a.o.).

In addition, moth species occurring in the transition zone to the Palaearctic fauna have also been included. This transition zone is comprised of most of the Arabian Peninsula (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen with Socotra) but not Iraq, Jordan and further north. Also, species from some Saharan localities have been included (e. g. Hoggar Mts. in Algeria, Tibesti Mts. in southern Libya).

### Species-group names

Species-group names treated in the Afromoths dataset are based on the principles defined by the 4th edition of the International Code of Zoological Nomenclature. These are as follows:

1) To refrain from infringing upon taxonomic judgement;
2) To provide all the names of Afrotropical moth species whatever taxonomic ranks and limits are given to them;
3) To provide information on name-bearing types without infringing upon taxonomic judgement;
4) To apply nomenclatorial rules;
5) To avoid ambiguity;
6) To provide information for taxonomic checklists; catalogues and revisions;
7) Problems in nomenclature are decided by applying the Code directly.

**Afromoths relational database www.afromoths.net**

The increasing amount of natural history data on Afrotropical moths and adoption of digital country distribution records made the biodiversity information accessible via dedicated websites. It became crucial to have online searchable tools which can be used to digest the extracted information, organize it, or to link it with other different information packages and to have visualized biodiversity data (De Prins 2016; De Prins & De Prins 2011–2021). A good visualization makes biodiversity information easily understandable for multi-linguistic users, touching all layers and all age groups of society and helping significantly for decision makers to adapt their policy for conservation of vulnerable habitats and threatened species (GBIF 2021).

The Afromoths database consists of five interrelated and interlined searchable modules that are linked into one information block: Literature, Taxonomy, Faunistics, Genitalia Preparation Manager, and Loan Manager (Fig. 1). The home interface is equipped with a search function linked to the individual specimen provided with a label of digital code read by a hand scanner (for details see De Prins 2016)

The database is presented online in the form of a searchable website. It provides taxonomic information on **all** species-group names of moths occurring in the Afrotropical region: 528 family-group names of moths, 8,161 genus-group names, 40,107 species-group names, 86,303 country distribution records, 8,580 host plant records retrieved from text and data mining of 9,313 publications on Afrotropical moths. The data on type specimens are mined from 140 museum collections. The taxonomic data are illustrated by 38,602 photographs (Fig. 2).

The data-obtaining sources are multiple, the raised complex questions required complex queries to answer. To navigate into the Superfamily, Family, Subfamily, Tribe, Genus, Species, and Subspecies levels, many tables were created that are interlinked with parent-child relationships into ONE relational system. It can be launched online in the form of a user-friendly searchable illustrative website (De Prins & De Prins 2011–2021).

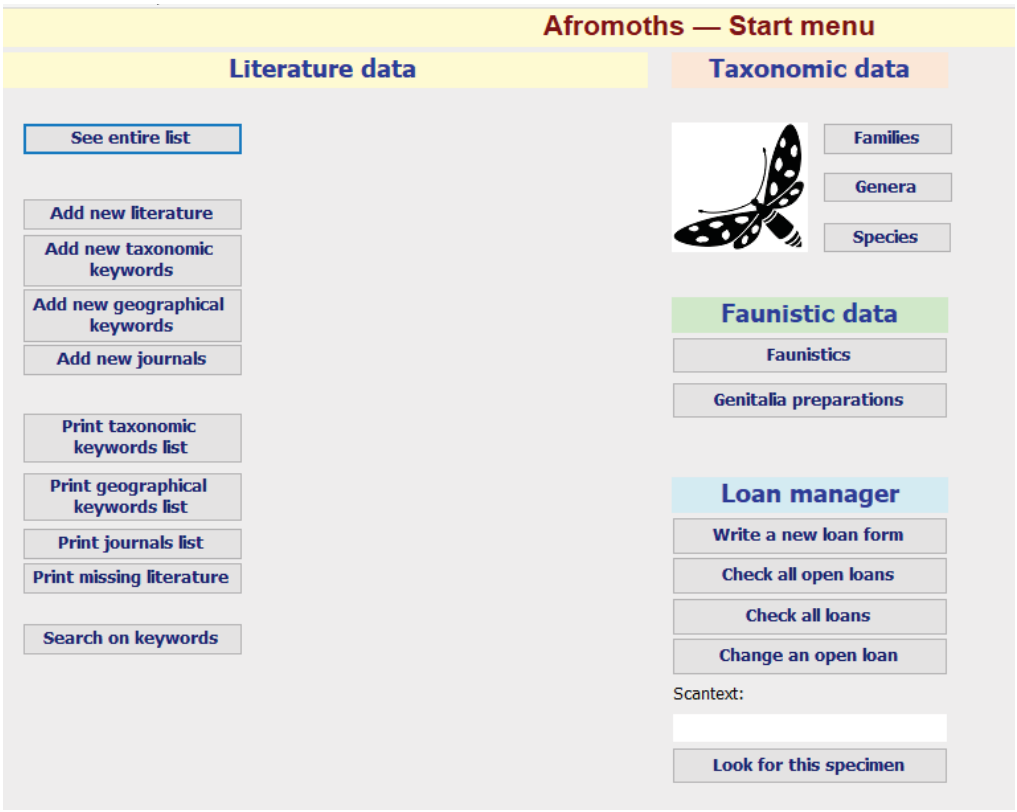


**FIGURE 1.** Start menu page of the relational Afromoths database.


**FIGURE 2.** Home page of the Afromoths website www.afromoths.net. Last updated 21 March 2021.

The first resource was the holdings of entomological libraries (see the Publications section above). Data from 9,287 published sources were scanned and checked from comprehensive synonymic checklists, catalogues and the Afrotropical moth species descriptions in historic archives, rigorously assembled and preserved by generations before us. Comprehensiveness (including all effectively published names of Afrotropical moth species-group names) was the initial stimulus to proceed. The technical possibility to create aggregations of published taxonomic data with distribution, images, linked host plant data, parasitoids, DNA data and collection specimens turned into a unique, dynamic, living, updatable in real-time endeavour, even a passion that could be shared online, queried in different combinations and serve as a source of information for those who are far from historic taxonomic resources (libraries, museum collections) but have unrestricted access to global internet and are interconnected by social media.

## Results

### Afrotropical moth species-group taxa described in *Zootaxa*

The first *Zootaxa* article describing a new species of moth from the Afrotropical region was published exactly 15 years ago by the author (De Prins & Mozūraitis 2006). This species is a tiny mining moth, *Phyllonorycter obandai* De Prins & Mozūraitis, 2006, belonging to the family Gracillariidae and discovered in Kenya using pheromone lures synthesized at Stockholm University by the second author of the species. This description sparked an international interest and created the possibilities for the cooperation on moth biodiversity research in different areas of Sub-Saharan Africa. The top year of Afrotropical moth species descriptions published in *Zootaxa* was 2012 (Fig. 3) with 103 new species described. This record year is probably due to the monograph published again by the author of these lines together with a colleague, molecular taxonomist from the Florida University (De Prins & Kawahara 2012). Most recently, 2019 and 2020 were equally fruitful with 66 Afrotropical moth descriptions in each year (Fig. 3). In total, 486 species-group taxa of moths from the Afrotropical region were described in *Zootaxa* between 2001–2020.

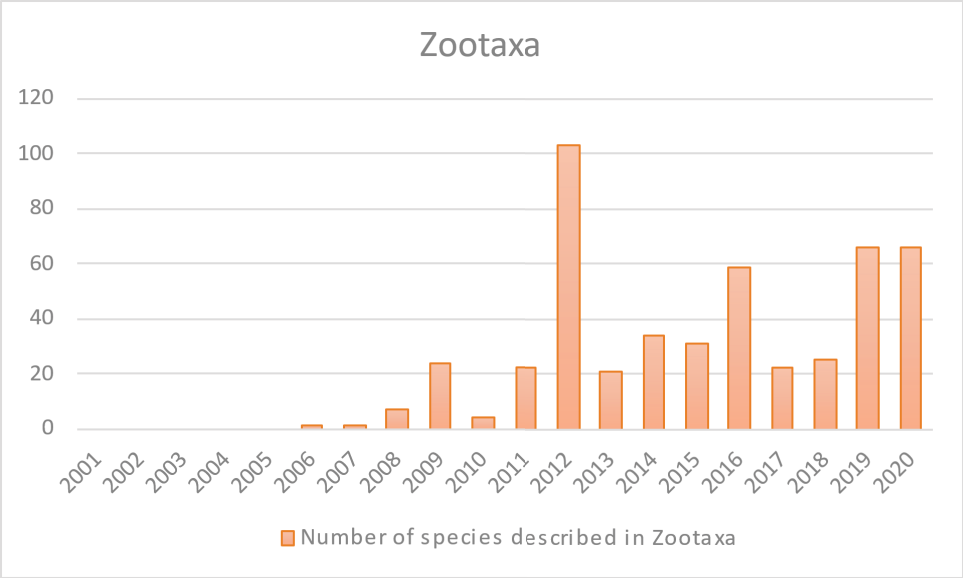


**FIGURE 3.** New species of Afrotropical moths published in *Zootaxa* during the years 2001–2020.

## Families of Lepidoptera treated in *Zootaxa*

The family with the most descriptions of new species of Afrotropical moth species published in *Zootaxa* is Erebidae (66 species-group taxa), followed by Lecithoceridae (61), Tortricidae (52), Gracillariidae (43), Pterophoridae (33), and Geometridae (29) (Fig. 4).

Other than the species-rich family Erebidae, the next four families that received the highest attention of the *Zootaxa* authors are all microlepidoptera. The species belonging to these families are usually dull-coloured and difficult to distinguish from each other. The popularity of families treated in *Zootaxa* mainly was linked with the productivity of taxonomists knowledgeable in a limited group, that seldom was treated by a broader community. In total 24 families of Lepidoptera from the Afrotropical region were expanded by the new species descriptions in *Zootaxa* (Fig. 4).

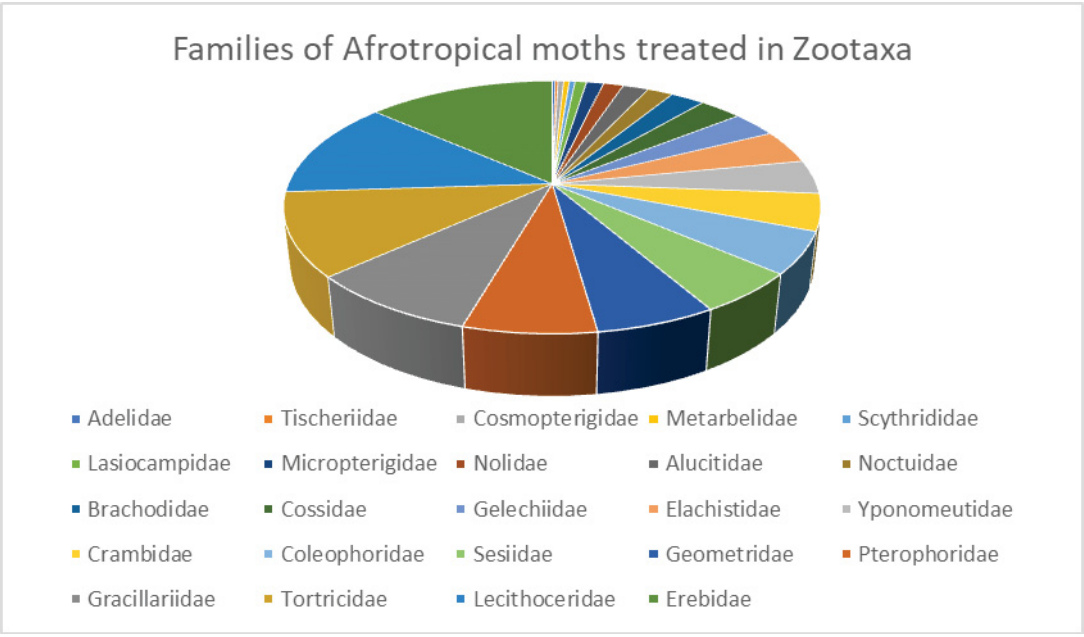


**FIGURE 4.** Lepidoptera families with new species descriptions treated in *Zootaxa* 2001–2021.

### *Zootaxa* versus non-*Zootaxa*

The trend of interest in Afrotropical moth taxa, and particularly new species descriptions, remains the same in non-*Zootaxa* publications. From 2007 to 2016, new species-group taxa discoveries / descriptions range with annual fluctuations from 252 to 463, with the exception of 2019 when an astounding 616 new species of Afrotropical moths were described (Fig. 5; Table 1). In total, 5112 species-group taxa of Afrotropical moths were described between 2001–2020 in non-*Zootaxa* publications.

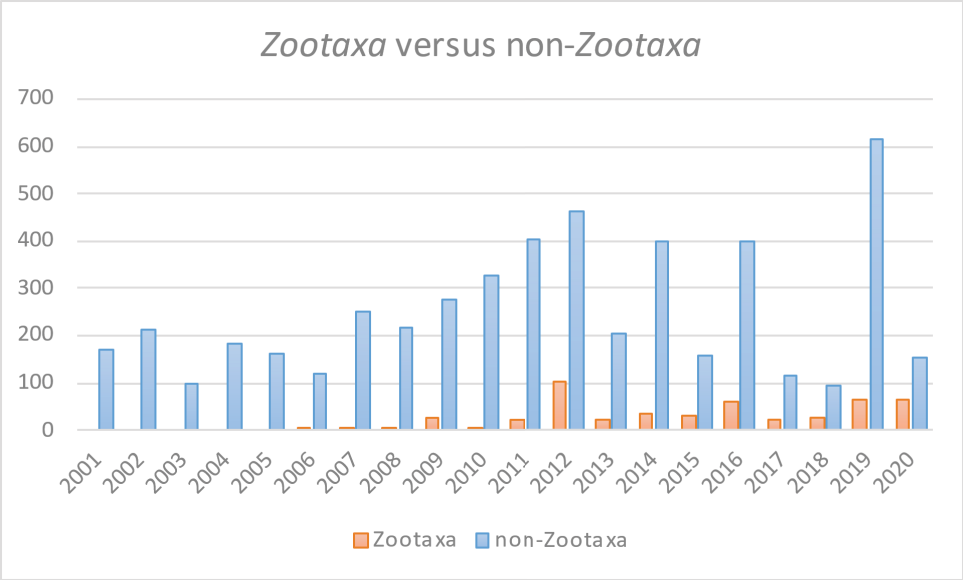


**FIGURE 5.** New species of Afrotropical moths published in non-*Zootaxa* publications during the years 2001–2020.

The contribution of *Zootaxa* into the general pool of descriptions of new species of Afrotropical moths varies from 1% in 2006 and 2010 to 30% in 2020 (Fig. 6).

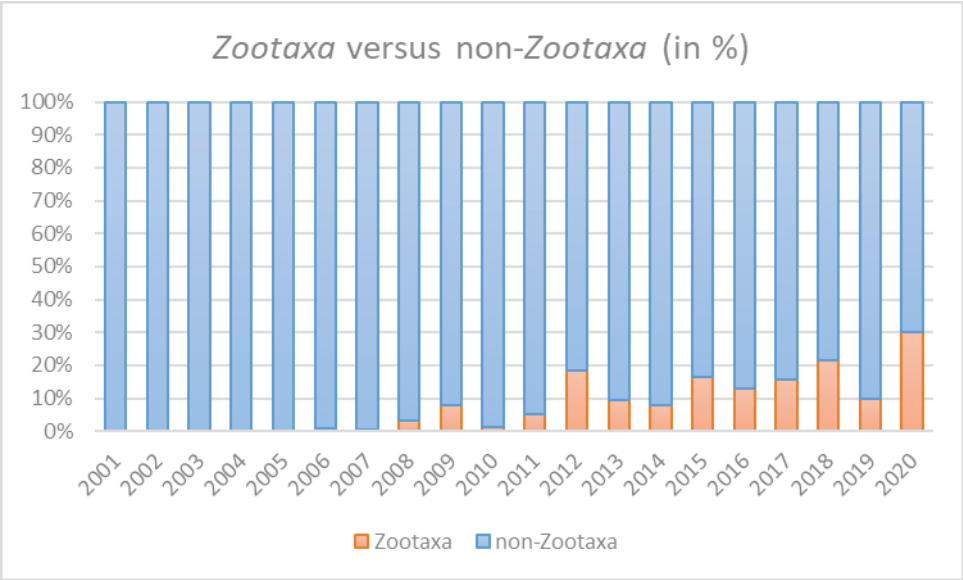


**FIGURE 6.** The proportion (in %) of new species descriptions of Afrotropical moths into the general pool.

The role and importance of *Zootaxa* for the publication of new species of moths from the Afrotropical region steadily increases (Fig. 7). Different factors might play a role, such as increased accessibility for all authors to publish in *Zootaxa* with option without page charges, relatively fast publication speed, and competent, known, approachable and responsible editors.

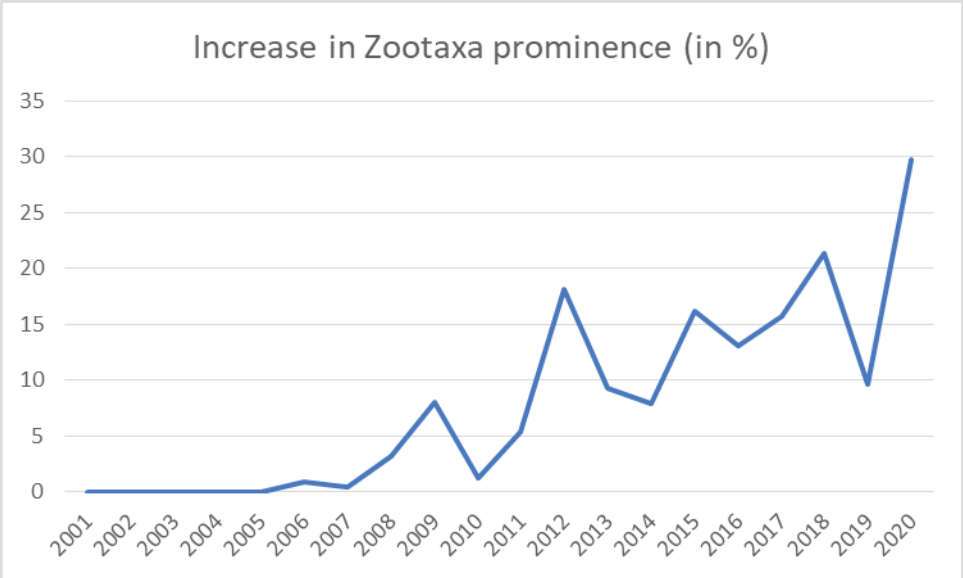


**FIGURE 7.** Increase (in %) of *Zootaxa* prominence for the publication of new taxa of moths from the Afrotropical region.

Despite the fact that *Zootaxa* is one of the leaders among the taxonomic journals to present new species of Afrotropical moths, the majority of new taxa are published in numerous small journals mainly financed and published by different environmental societies and organizations (Table 1). In total 112 journals published new species-group taxa of Afrotropical moths in the period 2001–2020 (Table 1).

The largest amount of new species descriptions were published in *Esperiana Memoir* and *Esperiana* (a combined 1573 spp. or 28.6% ) during the last twenty years. *Zootaxa*, with its 486 new species descriptions, is in third place, followed by journals published in France, South Africa, Belgium, and Poland.

**TABLE 1.** Journals that published new descriptions of Afrotropical moth species 2001–2020.

| Journal Title | No of species |
|---|---|
| *Esperiana Memoir* | 822 |
| *Esperiana* | 751 |
| *Zootaxa* | 486 |
| *Nouvelle Revue d'Entomologie (N.S.)* | 359 |
| *Annals of the Ditsong National Museum of Natural History* | 247 |
| *Neue Entomologische Nachrichten* | 182 |
| *Saturnafrica* | 159 |
| *Lambillionea* | 146 |
| *Acta zoologica cracoviensia* | 140 |
| *Transvaal Museum Monograph* | 138 |
| *Shilap, Revista de lepidopterología* | 131 |
| *Transvaal Museum Memoir* | 124 |
| *Revue française d'Entomologie (N. S.)* | 90 |
| *Revue Française d'Entomologie Générale* | 89 |
| *Bulletin of The Natural History Museum* | 86 |
| *Entomologia Africana* | 83 |
| *Atalanta, Würzburg* | 76 |
| *Bulletin de la Société entomologique de France* | 75 |

*...Continued on the next page*

**TABLE 1.** (Continued)

| Journal Title | No of species |
|---|---|
| *Polskie Pismo Entomologiczne* | 63 |
| *Norwegian Journal of Entomology* | 62 |
| *Tijdschrift voor Entomologie* | 62 |
| *Beiträge zur Entomologie* | 61 |
| *L'Entomologiste* | 57 |
| *Annales de la Société entomologique de France (N.S.)* | 50 |
| *African Entomology* | 48 |
| *ZooKeys* | 43 |
| *Entomofauna* | 41 |
| *Nachrichten des entomologischen Vereins Apollo* | 41 |
| *Revue suisse de Zoologie* | 37 |
| *Amurian Zoological Journal* | 31 |
| *Metamorphosis* | 31 |
| *The European Entomologist* | 29 |
| *Boletín de la Sociedad Entomológica Aragonese* | 28 |
| *Bulletin de la Société entomologique de Mulhouse* | 28 |
| *Journal of Entomological and Acarological Research* | 28 |
| *Ecologica Montenegrina* | 27 |
| *Journal of Afrotropical Zoology* | 27 |
| *Phelsuma* | 27 |
| *Deutsche Entomologische Zeitschrift* | 26 |
| *Mitteilungen der Münchner Entomologischen Gesellschaft* | 25 |
| *Spixiana* | 25 |
| *Entomologische Zeitschrift* | 21 |
| *Euroasian Entomological Journal* | 18 |
| *Journal of East African Natural History* | 16 |
| *Russian Entomological Journal* | 15 |
| *Zeitschrift der Arbeitsgemeinschaft österreichischer Entomologen* | 15 |
| *Zoologicheskyi Zhurnal* | 15 |
| *Smithsonian Contributions to Zoology* | 14 |
| *Bollettino della Società entomologica italiana* | 13 |
| *African Invertebrates* | 11 |
| *Antenor* | 11 |
| *Belgian Journal of Entomology* | 11 |
| *Genus* | 11 |
| *Journal of Natural History* | 11 |
| *European Journal of Taxonomy* | 10 |
| *Journal of Asia-Pacific Entomology* | 9 |
| *Zoölogische Mededelingen, Leiden* | 9 |
| *Redia* | 8 |
| *Stuttgarter Beiträge zur Naturkunde A, Neue Serie* | 8 |
| *Bulletin of Entomological Research* | 7 |
| *Phegea* | 7 |

*...Continued on the next page*

**TABLE 1.** (Continued)

| Journal Title | No of species |
|---|---|
| *Tropical Lepidoptera* | 7 |
| *Invertebrate Systematics* | 6 |
| *Journal of the Linnean Society of London. Zoology* | 6 |
| *Linzer biologische Beiträge* | 6 |
| *Tropical Lepidoptera Research* | 6 |
| *Galathea* | 5 |
| *Monografie del Museo regionale di Scienze Naturali di Torino* | 5 |
| *American Journal of Entomology* | 4 |
| *Annales Zoologici* | 4 |
| *Bulletin de la Société linnéenne de la Provence* | 4 |
| *Nota lepidopterologica* | 4 |
| *Proceedings of the Entomological Society of Washington* | 4 |
| *Quadrifina* | 4 |
| *Acta Zoologica Lithuanica* | 3 |
| *Bonn zoological Bulletin* | 3 |
| *Systematic Entomology* | 3 |
| *Zoosystematica Rossica* | 3 |
| *Acta Zoologica Hungarica* | 2 |
| *Animal Systematics, Evolution and Diversity* | 2 |
| *Bulletin mensuel de la Société linnéenne de Lyon* | 2 |
| *Entomological Review* | 2 |
| *Revue de l'Association Roussillonnaise d'Entomologie* | 2 |
| *Tinea* | 2 |
| *Vestnik Zoologii* | 2 |
| *Zoological Journal of the Linnean Society* | 2 |
| *Acta Zootaxonomica Sinica* | 1 |
| *Annalen des Naturhistorischen Museums in Wien* | 1 |
| *Annals of Carnegie Museum* | 1 |
| *Annals of the entomological Society of America* | 1 |
| *Beiträge zur Kenntnis des wilden Seidenspinner* | 1 |
| *Beiträge zur Naturkundlichen Forschung in Südwestdeutschland, Karlsruhe* | 1 |
| *Biodiversity Data Journal* | 1 |
| *Biological Bulletin of Bogdan Chmeltnitzkiy Melitopol State Pedagogical University* | 1 |
| *Bulletin bi-mensuel de la Société linnéenne de Lyon* | 1 |
| *Bulletin de la Société entomologique de Belgique* | 1 |
| *Bulletin de l'Institut fondamental d'Afrique noire* | 1 |
| *Bulletin des Lépidoptéristes Parisiens* | 1 |
| *Carolinea* | 1 |
| *Entomologica romanica* | 1 |
| *Entomologische Abhandlungen* | 1 |
| *Entomologische Berichten, Amsterdam* | 1 |
| *Far Eastern Entomologist* | 1 |
| *Italian Journal of Zoology* | 1 |

*...Continued on the next page*

**TABLE 1.** (Continued)

| Journal Title | No of species |
|---|---|
| *Journal of Insect Biodiversity* | 1 |
| *Journal of Insect Science* | 1 |
| *Mémoires du Muséum national d'Histoire naturelle* | 1 |
| *Proceedings of the Russian Entomological Society, St. Petersburg* | 1 |
| *Proceedings of the Zoological Institute, St. Petersburg* | 1 |
| *Proceedings of the Zoological Society of London* | 1 |
| *Thalassia Salentina* | 1 |
| *Veröffentlichungen des Tiroler Landesmuseums Ferdinandeum* | 1 |

## Discussion and Conclusions

To summarize the thoughts expressed above, a couple of conclusions can be drawn:

1) The majority of new taxa are described in low-profile journals targeted to a specific group of interested readers—taxonomists;
2) Even if these journals are online, they are not widely known, read, and consulted.

It is for certain that a correlation is present between the association of society or institution and the taxonomists studying Afrotropical moths. *Zootaxa* is an independent, international biodiversity issues related journal, valued for its focus on taxonomy and new species descriptions.

Though *Zootaxa* was initiated to be primarily a publishing platform for taxonomists in the last few years, it developed into an important source of other biodiversity-related information that is consulted by a wide range of users, including citizen scientists and the general public. The relationship between the journal and the online database Afromoths turned into a mutual interaction: Afromoths imports the quality taxonomic information obtained from the journal that is tractable while the database itself stimulates the production of quality taxonomic information that is published in the journal. Both the journal and the database value scientific rigour and are based on broad community participation.

In the context of the current biodiversity crisis, it is also noteworthy that taxonomic checklists and country distribution lists can be downloaded almost instantly. This information is continuously updated and vetted. There is no doubt that this is the right and correct approach to deal with various taxonomic issues related to Afrotropical moths in the future. Advances in internet network development and broadly accessible mobile telephone use in biodiversity rich areas are great aids for species recording, identification and taxonomic treatment, making this process a community-based endeavour.

The ultimate success of online taxonomic resources will be measured by the level of community use. Multiple factors come into play, such as a very clear communication on taxonomic issues, user friendly online taxonomic tools, and interaction of different actors on different levels including specialists' participation. The studies on biodiversity of Afrotropical moths have a great advantage: they facilitate a community-wide sense of agreement targeted to enhance the taxonomic knowledge and also form a collective responsibility to generate this knowledge.

Community interest and community participation will be the key for the continuation and sustainability of all taxonomic/biodiversity and conservation issues related to the Afrotropical moths.

## Acknowledgements

I thank many colleagues across six continents for many fruitful discussions and all possible help over 20 years related to taxonomy of Afrotropical moths (see http://www.afromoths.net/species/about). Willy De Prins is very cordially thanked for designing the database, his moral, financial and physical help to keep this dataset up-to-date. Dr. Albert Legrain is gratefully acknowledged for his discussions and especially for his very friendly financial support and

interest to the taxonomy of Afrotropical moths. Belgian Biodiversity Platform is very kindly acknowledged for the IT support and the Secretariat of GBIF for the very inspiring discussions on many aspects of biodiversity issues including the Biodiversity Information for Development programme. My thanks are also directed to my colleagues, *Zootaxa* editors of the Lepidoptera Section, for working together. Carlos Mielke and David Plotkin are sincerely thanked for their constructive comments and linguistic suggestions. The chief editor of *Zootaxa*, Prof. Zhi-Qiang Zhang, is acknowledged for his kind invitation to summarize our achievements of the last 20 years.

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