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PROSPECTS FOR THE FUTURE STUDY OF THE ODONATA ORDER: A REVIEW OF PUBLISHED ARTICLES FROM THE SCOPUS DATABASE 2019–2023

Norkobilova Zarina Boyqobil qizi [1]

[1] Karshi State University, Karshi, Uzbekistan

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Abstract

This article analyzes the problems in the study of perspective species of the Odonata order worldwide: a review of papers from the Scopus database published in English for the period of 2019–2023. During 2019–2023, 827 articles were published about insects belonging to the Odonata order, of which 94% (776) were published in journals as scientific research results, 1% (10) articles were conference proceedings, 5% (41) and the articles were covered as a literature review. Published scientific works were analyzed in the following directions: Trends of publications on Odonata order, Journals on Odonata order, Authors and their affiliated countries, Top funding sponsors on Odonata order, Top countries on Odonata order. According to the five-year results of the Trends of publications on the Odonata order, the most articles on Odonata order were published in 2021, accounting for 217 (26%) articles, compared to 131 (16%) articles in 2022, and only 74 by 2023. (9%) articles were published. The results of analyzes of journals show that 160 journals were published in 91 countries, of which 353 (42.68%) of these papers were published in top 12 journals and remaining 57.31% papers were published in other journals. At the same time, this section presents the analytical results of 12 journals that published the most (353) articles on Odonata order. In the "Authors and their affiliated countries" section of the article, you can get acquainted with 10 major odonatologists or scientists who study Odonata order in various directions, who have published the most articles worldwide as a result of their scientific research on the Odonata order. In addition, the analytical results of the 12 most published publications of the Odonata order are presented. The top funding sponsors on Odonata order section covers the analysis of 146 different funding sponsors worked in cooperation to publish 827 papers on Odonata order over the world in the period of 2019–2023, and provides information on the 14 funding sponsors who sponsored the most in the world. Top countries on Odonata order also lists the 10 countries with the most articles on Odonata order.

Keywords: *Odonata order, top journals, Scopus database, insects*

Introduction

The order of Odonata order is the most ancient representative of the class of insects and includes about 40 families and more than 6650 species. According to some sources, there are about 6,324 species of Odonata worldwide, almost all of which are distributed depending on freshwater habitats. According to Belyshev et al. (1989), dragonflies are distributed in all climatic zones of the earth and consist of about 6000 species of flowering insects. Dragonflies are one of the oldest types of insects, and they are attracting the attention of scientists even now because of their amazing adaptability. During 2019–2023, the scientific research results of scientists who studied insects belonging to the Odonata family were analyzed. Molecular-genetic analysis, fauna, ecology, distribution, adaptation, zoogeography of insects belonging to the family Odonata have been thoroughly studied by many scientists. During the study of dragonfly fauna, several new species were also discovered. More than 800 specimens of Ceriagrion species found in China were studied by X. Yu, C. Chen, M. Zhang, almost a quarter of which were used for molecular analysis. Nine species were identified and confirmed to occur in China. A taxonomic key of males was given. Two new synonyms (*Ceriagrion chaoi* to *Ceriagrion bellona*, *Ceriagrion olivaceum* to *Ceriagrion azureum*) were proposed, *Ceriagrion malaisei* was confirmed new to China, the distribution of *Ceriagrion rubiae* in China was eliminated, and three incorrect identifications were corrected (Yu, X., et al., 2022). D. S. Vilela & M. M. de Souza (2022) discovered a new species of dragonfly in Southeast Brazil as a result of scientific researc (Vilela, D.S., & de Souza, M. M., 2022). A new genus and species of dragonflies (Odonata, Zygoptera) were discovered from the USA (Archibald, S.B., & Cannings, R. A., 2021). 250 million years ago, dragonflies and butterflies developed separately, and their current status was studied at the molecular genetic level in the scientific data of E. R. Tolman et al. (2023) (Tolman, E. R., et al., 2023) Ischnura elegans and Platycnemis pennipes, and two dragonfly species, Pantala flavescens and Tanypteryx hageni, we demonstrate that the autosomes of Odonata have undergone few fission, fusion, or inversion events, despite 250 million years of separation. In the four genomes discussed here, our results show that all autosomes have a clear ortholog in the ancestral karyotype. Despite this clear chromosomal orthology, we demonstrate that different factors, including concentration of repeat dynamics, GC content, relative position on the chromosome, and the relative proportion of coding sequence all influence the density of syntenic blocks across chromosomes. However, these factors do not interact to influence synteny the same way in any two pairs of species, nor is any one factor retained in all four species. Furthermore, it was previously unknown whether the micro-chromosomes in Odonata are descended from one ancestral chromosome. Despite structural rearrangements, our evidence suggests that the micro-chromosomes in the sampled Odonata do indeed descend from an ancestral chromosome, and that the micro-chromosome in P. flavescens was lost through fusion with autosomes. © 2023 The Authors. Molecular Ecology published by John Wiley & Sons Ltd., “archive”: “Scopus”, “container-title”: “Molecular Ecology”, –DOI”:10.1111/mec.17147, ISSN : 09621083 (ISSN. D. Zheng et al.’s 2019) research revealed a new dragonfly species from Northwest China from the Early Jurassic period (Zheng, D., et al., 2019). A. Zia et al., 2020) studied the fauna and ecology of dragonflies distributed in Kurram District, Pakistan. District Kurram represents an important geographical position. It shares its border with Afghanistan and possesses unlimited water resources. Due to prolonged uncertain ground conditions, this area remains unexplored for insect fauna. Present study was carried out to record richness, abundance and species complex of Odonata. It revealed four families, fifteen genera and twenty-six species. Among recorded fauna, family Libellulidae appeared to be a dominant group representing 19 species, followed by family Coenagrionidae with 5 species and family Calopterygoidae and Aeshnidae representing single species each. Being a flying insect group, seasonal surveys and temporal data collection for dragonflies in this ecologically rich area can surely bring forward important information for the migratory species be-

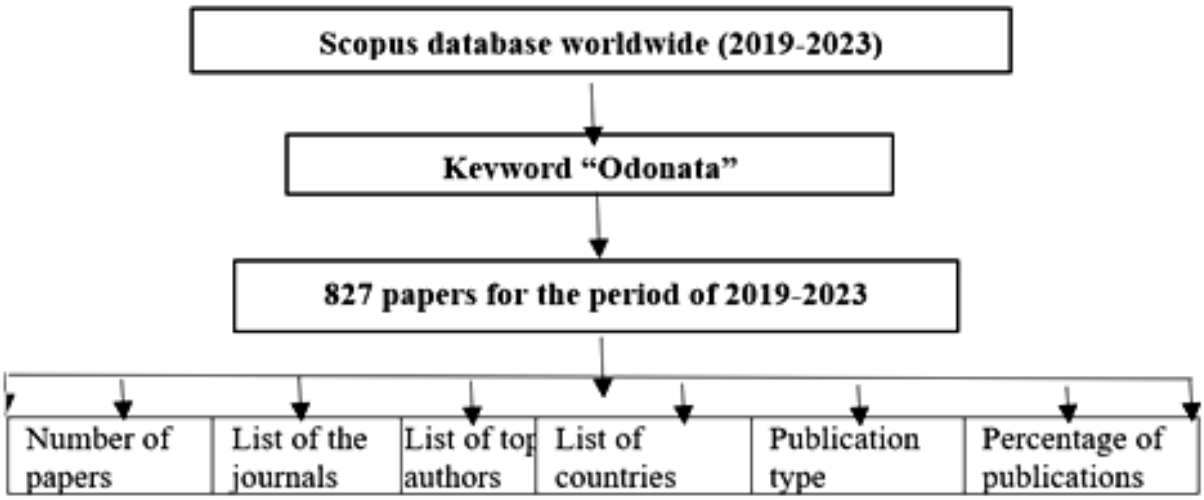
tween Afghanistan and Pakistan (Zia, A., et al., 2019). A. Tiple, V. Sharma & S.V. Padwad, 2022) studied the odonata fauna of central India. During the study period of 2008–2019 a total of 75 species of odonates belonging to two suborders and nine families were recorded. Twenty-one new species were recorded for Jabalpur district and four for Madhya Pradesh; 37% (28) species were abundant or very common, 19% (14) were common, 16% (12) were frequent, 24% (18) rare, and 4% (3) very rare. The maximum number of odonates were found in family Libellulidae (n= 32), followed by Coenagrionidae (n=17), Gomphidae (n=09), Platycenemididae (n=06), Aeshnidae (n= 05), Lestidae (n=03), Macromiidae (n=02), and Chlorocyphidae (n=01). Of 75 species recorded from Jabalpur city, 72 come under the IUCN Red List. Among them, Indothemis Carnatica come under Near Threatened (NT) category, 65 species come under Least Concern (LC) Category, six species under Data Deficient (DD), and three species remain not assessed. The study supports the value of the city area in providing habitat for Odonata (Tiple, A., et al., 2022) central India. During the study period of 2008–2019 a total of 75 species of odonates belonging to two suborders and nine families were recorded. Twenty-one new species were recorded for Jabalpur district and four for Madhya Pradesh; 37% (28. Cytogenetic analysis of dragonflies is becoming one of the urgent issues in the period of rapid development of modern science. The results of the research conducted by G.K. Walia & N. Katnoria, 2021) are given below. Taxonomically, in the family Calopterygidae, 183 species under 21 genera have been reported worldwide. Out of these, cytogenetic data pertains to only 22 species which is only 12% of the known species. In India, 9 species under 6 genera are present, while only 2 species have been studied cytogenetically. The present study has been conducted to linearly characterize the chromosomes of 4 species (*Matrona nigripectus*, *Neurobasis chinensis*, *Vestalis apicalis* and *Vestalis gracilis*) of family Calopterygidae by conventional staining, C-banding, silver nitrate staining and sequence-specific staining and also compiled the cytogenetic data of the family. The species were collected from Meghalaya, Goa, Kerala, Himachal Pradesh states of India. All the species possesses 2 n = 25 m as the diploid chromosome number with XO-XX sex determination except *Neurobasis chinensis* with 2 n = 23, characterized by the presence of two equal sized large autosomal bivalents originated by the autosome fusion. C-banding and silver nitrate staining results depict the presence of C-bands and NOR's on the terminal positions of autosomal bivalents, while X chromosome and m-bivalent show variation in distribution of C-heterochromatin and NOR's. Sequence-specific staining represents the complement of all the species as AT-rich due to more DAPI bright signals. All the cytogenetically studied species have been catalogued including the presently studied species and the list has been updated to 23 species (Walia, G.K., & Katnoria, N., 2021) in family Calopterygidae, 183 species under 21 genera have been reported worldwide. Out of these, cytogenetic data pertains to only 22 species which is only 12% of the known species. In India, 9 species under 6 genera are present, while only 2 species has been studied cytogenetically The present study has been conducted to linearly characterize the chromosomes of 4 species (Matrona nigripectus, Neurobasis chinensis, Vestalis apicalis and Vestalis gracilis. In the research of L. Wang et al., 2021), some species of dragonflies were analyzed molecularly (Wang, L., et al., 2021) lakes and other still water. In this study, we sequenced and analyzed the complete mitochondrial genome (mitogenome. In the article "Evolutionary history of a beautiful damselfly, *Matrona basilaris*, revealed by phylogeographic analyses: the first study of an odonata species in mainland China" published in 2018 by J. Xue et al., by molecular genetic study of several specimens of *Matrona basilaris* Selys, 1853 phylogeographic origin and demographic dynamics were analyzed (Xue, J., et al., 2019) 1853 is a damselfly distributed mainly in mainland China. A total of 423 individuals from 48 populations covering almost the entire range were sampled to explore the genetic diversity, phylogeographic structure, and demographic dynamics of the species using sequences of three mitochondrial genes (COI, COII, and ND1. D.S. In Vilela et al.'s, 2019) data, some

dragonfly species were studied in depth by morphological comparison (Vilela, D.S., et al., 2019). The scientific research conducted by I. Almudi & others (2020) is dedicated to the study of the adaptation of insects to water and land environment in relation to their genotype (Almudi, I., et al., 2020). I. E. Alvial & other scientists (2019) studied the genetic and morphological differentiation of the cosmopolitan dragonfly isolated on a special island (Alvial, I. E., et al., 2019) geographical and/or ecological factors can limit species distributions and promote population structure and morphological differentiation. In order to determine the effects of geographical isolation on population genetic structure and wing morphology, 281 individuals of the cosmopolitan odonate Pantala flavescens were collected from four continental (Central and South America. In the article "Similar Response of a Range Expanding Dragonfly to Low-and High-Elevation Predators" published by R. Zebsa, H. Mahdjoub, R. Khelifa (2022), the research results of the dragonfly Sympetrum striolatum were published. These authors tried to practically prove the idea that "Recent range expansion of many species northward and upward in elevation suggests that the expanding species are able to cope with new biotic interactions in the leading edge" (Zebsa, R., et al., 2022).

Methods

In this article, we went to the selected publications on worldly knowledge from the research done. The search collects the English-language academic literature retrieved from the Scopus database for the period 2019–2023. The analysis was carried out in November 2023. A total of 827 publications were downloaded with the keyword "Odonata". In the next step, articles were categorized according to year of publication. A database of all peer-reviewed papers was then created, including the year of publication, authors' names, countries, publication type, journal name, the percentage of publications by the topic cluster name and subject area. The analysis was performed using CSV file, Microsoft Excel 2021, RIS, VOS viewer. Figure 1 shows the flow of the selected methodology for the research.

Figure 1. *Flowchart of the methodology*



The reasons for the usage of these methods mentioned above are related to Scopus, a well-known database that collects authoritative literature from around the world, especially on irrigation and drainage systems. English is a universal language, therefore, the literature in English is more common than the literature in other languages.

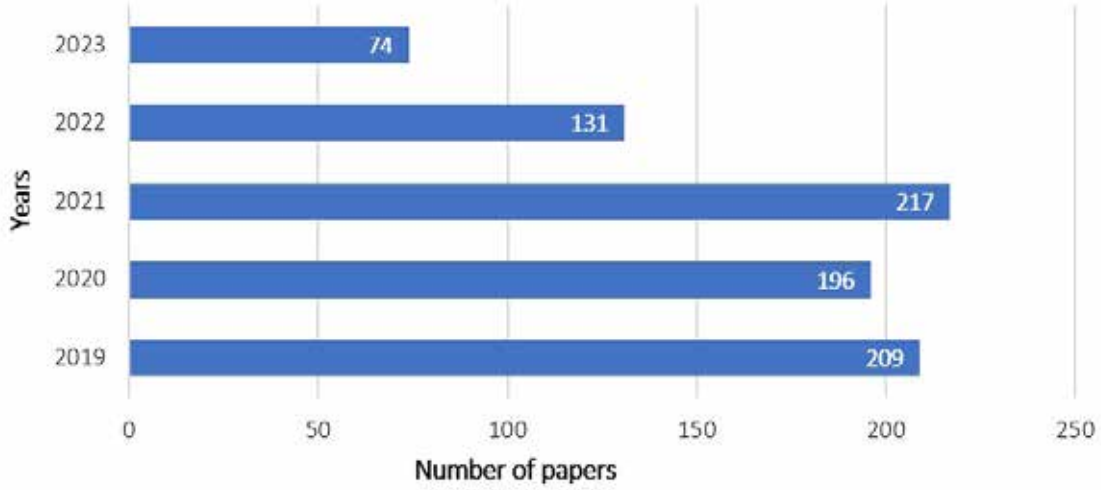
Results and discussion

1. Trends of publications on Odonata order

Overall, what stands out is that the number of published papers on a particular issue studied for the first time in the world. Total of 827 papers published between 2019 and 2023 on Odonata order issue. The number of records started to decrease between 2019 and 2023 from 209 to

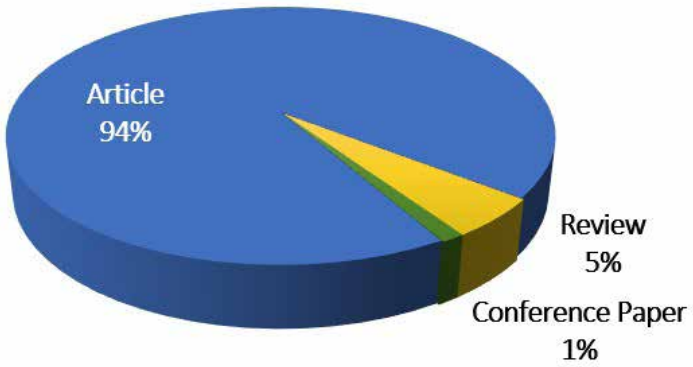
74 publications. Figure 2 shows 25% (209) number of papers at the beginning in year 2019. In 2020, the highest number of publications was reached during the period of analysis 23% (196). An analysis of publications in the studied years shows that 2021 was the year with the largest number of articles published on dragonflies, with 217 articles (26%) according to the five-year results. An analysis of the results of the last two years shows that the publication of articles on dragonflies has decreased. In 2022, 131 (16%) articles were published, but by 2023, only 74 (9%) articles were published (Figure 2). The results of the cross-year analysis show that 2021 was the year with the most articles published.

Figure 2. *Number of papers on Odonata order by the year of publication issues in the world*



During the period 2019–2023, 827 articles were published about insects belonging to the order Odonata, of which 94% (776) were articles published in journals as scientific research results, and 1% (10) articles were conference proceedings. The remaining 5% (41) of articles are covered as a literature review (Figure 3).

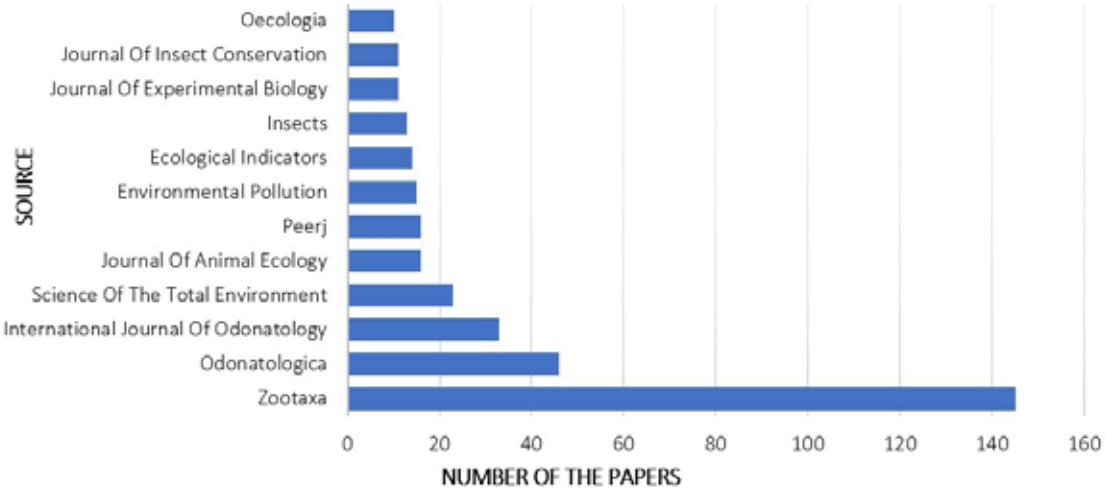
Figure 3. *Publication type on Odonata order issues in the world*



2. Journals on Odonata order

A wide variety of journals in different parts of the world are used by scholars to publish their research. The communication patterns of the scholars indicate that the total output was distributed across 160 journals published in 91 countries. 353 (42,68%) of these papers were published in top 12 journals and remaining 57,31% papers were published in other journals (Figure 4). The results of scientific research on dragonflies were published in the form of 48 articles in 16 scientific journals, 72 articles in 38 journals, and 1 article each in the remaining journals.

Figure 4. *Top journals on Odonata order by the year of publication issues in the world*

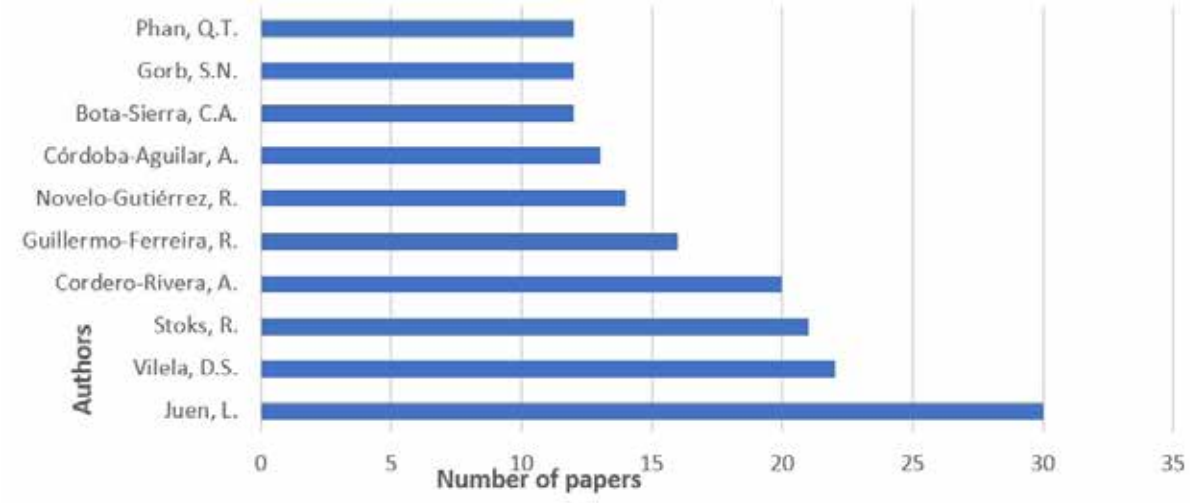


According to the analytical results of the 12 journals that published the most articles about dragonflies, 353 (100% compared to 12 journals), the first place was the Zootaxa journal, which published 145 (41%) articles about our object. Followed by Odonatologica with 46 articles (13%), International Journal Of Odonatology with 33 (9%) articles, Science Of The Total Environment with 23 articles (6%), Journal Of Animal Ecology and Peerj with 16 each (10%), Environmental Pollution 15 (4%), Ecological Indicators 14 (4%), Insects 13 (4%), Journal Of Experimental Biology and Journal Of Insect Conservation 11 articles each (6%), Oecologia and 10 (3%) articles were published (Figure 4).

3. Authors and their affiliated country

Our research revealed that 160 authors from 91 countries conducted research on the Odonata order during 2019–2023. Figure 5 analyzes the results of scientific research of the 10 authors who published the most number of articles. According to it, L. Juen is in the top 10 with 30 articles published, D.S. Vilela, R. Stokes, A. Cordero-Rivera participated as authors in publishing 20 to 22 articles and took 2–4 places. R. Guillermo-Ferreira ranked fifth in the top 10 for his Odonata order with 16 published research articles, R. Novelo – Gutiérrez ranked sixth with 14 published research articles, and A. Córdoba – Aguilar ranked sixth with 13 published research articles. seventh place with the article, C.A. Botha-Sierra, S.N. Gorb & Q.T. Phan took the last places by publishing 12 articles each. According to the results of the analysis, 23.75% of the 160 authors published 4 articles, while 37.50% of the authors published the least number of 3 articles.

Figure 5. *Top authors published on Odonata order issues in the world*



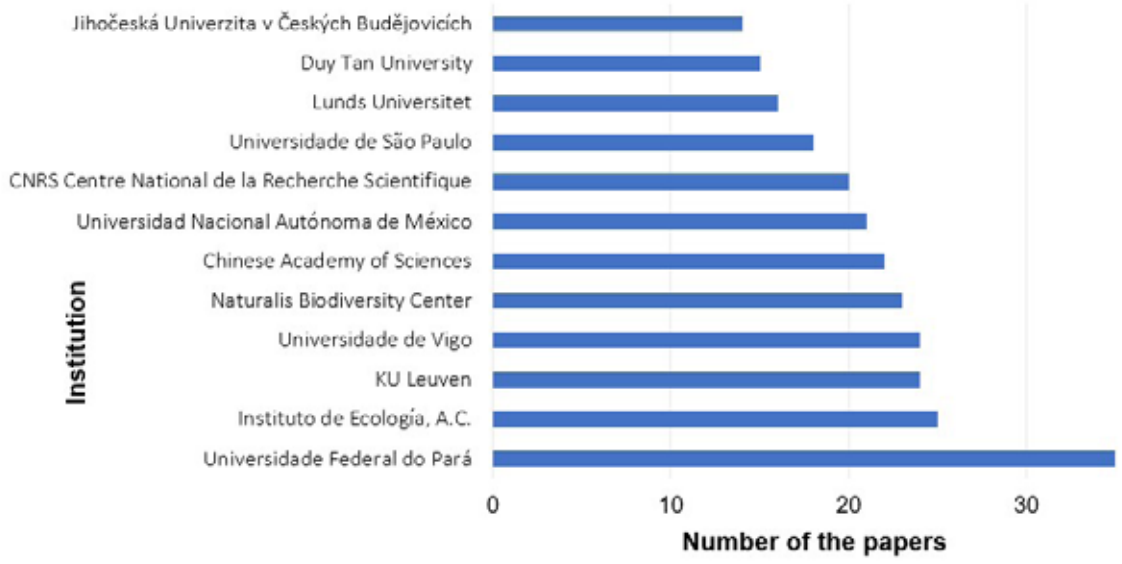
The quality of articles published by researchers on the Odonata order determines how institutions are ranked. During 2019–2023, one hundred and sixty different institutions of the world published 827 articles on Odonata order in cooperation. Our analysis of the top 12 institutional publications on the Odonata order allowed us to identify the most influential and effective institutions in the field (Figure 6). According to the results of the analysis, Brazil's Universidade Federal do Pará is in first place with 35 articles, Mexico's Instituto de Ecología is in second place with 25 articles, Belgium's KU Leuven is in 24 articles, Spain's Universidade de Vigo University Press is in third place with 24 articles, followed by: The Naturalis Biodiversity Center of the Netherlands published 23 articles, the Chinese Academy of Sciences published 22 articles, the Universidad Nacional Autónoma de México of Mexico published 21 articles, and the CNRS Center National de la Recherche Scientifique of France published 20 articles.

Publishing house of Universidade de São Paulo of Brazil published 18 articles, Lunds University Publishing House of Sweden published 16 articles, Duy Tan University of Vietnam published 15 articles, Jihočeská Univerzita v Českých Budějovicích published 14 articles and took 12th place. If we analyze the articles published in the top 12 institutions by country, Brazil is in the first place with 53 articles, Mexico is in the second place with 46 articles, Belgium and Spain are in the third place with 24 articles, followed by: Netherlands (23 articles), China (22 articles), France (20 articles), Sweden (16), Vietnam (15) and the Czech Republic (14 articles) took 12 places.

4. Top funding sponsors on Odonata order

There is a relationship between prevalence of affiliated countries and funding of large funding schemes and programs. 146 different funding sponsors worked in cooperation with 827 publishing papers on Odonata order over the world the period of 2019–2023. Based on our analysis of the top ten funding sponsors made publications on Odonata order, we were able to identify the most influential and productive institutions in this field. As indicated in Figure 7, of 14 funding sponsors, 72 articles were sponsored by Conselho Nacional de Desenvolvimento Científico e Tecnológico of Brazil, 47 articles were sponsored by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior of this country, 34 articles were sponsored by the National Science Foundation of the USA, 25 articles were sponsored by the Belgian Fonds Wetenschappelijk Onderzoek and the National Natural Science Foundation of China sponsored 25 articles, 19 articles under the auspices of the European Regional Development Fund and 19 articles under the auspices of KU Leuven of Belgium were published.

Figure 6. *List of top institutions on Odonata order issues in the world*

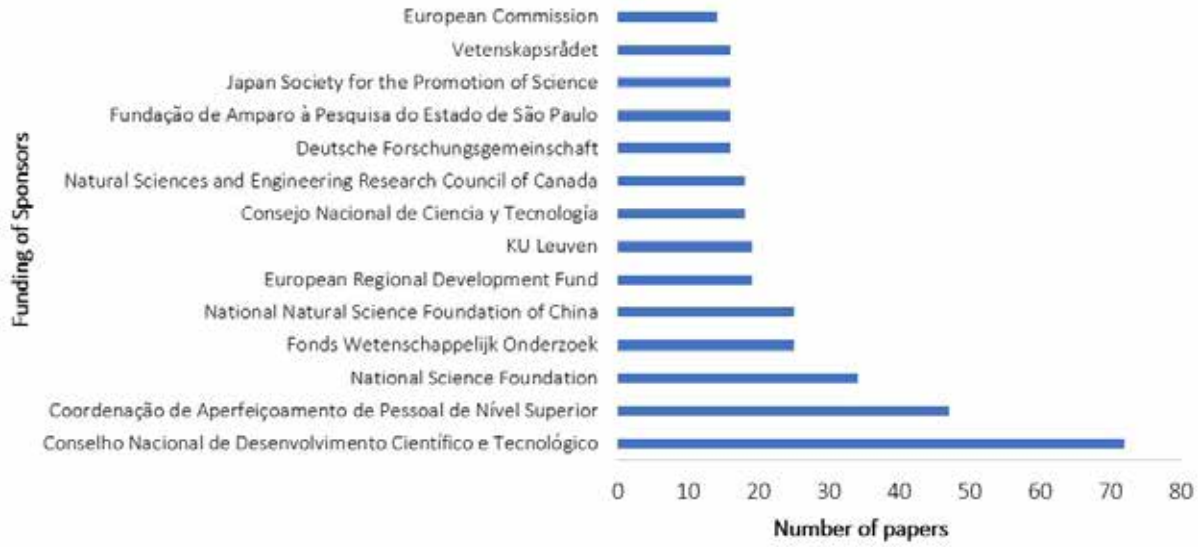


In addition to this, Mexico has 18 under the auspices of the Consejo Nacional de Ciencia y Tecnología, 18 under the auspices of the Natural Sciences and Engineering Research Council of Canada, 16 under the auspices of the German Deutsche Forschungsgemeinschaft, 16 under the auspices of the Brazilian Fundação de Amparo a Pesquisa do Estado de São Paulo, 16 articles were published under the auspices of the Japan Society for the Promotion of Science, 16 under the auspices of Sweden's Vetenskapsradet, and 14 under the auspices of the European Commission (Figure 7).

5. Top countries on Odonata order

The researches on Odonata order were published in 91 countries around the world. Countries which published 827 research papers in last 5 year (2019–2023) have been considered as prolific countries. These 10 countries published more than half (79.56%) of the total output. Among them, United States dominated with (152; 23%), Brazil (99; 15%), Germany (65; 10%), Mexico (53; 8%), China (52; 8%), Canada (51; 8%), United Kingdom (50; 8%), India (47;7%), Sweden (46; 7%), and Spain (43; 6%).

Figure 7. *List of top funding sponsors on Odonata order issues in the world*



Conclusion

While analyzing above mentioned issues in the study of perspective species of the order Odonata worldwide: a review of papers from the Scopus database published in English for the period of 2019–2023, trend of publications in the Odonata order, from 2019 to 2023, a total of 827 articles were published on the Odonata order, of which 94% (776) are articles published in journals as results of scientific research, 1% (10) of articles are conference proceedings, and 5% (41) of articles are literature reviews given. A five-year analysis of publications shows that 209 articles were published in 2019, 196 in 2020, 217 in 2021, 131 in 2022, and only 74 by 2023. According to the results of the cross-year analysis, the most articles were published in 2021, but by 2023, there was a threefold decrease in scientific publications compared to the highest number of publications shows that interest in dragonflies is decreasing. According to the analytical results of journals, 160 journals were published in 91 countries, of which 353 (42.68%) of these papers were published in top 12 journals and remaining 57.31% papers were published in other journals. At the same time, Zootaxa, Odonatologica, and International Journal Of Odonatology occupy the first 3, according to the analytical results of 12 journals that published the most, 353 articles about dragonflies. According to the results of our research, 160 authors from 91 countries published 827 articles in 2019–2023. According to the published papers of the authors who published the most articles, L. Juen (published 30 articles in co-authorship 3 or more), D. S. Vilela

(22), R. Stokes (21), A. Cordero-Rivera (20), R. Guillermo-Ferreira (16), R. Novelo-Gutiérrez (14), A. Córdoba-Aguilar (13), C.A. Bota-Sierra (12), S.N. Gorb (12) and Q.T. Phan (12) are occupied by scientists working in different areas of Odonatology. In addition, the analytical results of the 12 most published articles of the Odonata order are presented. Top funding sponsors on Odonata order 146 different funding sponsors worked in cooperation to publish 827 papers on Odonata order over the world in the period of 2019–2023. Top countries on Odonata order also lists the 10 countries with the most articles on dragonflies. Countries which published 827 research papers in last 5 years (2019–2023) have been considered as prolific countries. These 10 countries published more than half (79.56%) of the total output. If we analyze the publications about dragonflies by country, 23% of them are in the United States, 15% in Brazil and 10% in Germany.

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Contact: zarinanorqobilova1@gmail.com