Taxonomic papers as published products of the biodiversity inventory: if not the Impact Factor (IF) or Quartiles (Q), then what determines their importance estimated on the basis of the Research Interest Score?

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This study is uniquely based on the Research Interest Score (RGRI) and not on other existing bibliometric criteria for evaluation of published biological inventory products (articles and monographs). RGRI is a ResearchGate.net score that measures scientists’ interest in the publication and is based on its citations, recommendations, and reads. Our data revealed that high RGRI scores of publications were generally not determined by the journal’s Impact Factor (IF) or high quartiles (Q). However, open access to publications undoubtedly creates the strongest preconditions for the rise of RGRI. The importance and popularity of a publication can also be affected by its various other characteristics, for example, international collaboration of authors, ecological issues such as plant-insect interactions, and even the wording of the publication title.

Keywords: journal ranking, diagnostics, international collaboration, leaf-mining insects, new taxa, open access, plant-insect interactions, title
INTRODUCTION

The term 'biodiversity inventory' is interpreted as studies that cover the diversity of all organisms, including their genetic diversity, interspecific and intraspecific diversity, identification of relationships between species and ecosystems, the diversity of terrestrial and aquatic ecosystems and their evolutionary and ecological processes (Vermeulen, Kozieł, 2002; Morton, Hill, 2014). In fact, it is within the field of biological systematics or taxonomy with the ultimate task to document and understand the extent and significance of biological diversity (Vane-Wright, 1992, 1996). Such studies are also needed in order to obtain detailed information on grouping of endangered species (Mckinney, 2002) and, more importantly, to identify and protect critical habitats. The availability and quality of such information is essential for understanding the mechanisms of functioning of the global biota (Pereira et al., 2010), including the development of methods for using incomplete data (Girardello et al., 2019). In order to manage this process of research, technologies for studying various aspects of biodiversity are being developed (e.g., Grummo et al., 2019) and manuals are compiled (Cutko, 2009). Biodiversity inventory or biodiversity assessment has been particularly relevant because of human activities, reckless use of natural resources, destruction and fragmentation of habitats, industrial pollution, and climate change. Biodiversity has undergone dramatic change (Puplesis, 2002; Bellard et al., 2012; Morton, Hill, 2014) and is declining rapidly (Hallmann, 2017; Leather, 2018; Sánchez-Bayo, Wyckhuys, 2019; Zattara, Aizen, 2021).

Another problem is that the inventory of species diversity is often limited to the best-known groups of organisms such as vascular plants and larger vertebrates, and too little attention is being paid to the remaining 80–90% of taxa (Puplesis, 2002; Hawksworth, 2011). The availability and quality of information accumulated over the earlier genesis of the Earth’s biota (Stonis et al., 2020b). They have also been used as an express tool for monitoring biodiversity, rapid assessment of biodiversity areas of critical value, and determining priority areas from the environmental point of view in tropical America (Stonis, pers. comm.). On the other hand, larvae of leaf miners are pests or potential pests of wild and cultivated plants; they mine inside green tissues and produce leaf mines (Pitkin et al., 2019; Kirichenko et al., 2019). Although adults of leaf miners are often among the smallest lepidopterans in the world (Stonis et al., 2021b), a leaf mine produced by a tiny larva can be relatively large and cause damage because the larva consumes much of the photosynthetic tissues (Stonis et al., 2021b). Upon significant population increase or explosion, damage to the host plant may be significant or even severe (Puplesis, 1994; Puplesis, Diškus, 2003; Stonis et al., 2021b).

Final products of the biodiversity inventory can vary between online databases (De Prins, De Prins, 2006–2020; Robinson, 2019; Froese, 2019; De Prins, Heughebaert, 2019; Stephen-son, Stengel, 2020; Kitching, 2021) and issued publications: taxonomic lists of regional fauna or flora, identification keys, large-scale taxonomic revisions, or global or regional catalogues, etc. For example, the Catalogue of Lepidoptera of Russia (Sinev, 2008) reveals species composition of this huge country, outlines geographical distribution of individual species, and determines territories least studied in terms of the lepidopteran fauna. An important function of this catalogue is the introduction into the practice of domestic research of modern ideas about taxonomy and applying current nomenclature. The catalogue also serves as a very powerful impetus for further taxonomic and especially faunistic research. Therefore, a huge amount of new information accumulated over
the last decade within this field of the biological inventory resulted in the second revised and supplemented edition of the Catalogue of Lepidoptera of Russia (Sinev, 2019).

Efforts to inventory and monitor global biodiversity appear to be growing (Zhang, 2008, 2011; Cutko, 2009; La Salle et al., 2009; Pereira et al., 2010). The task, however, is huge and the speed is far from sufficient (Schmeller et al., 2017). Among various causes, there is a lack of qualified professionals (Stonis, 2014).

In order to speed up the global inventory, integration of DNA barcoding into an ongoing inventory has been actively propagated (Janzen et al., 2009; Miller, 2015; Miller et al., 2016; Aagaard et al., 2017) and some seriously controversial attempts have recently been undertaken. It is particularly the case of a minimalistic revision with description of 403 new species in 11 subfamilies of Costa Rican braconid parasitoid wasps (Sharkey et al., 2021) rejecting the usual standards for species description.

Another alarming situation is that the present funding of research in some countries may depend on the number of publications in the journals that are highly rated (quartiles Q1 and Q2 of a list ranked by the impact factor in a particular category, e.g., entomology) in the Clarivate Analytics Web of Science Core Collection database (hereinafter, IF publications). It indirectly influences biodiversity researchers who are obliged to refer to publications in these high-ranked journals instead of publishing their research in journals dedicated to the biodiversity inventory and aspire to their main goal: to accelerate the process of inventorying the global biodiversity. In some cases, the number of IF publications is considered the only criterion for assessing researchers’ performance during the most recent period or electing them for a new term. Meanwhile, papers published in unranked journals (including monographs, articles, or catalogues) or, even more so, the building of faunistic collections are generally not considered and left overboard. Often, this approach not only has a direct negative impact on researchers, but also does not help to maintain biological inventories. This situation is particularly detrimental to young researchers and is increasingly leading to the situation when biodiversity research (especially faunistics) is to a large extent done by amateur entomologists.

The purpose of this study is to analyse the significance and popularity of taxonomic publications as published products of the biodiversity inventory. Various analyses of article citation rates can be found in a number of publications (Falagas et al., 2008; Barreto et al., 2013; Aksnes et al., 2019). However, the change in the significance of scientific articles over time has been very little analysed (Chawla, 2018).

Our study is focused exclusively on the ResearchGate (researchgate.net) Research Interest (RGRI) score and not on other existing bibliometric criteria for the evaluation of published products of the biological inventory (articles and monographs). We are not aware of any cases where the indicators of scientific social networks (namely RGRI) are compared with usual bibliometric indicators.

Research Interest is a ResearchGate.net score that measures scientists’ interest in a publication and is based on its citations, recommendations, and reads. It should be mentioned that ResearchGate.net is not simply a ‘social club’ for researchers registered at this portal: all publications or their abstracts are available to any user via internet search engines. Therefore, the readability of publications from the ResearchGate and their citation appear to be important indicators of whether the published paper has attracted interest or not.

MATERIALS AND METHODS

A statistical sample and criteria for the selection of a subset. The analysis encompassed 69 publications. The following criteria were applied for the selection of publications: (1) diversity regarding occurrence in journals with different quartile (Q) and impact factor (IF) as well as in non-IF journals; (2) the same subject as regards organism groups and the nature of research; (3) the same recent period of publishing; (4) the presence of an RGRI score enabling comparison of publications, i.e., availability
of publications on ResearchGate.net. However, publications that conform entirely to all the above-mentioned criteria and comprise corpora large enough for analysis were not numerous. For this reason, we selected publications inventorying plant-mining Microlepidoptera (Insecta: Lepidoptera). The analysis did not compare papers addressing different subject areas, e.g., taxonomic publications were not compared with those dealing with applied research on them as pests. All publications dealing with a certain subject were taken from the database of ResearchGate, mostly (but not exclusively) from the period of 2013–2020 without excluding those which were ‘inapplicable’ for some reason. Part of the analysed publications dealt with taxonomic diversity of Opostegidae (Davis, Stonis, 2007; Remeikis et al., 2009; Stonis et al., 2013e, 2020f). Others focused on the inventorying of Tischeriidae (Stonis, Diškus, 2007, 2008; Lees, Stonis, 2007; Stonis et al., 2008, 2014a, 2017a, 2018a, 2019a, 2019b, 2019d, 2020a, 2020b, 2020d; Diškus, Stonis, 2015, 2017c, 2017d, 2017e, 2017f, 2018b, 2018c, 2018d, 2018e; Remeikis, Stonis, 2015; Stonis, Remeikis, 2014, 2015b, 2020e; Navickaitė et al., 2014a, 2014b), Central America (Šimkevičiūtė et al., 2009; Stonis et al., 2013a, 2013b, 2013c, 2013d, 2019g; Stonis, Remeikis, 2015), and South America (Remeikis et al., 2014, 2016; Remeikis, Stonis, 2015; Stonis et al., 2014b, 2015a, 2016b, 2016c, 2016d, 2016e, 2016f, 2017b, 2017c, 2017d, 2017e, 2017f, 2018b, 2018c, 2018d, 2018e, 2019c, 2019e, 2019g, 2020c; Stonis, Remeikis, 2016, 2017, 2018; Stonis, Diškus, 2018).

**Criteria for the evaluation of the significance and relevance of publications.** Although the importance of publications can be estimated by considering data on their reads and citation taken from Google Scholar or Clarivate Analytics, in this analysis, the main criteria for the evaluation of the significance and relevance of publications was a Research Gate Research Interest (RGRI) score. RGRI is a ResearchGate.net score that measures scientists’ interest in a publication and is based on its citations, recommendations, and reads. We cannot state that any scores necessarily depend on the quality of a publication. For example, the score for reads alone, as distinct from that for citation, is not always related to the publication quality but almost certainly to the particular title that the reader sees before reading the publication. The selection, therefore, focused on the total score of Research Interest and not on its component parts (‘Citations’, ‘Recommendations’, ‘Reads’, or ‘Full-text reads’) in order to comprise various aspects of the usage and popularity of a publication. RGRI can be affected by the number of followers of the publication’s authors and the number of those being followed within academic social networks. We, therefore, avoided including a wide variety of authors when selecting publications for analysis in order to eliminate, at least in part, the impact of this feature on RGRI.

RGRI is increasing (it is an accumulative score), though it generally stabilizes over time. Therefore, when analyzing the dynamics of RGRI’s increase (variation over several years), we selected only those publications which appeared from 2017 to 2020. All the RGRI data for the analysed publications were registered at the same time (16 January 2021), because these data may change in the future.

**Analysis.** Total values of RGRI scores were balanced with various characteristics of publications: IF, quartiles (Q2, Q3, Q4), Open Access (OA) or its absence, as well as other characteristics of publications which could affect the score value. Statistical assessments were done using Statsoft Statistics, version 8. The normality of distribution in variables was assessed using the Shapiro-Wilk test. In the cases of normal distribution, we applied the analysis of variance (ANOVA) and the Tukey’s ‘Honest significant difference’ (HSD) test. In other cases, the significance of difference among groups was assessed using the Kruskal-Wallis test and the Mann-Whitney test. The histograms (Figs. 5–8) were drawn according to the recommendations.
developed by Vilmantas Gėgžna (https://moky-
mai.github.io/biostatistika/).

RESULTS AND DISCUSSION

Analysis of published biodiversity inventory
products (articles and monographs) and
their RGRI value

The analysed publications had very different
RGRI values (scores) (Table 1), among which
the lowest RGRI value was 0.1 points and
the highest 17.2 points. Therefore, all publica-
tions were divided into two groups: (1) publica-
tions with low RGRI scores, i.e., from 0.1
to 9.9 points (mean = 5.1) and (2) publications
with high RGRI scores, i.e., ten or more points
(mean = 12.2). Judging by the value of RGRI
alone, the latter group brought together publica-
tions that were more relevant and apparently
more significant to RG users. It could be ex-
pected that the group of higher RGRI values
would be dominated by IF publications, while
the lower value group by publications pub-
lished in unrated journals. However, our data
showed that both in the group with lower RGRI
scores (Fig. 1) and in that with higher RGRI
scores (Fig. 2), publications that appeared in
IF journals accounted for the largest share.

Table 1. RGRI score of selected publications published in impact factor (IF) and non-IF journals

| Short title of publication | Reference | IF | RGRI value |
|----------------------------|-----------|----|------------|
| Lamiaceae-feeding Nepticulidae from South America | Stonis et al. 2017d | IF | 4.2 |
| Discovery of the *Stigmella magnispinella* group | Stonis et al. 2016f | IF | 3.6 |
| Diagnostics of the Andean *Stigmella sinuosa* complex | Stonis & Remeikis 2016 | IF | 3.6 |
| Updated checklist of Nepticulidae of the Crimea | Navickaite et al. 2014b | IF | 2.2 |
| Additions to the Nepticulidae of East Asia | Stonis & Rociene 2014 | IF | 3.1 |
| New generic concept: *Brachinepticula* gen. nov. | Stonis et al. 2018c | – | 12.2 |
| Mystery of Urticaceae-feeding Nepticulidae | Stonis et al. 2017a | – | 16.6 |
| A situation requiring urgent action: Colombia | Stonis et al. 2015c | – | 11.0 |

Figs. 1, 2. RGRI value and the share of analysed publications published in IF and non-IF journals. 1 – publications with RGRI values lower than 10 points; 2 – publications with RGRI values of 10 points or more
Moreover, there were relatively fewer (59%) IF publications in the group of high RGRI values (Fig. 2). This led us to the conclusion that high RGRI scores (and user interest) were not necessarily earned by publications in IF journals and that the mere fact of being published in IF journals did not guarantee greater readability or citation.

However, when analysing the same groups of publications, we found an obvious correlation of the RGRI value with the availability of open access (OA). Almost exclusively, the group of publications more valuable from the RGRI point of view (with the RGRI value >10, mean = 12.2) (Fig. 4) included open access publications; they made up about 96% within this group. Meanwhile, among the publications with low RGRI values (Fig. 3), nearly half of all of the publications (45%) were not open access (Table 2). The increase in RGRI value in relation to OA was confirmed by the data of our analysis (Fig. 5) (T-test: non-OA mean 4.772; OA mean 8.027; t-value 3.711; df 67; p = 0.00042; non-OA n = 25; n = 44).

Figs. 3–5. RGRI value and the share of analyzed publications published in journals with open access or without it. 3 – publications with RGRI value less than 10 scores; 4 – publications with RGRI value 10 scores or more; 5 – difference in RGRI median between publications published in journals with open access (OA) and without OA.
When grouping the analysed publications by their quartiles (Q) (Figs. 6, 7), it turned out that quartiles might be of little significance for the RGRI value of publications (Table 3) because in the sample analysed, the highest RGRI values are from the lowest quartile group (Fig. 7) and not vice versa (Fig. 6). However, since there was not a single Q1 item within the group of high quartile items analysed (Fig. 6) and the sample size of this group \(n = 16\) was too small, we could not draw definitive conclusions.

In this study, we hypothesised that international collaboration of the authors might have affected the popularity of published biodiversity inventory products (i.e., the extent of the RGRI value). Although most of the analysed publications were related to international cooperation in one way or another, we included only publications that had been prepared and published as a result of exceptional and highly significant international cooperation into the group ‘with international cooperation’.

### Table 2. RGRI score of selected publications published in open access (OA) and non-OA journals

| Short title of publication | Reference | OA | RGRI value |
|----------------------------|-----------|----|------------|
| Asteraceae feeding Nepticulidae of South America | Stonis et al. 2018b | OA | 14.7 |
| A Gondwanan concept of Simplicimorpha | Stonis et al. 2018d | OA | 8.5 |
| Documentation of guava pest, *Enteucha guajavae* | Remeikis et al. 2014 | OA | 17.2 |
| *Stigmella purpurimaculae* group from the Patagonian Andes | Stonis et al. 2014b | OA | 12.4 |
| Catalogue of species described by members of BRG | Navickaitė et al. 2011 | OA | 11.9 |
| Tischeriidae from South Africa | Stonis et al. 2019a | – | 0.8 |
| Odd Nepticulidae species from the Andes and Amazon | Stonis & Remeikis 2018 | – | 3.3 |
| Discovery of *Quercus*-feeding Nepticulidae in South America | Remeikis & Stonis 2015 | – | 3.6 |
| Nepticulidae of the Crimea, Sub-Mediterranean Europe | Navickaitė et al. 2014b | – | 2.2 |
| Nepticulidae of East Asia | Rociene & Stonis 2013 | – | 0.1 |

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![Figs. 6, 7. Frequency of publications with different RGRI values. 6 – publications in Q2 journals; 7 – publications in Q3–Q4 journals](image-url)
Table 3. RGRI score of selected publications published in Q2 and Q4 journals

| Short title of publication                                                                 | Reference         | Q | RGRI value |
|-------------------------------------------------------------------------------------------|-------------------|---|------------|
| Exceptional Tischeriidae diversity in Belize, Central America                             | Stonis et al. 2020a | 2 | 2.5        |
| Nepticulidae of East Asia                                                                  | Rociene & Stonis 2013 | 2 | 0.1        |
| Oposteoidae of the Himalaya                                                                | Stonis et al. 2013e | 2 | 0.7        |
| Brodest distribution range: *Astrotischeria neotropicana*                                 | Diskus & Stonis 2015 | 2 | 4.9        |
| Urticaceae-feeding Tischeriidae: *Paratischeria* gen. nov.                                 | Stonis et al. 2017a | 4 | 14.7       |
| Do Nepticulidae occur in the *Polylepis* forests?                                          | Stonis et al. 2016e | 4 | 10.9       |
| A revision of the New World Opostegidae                                                    | Davis & Stonis 2007 | 4 | 11.1       |

The analysis data also showed that the mean and median RGRI values of publications resulting from international collaboration (IC) were almost twice as high (Fig. 9) than non-IC publications (Fig. 8). In addition, IC publications were significantly more likely to have a higher

Figs. 8, 9. Frequency of publications with different RGRI values. 8 – publications without distinctive international collaboration (IC); 9 – publications characterized by exceptional IC.
RGRI value than those without IC. It should also be noted that the lower value of RGRI for publications without IC was very low (0.1), and its highest value was only 11.9 points. Meanwhile, the lowest value of IC publications was 2.5 points and the highest 17.2 points. The study showed that international collaboration between authors had a significant positive effect on the RGRI value. The median value of non-IC publications was 5.10, while the median of distinctive IC publications was 8.60 (non-IC mean 5.144; IC mean 9.073; t-value –4.909; df 67; p = 0.000006; non-OA n = 39, OA n = 30).

It was interesting to see if an RGRI value is affected by other indicators of the analysed publications. Do publications that provide descriptions of new taxa (Table 4, Fig. 10) have higher RGRI values than publications that do not describe such taxa? We attempted to determine whether publications that provide diagnostic tools (as shown in Fig. 14) become more valuable from the RGRI perspective than publications that do not provide diagnostics. Does the fact that a publication examines plant-insect interactions, including new host plants and pests of cultivated plants, boost its RGRI value? It was also interesting to determine whether the RGRI value could be influenced by the wording of the publication title. Among the analysed publications, most had titles that we considered traditional, for example, ‘Tischeriidae’, ‘The American species of the genus Glaucolepis Braun’, ‘A provisional checklist of Nepticulidae of the Crimea’. However, some publications had non-traditional titles, which, being fully aware of the subjectivity of the criterion, we considered intriguing or catchy. For example, ‘The mystery of the tiny Urticaceae-feeders: documentation of the first leaf-mining Nepticulidae species from equatorial America', 'Exceptional diversity of Tischeriidae from a single tropical forest site in Belize, Central America', ‘Exotic-looking Neotropical Tischeriidae (Lepidoptera) and their host plants', ‘A Gondwanan concept of Simplicimorpha Scoble’.

Although the analysis data showed an increase in RGRI values in all analysed cases (Figs. 10, 11), significant and statistically significant changes in RGRI values were found within groups of publications with the subject related to plant-insect interactions and had intriguing (rather than traditional) titles.

It is understandable that the RGRI value is not a constant but a gradually increasing and accumulating indicator. Although among the analysed publications higher-rated (IF) papers were in a slightly lower starting position, the RGRI of both rated and non-rated publications (i.e., non-IF) rose almost equally, i.e., RGRI values roughly doubled over the four years of the survey. The change in the RGRI value (i.e., the rates of change over the years) was unrelated or little related to the papers being published in IF or non-IF journals (Figs. 12, 13).

| Short title of publication | Reference | New taxa | RGRI value |
|---------------------------|-----------|----------|------------|
| New and little known Nepticulidae from the Asian continent | Stonis et al. 2020e | 11 | 0.6 |
| Diagnostics and catalog of Opostegidae of the Americas | Stonis et al. 2020c | 5 | 5.9 |
| Extraordinary sexual dimorphism of Stigmella pruinosa | Stonis et al. 2019g | – | 3.4 |
| Ulmaceae-feedino Tischeriidae from China | Xu et al. 2018 | 1 | 10.7 |
| Feeding strategies of Nepticulidae in Central & South America | Remeikis et al. 2016 | – | 7.3 |
| Nepticulidae from record high altitudes | Stonis et al. 2016d | 22 | 11.0 |
| A revision of the New World Opostegidae | Davis & Stonis 2007 | 71 | 11.1 |
Figs. 10, 11. RGRI values compared with different characteristics of analysed publications. 10 – RGRI mean; 11 – RGRI median
Figs. 12, 13. Growth rates of RGRI average over time. 12 – IF publications compared with non-IF publications; 13 – Open Access (OA) publications compared with non-OA publications
CONCLUSIONS

1. High RGRI scores for publications are not necessarily influenced (and often not influenced) by IF or high quartiles (Q), but open access to publications certainly provides the strongest premises for the rise of the RGRI score, i.e., readability and citation of publications.

2. In addition to open access, the RGRI value is affected by various other characteristics
of publications, including such factors as exceptional international cooperation, ecological aspects (as in the case of the analysed publications, plant-insect interactions), and an intriguing title of the publication.

3. RGRI values change over time, but despite their different starting positions, their growth rates do not depend on whether the publication is published in an impact factor (IF) or non-IF journal; RGRI growth rates are slightly faster for the publication that have open access compared to those that do not have it.

Note. In these times of commercialised and formalised science, professional researchers are indirectly yet systematically encouraged to abandon the preparation and publishing of papers in non-IF journals or in journals without high quartiles (Q). However, we believe that this does not contribute to the most important goal, which is faster inventorying of biodiversity, and probably has the opposite effect.

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Taxonomic papers as published products of the biodiversity inventory: if not the Impact Factor (IF)...

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**PUBLIKUOTI BIOLOGINĖS ĮVAIROVĖS INVENTORIZACIJOS PRODUKTAI: AR TIK CITAVIMO RODIKLIS (IF) BEI KVARTILĖS (Q) NULEMIA JŲ POPULARUMĄ IR SVARBĄ?**

**Santrauka**

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**Raktažodžiai:** žurnalo reitingas, taksonų diagnostika, tarptautinis bendradarbiavimas, nauji taksonai, atvira prieiga, augalų ir valždžių sąveika, straipsnio pavadinimas