Sorry, we’re open: Golden open-access and inequality in non-human biological sciences

Russell J. Gray

Received: 19 March 2020 / Published online: 9 June 2020
© Akadémiai Kiadó, Budapest, Hungary 2020

Abstract
Golden Open-access (GOA) journals make research more accessible and therefore more citable; however, the publication fees associated with GOA journals can be costly and therefore not a viable option for many researchers seeking high-impact publication outlets. In this study, metadata was collected from 174 open-access, non-human biological science journals and analyzed to determine relationships between Article Processing Charges (APC), Impact Factor (IF), Eigen Factor (EF), citability, h-index, journal rank, and potential contributing factors to publishing preference, such as years of available open access, publication frequency, and average review process time. Further, the aforementioned bibliometrics were examined in relation to country of publisher, as well as their national income threshold. The results of this study provide evidence that bibliometric values such as IF, EF, citability, h-index, and journal rank all increase as APC increases, and each of these metrics are higher in publishers from high-income countries in comparison to upper-middle and lower-middle income countries. Implications of these trends are discussed in regards to non-human biological sciences, and potential consequences of inequality within the global scientific community overall.

Keywords Open-access · Impact factor · Article Publishing Costs · Inequality · h-index

Introduction
With the prominence of entities such as Sci-Hub (Black Open-access) and ResearchGate (Green Open-access), the availability of journal articles has increased and may all but nullify the previous paywall system from creating capital for journals (Björk 2017; Fuchs and Sand-oval 2013). While this increase in accessibility of scientific literature has removed constraints of researchers and the general public on a global scale, it has also caused many high-impact

Electronic supplementary material The online version of this article (doi:https://doi.org/10.1007/s11192-020-03540-3) contains supplementary material, which is available to authorized users.

Russell J. Gray
rgrayherpetology@gmail.com

1 Wildlife Conservation Consultant, R J Gray Ecology, 705 Alligator Ranch Rd, New Smyrna Beach, FL 32168, USA
journals to transition to mandatory open-access, also known as Golden Open-access (GOA) in order to continue their profitability through scientific publication (Piwowar et al. 2018; Lewis 2012; Harnad et al. 2008). Although the concept of open-access science may seem genuine on its face, the cost associated with publishing in open-access journals (i.e. Article Processing Charges), as well as a journal’s perceived reliability and importance, is what makes this system potentially problematic.

Although many journals enable funding assistance for certain countries and institutions, and Article Processing Charges (APC) can sometimes be factor into project funding, this isn’t the case for all researchers and projects, especially when it comes to more expensive, prestigious journals. A study by Ellers et al. (2017) provided evidence that researchers from institutions in developing countries are still paying the full price of developed western nations to publish in high-impact “Mega-Journals” in order to gain exposure and credibility for their research. Unfortunately, the alternative, especially when it comes to GOA, is to publish in journals with a lower Impact Factor (IF), hybrid journals which allow subscription based options, or otherwise publish in potential predatory journals which have low-quality peer review and publish other questionable articles which then impact the credibility of a manuscript by affiliation (Beall 2013). Although publishing in predatory journals is typically frowned upon in the scientific community, researchers may publish in them unknowingly (Drake 2019), to inflate their curricula vitarum (CV) due to rapid publication rate (Pond et al. 2019), and to increase their likelihood of payout for academic research-output bonuses (Hedding 2019).

In this study, I build on the concepts of: (1) Demeter (2019) who, in an editorial, outlines the potential for inequality in publishing through Golden Open Access journals; (2) Björk (2017) who predicts that the most viable business model in lieu of increasing literature piracy outlets such as Sci-hub is a complete transition to GOA with APC for submissions; (3) van Vlokhoven (2019) who provides evidence that research quality and reliability is likely to be reduced with open-access publishing models, and (4) Björk and Solomon (2015), who provided evidence that researchers are more likely to submit to journals based on higher article publishing cost and perceived quality. By analyzing the metadata of open-access journals, I sought to answer the question of whether there are any correlations between journal impact factor, Eigen factor, citability, h-index, rank, years of available open access, publication frequency, average review process time, and article publication costs, as well as the aforementioned bibliometrics’ relationship to publisher country and associated country income level for comparable journals pertaining to fields of non-human biological sciences, which focus on plants, animals, fungi, bacteria and viruses. The objective of this study was to test various bibliometric statistics against APC to see how they correlate under the hypothesis that researchers seek the best journals, but aren’t always financially equipped to pay the high costs of publication. Furthermore, since research is international, there should theoretically be an equal system in place for researchers to gain exposure through their local (national) journals at a cost that represents their nations. Therefore, the additional analysis of publisher’s country was to reveal potential for upward mobility of journals from various nations and corresponding income levels.

Methods

Bibliographic measurements and metadata, also known as bibliometrics used in this study include impact factor, Eigen factor, citability, h-index, journal rank, article processing charge, total years of available as open-access, open-access publication frequency, and average review process time (Table 1).
The complete dataset from the Directory of Open-access Journals (DOJ) (Morrison, 2008) was used to acquire journal name, APC, country of publisher, average review time, first record of open-access publication, most recent open access publication, number of open-access publication records, and APC currency/cost data \((n = 14,275)\). R statistical software was used for all data analyses; functions and packages used in the analyses included: (1) the `get_impactfactor` function of the scholar package (Keirstead 2016), which accesses Google Scholar to generate impact factor, Eigen factor and citation metrics for vectors of journal name strings from the most recent year (2019); (2) the `getFX` function of the quantmod package (Ryan et al. 2019) to convert all currencies to USD for standardization, conversions were made using conversion rates of January 1st, 2020; (3) the dplyr package (Wickham et al. 2015) and reshape2 package (Wickham 2012) to clean and select specific data, and (4) ggplot2 package (Wickham et al. 2016) for data visualizations. In order to obtain journal rank and h-index values, the srjdata package (Kashnitsky 2020) was used to query all data from SCImago Journal & Country Rank Data (SJR) and merge with the journal data in the final analysis. Country income data was acquired using the wbstats R package (Piburn 2016), which queries all currently updated World Bank data.

A subset of journals \((n = 1047)\) which had topics relative to animals, plants, fungi, microorganisms, and viruses was queried by creating a subset from the keyword metadata column of the original DOJ dataset. Since there were large disparities between human (i.e. human medical, chemical, and physiological journals) and journals which are not exclusively pertinent to humans (hereafter “non-human biological sciences”) in relation to impact factor, journals with an IF > 40 were excluded from the analysis. The excluded

### Table 1  Terms and descriptions of bibliometrics used in the analyses

| Term                        | Description                                                                 |
|-----------------------------|-----------------------------------------------------------------------------|
| Impact Factor (IF)          | An index calculated by ratio of citations and publications: \(\text{IF} = \frac{n_{\text{citations}}}{n_{\text{publications}}}\) |
| Eigen Factor (EF)           | A relative measurement of journal importance, calculated the same way as IF, while omitting self-citations, and weighting references on a randomly distributed scale of assumed time researchers spend reading articles from the journal |
| Citability                  | Total citations of articles in the journal within the current year           |
| Article Processing Charge (APC) | The overall cost of publishing an article as open-access in a journal       |
| Years of Available Open-Access | Total number of years a journal has provided available open-access options |
| Publishing Frequency        | The number of open-access publication records weighted by years of available open-access: \(\text{Publishing Frequency} = \frac{n_{\text{records}}}{n_{\text{years of available open-access}}}\) |
| Avg. Review Time            | Average number of weeks taken from submission to publication for a given journal |
| h-index                     | Best used to compare authors and journals across similar and comparable fields, the h-index is as “the maximum value of \(h\) such that the given author/journal has published \(h\) papers that have each been cited at least \(h\) times.” (McDonald 2005) |
| Journal rank                | An evaluation of a journal’s overall impact and quality within its respective field, calculated by the number of citations for a journal and the relative prestige of the journals where the citations come from |
journals were checked via keywords to ensure none were related to non-human biological sciences; excluded journals were related to topics in oncology, medicine, and engineering. Finally, the remaining journals were manually checked via their relative websites to verify they were not human-centric. The final analyses were performed on a deeply vetted dataset of open-access, biological science journals \((n=174)\). However, h-index and journal rank metrics queried from SJR were only available for 156 journals out of the dataset, with a range of values for multiple years. To compensate for this, the SJR data was merged with the final dataset using only values for years of available open access of each journal, then h-index and journal rank values were aggregated to generate a mean for the available years combined.

In order to explore potential trends in the data, APC was examined in relation to overall citability (annual citations based on the currently available year), IF (general impact of the journal), and Eigen Factor (relative importance of the journal). However, since years of available open-access, publishing frequency, and avg, review time may indicate publishing preference and influence APC these statistical relationships were also considered. The country of each journal publisher was also examined against cost, citability, IF, Eigen Factor (EF hereafter), years of available open-access, publication frequency, and avg. review time to locate any potential similarities or disparities between them. Using functions from the ggpubr package (Kassambara 2020), Pearson’s correlation coefficient was used to analyze significance in correlation between the aforementioned bibliometrics, and country of publishers were highlighted to examine trends in top ranking nations above mean values. Finally, h-index and journal rank were tested against APC, and countries above the mean were highlighted using the available 156 journal data records. Both metrics were thereafter tested for correlations, with journal rank being tested as a negative value as lower journal rank is a positive indicator of journal success.

Results

A linear trend was evident between IF, EF, and citability in relation to APC. Additionally, it was found that journal publishers from developed countries were more likely to have higher APC, IF, EF, and citability (Fig. 1). Mean APC of open-access journals analyzed \((n=174)\) was $1354.77 USD, mean IF was 2.72, mean EF was 0.017, and mean total citation count or citability was 5034.32. APC was found to be significantly positively correlated with IF (Pearson correlation: \(r(174)=0.47, p<.001\)). There was also a significant positive correlation between APC and EF (Pearson correlation: \(r(174)=0.293, p<.001\)). Finally, there was a significant positive correlation between APC and citability (Pearson correlation: \(r(174)=0.284, p<.001\)).

Journals published in the United States, United Kingdom, Ukraine, Switzerland, Saudi Arabia, Poland, Netherlands, South Korea, Germany, Canada, Bulgaria, Brazil, and Australia were more likely to have an IF above the overall mean than other countries. Journals published in the United States, United Kingdom, Switzerland, and Germany were more likely to have an EF above the overall mean. Journals publish in the United States, United Kingdom, Switzerland, Germany and Canada were more likely to have more total citations than the mean of other nations. Publishing cost was highest journals from the United States, United Kingdom, Switzerland, Netherlands, and Germany.

Furthermore, trends varied between a journal’s years available as open-access, publication frequency, review times, and APC (Fig. 2). Mean years available as an open-access
Years of available open access was highest in publishers from the United States, United Kingdom, Switzerland, South Africa, Poland, Netherlands, Mexico, Italy, Iran, Germany, Finland, Canada, Bulgaria, and Brazil. Publications frequency was higher for journal publishers from the United States, United Kingdom, Switzerland, Poland, Lithuania, Italy, India, Germany, Canada, Bulgaria, and Brazil. Avg. review times showed no particular trend, though was higher from publishers based in the United States, United Kingdom, Switzerland, Saudi Arabia, Poland, Mexico, India, Germany, Finland, China, Chile, Canada, Brazil and Argentina.

Also, trends in h-index and journal rank showed similar trends in regards to APC and country of publisher comparable to IF, EF, and citability (Fig. 3). The mean h-index for journals in the revised SJR dataset \((n = 156)\) was 42.82, and the mean journal rank was 8154.53. A significant positive correlation was found between both h-index and journal rank in relation to APC (Pearson correlation: \(r(156) = 0.411, p < .001\)); Pearson correlation: \(r(156) = 0.503, p < .001\).

In relation to country of publisher, nations with journals above the mean h-index included the United States, United Kingdom, Ukraine, Switzerland, Russia, Poland, South
Korea, Germany, Finland, Canada, Brazil, and Australia. Publishers from countries which had journals above the mean journal rank included the United States, United Kingdom, Ukraine, Russia, Poland, South Korea, Italy, Germany, Finland, Canada, Brazil, and Australia.

Overall, trends among bibliometric values for countries of publishers and their associated income levels varied between measurements, though showed an overall bias toward high-income countries where journal values fell consistently over the overall mean (Table 2). Among the open-access, non-human biology journals in this study, journal publishers were most represented by high-income countries \( (n = 144) \), followed by upper-middle income countries \( (n = 29) \) and lower-middle income countries \( (n = 4) \). Journal publishers from exclusively high-income countries \( (n = 7) \) had the highest mean APC. Journals from eight high-income countries and one lower-middle income country had the highest mean IF. Journals from only three high-income countries had mean EF above the overall mean. Only two high-income countries had mean citation values above the overall mean. Five high-income and four upper-middle income countries had mean years of available open access above the overall mean. Four high-income and one Lower-middle income country had a mean publication frequency above the overall mean. Review times were ambiguous among country income level, with mean values above the overall mean occurring in journals based out of high-income countries \( (n = 5) \), upper-middle income countries \( (n = 3) \), and lower-middle income countries \( (n = 1) \).
majority of h-index values which fell above the overall mean were from journal publishers based out of high-income countries; however, there was also a single instance of publishers from upper-middle income (Russia), and lower-middle (Ukraine) income countries above the overall mean as well. Mean journal rank was highest in high-income countries \((n=8)\), with a similar trend from a single instance of an upper-middle income (Russia), and lower-middle (Ukraine) income country.

**Discussion**

The results of this study provide evidence that with increasing publishing costs, IF, EF, citations, h-index, and journal rank in open-access, non-human biological science journals also increase. Furthermore, the results show that the majority of journal publishers with
Table 2 Countries of publishers and associated income levels with overall mean bibliometric measurements of their journals; values which fall above the overall mean (top row) for each measurement (below the mean for rank) are bold

| Country                  | Income level          | APC  | IF   | EF    | Citations | Years available | Publication frequency | Review time | h-index | Rank |
|--------------------------|-----------------------|------|------|-------|-----------|-----------------|-----------------------|-------------|---------|------|
| Overall Mean Values      |                       | 1358.17 | 2.71 | 0.0167 | 5011.869  | 11.58           | 146.31                | 18.39       | 42.82  | 8154.53 |
| Argentina                | Upper middle income   | 20   | 1.19 | 0.0002 | 177       | 9               | 0.11                  | 24          | 7.09   | 18716.82 |
| Australia                | High income           | **1403.2** | **4.06** | 0.010 | 4432      | 8               | 73.25                 | 12          | **44.43** | **3513.86** |
| Brazil                   | Upper middle income   | 357.79 | 1.17 | 0.0017 | 1558.06   | **17.5**        | 107.02                | **22.06**   | 28.33  | 10734.22 |
| Bulgaria                 | Upper middle income   | 719.47 | 1.86 | 0.0027 | 878.83    | 13.5            | 88.08                 | 7           | 13.75  | 12008.1 |
| Canada                   | High income           | 763.7 | 2.35 | 0.0084 | 4961      | **15.5**        | 91.87                 | **44**      | 62.33  | 5228.55 |
| Chile                    | High income           | 475   | 0.63 | 0.0013 | 640       | 8               | 73.56                 | 27          | 21.18  | 12381.96 |
| China                    | Upper middle income   | 1000  | 1.27 | 0.0011 | 765       | 9               | 0.22                  | 24          | 18.36  | 13843.18 |
| Finland                  | High income           | 672.75 | 1.86 | 0.0013 | 1146.5    | **12.5**        | 9.4                   | **20**      | 32.24  | 10047.89 |
| Germany                  | High income           | **1583.78** | **2.79** | 0.0097 | 3310.88   | **14.9**        | 53.06                 | **21.12**   | 46.41  | 6580.17 |
| Hong Kong                | High income           | 336.4 | 1.7  | 0.0007 | 278       | 8               | 17.75                 | 5           | –      | –     |
| India                    | Lower middle income   | 200   | 0.53 | 0.0012 | 1244      | 11              | **214.91**           | **50**      | 27.05  | 12947.5 |
| Indonesia                | Lower middle income   | 72    | 0.47 | 0.0003 | 183       | 5               | 17.2                  | 8           | 13.1   | 18805.1 |
| Iran, Islamic Republic of| Upper middle income   | 144   | 1.23 | 0.0007 | 244       | 12              | 30.58                 | 8           | 11.43  | 12841.86 |
| Italy                    | High income           | 635.37 | 1.65 | 0.0016 | 1100      | **12.3**        | 101.49                | 8           | 36.42  | 7619.66 |
| Korea, Republic of       | High income           | 550   | 3.08 | 0.0044 | 2152      | 5               | 38.4                  | 7           | **64.15** | 5088.9 |
| Lithuania                | High income           | 224.3 | 1.07 | 0.0005 | 292       | 2               | **254.5**            | 15          | 21.13  | 11767.27 |
| Mexico                   | Upper middle income   | 200   | 0.44 | 0.0002 | 169       | **17**          | 25.82                 | **48**      | –      | –     |
| Netherlands              | High income           | **1422.27** | 2.4  | 0.0027 | 997.33    | 10.3            | 106.84                | 12.33       | 21.11  | 10175.38 |
| Poland                   | High income           | **513.33** | 1.68 | 0.0009 | 647.17    | **20.7**        | 54.12                 | **24.5**    | 22.5   | 11812.28 |
| Russian Federation       | Upper middle income   | 40.3  | 1.86 | 0.0031 | 3551      | 5               | 15.8                  | 5           | **73.1** | **5821.3** |
| Saudi Arabia             | High income           | 1250  | 3.14 | 0.0035 | 1787      | 11              | 94.55                 | **26**      | 27.6   | 12920.4 |
| South Africa             | Upper middle income   | 420.5 | 0.52 | 0.0003 | 189       | **14**          | 3.57                  | 12          | 11.09  | 13237.36 |
| Switzerland              | High income           | **1906.4** | **4.98** | **0.0214** | **6462.69** | 8               | **304.5**            | **15.23**   | **54.49** | **7602.84** |
| Country        | Income level     | APC   | IF   | EF    | Citations | Years available | Publication frequency | Review time | h-index | Rank  |
|---------------|------------------|-------|------|-------|-----------|------------------|-----------------------|-------------|---------|-------|
| Ukraine       | Lower middle income | 201.2 | 3.17 | 0.0039 | 2233      | 2.5              | 73.67                 | 9           | 47.76   | 4212.78 |
| United Kingdom | High income      | 1761.82 | 3.14 | 0.0299 | 8189.25   | 10.2             | 172.24                | 17.81       | 50.36   | 6664.11 |
| United States | High income      | 1948.38 | 3.29 | 0.0129 | 4334.76   | 9.2              | 187.12                | 17.19       | 48.37   | 7205.41 |
the highest APC, IF, EF, citability, h-index, and journal rank are from high-income countries, which indicates that research published in journals from countries which aren’t high-income are less likely to gain exposure, publisher are less likely to generate profit, and more importantly both lower income researchers and publishers are more likely to receive less credibility for their publications. These results confirm similar trends to the SNIP analysis conducted by Björk and Solomon (2015) in regards to correlation with APC.

Interestingly enough, after testing for other potential open-access journal statistics such as years of available open access, it was found that journals which have become open-access more recently were more likely to have higher APC, whereas journals which have provided open-access options for many more years had lower APC. In fact, two Polish journals, Acta Societatis Botanicorum Poliniae (available open-access for 97 years; APC = $24) and Acta Palaeontologica Polonica (available open-access for 63 years; APC = $483) were open access for the longest, the former of which has the lowest overall APC next to Revista De La Facultad De Ciencias Agrarias ($20 APC). This indicates that with open-access journals in non-human biological fields of science, age is not necessarily an indicator of prestige or value.

In regards to publication frequency, there was a significant positive correlation with APC, indicating that publishers with higher publication frequency were likely to have higher APC; however, average review times were ambiguously distributed among publishers and not correlated with APC. This means that average time of a manuscript being handled isn’t necessarily what drives researchers to publish in journal from these fields, and the correlated indicators such as IF, EF, citability, h-index, and journal rank are.

To summarize, these trends indicate that: 1) journals which have recently provided open-access options have more expensive APC than journals which have been open-access for longer; 2) publication frequency, citation scores, and associated indices/ranks increase as APC increases, and 3) publishers from high-income countries are better represented and are more likely to have higher APC, and therefore higher citation metrics and ranks. Therefore, APC appears to be the overall determining factor in perceived credibility and prestige of open-access journals based in high-income countries in these fields of biology rather than a journal’s history of open-access options, or review times. With that in mind, should all journals eventually transition over to Golden OA as theorized by Björk (2017), these issues will not only persist, but will likely become even more exaggerated, as concluded by van Vlokhoven (2019); thus leading to an increase in wide-ranging scientific inequality, biased toward developed nations and prestigious institutions, caused by the GOA movement, as projected by Demeter (2019). Not to mention, trends such as these may cause a rise in pay-to-publish (payment for publication rather than scientific reliability) and publish-to-pay (researcher bonuses for publication output) instances, which cause an increase in predatory journals, further muddying the waters of reliability in peer-reviewed scientific literature (Bartholomew 2014; Hedding, 2019).

To build on these points, it is worth noting that expensive APC in prestigious journals are not linked to reliability of the research published in them (van Vlokhoven 2019; Brembs 2018). Additionally, the impact factor of prestigious journals also creates a false perception of reliability in research they have published (Brembs et al. 2013). The paradox of GOA journals is that the system itself is inherently flawed, where the more manuscripts a journal publishes, the more capital it stands to generate, which gives rise to predatory journals and editorial complacency (Beall 2013). Therefore, GOA journals may create an environment where publisher profit is prioritized over scientific integrity of published research, while still maintaining prestige as an outlet of highly-credible research over other journals.
Unfortunately, the irregular distribution of resources throughout the world, and correspondingly in academia, creates a bubble where higher ranking institutions have more access to expensive, higher impact journals, while lower ranking institutions are forced to publish in less expensive or closed access journals (Siler et al. 2018). The alternative is that authors from developing countries must pay the prices of developed countries in order to gain access to higher impact journals (Ellers et al. 2017). As results of this study show, upward mobility of open-access journals of lower income countries is less likely, thus confirming and reinforcing this concept. On the other hand, options become even more narrow for individual researchers and groups who have no academic institutional affiliation, whether it be through personal career choice, transitional period, or numerous other situations that prevent the benefits of institutional finance allowances (Burchardt 2014). This is increasingly more problematic for scientific output, as independent researchers with no institutional affiliation have been on the rise over the past decade (ElSabry 2017). However, evidence suggests that the researchers being put on the backburner are no less reliable than the privileged few institutions which have the advantages to publish in high-impact, high APC journals (Brembs 2018; Brembs et al. 2013; ElSabry 2017; Siler et al. 2018).

Although there are many financial support options for GOA journals, there are also many caveats to their eligibility criteria. For example, once an international collaborator from a developed country is named as an author on a manuscript of authors which would otherwise be eligible for publication funding assistance such as Research4Life (Research4Life 2015), the eligibility for financial assistance becomes void. I know this from personal experience after being rejected from funding assistance multiple times while attempting to publishing important studies on the critically endangered Sumatran elephant in GOA journals. While my co-authors were from eligible developing countries, I am from the United States, but have no current institutional affiliation and therefore none of the accompanying financial benefits, and none of us had access to the > 1000 USD for publication fees. Does this mean the research we were reporting is not important, or reliable? Not at all. However, our options were narrowed significantly down to low-impact journals, which consequently are cited much less, and generally seen as less credible sources of scientific information. Cases like this may force an author to be removed from a manuscript in order to gain access to publication funds, which is not an environment that the process of publishing scientific research should ever be responsible for creating; nor should potentially important research on conservation of critically endangered species fly under the academic radar due to APC funding constraints preventing research exposure.

Since the journals analyzed in this study are related to non-human biological sciences, these results also have implications for the research regarding ecology and conservation of species. Most biodiversity hotspots are located in the tropics; therefore, the vast majority of conservation research is conducted in tropical regions (Myers et al. 2000). While many nations in tropical regions fall within the criteria for APC assistance from Research4Life, as they are considered developing or under-developed countries (Research4Life 2020), Many published articles coming from these undeveloped tropical regions historically include authors from developed countries (Stocks et al. 2008). With the current criteria systems in place for APC funding assistance in GOA journals for biological sciences through Research4Life, foreign authors from developed countries would nullify the eligibility for assistance with publication costs, forcing authors to seek closed-access or hybrid journals, low-impact open-access journals, or potentially even predatory journals to publish their research.
Conclusion

To conclude, the current transition to GOA publishing by prestigious, high-impact journals, namely in non-human biological sciences, shows trends in inequality in global research output. Inequality amongst institutions, publishers, journals, and researchers is likely to prevent adequate exposure of potentially important research, while promoting the false ideology that prestige and costliness of journal publications are the equivalent of reliable science (Brembs 2018; Brembs et al. 2013; ElSabry 2017; Siler et al. 2018). In the current age of technology, most journals have flipped the publication model from print to digital and online (Beall 2013; Fitzpatrick 2011), and even with a decrease in hardcopy production, publication fees are still increasing (Morrison 2018). Journal publications, research impact, and citations are the academic currency of career scientists and scholars (Hirsch 2005) and the scientific community is international. We must address these issues to create a more inclusive environment for important research to be recognized and researchers to prosper on a global scale, regardless of country, income, or institutional affiliation.

Compliance with ethical standards

Availability of data and material All data used in this manuscript are provided as supplementary material.

Code availability Rcode used for analysis in this study is provided as supplementary material.

References

Bartholomew, R. E. (2014). Science for sale: The rise of predatory journals. *Journal of the Royal Society of Medicine, 107*(10), 384.

Beall, J. (2013). Predatory publishing is just one of the consequences of gold open-access. *Learned Publishing, 26*(2), 79–84.

Björk, B. C. (2017). Gold, green, and black open access. *Learned Publishing, 30*(2).

Björk, B. C., & Solomon, D. (2015). Article processing charges in OA journals: Relationship between price and quality. *Scientometrics, 103*(2), 373–385.

Brembs, B. (2018). Prestigious science journals struggle to reach even average reliability. *Frontiers in human neuroscience, 12*, 37.

Brembs, B., Button, K., & Munafò, M. (2013). Deep impact: Unintended consequences of journal rank. *Frontiers in human Neuroscience, 7*, 291.

Burchardt, J. (2014). Researchers outside APC-financed open-access: Implications for scholars without a paying institution. *SAGE open, 4*(4), 2158244014551714.

Drake, P. P. (2019). Predatory Journals, Open-Access, and the Effect on Publishing in Finance. (January 13, 2019).

Ellers, J., Crowther, T. W., & Harvey, J. A. (2017). Gold open-access publishing in mega-journals: Developing countries pay the price of western premium academic output. *Journal of scholarly publishing, 49*(1), 89–102.

ElSabry, E. (2017). Unaffiliated Researchers: A Preliminary Study. *Challenges, 8*(2), 20.

Fitzpatrick, K. (2011). *Planned obsolescence: Publishing, technology, and the future of the academy*. NYU Press.

Fuchs, C., & Sandoval, M. (2013). The diamond model of open-access publishing: Why policy makers, scholars, universities, libraries, labour unions and the publishing world need to take non-commercial, non-profit open-access serious. *TripleC: Communication, Capitalism & Critique, 11*(2), 428–443.

Harnad, S., Brody, T., Vallières, F., Carr, L., Hitchcock, S., Gingras, Y., et al. (2008). The access/impact problem and the green and gold roads to open-access: An update. *Serials review, 34*(1), 36–40.

Hedding, D. W. (2019). Payouts push professors towards predatory journals. *Nature, 565*(7737), 267–268.
Hirsch, J. E. (2005). An index to quantify an individual’s scientific research output. *Proceedings of the National Academy of Sciences, 102*(46), 16569–16572.

Kashnitsky, I. (2020). sjrdata: SCImago Journal & Country Rank Data, Ready for R. R package version 0.2.0. https://github.com/ikashnitsky/sjrdata

Kassambara, A. (2020). ggpubr: ‘ggplot2’ Based Publication Ready Plots. R package version 0.2.5. https://CRAN.R-project.org/package=ggpubr

Keirstead, J. (2016) scholar: Analyse citation data from Google Scholar. R package

Lewis, D. W. (2012). The inevitability of open-access. *College & research libraries, 73*(5), 493–506.

McDonald, K. (2005). Physicist proposes new way to rank scientific output. Phys Org.

Morrison, H. (2008). Directory of Open-access Journals (dOAJ) (Doctoral dissertation, University of British Columbia).

Morrison, H. (2018). Frontiers: 40% journals have APC increases of 18 – 31% from 2017 to 2018. Sustaining the Knowledge Commons/Soutenir Les Savoirs Communs. Retrieved from https://sustainingknowledgecommons.org/2018/04/12/frontiers-40-journals-have-apc-increases-of-18-31-from-2017-to-2018/

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*(6772), 853.

Piwowar, H., Priem, J., Larivière, V., Alperin, J. P., Matthias, L., Norlander, B., et al. (2018). The state of OA: A large-scale analysis of the prevalence and impact of Open-access articles. *PeerJ, 6*, e4375.

Pond, B. B., Brown, S. D., Stewart, D. W., Roane, D. S., & Harirforoosh, S. (2019). Faculty applicants’ attempt to inflate CVs using predatory journals. *American Journal of Pharmaceutical Education, 83*(1).

Reich, E. S. (2013). Science publishing: The golden club. *Nature News, 502*(7471), 291.

Research4Life. (2020). Research4life: Eligibility. retrieved from: https://www.research4life.org/access/eligibility/

Ryan, J. A., Ulrich, J. M., Thielen, W., Teetor, P., Bronder, S., & Ulrich, M. J. M. (2019). Package ‘quantmod’.

Siler, K., Haustein, S., Smith, E., Larivière, V., & Alperin, J. P. (2018). Authorial and institutional stratification in open-access publishing: The case of global health research. *PeerJ, 6*, e4269.

Stocks, G., Seales, L., Paniagua, F., Maehr, E., & Bruna, E. M. (2008). The geographical and institutional distribution of ecological research in the tropics. *Biotropica, 40*(4), 397–404.

van Vlokhoven, H. (2019). The effect of open access on research quality. *Journal of Informetrics, 13*(2), 751–756.

version 0.1.5. http://github.com/jkeirstead/scholar.

Wickham, H. (2012). reshape2: Flexibly reshape data: a reboot of the reshape package. *R package version, 1*(2).

Wickham, H., Chang, W., & Wickham, M. H. (2016). Package ‘ggplot2’. *Create Elegant Data Visualisations Using the Grammar of Graphics Version, 2*(1), 1–189.

Wickham, H., Francois, R., Henry, L., & Müller, K. (2015). dplyr: A grammar of data manipulation. *R package version 0.4. 3. R Found. Stat. Comput., Vienna. https://CRAN.R-project.org/package=dply