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EDITORIAL

DEBASING THE CURRENCY OF SCIENCE: THE GROWING MENACE OF PREDATORY OPEN ACCESS JOURNALS

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ABSTRACT In recent years, the scientific publishing world has seen the creation and rapid growth of online journals, which do not respect the long-standing gentleman's agreement that has functioned as the primary quality-control mechanism for science: *bona fide* peer review and editorial oversight. Such predatory journals take advantage of the low cost and ease of online "publishing," the open access movement, and use feigned associations with international standards and misleading claims of impact factors, aimed at deceiving researchers (especially inexperienced scientists) into believing they are legitimate. We present the history, evolution, and tactics of such journals, as well as recommendations for dealing with this threat to science itself.

KEY WORDS: predatory journal, bibliometry, strategy, impact

INTRODUCTION

Call for papers and editors OA Journal of Desperately Seeking Your Money - (Gold OA) ISO 9001:2008 - Certified ISSN 2277-3754 - Scopus ISI Thompson Reuters Indexed - High Visibility - Impact Factor 3.7.

Such "announcements" are part of our daily E-mail landscape, even when we have efficient spam filters. The corresponding websites claim to have "rapid publication," "top innovation," "thirst for excellence," accompanied by an assortment of official-sounding labels, logos, and abbreviations. Most of us recognize such an organization for what it is: a pop-up website whose purpose is to lure us into sending manuscripts, which will be accepted, on condition of payment of page charges. They are predatory journals.

Beyond the wry smile or annoyed "delete" they may elicit, these "journals" have created problems so serious that we believe they threaten the very existence of science, more so than at any time since it began to emerge in 17th century Europe—and this peril has nothing to do with lack of funding. Rather, the very currency of science is being rapidly debased by thousands of predatory journals that have exploited a heretofore unperceived weakness in the scientific publishing system: the long-standing and multifaceted "gentleman's agreement," which constitutes its quality control backbone.

Science cannot exist without the communication of scientific information. Scientific communication can only be credible if it has an efficient system of quality control. There are no international conventions or laws governing this quality control, which has evolved informally within the scientific community to become the present-day peer review and editorial processes. The miracle of the scientific enterprise is that it has advanced so well with nothing more than the "gentleman's agreement," which morally binds authors, editors, and reviewers to producing good quality, honest work.

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The foundation of the review process is to reduce "Type 1" error—accepting a manuscript that is fatally flawed. "Type 2" error—rejecting a good manuscript—is considered potentially less harmful to science. Although we may quibble about this last point, we must recognize that the only way to ensure that no good manuscript is rejected, is to accept all submissions, and this would be fatal to science! Just as in statistics, it is impossible to reduce the probability of Type 1 errors without increasing the probability of Type 2 errors, so a rigorous approach to Type 1 publishing errors will invariably produce more Type 2 errors, but this is by far the lesser of the two evils.

Although there have been cases of malfeasance, and most scientists have experienced what they consider to be unfair quality assessments, it is truly a testament to the power of good will, and the scientific ideal of striving for truth that until recently, science has not been so hindered by corruption that it has been threatened with extinction. The progressive decline in the number of "gentlemen," however, together with the intrusion of considerable numbers of the exact opposite in the scientific publication sphere, have combined to now threaten the very existence of science. Predatory open access (OA) journals, which by their very nature have no regard for Type 2 errors, have thrown the prevention of Type 1 errors to the winds, and we believe that science, the cornerstone of modern human civilization, now faces an existential threat.

THE PRELUDE

The advent of the Internet has made it possible to dematerialize scientific journals, reducing the costs of publication to the initial outlay of a computer, a few programs, and an annual fee for provision of a website. Online versions of established print journals, as well as the first online-only journals, began to appear in the early 1990s. These were "well-intentioned" journals that adhered to the values, and gentlemen's agreement, of the traditional journals.

Given the near universal access to Internet, the printing and mailing cost savings, and the growing expectation of "free" content on Internet, the "OA" publishing model emerged, in which the user (reader) would have free access to all articles, and

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the administrative costs would be offset by page charges—in effect, authors would pay to have their work published. The embryo of this model already existed in the traditional journals of scientific societies (such as NSA), which provided their journals to members, who typically paid small annual membership fees, *ergo* the necessity for page charges, to cover the much greater costs of paper publication.

On February 14, 2002, the ease of desktop publishing and the OA business model intersected with a clearly social and quasi-political message, in the form of the Budapest Open Access Initiative (BOAI—http://www.budapestopenaccessinitiative.org/). "Open access" came to embody the "democratization" of access to knowledge, previously restricted to a perceived wealthy and exclusive scientific elite (http://www.budapestopenaccessinitiative.org/boai-10-recommendations; http://www.plos.org/open-access/; http://openaccess.mpg.de/Berlin-Declaration; http://blog.scienceopen.com/).

Like most manifestos, the BOAI statement is a cleverly designed document that substitutes "motherhood and apple pie" dogma for critical thought. It can be summed up in the "Vision statement" of the "Open Access Academy" website: "Freely available research results for everyone" (http://www.oaacademy.org/vision-and-mission.html)—apparently accustomed to gratuitous luncheons. The BOAI statement exploits human cognitive and moral weaknesses and provides a platform for members of a vocal social movement. Those wishing to announce their adhesion to the OA social movement simply repeat the ideas and concepts presented in the original Budapest statement or the ensuing copycat statements. The continual and collective repetition of the OA mantras has assumed the status of a consensual truth.

The fact that OA restricted access to publishing scientific information (Frank 2013, Burchardt 2014), and therefore further disadvantaged legitimate scientists with small research funding, both in developed and developing countries, seemed to be lost in the "free access" euphoria. It was proposed that these scientists need only send a letter to the OA journal declaring their impoverished state, and all would be fine. Intentionally or not, it apparently occurred to nobody that this was a demeaning process, which would constitute a very real barrier to publishing for many scientists, not least of them from European countries with great pride and small resources.

Setting aside these serious reservations about access, it must be said that the original OA intentions were honorable on the fundamental quality control issue. The BOAI reads "Open access to peer reviewed literature is the goal." In the years following the BOAI, we were to realize that this was a Panglossian statement, formulated as the OA proponents watched unicorns peacefully graze on the grass outside. While thus distracted, a sinister and previously unknown menace began to appear: predatory journals. These are the scientific journals equivalent to counterfeit coinage; like the latter, they appear to represent a guaranteed value, whereas containing at best a reduced value, and often virtually none at all. The reason is abandonment of the "gentleman's agreement." Predatory journals have no quality control. They have accepted and/or published papers by the Simpson family, by computer-generated nonsense programs, and by sting operations (http://www.sciencealert.com/two-scientific-journals-have-accepted-a-study-by-maggie-simpson-and-edna-krabappel, Bohannon 2013). Their publishers have appeared virtually overnight, like Scientific Online Publishing, which appeared in 2013, and by 2014 was "publishing" 42 journals, nominally covering a vast spectrum of scientific domains. Public Science Framework outdid them, opening instantaneously in 2015 with 42 journals with such sorely needed titles as "*Chemistry Journal*" and "*Physics Journal*" (http://www.random.org)!

CURRENT STATUS AND TREND

How many predatory journals exist today, and how does this compare with recent years? With sufficient time and desire to devote to such a question, it should be possible to ascertain a reasonably accurate number. Lacking both of these prerequisites, we instead randomly sampled 65 of the 693 publishers on Beall's 2016 list of predatory publishers (http://scholarlyoa.com/2014/01/02/list-of-predatory-publishers-2014/), computed the mean number of journals per publisher (11), and multiplied this by the number of publishers on the list, to obtain a very conservative estimate of the total number of predatory journals in 2015: 10,153. Applying the procedure above to each year since 2010, the progression of predatory journals is shown in Figure 1. Our measurement technique achieves results quite close to those recently published (Shen & Björk 2015) using a more complex multistage stratified sampling design (7,623 versus approximately 8,000 predatory journals in 2014, with an estimated 420,000 published articles!). The estimates are conservative because (1) the list includes only publishers of multiple journals, and not "stand-alone" journals, which number 882 to date (https://scholarlyoa.com/2016/01/05/bealls-list-of-predatory-publishers-2016/), and (2) the list is undermanned, and relies on volunteers to report predatory journals, which are then examined individually.

To date, the Directory of Open Access Journals lists 11,315 OA journals (https://doaj.org/). Before 2016, the only requirement for inclusion in the DOAJ list was that the journal be OA, which obviously qualified many predatory journals. Minimum quality criteria were introduced in 2015, such that the degree of overlap between the journals in the DOAJ database and Beall's list is currently not known, although if a reader has approximately 1 y of free time, this could be ascertained. Notwithstanding, the conservative estimate of the number of predatory journals in 2015 was 7,623, or ~75% of the number of DOAJ-listed journals in 2015 (Fig. 1).

The 2014 Institute for Scientific Information Journal Citation Reports (ISI JCR) lists approximately 14,000 journals, which are considered "genuine" (due to restructuring of the

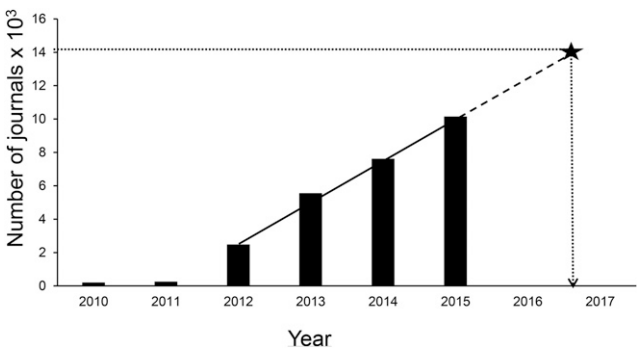


Figure 1. Progression and projection of conservatively estimated number of predatory OA journals, 2010 to 2015. ★ = approximate current number of journals in ISI Thomson-Reuters Journal citation reports.

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JCR website, we are unable to ascertain the current number). After less than 5 y, there were thus already half as many predatory journals as there were genuine journals, which have built their reputations over the past two centuries (Fig. 1). Although the number of data points is necessarily limited by the novelty of the predatory OA phenomenon (years), and thus far too small to construct a serious model, a very short-term projection suggests that if the current conditions persist, *by approximately mid-2016, there will be as many predatory OA journals as genuine journals*.

Just as the Internet has provided the conditions for predatory journals to flourish, it amplifies the dilution of science by giving predatory journals a visibility indistinguishable from normal journals, simply because search engines cannot evaluate quality, only recognize words. An analysis of the geographic origins of predatory journal authors, however, reveals that fully 80% are from developing countries (Shen & Björk 2015)—normally the ones who should have the least amount of money to pay for page charges! Such a situation raises even further questions of credibility, and in a perverted manner, vindicates the utopian belief that OA will increase the developing world's access to "publication!"

In the developed world, scientists can, at best, recognize most of the genuine journals in their fields, but are unable to do so consistently in other fields; understandably, their students at the undergraduate level cannot even do that. In the process of searching for referees for submitted manuscripts somewhat out of our own fields (PGB and SS), we now bring up as many recent articles from predatory as from genuine journals. Student reports now include predatory journals in their reference sections. As the number of predatory publications rises, science is facing a "dilution crisis," in which science itself will soon be reduced to homeopathic levels.

PSEUDO-JOURNALS

An even more insidious type of predatory journal is the pseudo-journal, in which perfunctory, sham peer reviews are performed. These journals are much more difficult to expose, because they actually do send manuscripts to reviewers, but publish virtually all submissions regardless of the reviews, in return for page charges. These pseudo-journals therefore claim a minimum legitimacy that the more clearly predatory journals lack altogether.

PREDATORY OA JOURNAL TACTICS

Predatory OA journals combine a variety of dishonest and unethical tactics to lure researchers past their pay gates. The most common of these are sham credibility devices and supporting structures, exaggerated quality claims, and professions of altruism.

Sham Credibility Devices and Supporting Structures

To date, the last and only bulwark against the complete interpenetration of predatory, pseudo-, and genuine science journals is the Thomson Reuters ISI JCR, which does not list predatory journals, and attempts to screen out the pseudo-journals. The response of the predatory and pseudo-publishers has been to create parallel, sham credibility devices and supporting structures. These are

- Ostentatious use of abbreviations such as "ISO" (International Organization for Standardization) and "ISSN" (International Standard Serial Number). Neither of these designations is related to any aspect of scientific or journal quality.
- Brazen imitations of well-known quality indicators. Since at its founding in 1960, the ISI did not envisage a world in which such predatory practices could exist, it unfortunately did not patent the words "Impact Factor," or even the abbreviations "ISI" or "IF." Predatory journals now advertise attractive "IF," but do not mention that they are "calculated" using vague and subjective criteria, by pop-up organizations (Beall's list references 27). For example, the "International Society for Research Activity" index awards points simply for having an editorial board, or for publishing in English (notwithstanding that the website is replete with its own embarrassingly egregious language problems). Other journals use the term "Impact Factor," yet it is calculated according to their own incomprehensible, and even absurd, formulae, for example (original grammar conserved):

> *Journal of Aquaculture Research & Development*
> *Impact Factor:* ***1.3****
> **Unofficial 2013 Impact Factor was established by dividing the number of articles published in 2011 and 2012 were cited in 2013 based on a search of the Google Scholar Citation Index database. If 'X' is the total number of articles published in 2011 and 2012, and 'Y' is the number of times these articles were cited in indexed journals during 2013 than, impact factor* $= X/Y$.

As is often the case, the use of these "alternative" IF is cunningly couched in quasi-political terms, which castigate the ISI JCR for being published by a for-profit organization:

> *There is only one official, universally recognised impact factor that is generated by Thomson Reuters; it is a proprietary measure run by a profit making organisation. It runs against the ethics and principles of open access. (ScientificResearch: http://www.scirp.org/journal/Journalcitationdetails.aspx?JournalID=164&utm_campaign=IF&utm_source=e_cp&utm_medium=abb_20150116_yuanting_zx#.VMOjPUdMzAs)*

- False or misleading indexing claims—some predatory OA journals do not balk at falsely claiming to be indexed in JCR, for example, "*Annual Research & Review in Biology (ARRB): ISI Thomson Reuters indexed journal.*"
- Establishment of an OA umbrella organization that acts to promote the OA model that spawned predatory journals (DOAJ).
- Use of the words "British" and "American" in the predatory journal title, although most originate in neither country, and many may have only one or no British or American members on their editorial boards. A good example is the *British Journal of Applied Science & Technology*. This journal is not listed by JCR, and only one editor in a total of 100 is "British." In a small disclaimer on the journal home page, however, we read "This international journal has no connection with any scholarly society or association or any specific geographic location or any country" (http://www.sciencedomain.org/about-journal.php?id=5)!
- Exclusive reliance on "post-publication peer review." This practice, originally used to collegially improve draft versions of manuscripts, for example, in particle physics and cosmology, can

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easily be subverted to dispense with any review at all, whereas the journal pockets the money from the page charges.

Exaggerated Quality Claims

Predatory and pseudo-journals universally profess high quality standards. Predatory and pseudo-journals, however, appear to either misunderstand the meaning of the term ''high quality,'' or they intentionally mislead readers with exaggerated quality claims. For example, the BJAST website announces (original spelling and grammar conserved):

> *Science (IF: 31) report confirmed the high standard of SDI journal.*
> *As per a recent report (Link) of Science journal (present Impact factor 31), one of our journal (British Journal of Pharmaceutical Research) passed a stringent test of quality of Peer review by rejecting a fake article (Link1, Link2, Link3).*

Obviously, rejecting a ''fake article'' cannot be considered the same as demonstrating the ''high standard'' of a journal, and the sting operation cannot be considered a ''stringent test of quality control.'' The author of the ''fake article'' calls it a ''spoof,'' and states: ''Any reviewer with more than a high-school knowledge of chemistry and the ability to understand a basic data plot should have spotted the paper's shortcomings immediately. Its experiments are so hopelessly flawed that the results are meaningless'' (Bohannon 2013). Furthermore, neither the pseudonym used nor the alleged institute even exist, so the manuscript should have been rejected without the first line even being read. We leave the readers to their own conclusions about the validity of this test of ''journal quality.''

Professions of Altruism

Some OA journals temporarily reduce or waive publication fees, ostensibly to provide all students and researchers with financially unrestricted access to publication of their work. Such appeals aim to provide some authentic, geographically heterogeneous manuscripts, allowing the journals to both gain some credibility and publish issues that might otherwise have been embarrassingly empty. Given the persistent lack of such heterogeneity (Shen & Björk 2015), the strategy has shown limited success to date. The following are examples: (original grammar conserved):

> *SDI is determined to bring down OA publication charges for the sake of wide dissemination of peer reviewed scientific research. As part of this policy, SDI announces special discount on normal Article Processing Charge (normal APC is US$ 500) for any Manuscript submitted within 01 January, 2015–31 March, 2015. (http://www.sciencedomain.org/page.php?id=publication-charge)*
>
> *Because I do not only want to ask or demand for more open access but also to do something for those who would benefit more of it than others, I personally waived APC fees at ScienceOpen for early career researchers until the end of November as announced at the end of worldwide OA week in October. (form E-mail from Alexander.Grossmann@scienceopen.com, Nov. 17, 2014).*
>
> *On this happy occasion we are delighted to inform you that OMICS Group is providing Discounts for the articles submitted on/before Jan 28th 2015 to Journal of Aquaculture Research & Development (Undated form E-mail from JARD, editor. jard@omicsgroup.biz).*

CONCLUSION

From the foregoing, it is clear that the ''gentlemen's agreement'' foundation of quality control has been so completely subverted that the scientific community has been flooded with journals having little or no quality control at all. Most readers who follow their own citation alerts know that their papers are now being cited to shore up dubious ''science'' in predatory journals. Because modern civilization only exists and can only continue to exist because of science, the danger posed by predatory OA journals extends to our civilization as a whole. A recent example may be found in the discovery that both Canada and New Zealand's Departments of Health unknowingly partnered with a predatory OA journal to publish food safety research (http://news.nationalpost.com/news/canada/health-canada-kept-predatory-publisher-despite-warning-about-shoddy-science-from-government-expert).

For science to remain credible, it is clear that the scientific community must adapt, confront, and defeat the threat posed by predatory and pseudo- journals. To this end, we propose the following recommendations:

For the Scientific Publishing Community:

1. *Deal with the mortal threat first*: the weaknesses and perversions of the JCR IF have been explored in many publications (http://blogs.nature.com/news/2013/05/scientists-join-journal-editors-to-fight-impact-factor-abuse.html, http://www.editage.com/insights/why-you-should-not-use-the-journal-impact-factor-to-evaluate-research, Amin & Mabe 2000, Garfield 2006, Simmons 2008, Casadevall & Fang 2015). This discontent culminated in the 2012 San Francisco Declaration on Research Assessment (DORA). Since the time of the original meeting in December 2012, 700 new predatory OA publishers have appeared, representing approximately 7,700 new predatory journals, along with the new sham supporting structures. It has become clear that of the two perils: misuse of IF and predatory journals, the former is a well-known nuisance, whereas the latter is a new and mortal threat to science. Although IF is a very blunt instrument for the inappropriate tasks which most administrators seek to accomplish, it is the best (by virtue of being the sole) blunt instrument available to stop the spread of the predatory OA journals. We must therefore rethink our position on IF: scientists must choose between living with a nuisance, which we could eliminate with some effort (IF abuse), or allowing science to become debased to the point of extinction (predatory OA journals).
2. *Clean house*: We must deal with the nuisance threat that led us to unwisely open the door to the mortal threat, that is, set IF back to what it was originally created to do: indicate which journals are most trusted and used by scientists. Although far from perfect, IF is currently the ''least bad'' way of doing this, and the DORA should be revised to reflect this. Reaffirming the legitimate IF for its original purpose—the evaluation of the impact of scientific journals in their fields—will not only eliminate the predatory OA journals in one easy stroke, but it will also relegate the more dangerous ''pseudo-journals'' to their well-deserved positions of obscurity.
3. *Trust the wisdom of our elders*: In the end, no totally objective criterion will ever unambiguously encompass and measure all of the dimensions of scientific journal quality control. All

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of these "objective" criteria have attempted to quantify an intangible yet irreplaceable quality evaluator: reputation. The best measure of journal quality will be that of seasoned scientists with a distinguished publication record spanning at least 10 y. They will not be able to make fine distinctions between journals of substantially equal quality, but this is neither useful nor desirable anyway. They will, however, succeed in many ways that bibliometric indices cannot; for example, by taking into account journal niche breadth (the best papers involving a particular taxon or group of organisms might be found in a journal devoted to that group (e.g., *JSR*), rather than in a more widely cited general ecology journal.

4. *Recognize that the OA model entails more than the idealistic "free science for all" concept*, but acts both as an impediment to genuine science publishing for researchers with few resources, and as an open floodgate to the uncontrolled publication of information bereft of any quality control. Predatory and pseudo-journals are the unexpected side effects of the OA model, which itself is a remedy far worse than the perceived original disease.
5. *Encourage the few quality OA journals to reconsider the company they keep*, and progressively disengage well-established, high-quality publishers from the OA model, rather than sponsor it, as currently do Wiley, Taylor & Francis, and Springer Nature—although most of their journals are, in fact, non-OA. Although not all OA journals are predatory, all predatory journals are OA. Open access is not the cause of predatory journals, but it is the unconditional prerequisite. There are currently very few high-quality OA journals, so it is not too late to stem the tide of predatory journals by disengaging from this business model.

For Students and Potential Authors:

1. Before citing or even reading a paper, and certainly before sending a manuscript to a journal, check to see whether it is listed in JCR. This will at least eliminate most predatory journals, but not the more crafty pseudo-journals. It should be noted that both categories contain a few journals with JCR impact factors—these are mostly previously—legitimate journals, which have "crossed to the Dark Side."
2. If you cannot access JCR, check to see if the journal's publisher is on any of Beall's lists (https://scholarlyoa.com/2016/01/05/bealls-list-of-predatory-publishers-2016/: predatory publishers, hijacked publishers, standalone journals, false metrics).
3. Be aware that regardless of utopian and / or disingenuous declarations to the contrary, your reputation is at stake when you choose a journal for your manuscript.
4. Above all, ask yourselves if you really want this article to come up on a computer screen next to your own, or have your article cited in it: Krizhanovsky and Choong (2014).

Our experience attempting to formally alert the scientific publishing community to the threat of predatory OA journals and pseudo-journals has shown that although individual scientists are quite receptive, the journals themselves are not. It is true that any shake-up of the scientific publishing world may generate some collateral credibility damage to all journals, but we feel that this is far preferable to the mortal credibility danger posed by the continuing existence and spread of predatory OA journals. Views similar to ours have recently been expressed in the *Journal of Korean Medical Science* (Barroga 2015, Gasparyan et al. 2015).

Many publishers and bibliometric researchers simply feel that predatory OA journals are a form of the unpleasant and abundant "junk," which is an inevitable part of the Internet landscape, and that scientists should just accept this, as have most other components of society (numerous personal communications). To the contrary, we argue categorically that accepting "junk" as a major, inevitable part of the scientific landscape is antithetical to the credibility, and therefore the very existence, of science itself. We call for determined, effective action to protect the currency of science.

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