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AS WE SEE IT

One in four citations in marine biology papers is inappropriate

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ABSTRACT: Citing sources that do not support the assertion being made can misinform readers, perpetuate mistakes and deny credit to the researchers who should have been acknowledged. To quantify citation fidelity in marine biology, we retrieved 198 papers from 2 recent issues of 33 marine biology journals. From each paper we randomly selected 1 citation, recovered the source material, and evaluated its appropriateness. We discovered that the assertion was 'clearly supported' by the citation in only 75.8% of cases, the support was 'ambiguous' in 10.6% of cases and the citation offered 'no support' to the original statement in 6.0% of cases. The remaining 7.6% of cases were classified as 'empty' (citations to secondary sources). We found no relationship between citation appropriateness and the position of the assertion in the paper, number of authors, number of references, article length and Journal Impact Factor. That 1 in 4 citations in marine biology should be viewed with scepticism is alarming and has important ramifications for both scholarship and bibliometrics.

KEY WORDS: Bibliometrics · Citation · Ecology · Impact factor · Marine biology · Performance indicators

INTRODUCTION

Citing source material has underpinned science writing for centuries. The practice serves various purposes, such as establishing the basis upon which inferences are drawn, directing the reader to additional and relevant information, and giving credit to those responsible for a theory, method, or other innovation (Zachlin 1948). Citing the work of others is 'a form of academic succession, a lineage of ideas and proofs, into which we place our own work' (Dupps 2008, p. 1419). More recently, as bibliographic-based performance indicators increasingly dominate the appraisal of scientific output, citations have become an important form of currency (Browman & Stergiou 2008, Lawrence 2008, Todd 2009). Hence, appropriate and accurate citing is essential for both good scholarship and more meaningful citation counts.

In his editorial 'Seduction by citation', Ingelfinger (1976) emphasises how citations provide an air of 'documented validity' whereas they may actually be misquoted, unreliable or inapplicable. For instance, citing peers can increase the chance of getting an article accepted (Smith & Rivett 2009) and therefore influence decisions regarding what paper to refer to. Work-related pressure can lead to 'corner cutting' and lack of diligence, or an author may genuinely misunderstand and thus misrepresent an article. Finally, not every institution can afford full access to all relevant academic journals, impelling authors to rely on imperfect data such as online abstracts (Todd & Ladle 2008a). Regardless of whether a miscitation is accidental or deliberate, the reader will be misinformed and the scientists who should have been cited will not be properly recognised. Key contributions may become inaccurately remapped (Dupps 2008) and mistakes propagated (Harzing 2002). Sloppy citation behaviour reflects badly on the author, the journal, and ultimately the discipline.

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Only medical/health science has taken a thorough and introspective look at citation practices (e.g. Fenton et al. 2000, Gosling et al. 2004, Lukić et al. 2004). Todd et al. (2007) were the first to measure citation misconduct in another branch of biology: ecology. They determined that approximately one-quarter of citations were ambiguous, 'empty' (citations to secondary sources), or did not support the assertion at all. Among medical sub-disciplines the percentage of citations that offer 'clear support' to the assertion vary from 64.8% (Goldberg et al. 1993) to 93.3% (Schulmeister 1998), and therefore differences among areas of field-orientated biology such as marine biology, conservation, biodiversity, and ecology may be expected. To initiate such comparisons, we examined the appropriateness of citations in marine biology and compared our findings to Todd et al.'s (2007) study of citation fidelity in ecology.

MATERIALS AND METHODS

To quantify citing behaviour among marine biologists in a way that could be directly compared with that of ecologists we followed the methodology of Todd et al. (2007) and selected randomly 3 papers from each of the 2 most recent issues (before January 2009) of 33 marine biology or marine biology-incorporating journals (Impact Factor >1) listed under 'Marine and Freshwater Biology' in the Thomson Reuters' ISI Web of Knowledge Science Citation Index. From each of the 198 papers (the 'primary articles') one citation was selected randomly from the reference list (the 'cited article') and the assertion it was ostensibly supporting was searched for. The point at which we started our searches was rotated among 'Introduction', 'Methods' and 'Results/Discussion' (papers that did not follow this format were classed as 'Other'). Only assertions supported by a single citation were used and, to ensure independence, only one citation per primary article was selected. The cited article was obtained, read carefully by 3 of us (P.A.T., J.R.G., J.L.) and its appropriateness classed into 1 of 4 categories (Table 1) by a majority decision. When the case was equivocal, the benefit of the doubt was given to the author(s) of the primary article. Throughout the study, only journals held by the National University of Singapore and University of Wollongong digital libraries were examined.

Chi-squared tests were used to determine whether associations existed between citation appropriateness and where the citation appeared in the manuscript ('Introduction', 'Methods', 'Results/Discussion', or 'Other'), number of authors (1–2, 3, 4, 5, >5), number of references in the reference list (<30, 31–40, 41–50, 51–60, 61–70, >70) and article length, i.e. number of words excluding reference list (<3000, 3001–4000, 4001–5000, 5001–6000, >6000). The Pearson's correlation between number of 'clearly supported' assertions and Thomson Reuters' ISI 2008 Journal Impact Factors was also calculated.

RESULTS

We found that the original assertion was 'clearly supported' by the citation in 75.8% of cases, the support was 'ambiguous' in 10.6% of cases, and the citation offered 'no support' to the original statement in 6.0% of cases. The remaining 7.6% of cases were classified as 'empty' (Fig. 1). There was no association between appropriateness and where the citation appeared in the manuscript ($df = 3$, $\chi^2 = 0.67$, $p = 0.88$), number of authors ($df = 4$, $\chi^2 = 4.94$, $p = 0.29$), number of references in the reference list ($df = 5$, $\chi^2 = 8.39$, $p = 0.14$), and number of words ($df = 4$, $\chi^2 = 4.49$, $p = 0.34$), and no correlation existed between 'clearly supported' and Journal Impact Factor ($n = 33$, $r = 0.187$, $p = 0.30$). We observed on several occasions that, even though an

Table 1. Definitions of citation categories (adapted from Todd et al. 2007). If the cited article was considered 'empty' plus 'no support', 'no support' took precedence. If the cited article was considered 'empty' plus 'ambiguous', 'ambiguous' took precedence

Category	Definition
Clear support	The cited article provides unequivocal support of the assertion, via either statements in the text or the data presented
No support	The cited article does not in any way substantiate the assertion via either statements in the text or the data presented. The cited article may even contradict the assertion in the primary article
Ambiguous	The material (either text or data) in the cited article has been interpreted one way, but could also be interpreted in other ways, including the opposite point. The assertion in the primary article is supported by a portion of the cited article, but that portion runs contrary to the overall thrust of the cited article. The assertion includes 2 or more components, but the cited article only supports one of them
Empty citation	Also called 'lazy author syndrome' (Gavras 2002). The cited article simply cites other articles that support the assertion made in the primary article. Citing a review article is acceptable if the support for the assertion is, for example, a new insight or opinion offered by the author(s) of the review

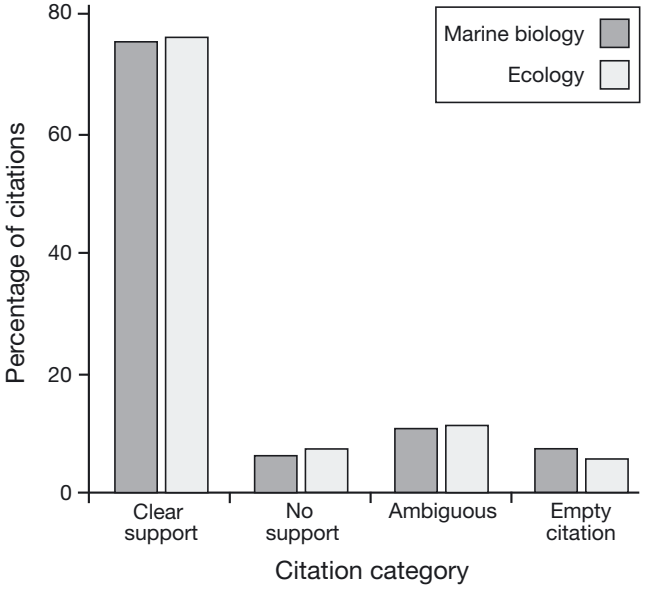

Fig. 1. Citation appropriateness in marine biology papers (the present study) and ecology papers (Todd et al. 2007). The methodology for both studies was identical

assertion was 'clearly supported', the choice of paper was a poor one. For example, the cited source may just have happened to have mentioned a fact or figure that was useful to the primary paper, even though that item was not a finding of the study. We also discovered one clear case of word-for-word copying.

DISCUSSION

The degree of miscitation observed for marine biology, i.e. 24.2%, falls within the range reported for medical and health science disciplines (Table 2) although the various studies used an array of methods and categories. A summary of the research on citation malpractice in medicine calculated that, from a total of 3836 citations checked, a median of 20% were 'inaccurate' (Wager & Middleton 2008). Our counts, however, are likely to be underestimates as we only examined single citations and predict more errors will occur when assertions are supported by a string of references. We found no relationship between citation appropriateness and the number of authors, number of references, article length, and Journal Impact Factor, suggesting citation malpractice is a chronic problem that cuts across a wide range of marine journals and article types.

Possibly the most remarkable aspect of our findings (apart from the fact that 1 in 4 assertions are not clearly supported) is the similarity between marine biology (75.8% of assertions 'clearly supported') and ecology (76.1% of assertions 'clearly supported') (Todd et al. 2007). To our knowledge, this is the first time that 2 such studies have followed identical methodologies and at least 1 author has been involved in both to ensure consistency, thereby allowing a direct comparison between 2 disciplines. Almost identical results across all categories (Fig. 1) suggest parallels in how investigators from ecology and marine biology write their reports. Such a finding is perhaps not surprising, given that both marine biology and ecology may fall under a general heading such as field-orientated or environment-related biology. But, among sub-disciplines in medicine, the percentages of citations that offer 'clear support' to the assertion vary greatly (Table 2). This may reflect different citing behaviour among those sub-disciplines, differences among the designs and authors of the medical and health science studies listed in Table 2, or a combination of both.

Implications for scholarship

Each case of an identified miscitation could fall into 1 of 3 broad categories: honest error, misconduct, or scientific fraud (Biebuyck 1992). Honest error includes genuine mistakes in understanding or interpretation, but not faults that could have been resolved if the authors had scrutinised their manuscript more carefully. Whereas poor diligence could be considered a relatively minor form of misconduct, authors who are cavalier about how they cite, knowing that readers rarely retrieve the cited work and check its relevance, are transgressing more seriously. Of course, deliber-

Table 2. Citation analysis for ecology and marine biology (in **bold** text) compared with results from various medical sub-disciplines. 'Clearly supported' was the only category common across all studies and therefore only these data are presented. n = number of citations checked

Subject area	Clear support (%)	n	Source
Nursing	93.3	180	Schulmeister (1998)
Radiology	90.5	95	Hansen & McIntire (1994)
Manual therapy	87.7	320	Gosling et al. (2004)
Burns and burn care	86.3	117	Al-Benna et al. (2009)
Otolaryngology/head and neck surgery	83	153	Fenton et al. (2000)
Anatomy	80.9	272	Lukić et al. (2004)
Ecology	**76.1**	**306**	**Todd et al. (2007)**
Marine biology	**75.8**	**198**	**The present study**
Ophthalmology	75	200	Buchan et al. (2005)
Surgery	70.8	137	Evans et al. (1990)
Emergency medicine	64.8	145	Goldberg et al. (1993)

ately misleading the reader is fraudulent, but identifying culprits is almost impossible.

Naturally, we like to think that peer-reviewed articles are scholarly, accurate and thoroughly researched. Our study demonstrates that this is not necessarily the case. Marine biological journal publications are generally viewed with a degree of trust that a reader would probably not endow upon a newspaper or magazine. Unless we are willing to accept that approximately one-quarter of the assertions we read are potentially unsubstantiated, good citation practices should not be allowed to erode.

Implications for bibliometrics

The research accomplishment of individuals, groups and institutions are increasingly being quantified using bibliometric-based performance indicators (Todd & Ladle 2008b, Adler & Harzing 2009). Such metrics are popular because they are relatively objective and transparent; they are also quick and easy to calculate. We suspect that it is the convenience of such metrics that make them so popular with assessors, and there is little indication that their use is waning. The paradigm that a citation represents a unit of (positive) quality is clearly flawed if only three-quarters of the citations actually support the assertion they are supposed to. At the micro-level, the authors of inappropriately cited papers will get undeserved boosts to their citation counts, but this will be at the expense of the research (assuming it exists) that is not duly credited. Institutionally, Journal Impact Factors ought to be viewed more cynically and grant-funding bodies that rely on citation-based indicators should take heed.

As Dupps (2008, p. 1419) notes 'citation is a human process' and papers are not referred to based simply on academic merit or appropriateness (Bornmann & Daniel 2008). Numerous factors are known to affect the probability of a paper being cited, including the language used (Ruiz 2008), the number of authors (Sala & Brooks 2008) plus their affiliations and status (Leimu & Koricheva 2005), the paper's length (Ball 2008) and the significance of the results (Nieminen et al. 2007). There are also multiple issues associated with self-citations (Schreiber 2009) and determining the precise number of cites a paper has accrued (Stergiou & Tsikliras 2006). Such biases and artefacts, combined with our own findings, cast serious doubt on the validity of citation counts.

Remediation

Even though journals 'have the responsibility to publish the truth' (Biebuyck 1992, p. 1) the technical editing required by journal staff to identify miscitations is too huge a burden. A meticulous referee with bona fide expertise in a submitted article's topic may recognise misappropriated citations, but such reviewers are atypical. Authors are undoubtedly in the best position to improve citation practices (Hansen & McIntire 1994, Gosling et al. 2004), and the senior author should shoulder the bulk of any accountability (Gupta et al. 2005). 'The author's responsibilities are absolutely clear: first, to consult the original paper; second, to quote the original material correctly and in context; and third, to present the bibliographic reference accurately' (Biebuyck 1992, p. 2). We would add: only cite review papers when they contribute something original, use the citation immediately after the assertion as opposed to grouping references together at the end of the sentence and do not provide long lists of citations if 1 or 2 will do. Some excellent guidelines on how to cite exist (e.g. Harzing 2002, Dupps 2008) and highlighting these in a journal's 'Instructions for authors' section may help promulgate good citation habits.

More proactive measures could be instigated to address citation malpractice, including requiring authors to sign a declaration stating their citations have been verified (Goldberg et al. 1993), instigating a system of random audits (Gosling et al. 2004), or publishing errors that are spotted by readers (de Lacey et al. 1985). A few references from a new submission could be selected randomly by the editor, and the authors would have to supply these with the supporting sections highlighted (Schulmeister 1998); with online submission, this process could even be automated. If errors are found, the manuscript can be returned and the author asked to provide the relevant parts of all work cited in their paper. Any such procedure that might result in time-to-publish penalties or outright rejection should provide sufficient incentive for authors to check their work for citation accuracy (Schulmeister 1998).

CONCLUSION

Dupps (2008, p. 1419) observes that when referring to previous research there exists an 'implied assent of the cited experts'. We wonder what those experts would think if they knew their work was being misrepresented (or, as another citation is accrued, perhaps they would not mind). Our results indicate that 1 in 4 citations in marine biology should be viewed with scepticism. The numbers correspond with Todd et al. (2007), suggesting they are representative of a wider problem within field-orientated biology.

Bibliometric-based performance indicators have a disproportionate influence on promotion and tenure,

grant capture and institution ranking (Lawrence 2007), yet a citation 'is not a unit, but an event' (Martyn 1975, p. 291) and adding them up has little heuristic value. Academia's veneration of citation counts and impact factors is problematic enough without those counts themselves being based on misattributed works. Such metrics are wholly 1-dimensional (Harnad 2008) and have no capacity to integrate the subtleties of miscitation and other biases.

The corrosive effects of poor citing behaviour are of particular relevance to junior scientists. Young investigators are probably exposed more to the journal game-playing of their mentors and colleagues than the ethics of science writing and publishing. Graduate students and postdoctoral fellows are pressured into establishing themselves as quickly as possible (Lawrence 2008), and swapping care and vigilance for increased output is almost inevitable unless action is taken. It is up to senior scientists to take the lead as role models (Retzer & Jurasinski 2009) and inculcate good citing practice.

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