1 **On the quest for novelty in ecology**

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Abstract

The volume of scientific publications continues to grow, making it increasingly challenging for scholars to publish papers that capture readers' attention. While making a truly significant discovery is one way to attract readership, another approach may involve tweaking the language to overemphasize the novelty of results. Using a dataset of 52,236 paper abstracts published between 1997 and 2017 in 17 ecological journals, we found that the relative frequency of novelty terms (e.g. *groundbreaking*, *innovative*) nearly doubled over time. All journals but one exhibited a positive trend in the use of novelty terms during the studied period. Conversely, we found no such trend for confirmatory terms (e.g. *confirm*, *replicated*). Importantly, only papers using novelty terms were associated with significantly higher citation counts and were more often published in journals with a higher impact factor. While increasing research opportunities are surely driving advances in ecology, the writing style of authors and the publishing habits of journals may better reflect the inherently confirmatory nature of ecological research. We call for an open discussion among researchers about the potential reasons and implications of this language-use and scientometrics issue.

The recent rise in scientific production

"*Eureka!*"– yelled Archimedes when he solved a scientific problem that, among other things, would have cost him his life. This is only one of many tales of serendipitous discoveries that populate the history of science. A common thread in these narratives is the presence of a lonely genius who, perhaps in a stroke of luck or inspiration, succeeded in shedding light on the unknown (Connor, 2005). However, the reality behind these tales can be quite different (Foucault, 1969). Modern science is a systematized body of positive knowledge (Hoyningen-Huene, 2013), primarily built through a lengthy and steady accumulation of confirmatory work, only occasionally disrupted by game-changing discoveries that typically arise from anomalous results or observations (Darwin, 1859; Kuhn, 1962). Even after such discoveries, paradigms rarely shift abruptly, and many pioneering ideas remain dormant until later researchers recognize their value (Van Raan, 2004).

   In the digital era, scientific results are published at an astonishing rate (Landhuis, 2016), with the number of scientific articles published annually more than tripling over the past two decades, surpassing six million papers in 2023 (www.dimensions.ai). The field of ecology is no exception to this trend (Pautasso, 2012), as researchers struggle to keep up with the ever-growing influx of new literature (Courchamp & Bradshaw, 2018). As a result, readers must be more selective in what they consume (Mabe & Amin, 2002), while writers may adapt their language to capture attention (Weinberger et al., 2015; França & Monserrat, 2019; Mammola, 2020). Further, journals may reinforce this trend by requiring authors to emphasize the novelty of their publications. As readers striving to keep up with the relentless production of ecological literature, we sensed that

66 an increasing number of papers are filled with terms that, in various ways, highlight the

67 novelty of the research. Here, we explore the question: Is this trend real or merely

68 perceived?

69   We analyzed the relative use (i.e. frequency) of novelty and confirmatory terms in

70 ecological publications over a twenty-year period. We developed a dual-hypothesis

71 testing framework (Fig. 1). If ecological research is primarily confirmatory, we would

72 expect a consistently higher relative use of confirmatory terms than novelty terms (H1;

73 Fig. 1A,C). Conversely, if the pressure to stand out in the "research crowd" influences

74 authors' writing and journal publishing practices, we should observe a significant

75 increase in the relative use of novelty terms over time (H2; Fig. 1B,C).

76   Additionally, we conducted a scientometrics analysis to examine whether

77 relationships exist between the use of novelty or confirmatory terms and (i) the Impact

78 Factor (Journal Impact Factor) of the journal in which a paper was published or (ii) the

79 number of citations a paper received. A relationship with Journal Impact Factor would

80 suggest a journal's tendency to either favor (positive relationship) or discourage

81 (negative relationship) papers using these terms. A relationship with citation count

82 would indicate whether readers are more (positive relationship) or less (negative

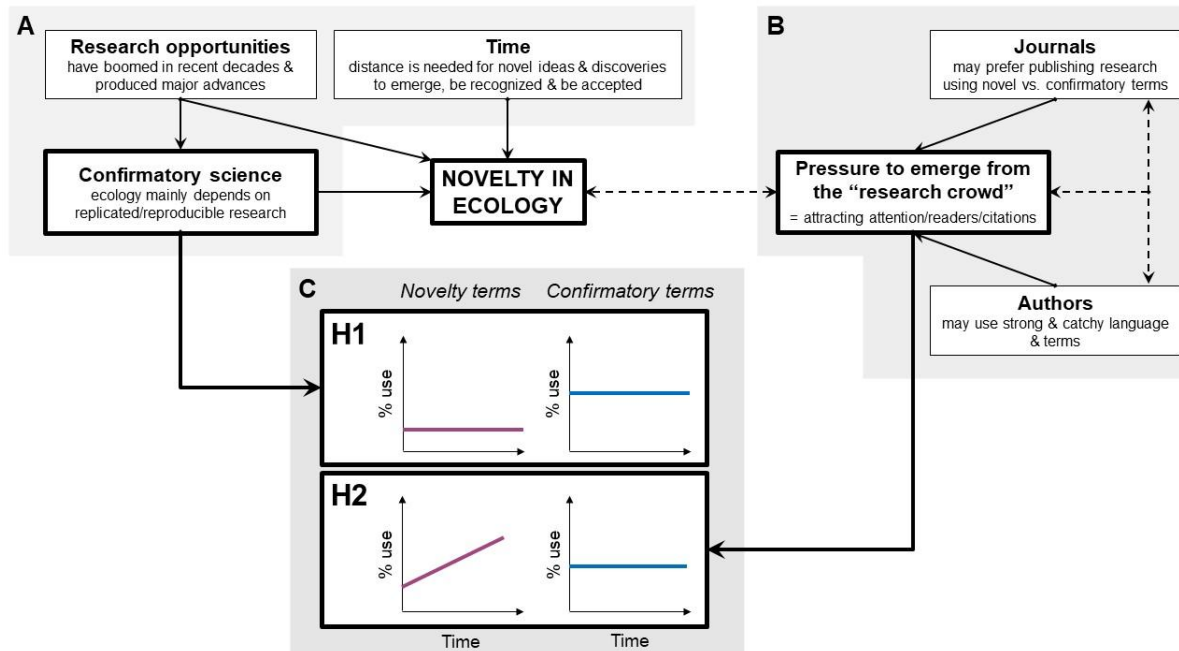83 relationship) likely to cite papers containing either type of term.

Fig. 1 Schematic of the dual-hypothesis framework. The confirmatory nature of ecological research (A) contrasts with the pressure on authors and journals to stand out in an increasingly crowded research landscape (B), leading to two distinct scenarios (C). Solid arrows indicate putative direct relationships between components, while dashed arrows represent plausible interactions or synergies that, in turn, shape the hypothesized temporal patterns in the use of novelty and confirmatory terms.

Dataset and statistical analyses

We used a dataset of 52,236 papers published between 1997 (year in which Journal Impact Factor was introduced) and 2017 in 17 representative ecological journals (Mammola et al., 2021) (Table S1) – these constituting ~20% of all ecological journals listed in the Web of Science in 1997, and ~11% of those listed in 2017, and covering most of the Journal Impact Factor range in ecology (e.g. 1.3-10.8 for the year 2023). We examined the frequency of appearance (presence/absence) of a set of selected novelty

99   terms ("breakthrough", "groundbreaking", "innovated", "innovation", "innovative", "new",

100   "newly", "novel", "novelty") and confirmatory terms ("confirm", "confirmatory",

101   "replicability", "replicate", "replicated", "replication", "reproducibility") over time in paper

102   abstracts. We focused on abstracts because they reflect the overall writing style of

103   articles (Plavén-Sigray et al., 2017), while representing the lark mirror to capture the

104   attention of readers (Martínez & Mammola, 2021).

105   We used regression-like analyses (Zuur & Ieno, 2016) to examine whether the

106   use of novelty or confirmatory terms has increased over the studied period across all

107   papers and journals (N = 52,236). Specifically, we ran two generalized linear mixed

108   models to test the relationship between the use of confirmatory and novelty terms and

109   publication year, with 'journal' included as a random-intercept factor, assuming that

110   abstracts from the same journal share more similar writing features than those from

111   different journals. Given the binary nature of the dependent variable (0 = non-use of the

112   term; 1 = use of the term in each paper), we specified a Bernoulli-family data distribution

113   and a complementary log-log link function to account for the unbalanced distribution of

114   zeros and ones. To provide a visual summary of the temporal trend, we plotted the

115   frequency of term usage as the percentage of papers using novelty or confirmatory

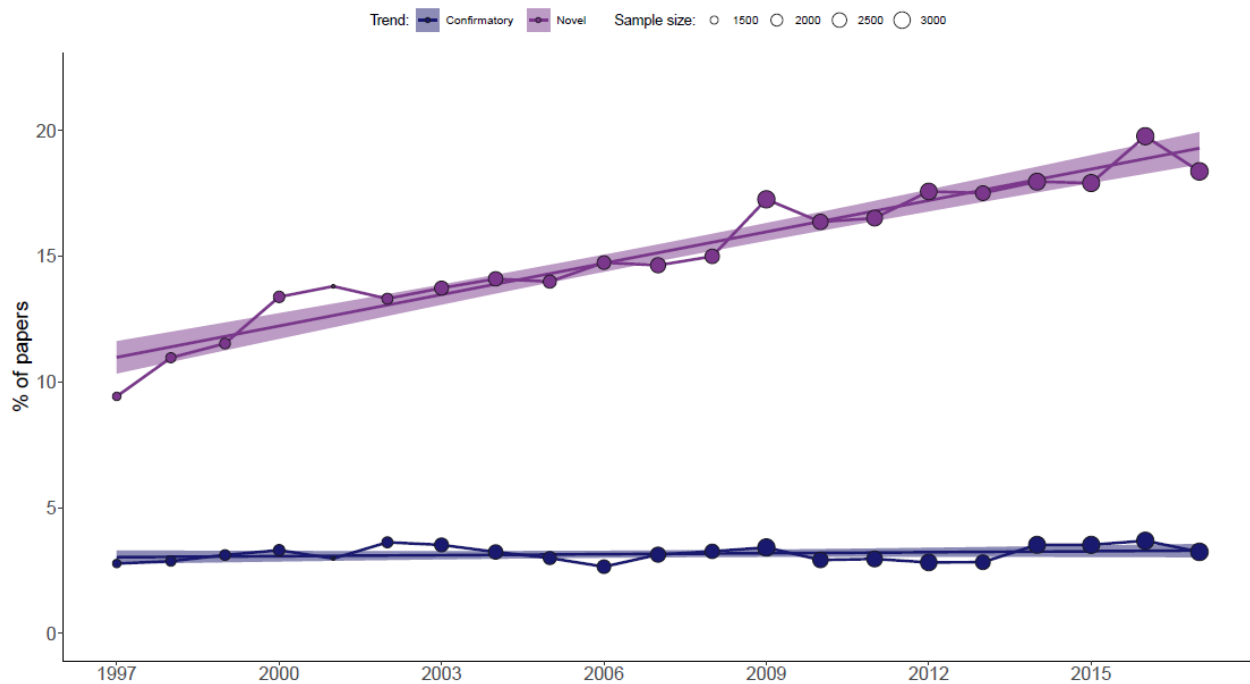116   terms per year—both in aggregate (Fig. 2) and for individual journals (Fig. 3).

117   Next, we used a generalized linear mixed model to test whether the number of

118   citations (response variable) is related to the relative use of novelty and confirmatory

119   terms (fixed effects). We also included abstract length (word count) and publication year

120   as covariates to control their potential influence on citations, and we treated 'journal' as

121   a random-intercept factor. Since citations are count data, we initially specified a

122   Poisson-family distribution. However, the Poisson model was highly over-dispersed

123   (dispersion ratio = 96.5, Pearson's χ^2 = 5040868.5, p < 0.001), so we switched to a

124   negative binomial distribution. To examine whether the use of novelty and confirmatory

125   terms is related to Journal Impact Factor, we ran a linear model with the same fixed

126   effects as in the citation model. Here, we did not include 'journal' as a random effect, as

127   it is inherently tied to Journal Impact Factor.

128   We ran all the analyses in R version 4.3.0 (R Core Team, 2023), using the

129   package glmmTMB version1.1.7 for regression analyses (Brooks et al., 2017),

130   performance version 0.9–7 for model validation (Lüdecke et al., 2021), and ggplot2

131   version 3.5.1 for plotting (Wickham et al., 2016).

132

133   **The growing use of novelty terms in ecology**

134   Across all journals, the relative use of novelty terms in paper abstracts doubled over the

135   study period, increasing from ~10% in 1997 to ~20% in 2017 (Fig. 2). Regression

136   analyses confirmed that the likelihood of an article using novelty terms was higher in

137   recent years (*Log-Risk* ± SE: 0.16 ± 0.01, *z* = 14.03, *p* < 0.001; Conditional R^2 = 0.05,

138   Marginal R^2 = 0.02). In contrast, we found no clear trend for confirmatory terms, whose

139   relative use remained steady at around 3% (Fig. 2). The probability of an article using

140   confirmatory terms also remained stable over the study period (*Log-Risk* ± SE: 0.04 ±

141   0.02, *z* = 1.54, *p* = 0.125; Conditional R^2 = 0.03, Marginal R^2 = 0.01). This overall

142   pattern for novelty and confirmatory terms was similar across all journals, except for

143   *Austral Ecology*, which—*nomen omen*—showed the opposite trend, with the use of

144   novelty terms declining over time (Fig. 3).

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Fig. 2. Increasing use of novelty terms in ecological abstracts. Temporal trends in

the relative use (i.e. annual frequency [%]) of novelty and confirmatory terms across 17

selected ecological journals (Table S1). Dot size represents the number of articles

published each year. Regression lines and confidence intervals are included for visual
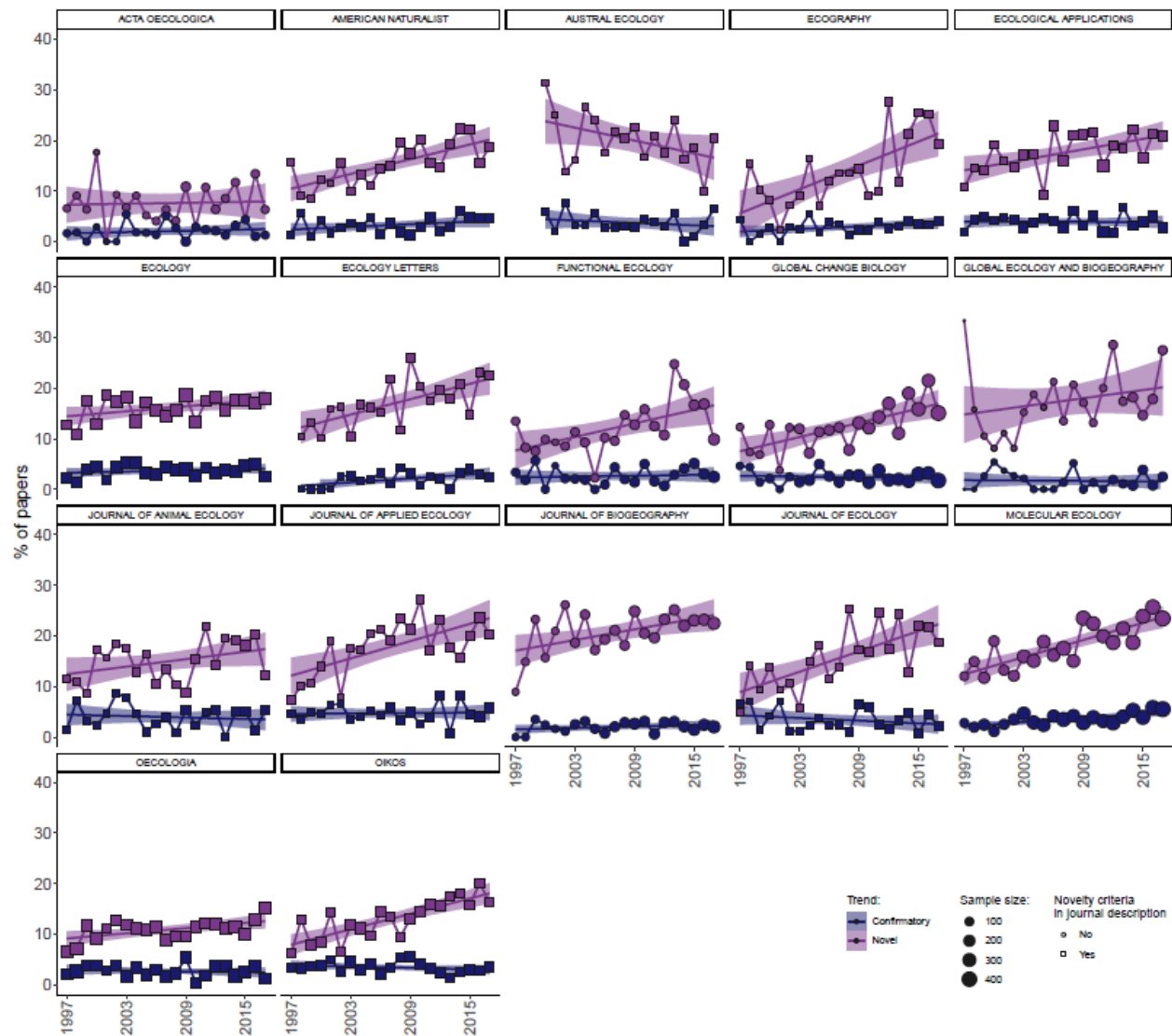
clarity.

Fig. 3. The trend of increasing use of novelty terms in ecological abstracts is consistent across all but one journal. Temporal trends in the relative use (i.e. annual frequency [%]) of novelty and confirmatory terms for each of the 17 selected ecological journals. Symbols indicate whether novelty is a criterion mentioned in the journal description (Table S1), and their size corresponds to the number of articles published each year. Regression lines and confidence intervals are included for visual clarity.

160   The use of novelty terms was positively associated with both the number of

161   citations and Journal Impact Factor, whereas no such relationships were found for

162   confirmatory terms (Fig. 4). Abstract length (number of words) was positively associated

163   with the number of citations and negatively with Journal Impact Factor, while publication

164   year was negatively related to the number of citations (i.e. more recent papers receive

165   fewer citations than older ones) and positively with Journal Impact Factor. The

166   unexplained variance suggests that several other factors, not accounted for in this

167   analysis, are likely influencing article impact—something that is well-documented in the

168   "science of science" literature (e.g., Tahamtan et al., 2016, 2019; Mammola et al.,
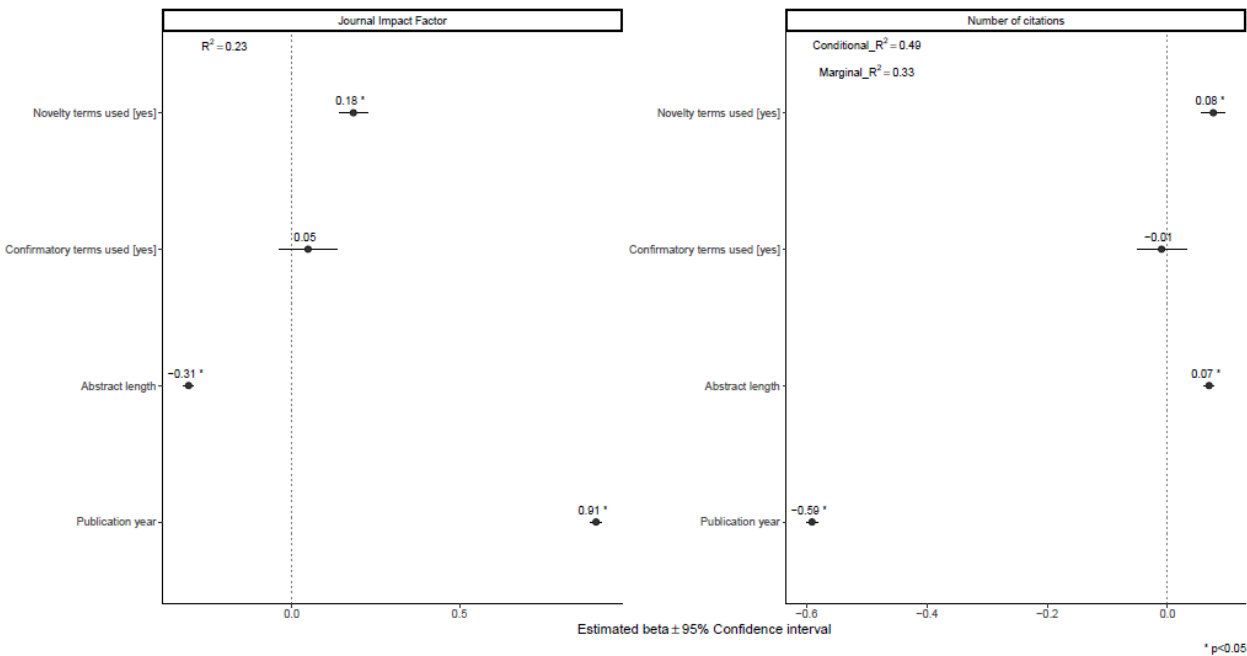
169   2022).

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171

172   **Fig. 4. Publication impact is tightly associated with the use of novelty terms.**

173   Forest plots summarize the estimated parameters of regression models testing the

174   relationship between novelty and confirmatory terms, abstract length (number of words),

175 and publication year on the Journal Impact Factor (left panel; based on a linear model)

176 and the number of citations (right panel; based on a generalized linear mixed model).

177 Bars represent 95% confidence intervals. Variance explained is reported as both

178 conditional R^2 (random + fixed effects) and marginal R^2 (explained by fixed factors

179 alone). Asterisks (*) indicate significant effects (α = 0.05).

180

181 **What could be behind the rising trend of novelty terms?**

182 We found strong evidence supporting our perception that more and more papers are

183 using novelty terms, while confirmatory terms showed no obvious temporal patterns and

184 were generally much less used by researchers over the studied 20-year timespan (Fig.

185 2, Fig. 3). Concurrently, the use of novelty terms tended to attract more citations and

186 was associated with journals having higher Journal Impact Factors compared to the use

187 of confirmatory terms (Fig. 4). As a result, we rejected H1 of our dual-hypothesis

188 framework, while H2 received striking support (Fig. 1). The increasing use of novelty

189 terms was confirmed across all our analyses, emerging across all journals (Fig. 2), as

190 well as within individual journals (Fig. 3). The only exception was the Australian journal

191 *Austral Ecology*, which exhibited a temporal decline in the relative use of novelty terms,

192 for which we do not have a plausible explanation for this anomalous "down-under"

193 pattern. Taken together, these findings support the idea that the pressure to stand out

194 from the "research crowd" felt by both researchers and journals plays a key role in the

195 current ecological writing and publishing landscape (Fig. 1).

196   Still, we can only speculate about the possible causes driving the upward trend in

197 the use of novelty terms in the last two decades, as correlation does not necessarily

198 imply causation. Perhaps, thanks to recent conceptual developments (Dubois & Peres-

Neto, 2022) and the increasing availability of data and analytical tools (e.g. Besson et al., 2022; Cardoso et al., 2020; McCallen et al., 2019; Tosa et al., 2021; Mammides & Papadopoulos 2024), ecologists are now truly able to make groundbreaking discoveries and write novel stories at an accelerating pace. However, the history of science suggests that game-changing findings are rare and take time to be recognized (Morris, 2009; Van Raan, 2004). This view is further supported by a recent overview illustrating how papers are increasingly less likely to make scientific breakthroughs (Park et al., 2023).

We must then face an uncomfortable alternative possibility: are we, as ecologists, using a more sensationalized and novelty-driven language (either consciously or unconsciously) to increase our chances of catching readers' attention amidst the incessant production of scientific literature (scenario depicted in Fig. 1B, C) (Weinberger et al., 2015; Doubleday & Connell, 2017; Mammola, 2020)? This speculation is supported by the positive significant relationship between the use of novelty terms, but not the use of confirmatory terms, and both number of citations and Journal Impact Factor (Fig. 4). These relationships also suggest that Journal Impact Factor could benefit from publishing papers that use novelty terms, as they are more likely to attract citations. Indeed, journals may be contributing to this trend. Among the 17 ecological journals included in our analysis, about 65% explicitly mention novelty as a criterion in their current author guidelines (Table S1). Similarly, novelty is a core requirement in pre-peer review editorial decisions for some journals (Arnqvist, 2013). Thus, this "quest for novelty" may partly stem from the challenges faced by journals in attracting readers and citations. At the same time, more "novel" papers may tend to be

published in journals with higher Journal Impact Factor, further shaping the observed patterns. In other words, such complex feedback loops between researchers and journals may therefore largely contribute to generating the spike in the use of novelty terms in ecological literature.

Limitations of the study

A deeper mechanistic understanding of what drives these scientometrics patterns related to writing and publishing behaviors would require a closer examination of each manuscript included in this study. This step would imply reading each of the >50k papers, and perhaps even contacting corresponding authors asking for their feedback and reasons behind the choice of using or not novelty terms. We are also aware that the selection of terms and searched journals can affect the revealed patterns. However, thanks to the representativeness of the chosen ecological journals, Journal Impact Factor range, and set of selected terms, we are confident that what we have found offers a reliable picture of what has happened in the studied 20-year timespan.

On the importance and impacts of confirmatory science and of language use in ecology

Ecology is experiencing unprecedented research opportunities worldwide. However, like any other scientific discipline, knowledge-building progresses through a lengthy and steady cumulative process, with most basic and applied research being inherently confirmatory in nature (Hoyningen-Huene, 2013). Novel ideas and discoveries may emerge in response to idiosyncrasies arising from observational or experimental

245   studies, which also form the theoretical foundations upon which we built—and ultimately

246   rejected—our H1. Nevertheless, the frequency of new discoveries in ecology typically

247   occurs at a rate of only a few per year or decade (Morris, 2009), which contrasts with

248   the trends we observed in our study.

249   From a semantic and cognitive standpoint, words are not just tools for

250   communicating our key findings to other scientists or the broader public (Feynman,

251   1969), but also serve as the building blocks of knowledge construction (Martínez &

252   Mammola, 2021). We wonder whether the increasing use of sensationalized language

253   (Mammola, 2020), where novelty may be exaggerated, could influence our thinking

254   process at various levels. After all, understanding what is truly new is crucial—not only

255   when writing and disseminating results but also when designing future projects and

256   experiments. Without this clarity, we risk reinventing the wheel. We join the call to

257   evaluate publications based on their quality, soundness, clarity, and replicability, giving

258   less emphasis to their confirmatory or novelty (true or claimed) nature (Pautasso, 2013;

259   Romero, 2017). Encouragingly, this approach seems to be increasingly adopted by

260   ecological journals, especially (but not exclusively) open-access ones. Therefore, we

261   emphasize the importance of starting a conversation about the potential root-causes

262   and implications of this linguistic and scientometrics trend for the scientific community

263   and science communication at large.

264

Author contributions

GO conceived the research idea, with significant inputs to further develop it provided by SM, AM, MPB. SM gathered the data and conducted the statistical analysis. GO and SM led the writing, and all coauthors contributed to revisions.

Data accessibility statement

Data supporting this study is available in Figshare: https://doi.org/10.6084/m9.figshare.12941639.v1.

The analytical pipeline to reproduce the analyses is also available in GitHub:

https://github.com/StefanoMammola/Ottaviani_et_al.

Artificial Intelligence (AI) declaration

No AI technologies have been used.

Conflicts of interests/Competing interests declaration

Nothing to declare.

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374 **Table S1.** The 17 journals selected for the analysis and sample size (readapted from

375 Mammola et al., 2021).

Journal name	Initial year	Timespan selected	N of primary research articles used	Use and requirement of novelty terms in journal description*
Acta Oecologica	1983	1997–2017	1,408	No
American Naturalist	1867	1997–2017	2,852	Yes
Austral Ecology	2000	2000–2017	1,434	Yes
Ecography	1978	1997–2017	1,743	Yes
Ecological Applications	1991	1997–2017	3,051	Yes
Ecology	1920	1997–2017	5,505	Yes
Ecology Letters	1998	1998–2017	2,098	Yes
Functional Ecology	1987	1997–2017	2,326	No
Global Change Biology	1995	1997–2017	3,937	No
Global Ecology and Biogeography	1993	1997–2017	1,377	No
Journal of Animal Ecology	1932	1997–2017	2,250	Yes
Journal of Applied Ecology	1964	1997–2017	2,407	Yes
Journal of Biogeography	1974	1997–2017	2,852	No
Journal of Ecology	1913	1997–2017	2,170	Yes
Molecular Ecology	1992	1997–2017	6,209	No
Oecologia	1968	1997–2017	5,446	Yes
Oikos	1949	1997–2017	3,812	Yes

376 * Novelty terms considered in the journal description (i.e. scope and authors' guidelines; search

377 conducted in 2021) are the same as of the paper abstract search.