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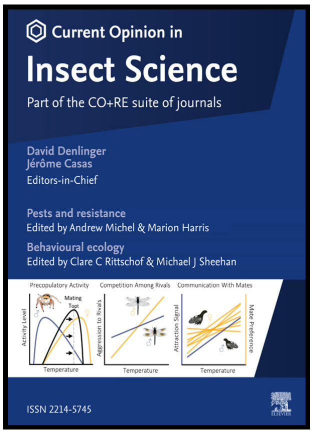

Understanding and counteracting the denial of insect biodiversity lossShort Title: Denial of insect biodiversity loss

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Understanding and counteracting the denial of insect biodiversity loss [1]

Short Title: Denial of insect biodiversity loss

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Abstract (100 words)

Biodiversity loss is occurring globally with negative impacts on ecosystem function and human wellbeing. There is a scientific consensus that diverse environmental and anthropogenic factors are altering different components of insect biodiversity, with changes occurring at all levels of biological organisation. Here we describe how uncertainty around specific trends and the semantics of 'decline' in relation to insect biodiversity have been leveraged by denialist campaigns to manufacture doubt around the insect biodiversity crisis. Disinformation is one of the biggest threats

[1] Given the role as Guest Editor, Eliza Grames had no involvement in the peer review of the article and has no access to information regarding its peer-review. Full responsibility for the editorial process of this article was delegated to Toke T. H�ye

to social cohesion and environmental integrity globally. We argue that scientists, academic institutions, policy makers, and journalists must combat denialism by relying on robust research, supporting efforts to communicate scientific uncertainty more effectively, and build consensus on the global impacts of insect biodiversity loss.

Keywords: science communication; denialism; insect decline; insect apocalypse; biodiversity loss; insect populations; insect conservation

Introduction

Biodiversity loss is a defining process of the Anthropocene. There is consensus among experts that a global biodiversity crisis is damaging ecological processes, disrupting ecosystem function, and reducing ecosystem services at local, regional and global scales [1]. Biodiversity loss encompasses complex trends that vary widely within taxonomic groups, across land uses and between regions. Moreover, biodiversity is more than just species richness and abundance; it also includes genes, traits, species interactions, ecosystems and bioregions [2]. Erosion of all aspects of this diversity defines the biodiversity crisis affecting humanity, not just the loss of individual species [3]. It is this range of biodiversity metrics, the variation in potential responses to stressors and drivers, as well as unknowns such as how changes affect ecosystem function that make the biodiversity crisis a challenge to communicate. From such complexity, mixed messages can arise and can be misused by denialist campaigners to manufacture doubt [3]. In this paper, we describe scientific uncertainty in relation to insect biodiversity loss, explain how this uncertainty has been leveraged by denialist campaigns and argue that scientists, academic institutions, policy makers, and journalists must invest in strategic approaches to combat denialism of biodiversity loss.

Evidence surrounding insect biodiversity loss

Insect biodiversity loss is one facet of the biodiversity crisis that has received a surge in attention over the past decade (Figure 1). There is strong scientific evidence for insect biodiversity loss in some parts of the world, despite high variation and uncertainty around trends, which may be heterogeneous across species, space and time [4, 5, 6]. Insect population declines are notoriously difficult to confirm. Data gaps, methodological issues and common biological characteristics of insect populations can lead to dramatic population fluctuations that require multi-decadal datasets, with frequent sampling across or even within years, to ascertain long-term trends [7]. Insects are also hyperdiverse, with an estimated 5.5 million species [8], some of which are 'winners', showing increasing trends in response to environmental change, even in long-term datasets [9, 10, 11]. Geographic bias in existing datasets, with much of the data coming from North America and Western Europe [4], has resulted in uncertainty in how representative those datasets are of global trends, especially for underrepresented but highly diverse regions like the tropics and places where the majority of insect biodiversity is yet to be formally described.

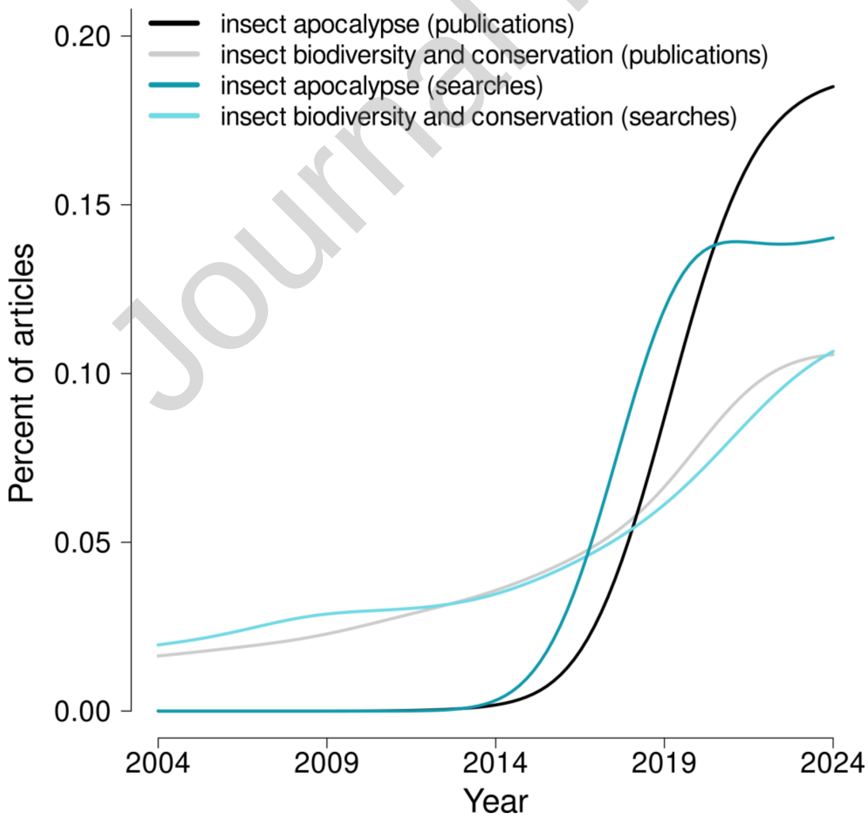

Figure 1. Recent increasing attention to the insect apocalypse narrative in scientific publications (black) and Google searches (turquoise) relative to insect biodiversity and conservation in scientific publications (grey) and searches (light teal). Data for public searches come from Google Trends for the terms 'insectageddon' and 'insect apocalypse' (apocalypse) and for 'insect biodiversity' and 'insect conservation' (biodiversity and conservation). Data for scientific publications come from articles in the BIOSIS Citation Index retrieved with the search ("insect decline*" OR "insect apocalypse" OR "insectageddon") for the apocalypse group, and by the title search (insect AND (biodiversity OR conservation)) for the biodiversity and conservation category. All searches were restricted to the years 2004-2024.

Despite these challenges, there is consensus among experts that there is an insect biodiversity crisis; insect populations and communities are changing rapidly around the world, with increased likelihood of extinction in some contexts, although the broader effects on biodiversity and ecosystem function are still unclear. Evidence for insect decline comes not only from long-term studies directly investigating insect population size and community structure, but also from other data sources that can provide inferential support for likely declines in insect biodiversity (Figure 2). Collating evidence across multiple study types is essential to provide strong evidence of global changes in insect biodiversity.

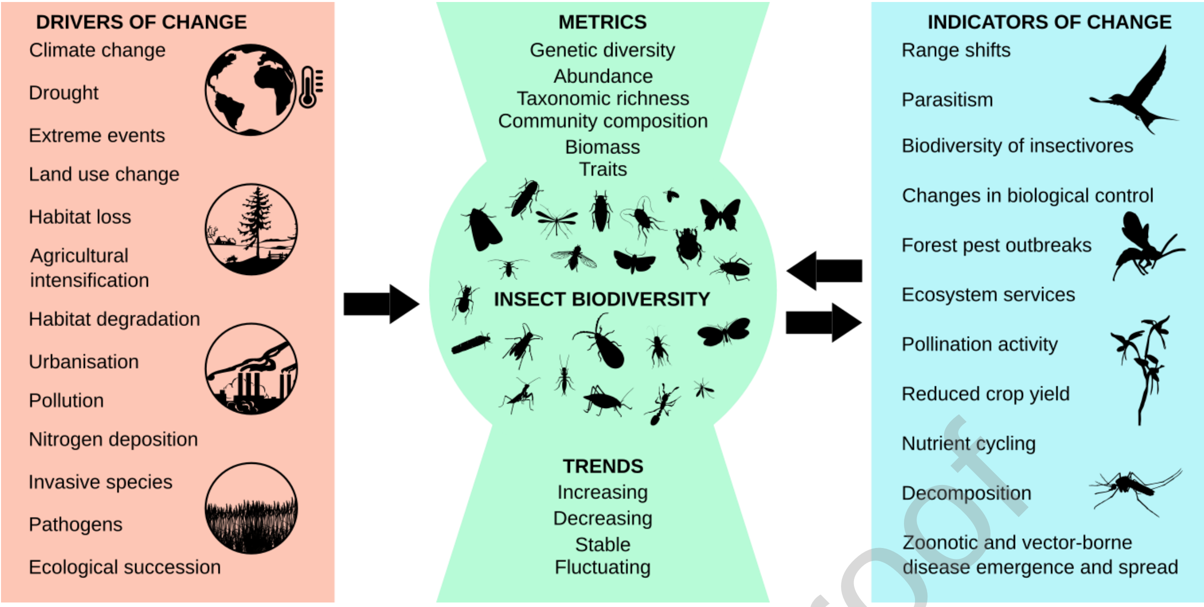

Figure 2: Measuring changes in insect biodiversity can be achieved by focusing on drivers that directly or indirectly impact insect biodiversity metrics and trends (left). Where data on insect populations specifically are unavailable, data from other species and ecological processes can provide inferential support for changes in insect biodiversity (right).

Anthropogenic and environmental drivers of change

We know from decades of scientific evidence that insect populations and communities are negatively impacted by numerous anthropogenic drivers. Agricultural intensification is associated with threats such as primary habitat loss, reduced plant diversity, increased landscape homogenisation, and increased pesticide use - all of which have local- and landscape-scale impacts on insect abundance and diversity [12, 13]. Urban development often results in reduced insect diversity and altered community composition [14], and human-caused climate change can catalyse insect range shifts, local extinctions, and changes in community network structure [15, 16].

There is evidence that climatic factors, such as long-term rainfall and temperature changes [e.g. 17, 18], and extreme events, such as wildfire and heatwaves [e.g. 15, 19, 20], can cause reductions or increases in different components of insect biodiversity, but our understanding of the taxonomic and geographic breadth of impacts is limited. The intensity and frequency of environmental processes and changes are now intrinsically tied to anthropogenic drivers, so common understanding on how these processes impact insect biodiversity across larger spatial and temporal scales will require more complex datasets and analytical approaches. However, some threats, such as habitat loss (changes in land-use and land cover extent), habitat fragmentation (increasing habitat subdivision) and habitat degradation (i.e., reduction in habitat quality) are known to reduce biodiversity and it is relatively easy to infer that such changes should lead to population declines [21].

Indicators: Proxies for insect declines

Given the challenges of understanding the magnitude of invertebrate declines we can also turn to more well-studied ecological proxies. For example, birds are arguably the most comprehensively studied taxonomic group [22] and around half of all bird species (5157 of 10662) are primarily insectivorous [23] consuming 400–500 million tons of prey annually [24]. Widespread declines and range contractions have been reported in many insectivorous bird species at both temperate and tropical latitudes [22]. Insectivorous birds are dependent on insect prey [25] and are likely to co-decline with insects, as shown where declines in insectivorous birds track spatial patterns in agricultural intensity across Europe [26]. Although insectivorous birds (and other taxa such as bats) face multiple threats in addition to loss of prey biomass, many of these threats, like climate change (including phenological shifts), environmental contamination, habitat loss, fragmentation and degradation also impact insects directly and indirectly [27].

Another useful proxy is changes in the ecosystem services provisioned by insects. For example, there is evidence for reduction in pollination services in some landscapes [28], and studies have directly linked reductions in pollinator phylogenetic diversity to crop yields [29]. Similar evidence has emerged for changes in dung removal [30] and might be detected in the future for decomposition rates of plant or animal matter [e.g. 31, 32] with implications for nutrient cycling and ecosystem productivity. Moreover, loss of insect biodiversity may also indirectly lead to ecosystem disservices if ecosystems become less resilient to invasion by non-native species, or shift to community dominance by generalist pest species or disease vectors [e.g. 12, 33].

Denial of biodiversity loss

Against a backdrop of uncertainty about the magnitude of loss and the scale of trends and impacts, there is a need to challenge disinformation [34]. Vested interests continually act to undermine authoritative figures and institutions, including science and scientists. Misinformation (defined as false or inaccurate information, often spread unintentionally) and disinformation (defined as deliberately misleading or biased information and manipulated narratives) are now widely recognised as major global threats to democracy, evidence-based policy, sustainable development, public health, and social cohesion [35]. Increasingly fragmented online communities combined with a public that is increasingly disengaged from socio-political institutions have created ideal conditions for misinformation and disinformation to proliferate and undermine political and scientific consensuses.

Denial of evidence is a key driver of mis/disinformation, but it is not simply a case of bad actors claiming experts are wrong. Denialism encompasses the rhetorical process and tactics used to frustrate legitimate debate, or to fabricate the perception of uncertainty of scientific consensus [36]. Five indicative characteristics of denialism include: conspiracy theories; use of fake experts; cherry-picking of data, quotes and information; misrepresentation and use of logical fallacies; and unrealistic expectations of research [36]. Science is particularly vulnerable to denialism, because the uncertainty that is an inherent and legitimate part of the scientific process is often misused, by those with vested interests, to manufacture doubt [37, 38].

The manufacture of doubt is a key denialist strategy that has been used to misrepresent evidence important for public health, social cohesion and environmental integrity for decades, from climate change to COVID-19 [39]. Denial of global biodiversity loss and the extinction crisis is now also a documented phenomenon [3, 34]. Given public concern following media coverage of the 'insect apocalypse', some vested interests shifted attention to insect decline denial. The uncertainty surrounding the rate and magnitude of insect declines can be easily leveraged by denialist campaigns to cast doubt on the existence of a biodiversity crisis in an attempt to maintain the status quo. These tactics were found on various politically-conservative online media platforms during the peak of the 'insect apocalypse' media spotlight and via greenwashing and pushback from some agribusiness industries against recommendations to reduce pesticide use and transition to more sustainable farming practices [34, 40].

Combatting denialism

Given the strength of evidence from multiple sources documenting insect biodiversity loss, entomologists, ecologists, and conservation scientists must combat unfounded denial of insect biodiversity loss. It is no longer sufficient to conduct rigorous scientific studies and expect the data to speak for themselves, we must also advocate to embed biodiversity conservation in public discourse, and limit denialism of the ongoing insect biodiversity crisis.

Recognize and engage with denialist tactics

Rather than engaging in debate over insect biodiversity loss, scientists must engage with the denialist tactics being used to manufacture doubt about the biodiversity crisis generally [4, 41]. As with climate change, the biodiversity crisis is happening whether or not people believe or directly experience it. Denialist tactics include: making it appear as if there is a lack of scientific consensus (in an attempt to polarize public opinion; creating a narrative based on a false dichotomy or vote counting; sowing seeds of doubt especially in the face of scientific uncertainty; discrediting experts; funding or publishing research that has the appearance of scientific legitimacy; and pursuing greenwashing campaigns. Counteracting denialist campaigns is not the sole responsibility of individual scientists. It requires investment in coordinated and strategic approaches to science communication and education by multiple actors and institutions. There is an established body of literature on tools and techniques to counteract denialism and disinformation in climate change and public health communication [42, 43, 44]. However, different crises require different approaches [42] and there is an urgent need for more research on what methods are most effective for addressing denial of biodiversity loss. For many audiences, impacts of biodiversity loss appear less immediate than a public health emergency, and less relevant than climate change, so different tools and techniques will likely be necessary.

Rely on well-executed research

Peer review is an imperfect process, and variably flawed scientific articles are occasionally published in reputable peer-reviewed journals. Not all of these flawed papers are retracted, and as researchers, it is our obligation to recognize these papers and not give them credence. For example, despite many academic blogs and peer-reviewed articles [4, 45] pointing out the numerous flaws and biased methods of a paper purporting to be a global meta-analysis of drivers of insect decline [46], the paper has been cited over 3600 times (according to Google Scholar, 4 December 2024) predominantly as evidence of insect biodiversity loss. Citing this flawed paper gives it the appearance of authority, undermining the legitimate evidence for changes in insect biodiversity presented in other, more rigorous analyses [5, 9, 10, 47, 48].

Effectively communicate scientific uncertainty

The scientific process is inherently uncertain, especially for complex issues like biodiversity loss. This uncertainty can open the floor for denialist attempts to portray the issue as an unknown, or open for debate. Estimated rates of insect decline are uncertain and actual rates of loss could be lower or could be much higher. How scientists communicate this uncertainty can change public perception of the issue. For example, science communication focused on the processes and interpretations that led to a particular result can be more effective at engaging audiences with scientific uncertainty behind the data than simply presenting a study's result as fact.

Communicating uncertainty is also critical in media and public discussion of scientific research. However, current strategies of many academic institutions focus on engaging the media with the promotion of individual researchers and published studies, rather than the broader scientific issues and the process behind the science. The system and process of science is designed to be self-correcting, whereby a flawed scientific article published in a reputable journal should eventually be superseded by critiques and new analyses. However, when news media are encouraged to cover those individual studies immediately after publication, the uncertainty and complexity of the science is often lost in translation [4].

Build consensus and focus on biologically meaningful effects

Denialist campaigns often rely on portraying scientists as being in disagreement and polarizing the issue (similar to bothsideism in journalism, where equal journalistic attention is given to 'both sides' of a fabricated scientific debate despite overwhelming scientific consensus), thus building consensus on key issues is essential. However, it is imperative to recognise that not all scientific debate around biodiversity loss is denialism. Colleagues can, and should, attempt to correct flawed science through the scientific record, either through new data analyses or rigorous commentary highlighting flaws in published studies [e.g. 4, 49]. This process often takes time and can occasionally be waylaid by power dynamics and confirmation biases inherent in parts of the peer review system. In the meantime, scientists must be supported to speak publicly about any concerns with published data or analyses, without being misrepresented as a 'denier' themselves.

Similarly, denialist campaigns often rely on presenting a false dichotomy in the data, for example, that there are 'winners and losers' of the Anthropocene and treating both groups equally. In reality, there are likely many more species that are 'losers', while some 'winners' may be invasive or pest species that have damaging impacts on ecosystem function and services [15, 50].

Vote counting approaches to synthesis, which tally up the number of papers or data points that do or do not show simplistic categories of evidence, can greatly exacerbate this issue. For example, [51] tallied up the number of studies in which populations were declining or increasing and what drivers of population trends were discussed; however, what is far more important than the number of studies is the direction and magnitude of the effects they report. The main article that led to global popular media coverage of insect decline [46] also used a vote-counting approach and tallied up the number of species within a study that exhibited any negative population trends as a 'rate' of decline, resulting in an inaccurate estimate that 40% of insects were threatened with extinction [4]. This unsubstantiated 'rate of decline' continues to be presented in popular news articles as if it is scientific consensus. These type of vote-counting approaches are akin to 'cherry-picking', also a common tactic in denialism, and must be addressed by the scientific community. Researchers, peer reviewers, and editors must recognize when improper synthesis and meta-analysis approaches have been used and advocate for more robust synthesis, especially for critical issues like insect biodiversity loss.

Here we have highlighted an emerging critical issue that impacts the future of biodiversity science and conservation. Denialism campaigns are proliferating in attempts to discredit science, scientists and the scientific process generally. The spread of mis- and disinformation about the global biodiversity crisis can potentially have wide-ranging impacts on policy, legislation, funding availability, and public understanding and trust of science. Academic systems and institutions, media and policy-makers must play a key role in supporting scientists to combat denialism.

Acknowledgements

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Highlights (3-5 points max 85 characters each)

- Globally, biodiversity loss is impairing ecosystem function
- Insect biodiversity is impacted by multiple anthropogenic and environmental drivers
- Scientific uncertainty about specific trends has been misused in denialist campaigns
- Combatting biodiversity loss denialism is a critical challenge for science