

Letter to the Editor**Towards a more inclusive and diverse invasion biology workforce**

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Citation: Davinack AA (2022) Towards a more inclusive and diverse invasion biology workforce. *BioInvasions Records* 11(2): 307–311, <https://doi.org/10.3391/bir.2022.11.2.01>

Received: 13 February 2022

Accepted: 16 February 2022

Published: 29 March 2022

Thematic editor: Stelios Katsanevakis

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OPEN ACCESS**Abstract**

The future of invasion biology, like any other science, is dependent on its ability to successfully recruit and train the next generation of scientists. A major obstacle in accomplishing this goal is the lack of inclusivity in the field, which has historically maintained a monolithic and relatively homogenous workforce. Here, I provide three action-items, which can be deployed to help diversify the field of invasion biology: (i) diversify the gatekeepers, (ii) secure representation and (iii) contextualize and reframe terminology. The problem of invasive species has an extensive global reach and therefore it is only logical that the demographics of the invasion biology community should reflect this.

Key words: decolonization, STEM, education, ecological

As a significant driver of anthropogenic-mediated ecological change, invasive species pose one of the greatest threats to global biodiversity. It is therefore not surprising that the discipline of invasion science has grown tremendously since its founder Charles Elton first codified the science in his 1958 publication, *The ecology of invasions by animals and plants* (Elton 1958). Despite misinformed scientific and epistemological arguments aimed at the field (Clark 2006; Guiasu and Tindale 2018; Sagoff 2020), the largely negative ecological and economic impacts of invasive species are real, and are expected to be modulated by another equally pressing threat; climate change. Invasion science is unique because it deals specifically with studying contemporary ecological changes that are dynamic and involves varying levels of uncertainty that must be incorporated into the tools and models used to assess the changing system. However, like any ecological subfield, invasion science also has a strong social component because it must take into consideration the relationship between humans and their environment and also incorporate how humans perceive these changes. For example, many species, both terrestrial and aquatic have been translocated across the globe into vastly different biogeographic regions from where they originated. For introduced species that have managed to survive, thrive, and become established, their presence has often been met with mixed attitudes by public stakeholders. For example, some

communities understand the negative environmental impacts that these species have on local fauna and aid scientists with their eradication efforts (e.g. water milfoil in the Adirondack region of New York) but other communities may view these species in a positive light and may even hinder management efforts, e.g. the case of the ruddy duck in the UK (Kapitza et al. 2019 and references therein). Invasion science therefore has multiple levels, which must be engaged with synergistically for practical solutions to emerge. This requires a scientific workforce that is diverse and multi-faceted as the problems that the science addresses. Such a workforce would ideally be “borderless” and represented by a network of globally connected researchers from different countries, and from each country the workforce would be represented further by a variety of demographics in terms of gender, ethnicity, sexual orientation, and any other relevant cultural demarcations. In other words, the demographics of the workforce must reflect the community that they serve, yet, as anyone who has attended an invasion science conference will tell you; this ‘ideal’ workforce is very far from reality.

Invasion science is plagued by the same diversity issues that faces many of its sister fields in Science, Technology, Engineering and Mathematics (STEM). For example, a recent self-study by the journal *Biological Invasions* found that more than 75% of its editorial board were from ‘high-income’ nations (almost 50% coming from the United States), 85% identified as white, more than 60% identified as male, and more than 70% chose English as their first language (Kuebbing et al. 2021). Such a monolithic composition has been reported in other environmental science fields including the broader ecological sciences and geosciences. The Ecological Society of America, for instance, reported in 2015 that the ethnic diversity of its membership was only 9% (Beck et al. 2014). Within the United States, which invests the most capital in scientific research and development than any other nation (USD \$612 billion – OECD), underrepresented minorities (URMs) make up only 9% of faculty in the academic doctoral workforce (National Science Foundation 2019). This lack of diversity has traditionally been attributed to the ‘leaky’ STEM pipeline where students somehow are ‘lost’ or intentionally exit the scientific training process (grade school → university → professional scientist). The cause of this leaky pipeline has been attributed to several factors, one of which includes systematic racism within the scientific enterprise and reluctance or slowness to address the problem at the institutional level, both of which create a feedback loop that further exacerbates the problem (Schell et al. 2020; Miriti 2020). In this letter, I briefly outline three recommendations towards diversifying the invasion biology workforce. These are not long-term investments that require extensive bureaucratic wrangling and monetary investments, but actionable items that are relatively easy to implement as long as the issue of inclusion is regarded as a priority for this field.

(i) Diversify the gatekeepers

As mentioned earlier, the editorial boards of our journals are monolithic which is problematic, considering that the problem of biological invasions has far reaching global implications. Applying the Kuebbing et al. (2021) self-survey to *BioInvasions Records*, we found that 83% of our editorial board identified as white, 64% identified as male and 34% chose English as their first language (N = 74; 95% response rate). With the exception of language diversity, these demographics are similar to that of *Biological Invasions*. Actively recruiting underrepresented minorities (URMs) to editorial boards and executive committees should be considered a priority in making invasion biology more inclusive. URMs can help shape the field in a positive manner since they can contribute unique perspectives to complex studies that has multiple dimensions (e.g. studies which integrate research, management and public outreach/citizen science). In return, URMs can use this experience to help them guide the next generation of researchers as they begin preparing and submitting their first manuscripts and begin actively participating in scientific societies.

(ii) Secure representation in courses, societies and at conferences

Intersectional representation (one that incorporates racial, ethnic and gender representation) matters and is an important step in diversifying the invasion biology workforce. Representation helps shape the self-image of URMs early in their careers because it is psychologically easier to overcome resistance and barriers if one can “see” themselves represented in positions of authority (Ijoma et al. 2021). This type of representation must be implemented at every level from K-12 to university, where aspiring scientists can see teachers, lecturers and mentors that they can identify with. In addition, rather than only presenting the ‘canonical’ scientists associated with certain discoveries and theories, educators should also consider highlighting the pioneering work of current URM researchers who are building upon and in some cases, even re-conceptualizing those theories. Special sessions that highlight the work of URMs at invasion science conferences would also greatly aid in developing and fostering collaborative networks. Equally important is diversifying the group of keynote speakers at the larger international conferences, which provides an additional level of representation for early career researchers (specifically doctoral students and post-docs). At the last three major conferences on biological invasions (Neobiota, International Conference for Aquatic Invasive Species and International Conference on Marine Bioinvasions), there were no keynote speakers of color represented.

(iii) Contextualize and reframe terminology

Invasion biology has often been criticized for its terminology which some argue possesses nativist undertones that harken back to darker periods in

history, with some linking it to actions carried out by Nazi scientists, such as the fervent attempts by botanists of the third reich to eliminate non-indigenous plants from Germany (Sorvig 1994, but see Uekotter 2007 for a more nuanced discussion of the topic). Terms such as “alien” and “non-native” when coupled with the notion of “eradication” does indeed seem to reflect xenophobic sentiments. Altering the terminology of an entire field and ensuring compliance at the peer-review stage is not an easy feat. Fortunately, we are now seeing an inkling of change occurring in the broader zoological community, such as recent efforts to rename racist and offensive common names of organisms (Driver and Bond 2021; Chen-Kraus et al. 2021). The problem is a bit more complicated in invasion biology because terminology plays a particularly important role in communicating basic concepts and processes associated with invasions (Rejmanek et al. 2002; Richardson et al. 2011; Robinson et al. 2016). Both Larson (2005) and Davis (2020) offer potential solutions to this problem. Larson (2005) suggested abandoning the militaristic language used when discussing invasions and instead focusing on metaphors and words that are associated with ecosystem health and stability – essentially borrowing language from restoration ecology. Davis (2020) originally suggested including perspectives from the social sciences and humanities as a means of addressing “invasive species denialism” (a charge which has been leveraged primarily by social scientists). Interestingly, not only would such voices provide different perspectives on the technical and philosophical aspects of invasion biology, but they may also help provide some much-needed strategies on making the field more inclusive, since the roots of anti-racism and de-colonization originated in the social sciences.

We are at a crucial turning point in the world where societies are grappling with not only environmental problems but also the emergence of social unrest. As a result, a diverse group of voices in the scientific workforce, reflecting the multicultural globalized world we live in, is needed now more than ever to address the myriad of issues. *BioInvasions Records* publishes the results of biomonitoring surveys and rapid dissemination of new species occurrences in areas where they have been previously absent. Some of these sampling areas are located in remote regions of the world in places where local knowledge can play a significant role in confirming the results of such studies. A multicultural team of researchers will more likely form deeper connections with local scientists and laypersons from these communities. Another more obvious benefit is a general one; more diverse research teams are more likely to produce more diverse solutions to problems than homogenous ones (Page 2007). In closing, I hope that this letter at the very least, sparks the necessary conversations among researchers at conferences and in laboratories and hallways at various institutions. There will obviously be detractors and those who disagree that there is a diversity problem in invasion science and

their opinions should also be included in the wider discussion, because solving this issue will require a *bona-fide* consensus within the invasion science community, not just a group of socially-conscious researchers “preaching to the choir”.

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