Taxonomic bias and lack of cross-taxonomic studies in invasion biology

Peer-reviewed letter

Invasion biology is the study of non-native species and their introduction to – as well as potential establishment, spread, and impact within – exotic ranges. Although the concepts of invasion biology are applicable across taxonomic boundaries, Pyšek *et al.* (2008) reported a strong taxonomic bias in the discipline. Such a bias is critical; if scientists study a biased subset of species, or disregard some taxa altogether, then important differences among taxa may be overlooked, thereby leading to incomplete or inaccurate generalizations. Here, we extend the work of Pyšek *et al.* (2008) by investigating whether the taxonomic bias in invasion biology has changed over time. Although past articles on non-native species may have focused on only a few groups of organisms, the field may have since become less taxonomically biased; we test this hypothesis on the basis of a systematic literature search using Thomson Reuters Web of Science. We also examine articles that consider non-native species of *multiple* major taxonomic groups, assessing whether such cross-taxonomic articles have become more frequent over time. We present results for (1) articles about non-native species in general and (2) empirical studies focusing on six of the discipline's major hypotheses – biotic resistance, island susceptibility, invasional meltdown, novel weapons, enemy release, and the tens rule (see WebPanel 1 for details) – which can be applied to organisms of different taxonomic groups.

Of the investigated articles, most focused on plants, followed by vertebrate and invertebrate animals; few studies examined other taxonomic groups (Figure 1; cf Pyšek *et al.* [2008] who analyzed articles published until mid-2006). This taxonomic bias appears to be relatively stable since the late 1980s. Articles on plants were more dominant in the 1970s than today but, at that time, publications on non-native species were rare. The total number of publications per year about non-native species has been rising through time (Richardson and Pyšek 2008; Kühn *et al.* 2011). Plant-associated taxonomic bias detected in invasion biology in general was found to be more pronounced for certain hypotheses (biotic resistance, novel weapons, enemy release), less pronounced for others (invasional meltdown, tens rule), and even reversed for one hypothesis where most studies have focused on vertebrates (island susceptibility; however, this hypothesis is the one affiliated with the fewest studies; Figure 2).

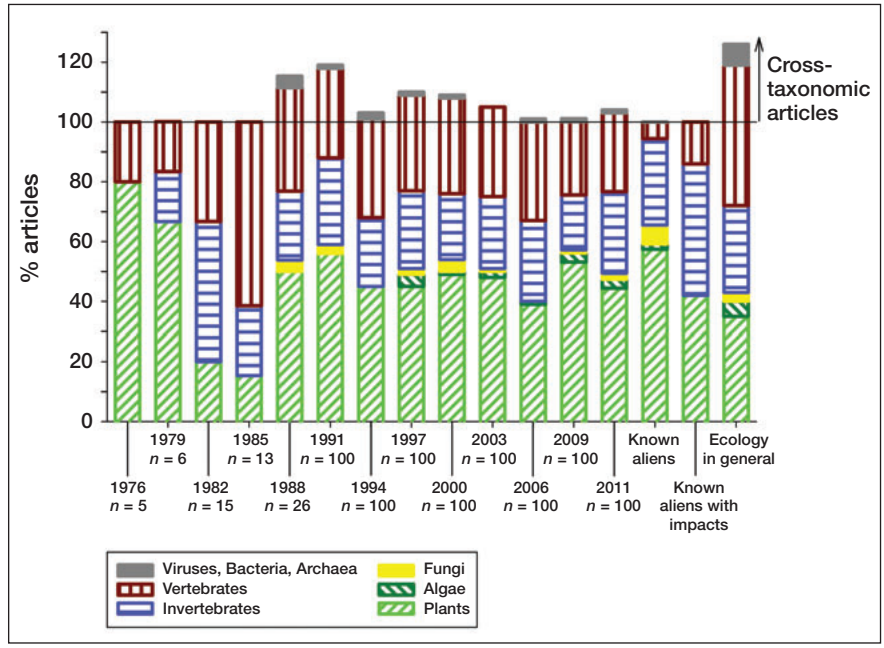

Figure 1. *Percentage of articles about non-native species of different taxonomic groups published between 1976 and 2011 (in intervals). Percentages that add up to more than 100% are due to cross-taxonomic articles that cover at least two of the given taxonomic groups. The percentage above the line can thus be used as a cross-taxonomic index. The three right-most bars are shown for comparison. For more information, see WebPanel 2.*

The main reason why non-native plants are studied more frequently than other non-native species is probably because most known non-native species are plants. Considering the large number of recognized non-native plants in Europe, for instance, this taxonomic group indeed seems to be understudied (Figure 1; cf Pyšek *et al.* 2008). Conversely, abundance estimates of other non-native taxa (eg algae, fungi, bacteria) are unavailable because of the paucity of studies about such organisms. One concern is whether numbers of known non-native species are the cause or consequence of observed differences in research across taxonomic groups. Also, although there are many non-native plants, the percentage of *harmful* non-native plants is relatively low compared with other taxonomic groups. According to Vilà *et al.* (2010), only 5.6% of non-native terrestrial plants in Europe have ecological impacts, as compared with 30.4% of non-native terrestrial vertebrates. With regard to absolute numbers of species with ecological impacts, non-native terrestrial invertebrates outnumber non-native plants (Figure 1). These are strong arguments for conducting biological invasion research that is less taxonomically biased.

If results from one taxonomic group could simply be extrapolated to another group, then the best strategy would be to focus research on a taxonomic group where it is most cost-effective. This extrapolation is not possible, however, because of taxonomic differences in (1) the impacts

of invaders, (2) introduction pathways (Hulme *et al.* 2008), or (3) the level of support for major invasion hypotheses (Jeschke *et al.* 2012).

Our results also show that cross-taxonomic articles – although comprising a greater proportion of articles published in ecology as a whole – are rare in invasion biology and have not increased over time (Figure 1). Studies focusing on leading invasion hypotheses – except those on invasional meltdown, which regularly investigate positive interactions between invaders of different taxa – rarely cover more than one major taxonomic group (Figure 2). While vital for exploring the possibilities and limitations of synthesis across taxonomic groups (Blackburn *et al.* 2011), cross-taxonomic studies are also critical for both informed policy and effective management actions against harmful non-native species. Given that plants, animals, and other organisms (eg viruses, bacteria, fungi) are not invading ecosystems separately, management decisions should consider these invaders simultaneously (Carrasco *et al.* 2010). When taxonomic borders are crossed and knowledge is exchanged across these borders, redundant research in "invasion botany" and "invasion zoology" is avoided, and invasion biology becomes truly unified.

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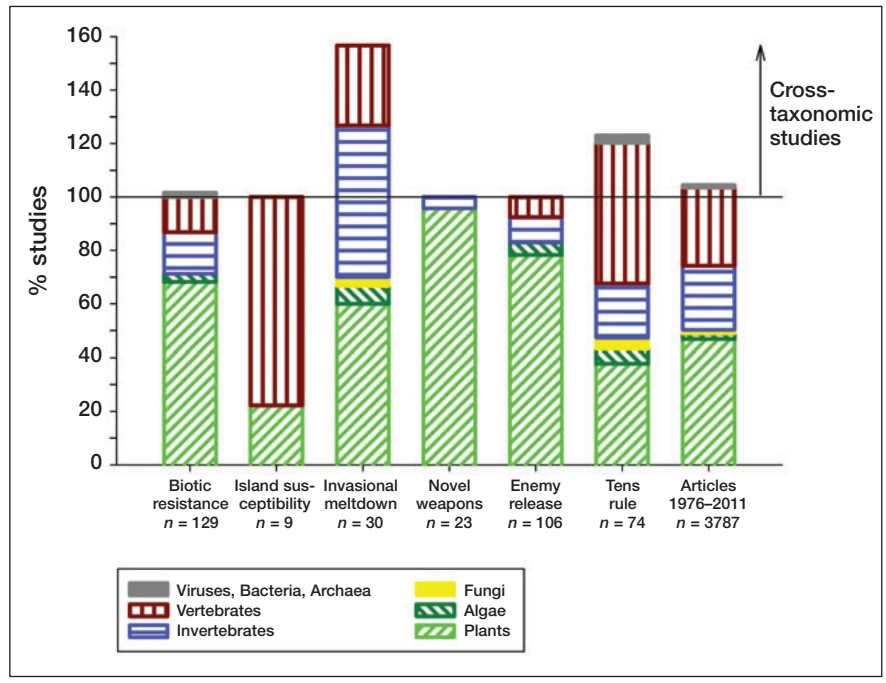

Figure 2. *Same as Figure 1, but considering empirical tests (published until early 2010) of six major hypotheses in invasion biology. For comparison, a bar for articles about non-native species published between 1976 and 2011 is shown as well. This bar is based on percentages provided in Figure 1. For more information, see WebPanel 3.*

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