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# Birds as key vectors for the dispersal of some alien species: Further thoughts

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## Abstract

W. Solarz, K. Najberek, A. Pociecha & E. Wilk-Woźniak (2017, *Diversity and Distributions*, **23**, 113–117) published a letter in *Diversity and Distributions* debating our view that waterbirds are important vectors of alien species (C. Reynolds, N. A. F. Miranda & G. S. Cumming, 2015 *Diversity and Distributions*, ***21***, 744–754; A. J. Green, 2016 *Diversity and Distributions*, ***22***, 239–247) and question whether future research into the mechanisms under-pinning this phenomenon can be advantageous for the practical management of alien species. Additionally, Solarz et al. suggest that human activities are the primary source of all alien species introductions and that waterbirds may only act as vectors of secondary dispersal. In this letter, we respond to several arguments raised by the authors surrounding the relevance of waterbird-mediated dispersal in the introduction and spread of alien species. We emphasize the partly deterministic nature of waterbird dispersal and the significance of long-distance dispersal events (and hence the potential for primary introductions of new alien species across political boundaries). Finally, we reaffirm the importance of further research into dispersal by birds to improve our capacity to foresee and manage invasions of those alien species with strong capacity to spread via avian vectors.

**KEYWORDS**

alien species, biological invasions, dispersal vectors, invasion pathways, invertebrate, long-distance dispersal, multi-scale, waterbirds

## 1 | INTRODUCTION

Two recent papers (Green, 2016; Reynolds, Miranda, & Cumming, 2015) presented strong evidence that waterbirds facilitate the introduction, establishment and spread of some alien plant and invertebrate species. We thus highlighted the need for further research to improve our understanding of this invasion pathway. Solarz, Najberek, Pociecha, and Wilk-Woźniak (2017) questioned this conclusion and suggest that new research into the dispersal of alien species by waterbirds will unfortunately contribute little to the management of alien species. Their main viewpoint is that all alien species are introduced primarily by humans, with birds acting solely as secondary dispersers. They strongly advocate adherence to the three-stage hierarchical approach recommended by the Convention on Biological Diversity (CBD) on invasive alien species management and emphasize that understanding non-human dispersal pathways will likely not improve prevention on the introduction of invasive alien species.

Continuing this interesting discussion, we will respond by (1) detailing and addressing each of their major arguments, and (2) reaffirming the importance of further research into dispersal of alien species by waterbirds.

## 2 | DETAILING AND RESPONDING TO THE ARGUMENT

The argument of Solarz et al. (2017) has three key points. First, they propose that the dispersal of alien species by waterbirds is highly stochastic. Specifically, they suggest that these interactions are not species specific and that dispersal arises through casual interactions

  

between the vector and the dispersed organism where an alien species atypically hitchhikes onto a bird. Second, Solarz et al. maintain that the dispersal of alien species by waterbirds is only relevant in the context of secondary dispersal. They suggest that primary introductions brought about through long-distance dispersal (LDD) events of alien species by native birds are perhaps non-existent. Furthermore, Solarz et al. state that the only situation in which a bird movement would be considered a primary pathway of alien species introduction is if the dispersing bird itself was an alien and bought a new alien species into its destination region. Third, although there are as yet few detailed studies of alien species dispersal by waterbirds, Solarz et al. conclude that further research into the mechanisms underpinning this phenomenon will likely not aid our ability to practically manage alien species introduction and spread. They propose that managers do not need to consider avian pathways, or any other pathway classified as "unaided" under the Convention on Biological Diversity (CBD), because doing so would likely be too challenging to implement and/or would provide no practical benefits to alien species management. Solarz et al. therefore advocate that the primary management response should be focussed on limiting the introduction and establishment of potential hitchhikers through human activities, such as shipping and angling.

In the next paragraphs, we respond that (1) there is evidence that suggests that seed dispersal by waterbirds is not entirely stochastic, (2) long-distance dispersal events by native waterbirds could act as a source of primary introduction, and that (3) improved knowledge of dispersal pathways facilitates the adoption of a wide range of appropriate, non-lethal response options (ranging from direct management through to education).

Point 1: Avian dispersal of alien species is not adequately represented as "hitchhiking" through "casual links". In addition to the widely recognized and more intensively studied mutualisms between frugivores and alien plants with a fleshy fruit, which we acknowledged in our reviews, there are other widespread mutualistic dispersal relationships. Waterbirds readily prey on invertebrates while dispersing the resting eggs within them, or feed on seeds, a proportion of which survive and may show increased germination rates post-ingestion (Brochet, Guillemain, Gauthier-Clerc, Fritz, & Green, 2010; Reynolds & Cumming, 2016a). In addition, many waterbirds have predictable movement patterns, particularly in relation to seasonal migrations and moult migrations (Green, Figuerola, & Sánchez, 2002; Ndlovu, Cumming, Hockey, Nkosi, & Mutumi, 2013). Furthermore, seed dispersal by gulls is a well-documented phenomenon (Calvino-Cancela, 2011; Green, Brochet, Kleyheeg, & Soons, 2016) that should not be dismissed as a kind of "contamination". Dispersal of alien species by birds is largely a deterministic process; hence, more research will help us to improve our predictions of alien species spread and identify areas that are susceptible to invasion (Buckley, 2008). To give one example (see Reynolds et al., 2015 and Green, 2016 for more), focused research has shown that marsh-inhabiting alien buttonweed *Cotula coronopifolia* (Asteraceae) is a preferred food plant for ducks in California (Casazza, Coates, Miller, Overton, & Yparraguirre, 2012) and that it is dispersed by ducks in Australia (Raulings, Morris, Thompson, & Mac Nally, 2011); hence, it can be predicted that its ongoing expansion in Europe is also related to waterbird movements. New observations from the UK support this (AJG, A. Lovas-Kiss and D.M. Wilkinson unpublished data).

Point 2: Bird species that are long-distance migrants can readily disperse alien and native taxa over huge distances that can exceed 1,000 km, as demonstrated by modelling (Viana, Santamaría, & Figuerola, 2016). The ways in which aliens can be introduced depends critically on the position of the migratory flyways. Thus, while birds are not likely to move alien species between the Old World and the New World, their migrations can readily facilitate the dispersal of aliens, for example between North Africa and Europe, between Australia and Asia, or between the UK and continental Europe, all of which can potentially be considered as "primary" introduction events. Field studies we documented (Green, 2016; Reynolds et al., 2015) repeatedly demonstrate dispersal of alien species by shorebirds, geese, ducks and other waterbirds that are long-distance migrants, as shown by contrasting the breeding and wintering distributions of the species. Such birds can lead to the introduction of alien species at sites well away from hotspots of human activity. We do not foresee a major role for *alien* birds as vectors of primary introduction, especially when excluding microbes in this context. Like native birds, alien birds could be vectors of alien species with which they interact in their new environments (e.g., Simberloff & Von Holle, 1999), but generally native waterbirds will be more important than alien waterbirds owing to their much greater abundance and higher tendency for long-distance migration (see Best, 2008 for an exception).

While introduction of new alien species by waterbirds is certainly less common than human-mediated dispersal and the spread of already introduced alien species via secondary dispersal, we maintain that given current threats to biodiversity, the role of waterbirds in introductions of some alien species should be considered. To deny a role for waterbirds in the potential primary introduction of alien species is to deny their major role in LDD and biogeography of native species, which has been broadly accepted since it was recognized by Darwin (Green et al., 2016).

Point 3: Finally, we agree with the statement that "stopping primary introductions of new alien species and preventing their establishment" are the two most important conditions for avoiding further spread of alien species. However, acknowledging a role for birds as vectors of novel alien species and undertaking rigorous research into avian dispersal do help us to comply with both conditions. Thus, our proposal for further research is not incompatible with the CBD approach to invasive species control. The CBD urges the identification and quantification of the pathways of alien species introduction to manage them properly. One of the recognized pathways is the transportation of alien species as a contaminant on animals.[1] Therefore, identifying the alien species that can be introduced and effectively spread by waterbirds is particularly important and requires much more research. Ignoring birds can lead to bad management by focusing only on human pathways for species that can cross frontiers via birds.

[1]UNEP (2014) Pathways of introduction of invasive species, their prioritization and management. UNEP/CBD/SBSTTA/18/9/Add.1, Subsidiary Body on Scientific, technical and Technological Advice, Eighteenth Meeting, Montreal.

## 3 | REAFFIRMING THE NEED FOR FURTHER RESEARCH

The existing research demonstrates that waterbirds are more important as vectors for some alien species than others, but one major reason for further research is that our current ability to predict *which* species are readily dispersed is limited and inadequate. We know that alien plants with particularly large seeds are unlikely to be dispersed by waterbirds (Soons, Brochet, Kleyheeg, & Green, 2016). Furthermore, recent research has identified 13 alien plants previously unknown to have been dispersed by waterbirds in South Africa (Reynolds & Cumming, 2016b), and the Khakiweed, *Alternanthera caracasana* (Amaranthaceae), stands out for its particularly high rates of dispersal. Important variation in the capacity to disperse by birds is also apparent for alien invertebrates, and those with resistant resting eggs have a clear advantage. Reynolds et al. (2015) reviewed the breadth of evidence showing that alien brine shrimp *A. franciscana* disperse long distances with particular ease inside shorebirds. Additionally, research into dispersal of native species (Green, Frisch, Michot, Allain, & Barrow, 2013; Reynolds & Cumming, 2015) suggests that alien bryozoans, ostracods and cladocerans will also be spread readily by waterbirds.

We see further research on the role of waterbirds in species invasions as vital to improving manager awareness and facilitating management actions. We do not foresee this science and management agenda and the hierarchical approach of the CBD as conflicting, but rather advocate for the continuation of evidence-based policymaking to aid management decisions. Additionally, our proposed avenues for research feedback to several levels of the CBD framework. For example, research and education to create expectations of what waterbirds may introduce to wetlands help managers to be prepared, allowing them to look out for problem species on wetland shorelines and remove them before they become a major problem. Identifying the bird species involved in alien species spread and quantifying key input variables helps to model the alien expansion facilitated by birds (Viana et al., 2016). This knowledge can be fed directly to management by helping to identify the most effective measures to prevent establishment of new species within a political unit (e.g., through identifying key sites for monitoring work in anticipation of arrival of alien species). Additionally, it can avoid investment of limited resources into lost causes, helping to select areas where management efforts could be concentrated. For example, for aquatic species shown to have a strong capacity to disperse by waterbirds, there is less point investing in monitoring sites of human leisure activities such as fishing and implementing measures to clean tackle and boots. Alternatively, such an investment can be prioritized for aliens with limited abilities to spread via birds. For likely future invaders identified by horizon scanning initiatives, it is particularly important for potential avian pathways to be investigated. For agricultural investment, it may be beneficial to identify alien weeds that disperse most readily by migratory waterfowl, for example, as this would allow prediction of rates of geographical spread of genotypes that are resistant to new herbicides. Finally, birds can facilitate the movement of biocontrol agents to a broader wetland network (Reynolds et al., 2015), a potential management solution requiring dedicated research.

Ignoring unconventional possibilities for alien introductions and establishment can lead to unexpected failure of management actions. We encourage readers to embrace further research into avian pathways of alien species. Fortunately, new research is continuously expanding our knowledge about which aliens are being dispersed by waterbirds on a regular basis (e.g., Reynolds & Cumming, 2016b; Soons et al., 2016).

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## AUTHOR CONTRIBUTIONS

C.R., G.S.C., M.V. and A.J.G. conceived the ideas. C.R. and A.J.G. led the writing.

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