diversity

MDPI

Editorial

Biological Invasions 2020 Horizon

Elsa Bonnaud

AgroParisTech, Ecologie Systématique Evolution, Université Paris-Saclay, CNRS, Orsay 91405, France; elsa.bonnaud@universite-paris-saclay.fr

Received: 7 February 2020; Accepted: 8 February 2020; Published: 18 February 2020

Abstract: This special issue points to the necessity to continue actively working on biological invasions, as invasive species remain a main and global threat for biodiversity through a global homogenization process. This issue includes six research papers, covering a large range of taxa, studying new invasive processes and proposing innovative management solutions. The way forward will be to continue working in close relation with other stakeholders and decision-makers, increase communication efforts, solicit societal feedback, and quickly implement consistent legislation.

Keywords: alien species; human-mediated ecosystems; global changes; biodiversity homogeneisation

The 2020 year began with a series of catastrophic events that reminded us of our considerable anthropogenic impact, particularly on climate and biodiversity, and how it has the potential to spin out of control. In this special issue, we focus on one of the major threats contributing to the general biodiversity crisis: biological invasions. To begin, even in specialized scientific issues, it is always necessary to define the terminology, especially since this is one of the first issues on biological invasions [1]. Currently, there is a general consensus that an invasive species is an introduced species that is widely spread (invasive biological traits) and can cause negative impacts (i.e., ecological, economic, health), although other aspects of biological invasions such as human-induced introductions or the magnitude of species spread and impact remain debated. In addition, many other difficulties are prone to emerge when dealing with biological invasions, for example: (i) understanding the specificity of each case, (ii) supporting management actions that may impact indigenous species, (iii) implementing costly actions, and even (iv) alerting the public about complex and diverse processes [1]. These difficulties add complexity to the management of invasive species, bringing about a global societal view of invasive processes, impacts, and consequences.

Such difficulties are illustrated in this special issue dedicated to biological invasions, which seeks to demonstrate the diversity and complexity of this threat that affects numerous taxa, habitats, geographical scales, and organizational levels of biodiversity (from genetic diversity to ecosystems) and to study the topic by means of biology, ecology, evolution, mathematics, biogeography, and more. In addition, biological invasions are often case-specific, as few attempts succeed in devising general rules using standardized management choices/decisions. Some (if not most) invasions can be linked to strong human values, human–commercial choices, and even political and societal outcomes. Consequently, this calls for precautions, explanations, and co-constructed management practices, which should be decided, accepted, and implemented in line with societal approaches. In this respect, the humanities and social sciences are the keys to better addressing this global, ecological, and societal concern. In this issue, we seek to emphasize new invasive processes and innovative management solutions.

It is still discouraging to state that there is "no saturation in the accumulation of alien species worldwide" [2]—even if alien does not mean invasive here—indicating that we are still unable to mitigate future invasions. Even if it were possible to conduct and successfully apply scientific research, management actions, and political decisions to reduce the population extinctions caused by invasive species [3–8], the drastic increase in species introductions due to rising globalization should be tackled

as a priority to preserve Earth biodiversity. Recently, scientists observed and demonstrated the premise of the sixth extinction, or current biodiversity crisis, along with habitat homogenization and the subsequent loss of ecological functions, notably due to invasive species [9–12]

Most species introductions are dependent on human movements and activities, and this trend is even more accentuated when focusing on invasive species [13]. As Hima et al. [14] showed, new research and work on the study and management of invasive species should take into account these human-mediated invasive "routes" (e.g., trade routes, tourism, national and international exchanges) as well as invasive hotspot "nodes" (e.g., airports, harbors, postal hubs, main cities, urban centers) to better understand the dynamics of invasive species, community composition, and species turnover. Focusing on routes and nodes is crucial in order to limit the "introduction flow," because preventing introductions is less time- and money-consuming than controlling established invasive species: the best strategy is to fix the leak rather than remove the water.

The recent exponential increase in the pet trade (Kopecky et al [15]) and the technical improvements in aquaculture to enhance productivity (Anae-Taabeah et al. [16]) have significantly contributed to increasing both the invasion rate and risk. Kopecky et al. focuses particularly on the importance of studying, listing, and ranking biological species traits to better prevent the transportation and subsequent introduction of species with a high risk of invasiveness. This new research area on biological traits should be encouraged and further developed in the near future. Anae-Taabeah et al. raise the more recent concern of disturbing biodiversity not only at the community and population levels, but also at the genetic level by the interbreeding of closely related species (e.g., introgression, hybridization). Thus, scientists, managers, and entrepreneurs should pay particular attention to these new developments in human activities, which specifically increase the spread and impact of biological invasions.

Dimitriou et al. [17] make innovative use and analysis of global genetic databases to better understand the various factors relating to invasive dynamic processes (origin, number of introduced individuals, frequency of introduction) and routes (ballasts, ornamental trade). This knowledge will allow scientists, managers, and entrepreneurs to propose, develop, and execute better management options to reduce the risk of invasiveness or limit the spread of new or even former invasive species.

Although we can study and manage invasive species without considering social values, social perceptions and societal concerns are important aspects that should be integrated into the study of biological invasions. Atlan and Udo [18] propose the concept of an invasive niche, which takes into account both the natural and social parameters that "allow a species to be considered invasive in a given socio-ecosystem." This idea considers the diverse components of socio-ecosystems that allow scientists, managers, and decision-makers to better link ecological and biodiversity requirements to social and cultural values.

In my view, the main issue and challenge that we are facing in the 21st century relate to limiting the homogenization of biota in order to maintain most of the ecological functions, processes, and species interactions. Morri et al. [19] stress this aspect, namely that the presence of invasive species generally induces biotic homogenization, even if the invasive processes are context-dependent. Invasive spread decreases native species abundance and/or richness, which can, in turn, accelerate invasions.

First, it is urgent to limit new introductions, especially of species with known invasive characteristics. Second, management actions should gain in effectiveness (gathering feedback) and identify priorities based on clear criteria such as the number of impacted species, the loss of genetic biodiversity, and the dispersal ability of invasive species. In addition, we should encourage actions to promote the use, commercialization, and interest in native species to counterbalance the spread of exotic species by drawing on all the available levers: ecological, human, and legislative. In other words, as scientists, we should continue working in close relation with other stakeholders and decision-makers to better implicate society as a whole, increase communication efforts, solicit societal feedback, and quickly implement consistent legislation. This more integrative approach to research will help us to better understand, adapt, and apply future legislation, which should not be viewed as

a restriction of freedom but rather as a measure to preserve Earth biodiversity, ecological functions, and human well-being.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Courchamp, F.; Fournier, A.; Bellard, C.; Bertelsmeier, C.; Bonnaud, E.; Jeschke, J.; Russell, J. Invasion Biology: Specific Problems and Possible Solutions. *Trends Ecol. Evol.* **2017**, *32*, 13–22. [CrossRef] [PubMed]
2. Seebens, H.; Blackburn, T.; Dyer, E.; Genovesi, P.; Hulme, P.; Jeschke, J.; Pagad, S.; Pyšek, P.; Winter, M.; Arianoutsou, M. No saturation in the accumulation of alien species worldwide. *Nat. Commun.* **2017**, *8*, 1–9. [CrossRef] [PubMed]
3. Decision VI/23 of Convention on Biological Diversity. Available online: https://www.cbd.int/decision/cop/?id=7197 (accessed on 7 April 2002).
4. EU Regulation 1143/2014 on Invasive Alien Species. Available online: https://ec.europa.eu/environment/nature/invasivealien/index_en.htm (accessed on 1 January 2015).
5. Brenton-Rule, E.; Frankel, S.; Lester, P. Improving management of invasive species: New Zealand's approach to pre- and post-border pests. *Policy Q.* **2016**, *12*, 17–25. [CrossRef]
6. Hoffmann, B.D.; Luque, G.M.; Bellard, C.; Holmes, N.D.; Donlan, C.J. Improving invasive ant eradication as a conservation tool: A review. *Biol. Conserv.* **2016**, *198*, 37–49. [CrossRef]
7. Jones, H.P.; Holmes, N.D.; Butchart, S.H.M.; Tershy, B.R.; Kappes, P.J.; Corkery, I.; Aguirre-Muñoz, A.; Armstrong, D.P.; Bonnaud, E.; Burbidge, A.A. Invasive mammal eradication on islands results in substantial conservation gains. *Proc. Natl. Acad. Sci. USA* **2016**, *113*, 4033–4038. [CrossRef] [PubMed]
8. De Brooke, M.L.; Bonnaud, E.; Dilley, B.J.; Flint, B.; Holmes, N.D.; Jones, H.P.; Provost, P.; Rocamora, G.; Ryan, P.G.; Surman, C.; et al. Seabird population changes following mammal eradications on islands. *Anim. Conserv.* **2018**, *21*, 3–12. [CrossRef]
9. Bellard, C.; Cassey, P.; Blackburn, T.M. Alien species as a driver of recent extinctions. *Biol. Lett.* **2016**, *12*, 24–27. [CrossRef] [PubMed]
10. Bellard, C.; Rysman, J.; Leroy, B.; Claud, C.; Mace, G.M. A global picture of biological invasion threat on islands. *Nat. Ecol. Evol.* **2017**, *1*, 1862–1869. [CrossRef] [PubMed]
11. Ceradini, J.P.; Chalfoun, A.D. When perception reflects reality: Non-native grass invasion alters small mammal risk landscapes and survival. *Ecol. Evol.* **2017**, *7*, 823–1835. [CrossRef] [PubMed]
12. Blackburn, T.M.; Bellard, C.; Ricciardi, A. Alien versus native species as drivers of recent extinctions. *Front. Ecol. Environ.* **2019**, *17*, 203–207. [CrossRef]
13. Bellard, C.; Leroy, B.; Thuiller, W.; Rysman, J.F.; Courchamp, F. Major drivers of invasion risks throughout the world. *Ecosphere* **2016**, *7*, 1–14. [CrossRef]
14. Hima, K.; Houémenou, G.; Badou, S.; Garba, M.; Dossou, H.-J.; Etougbétché, J.; Gauthier, P.; Artige, E.; Fossati-Gaschignard, O.; Gagaré, S.; et al. Native and Invasive Small Mammals in Urban Habitats along the Commercial Axis Connecting Benin and Niger, West Africa. *Diversity* **2019**, *11*, 238. [CrossRef]
15. Kopecký, O.; Bílková, A.; Hamatová, V.; Kňazovická, D.; Konrádová, L.; Kunzová, B.; Slaměníková, J.; Slanina, O.; Šmídová, T.; Zemancová, T. Potential Invasion Risk of Pet Traded Lizards, Snakes, Crocodiles, and Tuatara in the EU on the Basis of a Risk Assessment Model (RAM) and Aquatic Species Invasiveness Screening Kit (AS-ISK). *Diversity* **2019**, *11*, 164. [CrossRef]
16. Anane-Taabeah, G.; Frimpong, E.A.; Hallerman, E. Aquaculture-Mediated Invasion of the Genetically Improved Farmed Tilapia (Gift) into the Lower Volta Basin of Ghana. *Diversity* **2019**, *11*, 188. [CrossRef]
17. Dimitriou, A.C.; Chartosia, N.; Hall-Spencer, J.M.; Kleitou, P.; Jimenez, C.; Antoniou, C.; Hadjioannou, L.; Kletou, D.; Sfenthourakis, S. Genetic Data Suggest Multiple Introductions of the Lionfish (*Pterois miles*) into the Mediterranean Sea. *Diversity* **2019**, *11*, 149. [CrossRef]

18. Atlan, A.; Udo, N. The Invasive Niche, a Multidisciplinary Concept Illustrated by Gorse (*Ulex Europaeus*). *Diversity* **2019**, *11*, 162. [CrossRef]
19. Morri, C.; Montefalcone, M.; Gatti, G.; Vassallo, P.; Paoli, C.; Bianchi, C.N. An Alien Invader is the Cause of Homogenization in the Recipient Ecosystem: A Simulation-Like Approach. *Diversity* **2019**, *11*, 146. [CrossRef]