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Edited by Judith S. Weis , Daniel Sol
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1 Introduction

Andrew V. Suarez and Phillip Cassey

Human modification of the Earth has turned ecologists and evolutionary biologists into harbingers of global change and stewards of the planet's remaining diversity. Global change takes many forms including habitat loss and fragmentation, biological invasions, emerging infectious diseases, harvesting/exploiting natural resources at unsustainable rates, pollution and climate change. Moreover, these mechanisms of change are interrelated, each increases the impact of the others. If we do not take immediate measures to reduce the impact of these processes, we will face a new era of mass extinction – the Anthropocene – where global diversity will be replaced by a subset of species whose distribution and persistence is aided predominantly by human transport and activity.

The interdisciplinary field of conservation biology has been recognized as a discipline for over 35 years (Soulé and Wilcox, 1980; Soulé, 1985). However, for its first decade, the role of behaviour in the field was largely restricted to issues related to captive breeding and reintroduction efforts. Empirical and theoretical research in conservation largely focused on the genetics of small populations, viability analyses, community ecology, responses to habitat fragmentation, and measures of diversity and its loss. Over the last 20 years, a number of books and edited volumes have been published that have attempted to fill in the gap created by the omission of behavioural perspectives in conservation (Sutherland, 1996; Clemmons and Buchholz, 1997; Caro, 1998; Gosling and Sutherland, 2000; Festa-Bianchet and Apollonio, 2003; Candolin and Wong, 2011). However, these publications spread their focus across the many stochastic and deterministic processes responsible for species' decline and subsequently often only scratched the surface of how behaviour can be used to manage and mitigate the loss of diversity.

Biological invasions are now recognized as a major form of human-induced global change (Vitousek *et al*., 1996). The implications of biological invasions have been discussed for almost 200 years (since Darwin) and Charles Elton's (1958) seminal contribution laid the foundation for the study of invasive species to be appreciated as its own integrative discipline. As with conservation biology generally, the field of invasion biology has benefited immensely by adding the perspective of behavioural research (Holway and Suarez, 1999; Sih *et al*., 2010; Chapple *et al*., 2012). Behaviour is the mechanistic link that determines how species interact with each other and their environment and is

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therefore essential for understanding why some species succeed in new environments and what impacts they will have once established.

In this edited volume, Daniel Sol and Judith Weis bring together a diverse group of scientists to examine how a careful study of behavioural mechanisms can guide efforts to understand the processes associated with biological invasions including their establishment, spread and impact. These chapters draw from diverse perspectives, ecosystems and taxa, including fish, birds and a variety of terrestrial and aquatic arthropods.

Many chapters examine the role of behavioural flexibility as a mechanism for success across the various stages of invasions. Amy Deakin and Anne Magurran examine how behavioural flexibility facilitates poeciliids to establish and spread in new environments. Jennifer Rehage, Julien Cote and Andrew Sih compare individual variation in behaviour (e.g. personality) between native and invaded habitats in mosquitofish. They also examine how personality traits can promote success through different steps of the invasion pathway (introduction, establishment, spread, impact on community). Andrea Griffin and colleagues examine behavioural flexibility from the perspective of learning and cognition in an introduced bird, the Indian myna. Finally, Ben Phillips addresses the issue of how different behavioural types within populations influence dispersal rates and can potentially cause accelerating rates of spread post establishment.

Invasions provide a powerful unintended experimental system for examining novel species interactions including predator–prey and host–parasite coevolution. Ted Grosholz and Elizabeth Wells, for example, discuss predator–prey recognition with novel assemblies of predators and prey of crabs and whelks, and examine the roles of novel weapons and enemy release in these interactions. Judith Weis reviews the invasion of arthropods in aquatic systems to examine how behavioural mechanisms may allow a novel predator to escape detection by naïve prey, and how novel prey may be avoided by resident predators. She also examines the defensive strategies of introduced prey and the characteristics that may make introduced species particularly effective predators. Andrea Griffin and colleagues use experiments to provide evidence of the importance of learning in avoiding novel predators.

Predation is not the only negative species interaction caused by introductions. Chapters by Jules Silverman and Grzegorz Buczkowski on ants and by Elena Tricarico and Laura Aquiloni on crayfish examine how behavioural traits may influence not only predation but also inter- and intraspecific competition. Invasions also offer unique opportunities to study host–parasite relationships. Steven Juliano and Phillip Lounibos examine the role of invasive mosquitoes as novel vectors of disease. They discuss how both adult and larval behaviours influence interspecific interactions such as predation and competition with other mosquitoes. Sonia Kleindorfer and colleagues question whether behavioural studies can guide efforts to save Darwin's finches threatened by an introduced parasitic fly, which causes high nestling mortality. Tomáš Grim and Bård Stokke use introduced birds to examine the coevolution of brood parasite–host behaviour in novel ecological settings.

Not all species interactions are negative and novel mutualisms may also arise due to species introductions. New links in a mutualism network (e.g. pollination) can have both positive and negative impacts on existing constituent members. Ignasi Bartomeus and

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colleagues write about how introduced plants affect the behaviour of pollinators and the complex impact that this can have in pollinators' webs.

Behavioural processes undoubtedly act synergistically with other mechanisms to determine why some species are successful invaders while others are not. Lynn Martin and colleagues address how physiological and behavioural traits combine to mediate species' invasiveness. Specifically they examine how hormone regulation might influence invasions via plasticity, e.g. modifying a phenotype to match a new environment before evolution has time to act. Mark Albins examines the range of life history and behavioural traits that have facilitated the rapid invasion of introduced lionfish (*Pterois* spp.) in the Atlantic. In particular, the high population growth rates of lionfish are likely influenced by fast growth and early maturation, high fecundity, high fertilization success, high survival of eggs and larvae, and a high capacity for those propagules to travel long distances. These traits are all backed-up by an impressive tolerance to a variety of environmental conditions. Daniel Sol and Joan Maspons ask how examining behaviour together with life history traits can assist our understanding of how species persist in novel environments.

Finally, many authors use behavioural insights to provide key management recommendations for their specific systems and for directing future research on invasion biology more generally. The role of behaviour in facilitating invasions has been overlooked, often, in the study of global biological change. In many cases this has been due to our scientific obsession with quantifying and interpreting the risk-based measures of interspecific invasion success. The result has been that we know much less about the intraspecific traits that influence biological invasions throughout the transitions of the invasion pathway. The chapters in this book on 'Biological Invasions and Animal Behaviour' go a long way towards balancing this ledger.

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