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EDITORIAL Special Issue on Invasive Mammal Species

Non-native invasive mammal species: introduction to a themed issue

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Times are changing, and often we don't realise it. Automation has recently entered the industrial processes, and already a new era of robots is about to begin. The effects cannot yet be assessed, but there will be winners and losers.

The environment around us is changing too, and we, as humans, are responsible for these changes. Our impact on the earth is so deep that it has been formalised in the Anthropocene, a new geological epoch, in which humans are the primary drivers of planetary change. The term has not yet been officially approved by international bodies as a subdivision of geological time, but the debate is open and lively. Atmospheric carbon dioxide; methane, nitrogen and phosphorus concentrations in soil and lakes; radioactive nuclides; and micro-plastics are all possible markers of this epoch. Welcome to the Anthropocene!

Humans are changing ecosystems, resulting in an unprecedented rate of species extinction (De Vos et al. 2015), and we are also moving species around the world at a pace which has never seen before. Some species are lost forever, while some others have become ubiquitous: winners and losers (McKinney & Lockwood 1999). These two processes are strictly connected, since the introduction of new species is among the main drivers of extinction (Bellard et al. 2016).

The number of introductions is growing rapidly, and there is no sign of any decrease (Seebens et al. 2017). Therefore, research on biological invasions, after an initial stasis, has increased exponentially over the last few decades. Invasion ecology was formalised as a discipline with the book published in 1958 by Charles Elton – *The Ecology of Invasions by Animals and Plants* – but it attracted the interest of ecologists only thirty years later. However, the field now grows rapidly and hundreds of papers are published on non-native species every year, mainly to explain the causes and dynamics of species invasions and to document their impacts (Lowry et al. 2013).

A search in the Scopus database using different words indicating non-native species ("introduced species" OR "invasive species" OR "invasive alien species" OR "IAS" OR "alien" OR "non-native"

OR "nonindigenous" OR "invasive") matched with the term "mammal" gave back 1755 papers, with a temporal trend reported in Fig. 1. These results show a step increase in the number of publications on non-indigenous mammals from the 2000s. A similar trend was reported by other authors for all taxa (Richardson & Pyšek 2008, Lowry et al. 2013).

On 9 and 10 November 2018, the Mammal Society organised a symposium in London on 'Non-native Mammals in Great Britain', with the aim to discuss the state-of-the-art on non-native species management, from biosecurity policies to species management. The present Special Issue of *Mammal Review* is the result of those two days of presentations and discussions about present actions and future directions. Seven papers have been selected from those presented in the symposium, while two further invited reviews broaden the topics covered in this issue.

The bulk of the papers focuses on the management of invasive species. Capizzi (2020) presents a review of mammal eradications on the Mediterranean islands. Islands are key areas for the protection of global biodiversity, being home to about 20% of terrestrial species and a disproportionately large number of endemisms (Kier et al. 2009). At the same time, island ecosystems are particularly fragile and they represent contexts where the introduction of new species can have disastrous consequences for native biodiversity (Keitt et al. 2011). Fortunately, we know how to remove species from islands, and eradications have become routine interventions with outstanding results in terms of native species protection (Jones et al. 2016). The work of Capizzi (2020) also reveals intense eradication activity in the Mediterranean islands. While I was reading his paper, I realised that there have been 118 completed mammal eradication projects in the Mediterranean islands, of which 105 (89%) were successful, with great benefits for native species.

On the other hand, in many cases invasive species are so widespread that their eradication is not possible and their long-term management is the only way to mitigate their impacts. This is the focus of the perspective paper from Mills et al. (2020b), which reviewed the management of widespread invasive mammal species on the UK mainland. The authors list five challenges that managers should address for successful long-term management, including co-ordination, stakeholder and community engagement, and evidence requirement. A companion paper from Richardson et al. (2020) presents a systematic review of adaptive wildlife management for the control of invasive non-native mammals and related human-wildlife conflicts. The authors call for a broader adoption of an adaptive approach to species management, so as to increase the efficiency and success of management campaigns.

Other papers deal with species-specific management. Harrington et al. (2020) critically discuss the available data on the status of the American mink *Neovison vison* in Britain. They conclude that it is not possible to assess population trends and the current status of the species. Despite this limitation, Martin and Lea (2020) argue that it is time to join the scattered efforts of many local

control projects into a global plan for eradicating American mink from the British Isles. This would be the largest and most challenging eradication program ever attempted in Europe, comparable only to the strategy for a predator-free New Zealand (Russel et al. 2015).

Another species-specific paper from Mills et al. (2020a) presents the result of the first use of fertility control to manage a free-living feral goat *Capra hircus* population in Europe. Fertility control is often presented as a socially acceptable solution for the eradication of invasive species. However, its application outside confined areas has been very slow. Though applied to a small population, this paper presents an interesting application of this method to the numerical control of feral goats.

The remaining three papers are related to more general topics. Bertolino et al. (2020) review the use of different spatially-explicit models as tools to inform managers and scientists working with species at different invasion stages. Modelling could support the decision process in the screening of priority species for risk-assessment, prevention, and management. However, modelling has seldom been adopted for the management of invasive mammals, and most studies are limited to a restricted pool of species.

McDevitt et al. (2020) focused on the use of genetic tools involved in the management of mammalian invasions globally, considering advantages and disadvantages. Alongside traditional sequencing technologies generally used for monitoring and tracking invasive pathways, new techniques, such as environmental DNA metabarcoding and genome editing, have recently emerged. The technique is moving from the laboratory to the first trials for the eradication of invasive rodents and, although very promising, it raises social and ethical issues (Breed et al. 2019).

Invasive species management decisions, even when based on robust data, an uncommon best-case scenario, always carry with them a certain level of uncertainty. Ward et al. (2020) revise different sources of uncertainty: epistemic, related to the accuracy and precision of measurements, outputs or estimates; and linguistic, arising from poor communication. The authors discuss how to communicate uncertainty in the framework of invasive non-native species management. We can only communicate effectively what we have fully understood, and managers need to realise that uncertainty is part of science, especially in applied ecology and management.

Overall, this Special Issue of *Mammal Review* presents a selection of papers that emphasise some aspects of the invasions process and some attempts to counteract this growing phenomenon. We recognise that only parts of the possible topics are presented and mostly from a British perspective, though with some contribution from Southern European researchers. We hope you will find this issue of *Mammal Review* useful and enjoyable.

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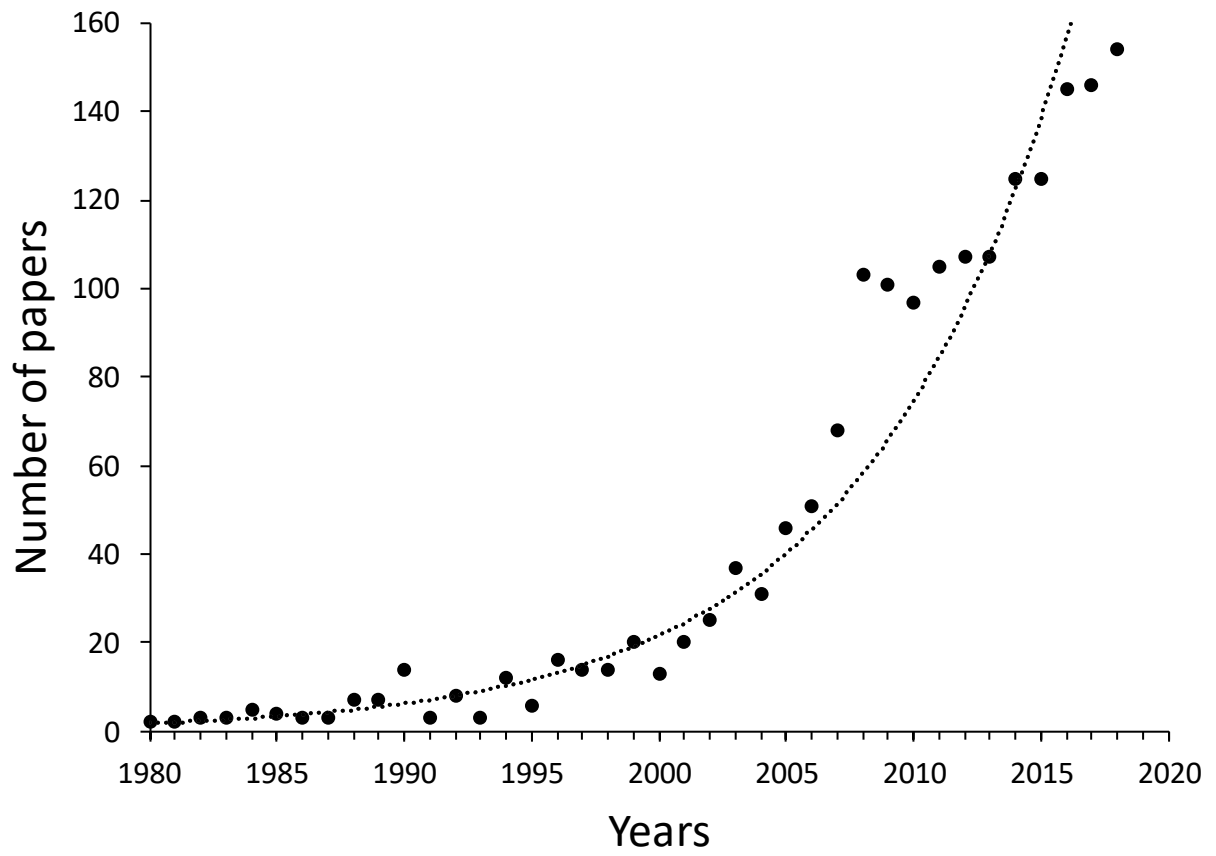
Fig 1. Temporal trend of papers yearly published on non-native mammals.