universität wien

DISSERTATION / DOCTORAL THESIS

Titel der Dissertation /Title of the Doctoral Thesis

„The ecology of alien mammals: distribution, impacts and threats“

verfasst von / submitted by

Lisa Tedeschi

angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Doctor of Philosophy (PhD)

Wien, 2024 / Vienna 2024

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 794 685 437
Dissertationsgebiet lt. Studienblatt / field of study as it appears on the student record sheet:	Biologie / Biology
Betreut von / Supervisor:	Assoz. Prof. Mag. Dr. Franz Essl Prof. Carlo Rondinini (SAPIENZA Università di Roma)

SAPIENZA
UNIVERSITÀ DI ROMA

Department of Environmental Biology

PhD in Environmental and Evolutionary Biology

XXXVI Cycle

PhD thesis

THE ECOLOGY OF ALIEN MAMMALS: DISTRIBUTION, IMPACTS AND THREATS

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Academic Year 2023/2024

Acknowledgments

First, I would like to thank my supervisors Carlo Rondinini and Franz Essl, who built cutting-edge research labs full of beautiful people where I always felt welcome. You believed in me and in this project from the beginning, and you taught me how to be a better researcher in an international environment. Thanks for all the fruitful discussion and feedback. Thanks to César Capinha, who was always a great support when needed. Thanks also to Luigi Boitani, my Master's thesis advisor, for sparkling me with a love for conservation biology.

Thank you to my family; to my mother Daniela, who tries to understand my reasons and accept my desire to pursue research. To my sister Maja, who always makes me feel loved, and my nephew Riccardo and my niece Astrid, for all the good talks and laughs.

Many of my colleagues in Vienna became friends, and I could have never made it here without all their support, counselling, and trust. Bernd, you were my very first friend in Vienna, and I will be forever grateful for how you adopted me in your group of friends. Your door was always open for my vents and problems, and I deeply thank you for your constant support and friendship. Anna, thank you for caring about me and for always being ready to help, at work and in personal life. Tom, the time we spent together was always precious and I cherish every moment and deep talk we had, thank you for those memories. Thanks, Adrián, for making me feel like your little hermana, your affection is invaluable. Jen, thank you for your trust, and for teaching me how to be more communicative and openhearted. Thank you, Michi, for being my buddy and guiding me through Rennweg from the first day. Thanks to all my colleagues in Vienna with whom I shared laughs, boulders, drinks, advice, and lunch breaks: Johannes, Rym, Julia, Agnes, Norbert, Johannes, Elias, Katie, Daijun, Pablo, Gilles, Ekin, Stefan, Ali, Stefan, and Andi.

Carmen, I am so grateful to have your chaotic funny brilliant person in my life. Thank you for always being there to listen to me and cheer me up, even when I am the grumpiest. Marta, thank you for everything we shared in this adventure, from confidences to conferences. Valeria, thank you for your friendship; you are one of the most brilliant people I know, I love how we can talk about patriarchy and poems for hours like we are in Sally Rooney's books. Thank you, Michela, for always believing in me; your strength inspires me, and I am honored to have you as a colleague and a friend. Thank you, Giordano and Davide, for all the vents, laughs, and research discussions we shared, you both have brilliant minds and will be amazing researchers. Thank you, Alessandra, for letting me feel a bit of Rome in Vienna and thank you, Dario, for bringing me a bit of Bologna to Rome. Thank you, Chiara, for showing me what means to have working boundaries and determination. Thanks, Dino, for your great support from the very beginning of this journey; you showed me the path to critical thinking. Many thanks to my fellows with whom I shared part of the path: Claire, Milena, Federica, Alessandra, Lara, Claudia, and Andrea. Lastly, thanks to all the professors of DBBCD who were always available to answer to my doubts: Luigi Maiorano, Luca Santini, and Moreno Di Marco.

Thanks, Ekat, for always supporting me and checking in; I am very grateful for the time spent together and our conversations. Thank you, Chiara and Ruth, for teaching me the basis of living in Vienna: where to find the coolest parties and how to rope climb. Thanks to all my friends who adopted me in their group: Thomas, Jojo, Geli, Manu, Toni, and Nino.

Thank you, Annalisa, for all the deep talks and lucubration, and for always being understanding and staying at my side. Thanks, Benedetta, for letting me into your life and family; you will be a great researcher, and I will miss our breakfasts where we discussed societal collapse before coffee. Thanks, Francesca, for being there for so long and for all the talks, and for sharing with me part of this path and so many adventures.

Chiara and Meri, thank you for never giving up on me. You were always knocking at my door even when I didn't feel like talking, always ready to listen when I needed your support. I am so grateful for all the beautiful moments we shared in these years, all the holidays, the hikes, the electric scooters, and the weddings. Thank you, Vale, for your friendship, interest, and support. And thank you, Vale, for sticking even in the worst moments, and for being the person I love spending time with the most.

Lello, thank you for trying to understand what I do and for your lovely company. Thank you, Sava, Dodo, and Matias, for being such a funny and supportive group of friends. Thanks, Fillo and Taba, for your invaluable friendships; I love how you both are always up for trying new things. Thanks to Cate and Marti for being with me for so many years, I love our endless talks that range from the perfect recipes to our deepest fears, and thanks to Gaccio and Jacki. Marta, thank you for the endless night talks in front of a beer. Thank you, Sofia, for all the talks and for always being super interested in my research. Thanks to Irene, for being with me in different forms from the very beginning of this journey; I am grateful for that, and for having each other's back.

Finally, heartfelt gratitude to the diverse community of researchers and practitioners who generously shared their insights, codes, and advice through online forums and conferences. The invaluable support from this committed Open Science collaborative community significantly speeded up the progress of my PhD.

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English abstract

Biological invasions, a major driver of biodiversity loss, are on the rise, threatening native biotas and human well-being. Mammals are the most widespread taxa of invasive animals and, simultaneously, they are among the most threatened Tetrapods. It is imperative to effectively inform stakeholders and the public about the negative impact invasive alien mammals can exert and stress the importance of prevention measures. Considering the rapid global changes we are witnessing, which are already leading to increased extinction and introduction rates, paramount is to have a solid understanding of the ecology of alien species. Human-related factors can shape alien species' distributions, and under global changes, it is essential to understand why those species are present where observed, identifying modifiable human behaviors to limit their spread. This allows making informed management and conservation decisions, notably when those decisions may need to be context-, species-, or population-specific.

Addressing some of these points, in my PhD thesis I investigated a subset of highly invasive alien mammals of European Union concern, and I provided novel information on alien mammals' potential distribution (and its drivers). I also explored globally the threats alien mammals are experiencing in their native range. With this work, I seek to contribute to invasion ecology's academic understanding, while supplying a solid foundation for evidence-based strategies and aiding the proactive development of biodiversity loss mitigation strategies.

German abstract

Biologische Invasionen, eine der Hauptursachen für den Verlust der biologischen Vielfalt, nehmen kontinuierlich zu und bedrohen einheimische Biota und das menschliche Wohlergehen. Säugetiere sind die am weitesten verbreiteten Taxa invasiver Tiere und gehören gleichzeitig zu den am stärksten bedrohten Tetrapoden. Es ist unerlässlich, die Interessengruppen und die Öffentlichkeit wirksam über die negativen Auswirkungen zu informieren, die invasive gebietsfremde Säugetiere haben können sowie die Bedeutung von Präventionsmaßnahmen zu kommunizieren. In Anbetracht der rasanten globalen Veränderungen, die wir derzeit erleben und die bereits zu einer erhöhten Extinktions- und Einführungsrate geführt haben, ist ein solides Verständnis der Ökologie gebietsfremder Arten von größter Bedeutung. Menschliche Faktoren können die Verbreitung dieser Arten beeinflussen, und angesichts der globalen Veränderungen ist es wichtig zu verstehen, warum Arten dort vorkommen, wo sie beobachtet werden, und welche menschlichen Verhaltensweisen geändert werden können, um ihre Ausbreitung zu begrenzen. Auf diese Weise können fundierte Management- und Erhaltungsentscheidungen getroffen werden, insbesondere wenn diese Entscheidungen kontext-, arten- oder populationsbezogen sein müssen.

In meiner Dissertation habe ich einige dieser Punkte aufgegriffen und jene Untergruppe hochinvasiver gebietsfremder Säugetiere untersucht, die für die Europäische Union von Belang sind, und ich habe neue Informationen über die potenzielle Verbreitung gebietsfremder Säugetiere (und deren Einflussfaktoren) geliefert. Außerdem untersuchte ich weltweit die Bedrohungen, denen gebietsfremde Säugetiere in ihrem Heimatgebiet ausgesetzt sind. Mit dieser Arbeit möchte ich einen Beitrag zum akademischen Verständnis der Invasionsökologie leisten und gleichzeitig eine solide Grundlage für evidenzbasierte Strategien und die proaktive Entwicklung von Strategien zur Eindämmung des Biodiversitätsverlustes liefern.

English summary

In a world experiencing rapid global changes, human activities introduced, and are still introducing, alien species to various regions, ecosystems, and biomes across the globe at unparalleled rates. Biological invasions are a major threat to nature, nature's contributions to people, and good quality of life. Some of these species can spread, adversely—and, in certain instances, irreversibly—impacting native biotas and human individuals and societies. This includes the loss of the distinctiveness of biological communities, contributing to an unprecedented level of deterioration in the biosphere that is crucial for humanity's well-being. The reshuffling and homogenization of biological communities constitute a phenomenon that requires understanding and, potentially, management. A foundational element for this understanding is scientific knowledge, which allows us to identify the species being introduced, the areas affected, the means of introduction, the reasons behind such introductions, and the possible effects. Recognizing that prevention, management, and eradication may not always be feasible, it is equally important to identify future opportunities for species that are becoming stable additions to native biotas.

In my PhD I attempted to unravel some facets of the ecology of alien species of mammals. Mammals are among the best-known and best-studied group of species both in invasion science and conservation biology: for centuries, humans have transported and kept them for various purposes (food sources, transportation, companionship), allowing mammals to be nowadays ubiquitous inhabitants of every continent, playing pivotal roles in shaping ecosystems. Simultaneously, they are among the most threatened Tetrapods.

It is imperative to effectively inform stakeholders and the public about the negative impact invasive alien mammals can exert and stress the importance of prevention measures. Especially considering the rapid global changes we are witnessing, which are already leading to increased extinction and introduction rates, paramount is to have a solid understanding of the ecology of alien species. Human-related factors can shape alien species' distributions, and under global changes, it is essential to understand why those species are present where observed, identifying modifiable human behaviors to limit their spread. This allows making informed management and conservation decisions, notably when those decisions may need to be context-, species-, or population-specific. I addressed some of these points in my PhD thesis, through a comprehensive exploration across three distinct yet interconnected analytical chapters.

For my first analytical chapter (Chapter II: *Introduction, spread and impacts of invasive alien mammal species in Europe*), I reviewed the current knowledge on a subset of highly invasive mammals (16 species), to characterize their introduction history, spread dynamics, and environmental impacts. By systematically reviewing the literature, I found that pet trade was

the most common way in which the study species reached Europe, and then they escaped from captivity or were intentionally released. Most species are still expanding their alien ranges by colonizing neighboring territories, and I showed that France is the most invaded nation, followed by Germany, Italy, and the Russian Federation. The muskrat *Ondatra zibethicus*, the American mink *Neovison vison*, and the raccoon dog *Nyctereutes procyonoides* are the most widespread species. Lastly, I also showed how these invasive mammals are threatening human well-being, as 81% of them are implicated in the epidemiological cycle of zoonotic pathogens. I concluded by remarking how containing secondary spread to further countries is of paramount importance to avoid the establishment of new populations of invasive mammals and the related impacts on native communities, ecosystem services, and human health.

In my second analytical chapter (Chapter III: *Patterns and drivers of range filling of alien mammals in Europe*), I explored how socio-economic factors influence differences between observed and potential distributions of 46 established alien mammals in Europe. Using species' known introduction localities, residence time, dispersal ability, generation length, and climatic suitability, I modeled potential alien ranges. I compared the potential and observed ranges through three range indices (range filling, overfilling, and unfilling), and analyzed the effects of native range size, introduction pathways, and socio-economic variables on these indices. Range patterns were overall strongly shaped by propagule pressure and markedly differed among species, with many still having wide potential areas unoccupied. Median value of range overfilling was high (68%), suggesting that alien mammal species are spreading outside the potential areas they should have occupied. Conversely, median values of range filling (8%) and range unfilling (0%) were low, confirming how existing information on recorded introductions falls short in elucidating alien mammals' distributions. Human population density showed a consistent, positive influence on all the three range indices, driving range patterns and influencing alien mammals' introduction and establishment. Contrarily, land-use was negatively related to range filling and unfilling, introduction pathways' number and transportation infrastructures to range overfilling, and native range size to range unfilling. These socio-economic factors ultimately depend on human behavior rather than environmental characteristics or species' ecology. My findings confirm that alien mammals' distribution in Europe is driven also by human agency, highlighting that modifying human behavior and societal norms is key to limit further spread.

Finally, for my last analytical chapter (Chapter IV: *A synthesis on alien mammals threatened in their native range*) I broadened my perspective to a global scale, aiming to conduct an ecological analysis of alien threatened mammals, encompassing their native and alien distributions, introduction pathways, assessing threats and conservation measures qualitatively and holistically, and re-assessing their IUCN Red List Category. I identified 41 alien threatened mammals, whose native ranges are mainly located in continental and insular Southeast Asia, with a hotspot of alien ranges located in insular Southeast Asia and eastern Australia. Alien

threatened mammals were mainly introduced for hunting purposes and within Asia. The most important threat affecting the study species was biological resource use; however, native populations of alien threatened mammals are also subjected to a range of different conservation measures, the most important being species management. Lastly, I found that almost 22% of the species would shift their IUCN Red List Category if alien populations would have been considered in the assessment.

My PhD thesis is the result of a joint PhD (co-tutelle) I pursued between Sapienza University of Rome (where I was supervised by Prof. Carlo Rondinini, head of the Global Mammal Assessment programme) and the University of Vienna (where I was supervised by Prof. Franz Essl, head of the Division of BioInvasions, Global Change & Macroecology). This thesis provides the full picture on a subset of highly invasive alien mammals of European Union concern, novel information on alien mammals' potential distribution (and its drivers) in Europe and approaches the threats some alien mammals are experiencing in their native range at a global scale. With this work, I seek to contribute to invasion ecology's academic understanding, while supplying a solid foundation for evidence-based strategies. The prevention and management of some alien mammals can be challenging, and the results presented here may aid the proactive development of biodiversity loss mitigation strategies.

Chapter I: General introduction

Biological invasions are a major cause of biodiversity loss

Our planet has entered a new human-dominated geological epoch, the Anthropocene (Lewis & Maslin 2015), where human beings are primarily liable for the global collapse of nature and of its vital contributions to people, which together embody biodiversity and ecosystem functions and services (IPBES 2019). The main factors responsible for the decline and loss of biodiversity are land-use change, overexploitation, climate change, pollution, and biological invasions (IPBES 2019).

Biological invasions, which are the result of direct and indirect human-mediated introductions of species to regions outside their natural native range (Blackburn et al. 2011), are nowadays threatening people and nature in all regions of Earth (IPBES 2023). Many species introduced in new regions—so-called alien species—fail to establish self-sustaining populations or remain localised, whereas others become permanent additions to the receiving ecosystems and spread over substantial distances (Tedeschi et al. 2022). In doing so, they can have severe impacts on native biotas (Blackburn et al. 2019) at different biological organization levels (Hawkins et al. 2015), on ecosystems services (Vilà & Hulme 2017), and on human livelihoods (Bradshaw et al. 2016, Diagne et al. 2021); i.e., they can become Invasive Alien Species (IAS).

Those dramatic and sometimes irreversible changes to ecosystems, to their services, and to biodiversity can result in detrimental and complex outcomes throughout the globe (Bacher et al. 2023). Some of the most frequently observed mechanisms through which invasive alien species negatively impact biodiversity include competition, predation, and herbivory (Bacher et al. 2023). Alarmingly, these mechanisms can even lead to the extinction of native species: in fact, IAS have contributed to at least 60% of extinctions globally (IPBES 2023). Species extinction's global rate is already at least tens to hundreds of times higher than the past average rate, with around 1 million species facing extinction, and terrestrial vertebrate populations declining of 40% in the last 50 years (IPBES 2019)–a massive phenomenon that has been referred to as "Anthropocene defaunation" (Dirzo et al. 2014).

Currently, at least 37,000 alien species have been identified globally, and detrimental impacts have been recorded for at least 14% of them (Seebens et al. 2023). These numbers are severely underestimated (Seebens et al. 2023) and, despite a rise in awareness and the adoption of legislation to reduce species introductions, the number of newly introduced species has unparalleled risen in recent decades (Seebens et al. 2017) and is expected to continue to do so in future (Seebens et al. 2021). International trade (Capinha et al. 2023), global transportation

networks (Hulme 2009), land-use change (Essl et al. 2020b), and climate change (Diez et al. 2012, Bellard et al. 2018) are the main drivers promoting species' introduction and spread, and they continue to intensify.

Crucially, impacts and number of invasive alien species in the future may escalate, due to the continuing amplification of these drivers of change in nature (Hulme et al. 2023). This underscores the intricacy of studying and effectively addressing biological invasions under global changes, where discerning the individual contributions of distinct drivers proves challenging. Moreover, it is arduous to disentangle the action of one global driver of change from the other, as those drivers can exhibit synergistic interactions (Bacher et al. 2023), generating outcomes that elude predictability.

Tackling biological invasions at continental scale: the European Regulation

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) dedicated to biological invasions their 2023 Thematic assessment, highlighting the paramount importance of safeguarding nature from the negative impacts of many alien species. The assessment indicates that achieving the goals of preventing and controlling invasive alien species is feasible with adequate resources, political determination, and sustained commitment (IPBES 2023). Such efforts promise substantial and enduring benefits for both human well-being and natural ecosystems (IPBES 2023). However, so far policies and their implementation failed to manage biological invasions or control and prevent invasive alien species (McGeoch et al. 2023).

Regulations or national legislations aiming to prevent and control invasive alien species are lacking in the majority (83%) of countries (Pagad et al. 2020), reflecting that the prevention and mitigation of biological invasions in some parts of the globe is indeed a significant challenge. In Europe, policies aim to the free circulation of people and stocks (Genovesi et al. 2015), facilitating species' movements across the continent. To tackle this point, the European Union (EU) adopted the Regulation (EU) No 1143/2014, aimed at "prevent, minimise and mitigate the adverse effects of invasive alien species on biodiversity and related ecosystem services, and on human health and safety as well as to reduce their social and economic impact" (Regulation (EU) No 1143/2014). Informed by decades of research in invasion science (Genovesi et al. 2015), the Regulation called for the establishment of the "Union List", a list of IAS of animals and plants of European Union concern. The inclusion of a species in the List should effectively prevent, minimise, or mitigate the negative impact of the species in a cost-efficient way (Regulation (EU) No 1143/2014). Each member state of the Union is required to collect information and take actions related to limiting the introduction and to the detection and eradication of the species included in the List, and to mitigate their impact (Regulation

(EU) No 1143/2014). Additionally, this pool of invasive alien species is subject to a ban on intentional trade and importation in the European Union.

Of the 88 species currently included on the Union List, more than half (47 species, 53%) are animals, and the majority are vertebrates. Vertebrates are indeed one of the taxonomic groups hosting the most invasive alien species globally, with at least 14% of established alien species showing documented impacts (compared to a mean of 11% across all taxa considered in Bacher et al. 2023). Recognizing the severity of threats posed specifically by vertebrates, it is therefore essential to expand our current understanding on both alien and invasive alien species included in this taxonomic group. In general, invasive alien species included in the Union List should be prioritized for prevention and management actions. It is therefore important to have a solid base of knowledge on those species.

The last study available specifically on alien mammals in Europe date back to 2012 (Genovesi et al. 2012). After the implementation of the Regulation (EU) No 1143/2014, several technical reports have been issued by the European Union (Tsiamis et al. 2017, 2019b, a, 2021), but an updated, quantitative, and discursive compendium that could have been used to effectively inform researchers, practitioners, and the general public was still lacking. Exploring the ecology of these species contributes to the development of well-informed strategies for preventing and managing biological invasions. This, in turn, provides policymakers, conservationists, researchers, stakeholders, and the general public with the essential tools to safeguard the integrity of ecosystems both globally and locally.

Patterns and drivers of alien species' distribution

Due to the potential threats they can pose, understanding the factors driving the distribution of alien species is paramount to effective biodiversity conservation. The choice of the correct management action can be assisted by decision-support approaches, methods, and tools (Sankaran et al. 2023). Those include evidence-based modeling and scenarios, which can prioritize introduction pathways, areas, and species for action, and identify hazards (Sankaran et al. 2023). These recent years have seen a steady increase in the number of published studies using those approaches, for instance to determine areas at risk of invasion (Strubbe et al. 2023), to identify hotspots of IAS richness to prioritize prevention and control (Polaina et al. 2020), or to understand how biological invasions might unfold in the next years across time and space (Lenzner et al. 2019, Pérez-Granados et al. 2023).

The fact that alien species are still spreading in their alien range (Seebens et al. 2023) suggest that many of them are not yet in equilibrium with their new environment, and that they likely still have suitable space to fill. One key factor influencing the potential space available for

species is environmental conditions, as self-sustaining populations can only establish in areas where specific environmental needs are met (Richardson & Pyšek 2012). Areas where species are theoretically expected to be present but have not yet been observed may be particularly relevant in the context of biological invasions. Such regions could represent potential hotspots for invasion, if not promptly identified or subject to management strategies. Therefore, it is imperative to assess which are the drivers of species' current distributions and the extent to which these species can further expand their ranges. This knowledge not only enhances our capacity to predict and prevent invasions but also underscores the importance of proactive measures to mitigate the potential expansion of these species into currently unaffected areas.

Understanding the potential distribution of species becomes therefore crucial in identifying areas where species may be theoretically present but not yet observed. Species Distribution Models (SDMs) are frequently used to predict species' potential distribution by correlating currently known species' occurrences (obtained, for instance, from literature, field-work, or public databases such as the Global Biodiversity Information Facility GBIF) with environmental (e.g., climate) conditions (Guisan et al. 2017).

The distribution of a species is the outcome of a complex interplay of several biotic and abiotic factors (Wisz et al. 2013), species' environmental preferences, and dispersal ability and limitations (Guisan et al. 2017). Moreover, in the case of alien species, it is important to account for anthropogenic factors such as the intensity and frequency of species introductions (i.e., propagule pressure; Cassey et al. 2018), the timing of introduction (i.e., minimum residence time; Mahoney et al. 2015, Abellán et al. 2017), and socio-economic variables that may influence them (Dawson et al. 2017, Pouteau et al. 2021, Capinha et al. 2023). The relationship between observed and potential ranges of alien species remains largely unexplored, likely due to the complex interactions among these factors.

The current observed distribution of a species (observed range) can exhibit different relationships with its potential distribution (potential range). When a species is found where it should be present (based on its niche and ability to reach the area), those ranges can overlap, a phenomenon called "range filling". Conversely, the species may be observed where its presence is unexpected, termed "range overfilling". Lastly, the species can potentially reach a suitable area, but there it still lacks documentation, and that is "range unfilling".

Research on this topic is still limited, and especially studies integrating different approaches—such as mechanistic (e.g., simple spread models) and correlative (e.g., SDMs) approaches—remain exceptionally scarce (but see Sherpa et al. 2020, Strubbe et al. 2023). While it's advisable for predictions of potential alien species spread to account for historical patterns, biases in introductions (Pigot et al. 2018) and for human pressures (Gallardo et al. 2015)—aspects often omitted in models relying solely on SDMs—these critical factors influencing distribution patterns are often overlooked (Pyšek et al. 2020) or analyzed separately. It is therefore crucial to employ models that collectively investigate multiple

drivers, helping identifying areas at the highest risk of future invasions (Gallardo et al. 2015, Pyšek et al. 2020). This can allow understanding the impact of human activities on species range patterns, providing valuable insights for policies aimed at preventing and managing biological invasions.

The conundrum of alien species threatened in their native range

Nowadays, some threatened species have been introduced to urban centers or other areas far from their natural ranges (Gibson & Yong 2017). Many of these introductions were carried out for conservation purposes, and to protect species from habitat loss, overhunting, and invasive alien predators (Seddon et al. 2015, Woinarski et al. 2015, Biancolini et al. 2021), but others were not driven by the same intents (Gibson & Yong 2017). A recent study performed at European scale identified 33 terrestrial vertebrates native to at least one Member State but alien (and potentially invasive) in others; of those species, 36.4% are threatened (Baquero et al. 2023). In this context, conservation biology and invasion science are faced with a challenging issue, that is the ambivalent situation of alien threatened species, which are species that are at risk of extinction in their native range and have been introduced elsewhere.

Those introduced populations may simultaneously be a problem and a resource. Some of them may have become invasive, and therefore need to be managed. At the same time, other populations can support conservation efforts (Marchetti & Engstrom 2016), for instance providing a substitute for the supply of traded species, curbing demand for native wild populations (Gibson & Yong, 2017). The double-faced nature of alien mammals threatened in their native ranges underlines how conservation and/or management efforts towards those species may need to be context-, species-, and population-specific. Previous research on this topic focused mainly on species-specific case studies (Lees & Bell 2008, Garzón-Machado et al. 2012, Cassinello 2018), few species (Marchetti & Engstrom 2016) or countries (Baquero et al. 2023), but a global and updated synthesis was unfortunately and surprisingly unavailable (but see Gibson & Yong 2017). Filling these knowledge gaps addressing which mammals are at risk of extinction globally, which threats they are experiencing, where they have been introduced, and if (and how) the alien populations should be used for conservation efforts or managed is essential to allow making informed management and conservation decisions. This is crucial considering rapid global changes which are already leading to increased extinction and introduction rates.

The study taxon

Human beings have transported and kept mammal species for various purposes (food sources, conveying, pets) for centuries (Long 2003), and mammals are nowadays present in every continent. They are among the best-known and best-studied group of species both in invasion science and conservation biology, with several studies published on their global

status and experienced threats (e.g., Schipper et al. 2008, Crooks et al. 2017), responses to global changes (Pacifici et al. 2015, 2017, Baisero et al. 2020), introductions outside the native range (Long 2003, Genovesi et al. 2012, Biancolini et al. 2021) and negative impacts (Blackburn et al. 2019, Tedeschi et al. 2022, Wang et al. 2023).

The latest version of the International Union for Conservation of Nature (IUCN) Red List I downloaded identified 5,769 terrestrial and freshwater mammal species (IUCN 2023), of which 1,313 (22.8%) have been classified as threatened (i.e., Vulnerable VU, Endangered EN, or Critically Endangered CR). Among Tetrapods, mammals are the second most threatened group and the second with the highest cumulative percentage of species driven extinct after amphibians (IPBES 2019, IUCN 2023). Conservation efforts aimed at restored threatened mammals' populations are deployed worldwide, and without them, the overall pattern of mammal species' losses and population declines would have decreased by another 18% (Hoffmann et al. 2010).

At the same time, mammals are the most widespread group of IAS of animals with regards to the number of invaded regions globally (Seebens et al. 2023). Currently, 88 species are included on the Union List, of which 13 (~15%) are mammals, highlighting the perceived impact of this taxon across Europe. Indeed, mammals represent 60% of the worst invasive terrestrial vertebrates in Europe (DAISIE 2009, Polaina et al. 2020). More than 60 species of alien mammals are currently established in this continent (more than a quarter of all 230 identified established alien mammals globally; Biancolini et al. 2021). Worryingly, alien mammals are still expanding their ranges across Europe (Tsiamis et al. 2019a, Tedeschi et al. 2022), also due to ongoing environmental change providing new suitable areas, presently and in the future (Louppe et al. 2019, 2020, Polaina et al. 2020, Schertler et al. 2020). Therefore, preventing alien mammals' further introductions and spread, managing (if possible) their invasive populations, and (if needed) conserving some of them in the face of global changes may already be a pressing issue.

Thesis structure and objectives

This project focuses on alien mammals, and its main aim is to understand and characterize the introduction, spread, impacts, and distribution patterns (observed and potential) of alien mammals in Europe, with a global conservation focus on alien threatened mammal species.

The present chapter (Chapter I) serves as an introduction, providing the context and objectives of my PhD thesis. The core of this thesis are three main analytical chapters (Chapters II, III, and IV). In the concluding chapter (Chapter V) I summarize the findings of my PhD thesis, discuss the broader implications of the research presented, and suggest further research topics and directions. Here, I briefly describe the objectives (and methods used to reach them) of each analytical chapter in order of appearance.

Chapter II: Introduction, spread and impacts of invasive alien mammal species in Europe

The objective of Chapter II was to review the current knowledge on a subset of highly invasive mammals (those listed in the Union List), to characterize their introduction history, spread dynamics, and environmental impacts. I performed a systematic review of published literature on the mammal species of Union concern (and candidate species to be included in the Union List, that are invasive alien mammals established in Europe and prioritized for 2018-2020) in the last 15 years (2005-2020). I compared the study species' traits, summarized the pathways of introductions, reconstructed the temporal trajectories of mammal invasions, illustrated the geographic distribution patterns, and investigated the environmental and social impacts, with a focus on human health.

Chapter III: Patterns and drivers of range filling of alien mammals in Europe

The objective of Chapter III was to explore the role of socio-economic factors in shaping the differences between the observed and potential distributions of established alien mammals in Europe. Therefore, in this chapter I calculated potential ranges for 46 alien established mammals introduced in Europe using a hybrid approach, including a mechanistic and a correlative part. I compared the potential and observed ranges through three range indices (range filling, overfilling, and unfilling), and I investigated the effects of native range size, introduction pathways, and socio-economic factors on these indices.

Chapter IV: A synthesis on alien mammals threatened in their native range

The objective of my last analytical chapter (Chapter IV) was to conduct an ecological analysis of alien threatened mammals, encompassing their native and alien distributions, introduction pathways, and assessing threats and conservation measures qualitatively and holistically. I collected native distributions for 41 alien threatened mammals globally, and I extracted information on countries of occurrence (both native and alien), countries and pathways of introduction (in the alien range), and threats and conservation measures (in the native range). Lastly, I re-assessed those species: I performed an IUCN Red List assessment to investigate whether including the alien population(s) in the assessment would change substantially the IUCN Red List category of the species.

Chapter II: Introduction, spread and impacts of invasive alien mammal species in Europe

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Tedeschi L, Biancolini D, Capinha C, Rondinini C, Essl F (2022) Introduction, spread, and impacts of invasive alien mammal species in Europe. *Mammal Review* **52**: 252–266.

Abstract

1. Biological invasions have emerged as one of the main drivers of biodiversity change and decline, and numbers of species classed as alien in parts of their ranges are rapidly rising. The European Union established a dedicated regulation to limit the impacts of invasive alien species (IAS), which is focused on the species on a Union List of IAS of particular concern. However, no previous study has specifically addressed the ecology of invasive alien mammals included on the Union List.

2. We performed a systematic review of published literature on these species. We retrieved 262 publications dealing with 16 species, and we complemented these with the most up-to-date information extracted from global databases on IAS.

3. We show that most of the study species reached Europe as pets and then escaped from captivity or were intentionally released. On average each year in the period 1981-2020, 1.2 species were recorded for the first time as aliens in European countries, and most species are still expanding their alien ranges, colonising neighbouring territories. France is the most invaded nation, followed by Germany, Italy, and the Russian Federation, and the muskrat *Ondatra zibethicus*, the American mink *Neovison vison*, and the raccoon dog *Nyctereutes procyonoides* are the most widespread species, having invaded at least 27 countries each. Invasive mammals of European Union concern are threatening native biodiversity and human well-being: worryingly, 81% of the 16 study species are implicated in the epidemiological cycle of zoonotic pathogens.

4. Containing secondary spread to further countries is of paramount importance to avoid the establishment of new populations of invasive mammals and the related impacts on native communities, ecosystem services, and human health.

5. We present a compendium on the ecology and impacts of invasive mammals of European Union concern. It can be used to assist environmental policies, identify and subsequently fill knowledge gaps, and inform stakeholders.

Keywords: biological invasions, environmental impact, Europe, invasive mammals, pathways of introduction, spread, zoonotic diseases.

Introduction

The human-mediated introduction of species to regions outside their native range has become one of the main drivers of biodiversity change and decline in recent human history (IPBES 2019). Despite a rise in awareness and the adoption of legislation to reduce these introductions, the number of newly introduced species has risen strongly in recent decades (Seebens et al. 2017) and is expected to continue to do so in the future (Seebens et al. 2020). International trade, global transportation networks (Hulme 2009), land-use change (Essl et al. 2020b), and climate change (Diez et al. 2012, Bellard et al. 2018) are the main drivers promoting species' introduction and spread, and they continue to intensify. Many species introduced in new regions fail to establish self-sustaining populations or remain localised, whereas others

become permanent additions to the receiving ecosystems and spread over substantial distances. In doing so, they can have severe impacts on native biota (Blackburn et al. 2019) at different biological organisation levels (Hawkins et al. 2015), ecosystems services (Vilà & Hulme 2017), and human livelihoods (Bradshaw et al. 2016, Diagne et al. 2021), i.e., they can become invasive alien species (IAS).

The prevention and mitigation of biological invasions in Europe is a significant challenge, as policies are devoted to the free circulation of goods and people (Genovesi et al. 2015). To address this issue, the European Union (EU) adopted the Regulation (EU) No 1143/2014, aimed at the prevention of IAS introduction and spread (Regulation (EU) No 1143/2014). The Regulation, informed by years of invasion science research (Genovesi et al. 2015), called for the creation of a list of plant and animal IAS of Union concern, the Union List. Each member state of the EU is required to collect information and take actions related to limiting the introduction and to the detection and eradication of these species, and to mitigate their impact (Regulation (EU) No 1143/2014). Furthermore, this subset of IAS is subject to a ban on intentional importation and trade in the EU.

Of the 66 species currently included on the Union List, 11 (~ 17%) are mammals, highlighting the perceived impact of this taxon across Europe. Indeed, mammals represent 60% of the worst invasive terrestrial vertebrates in Europe (DAISIE 2009, Polaina et al. 2020) and, overall, more than 50 species of alien mammals are currently established in this continent (Biancolini et al. 2021). Alarmingly, due to climate change, suitable climatic space is projected to increase for most invasive mammals in Europe (Polaina et al. 2020). For instance, this is the case for the coypu *Myocastor coypus* (Schertler et al. 2020), the raccoon *Procyon lotor* (Louppe et al. 2019), and the small Indian mongoose *Herpestes auropunctatus* (Louppe et al. 2020). Invasive mammals exert negative impacts on biodiversity through competition (Mazzamuto et al. 2017), disease transmission (Collins et al. 2014), habitat alteration (Nogales et al. 2005), hybridisation (McFarlane et al. 2020), and predation (Dahl & Åhlén 2019).

We provide a comprehensive synthesis of the invasion process, current distribution, and impacts of the invasive mammals of Union concern, by reviewing the literature for these species. Specifically, we: (1) analyse trends in the recently published literature regarding 16 mammal species of Union concern (and candidate species to be included in the Union List, that are invasive alien mammals established in Europe and prioritized for 2018-2020) in the last 15 years (2005-2020); (2) summarise pathways of introductions; (3) reconstruct the temporal trajectories of mammal invasions; (4) illustrate geographic distribution patterns; and (5) investigate environmental and (6) social impacts, with a focus on human health. This review updates the current knowledge on a subset of highly impacting mammals. This knowledge is crucial, especially in the light of recent developments in international agreements to protect native biodiversity (Regulation (EU) No 1143/2014, CBD 2020). Our review will aid the protection of native biodiversity, and informs a wide audience of stakeholders and practitioners.

Methods

We searched for relevant publications on invasive mammals of EU concern. To provide a wider geographic context, the study area was not limited to the EU; we define as the 'European territory' the 47 member states of the Council of Europe, including also the outermost regions of the EU located in the North Atlantic (i.e., Azores, Madeira, and Canary Islands), but excluding the remaining ones (e.g., French Guiana, Guadeloupe). Of the 11 mammal species with self-sustaining populations included on the Union List, we selected 10 (thus excluding the Eastern fox squirrel *Sciurus niger*, as no established populations are currently present in Europe). Further, based on the work of Carboneras et al. (2018), we selected another six species recommended for future inclusion with high priority (i.e., for the time frame 2018-2020 and with impacts classified as 'major' or 'massive'; see Carboneras et al. 2018). This selection excluded the globally ubiquitous species Brown rat *Rattus norvegicus* and species that are not yet found or established in Europe, therefore having no recorded impacts. Finally, a total of 16 established species were included in this review (Table 1).

Literature search

The literature search was carried out by the first author following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Appendix S1; Moher et al. 2009) in August and September 2020. For each species, we downloaded available information from the EU Commission CIRCA website (https://circabc.europa.eu/ui/welcome) in the form of the EU Non-Native Risk Assessment Scheme or the Great Britain Non-Native Risk Assessment Scheme. In addition, we downloaded CABI species' datasheets (www.cabi.org) and the NOBANIS factsheets (www.nobanis.org). Hereafter, for brevity, we will refer to all these documents as 'datasheets'. As these datasheets were highly comprehensive on the scientific knowledge of the study species at the time of completion, the time range of the search for additional publication was adapted for each species, depending on the date of the most recent datasheet. If no prior datasheet was found, the search in the literature databases was performed without a temporal filter.

Subsequently, we searched for additional recent information on each species in Scopus and the Web of Science. In Scopus, we conducted an advanced search refined for the sub-areas of Agricultural and Biological Sciences and Environmental Sciences. In the Web of Science, we performed a basic search without sub-areas limitations, except for the American beaver *Castor canadensis*, for which we filtered Web of Science results due to the large literature retrieved on unrelated topics (such as engineering or fluid mechanics). For each species, we conducted a separate search with a combination of the scientific name and its synonyms, common name(s) and the relevant keywords, linked by the Boolean operators AND/OR. The list of countries encompassing the alien range, to be used as species-specific keywords, was obtained from the global Distribution of Alien Mammals database (DAMA; Biancolini et al. 2021). Keywords were identified *a priori* based on the known alien distribution of each species, European Regulation, invasion history, characteristics linked to invasiveness, and impacts caused (Appendix S1).

Two species are identified with different scientific names in the Union List and the International Union for Conservation of Nature (IUCN) Red List, namely the small Indian mongoose (*Herpestes javanicus* in the Union List, *Herpestes auropunctatus* in the Red List) and the Siberian chipmunk (*Tamias sibiricus* in the Union List, *Eutamias sibiricus* in the Red List). We are aware of the recent taxonomic revision, and in this work we chose to follow the IUCN taxonomy (IUCN 2020).

Data extraction and preparation

To be included in the review, literature results had to fulfil the following criteria: refer to the European territory (defined as described above), be written in English, and contain information related to at least one of the following: (1) year(s) of first record of a study species, (2) location(s) of first record, (3) pathway(s) of introduction, and (4) impact(s).

The publications we collected were subjected to screening by reading the title and abstract; if these elements did not provide definite information, the full text was screened. After this screening, the full-text of each retained publication was assessed for eligibility. The same publication investigating two (or more) focal species was counted for each species, but duplicates were removed for higher-level analyses. A primary research topic was assigned to each publication, based on its aims, as follows: community ecology, datasheet (sub-topics: CABI, NOBANIS), ecological modeling, economic impacts, environmental impacts (sub-topics: competition, disease transmission, habitat alteration, hybridisation, predation), general ecology (sub-topics: activity pattern, behavioural responses, diet, reproduction, space use), genetics (sub-topics: genotyping, methodology, phylogeny, population genetics), health status, management, population status, review, risk assessment (sub-topics: EU Non-Native Risk Assessment Scheme, Great Britain Non-Native Risk Assessment Scheme, other), social impacts, and systematics. Publications of pathogens were classified based on whether they were focussed on the threats posed to native fauna (topic: environmental impacts/disease transmission), on threats to humans (social impacts), or on general investigation of the invasive species' pathogens (health status).

In Tables and Figures, countries are indicated by their International Organization for Standardization country codes, and RU refers to the European part of the Russian Federation. Countries for which information on the study species was not available or was not informative (e.g., Turkey) are not shown in Figures. Species with occasional occurrences (i.e., not established) or with an unknown status are indicated as 'casual presences'. Alien geographic ranges for the study species were obtained from DAMA (Biancolini et al. 2021), as well as from the list of all established mammals in Europe, regardless of their inclusion in the Union List, to get a more comprehensive picture of alien mammals' status in Europe. Native zoogeographic realms (Holt et al. 2013) for the study species and all established mammals in Europe were obtained based on species' native ranges (IUCN 2020). Marginal parts of native ranges occurring in less than 1% of a zoogeographic realm were not considered.

Capellini et al. (2015) and Blackburn et al. (2017) identified body size, litter size, litters per year, and generation length as species' traits affecting the introduction, establishment, and spread of invasive mammals. We extracted these trait values from the recently developed

Coalesced Mammal Database of Intrinsic and Extrinsic traits (COMBINE; Soria et al. 2021). Reproductive life-span was calculated as the difference between maximum longevity and age at first reproduction (Soria et al. 2021).

Each species was assigned to one or more pathway(s) of introduction following Convention on Biological Diversity (CBD) categorisation (CBD 2014, Biancolini et al. 2021). First records of the species were mainly obtained from Version 2 (last updated in March 2021) of the Alien Species First Records Database (Seebens et al. 2017). For first records obtained from publications encountered during the literature review, the earliest year was retained in cases of multiple introductions and/or continuous introduction into a country. Information regarding species' pathogens (e.g., prevalence) was extracted both from original publications and from reviews encountered during the literature search.

Results

Literature search

The literature search yielded 3322 publications published between 2005 and 2020. All the species but one (Barbary ground squirrel *Atlantoxerus getulus*) had at least one datasheet available for download, resulting in a total of 36 published datasheets. After the first screening, 591 publications (not including the datasheets) were retained. A backward reference search ('snowballing') was performed on the reference list of each of these publications to identify other relevant publications, adding a further 30 publications. Duplicate records resulting from an overlap of the database outcomes were removed. 26 publications could not be assessed due to access restrictions. Eventually, 262 publications were included in the review (Appendix S2).

Published information was available mostly for the raccoon (that accounted for 16% of all publications), the American mink (14%), and the sika deer *Cervus nippon* (12%; Appendix S3). The majority of the datasheets collected (88%) were published from 2009 to 2014 (Appendix S3) and, due to the temporal filters adopted, for most of the study species the literature search supplied mainly publications issued after 2015. Accounting for these filters adopted in the literature search, mainly species' environmental impacts were investigated (24% of all publications), with a peak of publications in 2017-2018, followed by publications on health-related issues (18%) and social impacts (12%).

Taxonomic characterisation, traits, and native ranges

The 16 study species belong to three orders and nine families. Half of them belong to the order Rodentia (Appendix S3); the remaining species are either from Carnivora (31%) or Artiodactyla (19%). The Sciuridae family is the most represented, accounting for 31% of all species, followed by Cervidae (19%) and Procyonidae (13%). In comparison, the full ensemble of 53 alien mammal species established in Europe is divided into seven orders and 17 families (Biancolini et al. 2021). The order Artiodactyla is the most numerous (28%), followed by

Rodentia (23%) and Carnivora (17%; Appendix S3). The most represented family is Cervidae (15%), followed by Leporidae (13%) and Bovidae and Mustelidae (11% each).

Adult body mass for the study species varied between 85 g for the Siberian chipmunk and 53000 g for the sika deer (mean for all study species 9762.4 g, median 2499 g, interquartile range 8305.4 g; Appendix S3). Litter size was between one for sika deer and Reeves' muntjac *Muntiacus reevesi* and 6.4 for the muskrat (mean for all 16 species: 3.3 young per litter). Litters per year ranged from one for American beaver, sika, American mink, and raccoon to 2.6 for the muskrat (mean for all species: 1.5 litters per year). Lastly, generation length (in days) fluctuated between 2941 for the Barbary ground squirrel and 8504 for the sika deer (mean for all species: 5781 days).

The study species originate mainly from the Palearctic, Sino-Japanese, and Oriental zoogeographic realms (Appendix S3). Similarly, the full ensemble of alien mammals established in Europe originate mainly from the Palearctic, Saharo-Arabian, and Sino-Japanese realms (Appendix S3).

Pathways of introduction to Europe

The main pathway of introduction for the study species in Europe was the pet trade (Fig. 1): 69% of the species escaped after they were introduced at least once through the pet trade (i.e., from private owners), 50% escaped from zoos (i.e., from public exhibitions), and 38% escaped after they were introduced to be bred in fur farms. One species was released in nature for biological control (the small Indian mongoose in Croatia), and another one for conservation purposes (the American beaver in Finland). The chital *Axis axis*, introduced in Croatia, was the only species with an unknown introduction pathway, although subsequent repeated introductions within Croatia were reported for hunting purposes (Šprem & Zachos 2020). No study species was reported to be introduced as a contaminant, stowaway, or via a corridor.

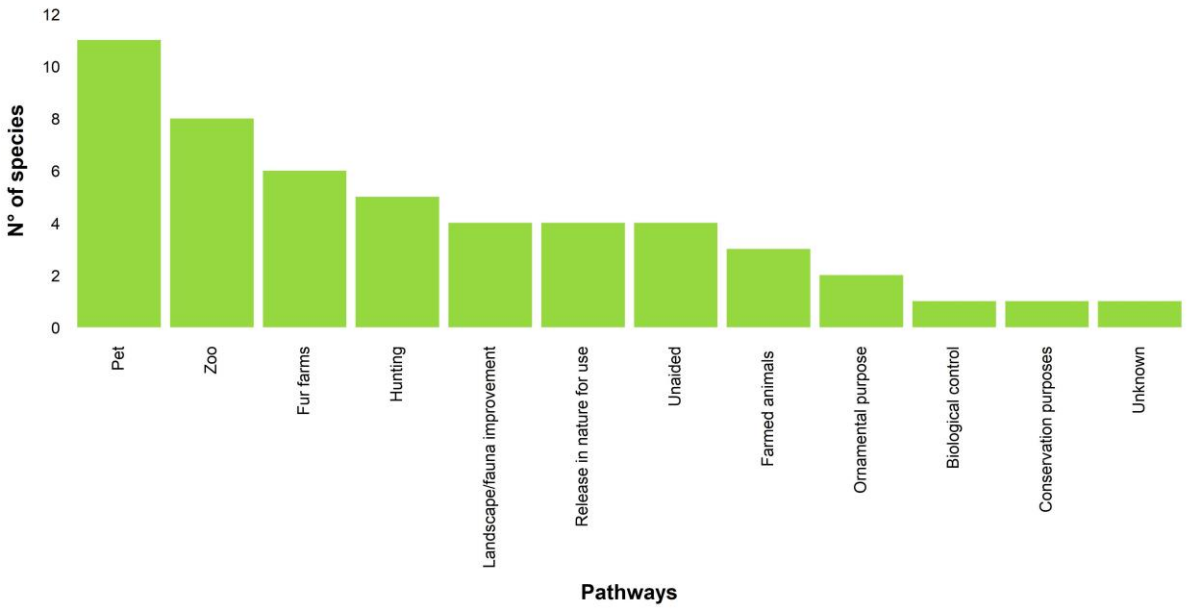

Figure 1. The Convention on Biological Diversity's pathways of introduction applied to the study species in Europe (n = 16). Each species was assigned to one or more pathways (n = 50). Pathways with zero occurrences or nomenclature not relevant for terrestrial mammals are not shown. Pathway names are abbreviated following CBD (2014).

Temporal trajectories of mammal invasions in Europe

The rate of first records (of both established and casual presence records) of the study species in countries of Europe increased on average from 1.4 new records/year over a 40-year period (1900-1940) to 2.3 records/year in 1941-1980, and then dropped to 1.2 records/year in 1981-2020 (Fig. 2, Appendix S4). Overall, the American mink, the raccoon dog, and the muskrat accounted together for 47% of first records.

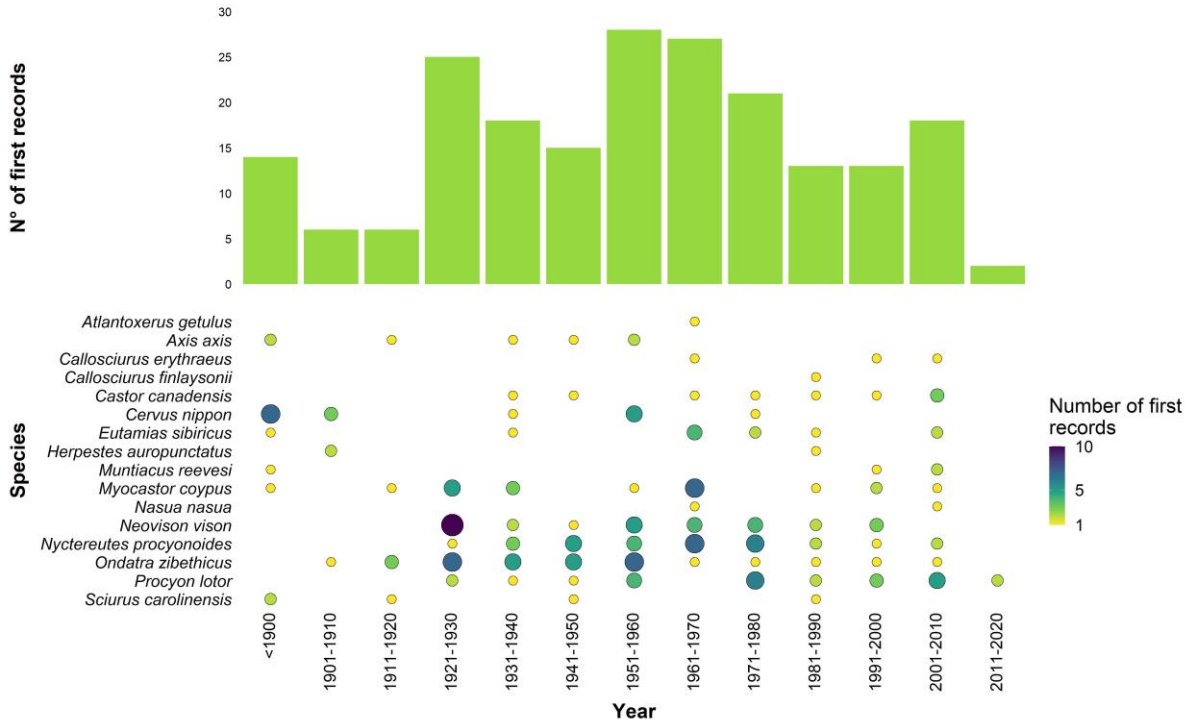

Figure 2. Temporal distribution of first records (n = 197) of the study species in the countries of Europe. Point sizes represent the number of records per species and time period.

Geographic distribution patterns in Europe

The UK and the Russian Federation first recorded three of the study species each, namely the sika deer (1860), the Eastern grey squirrel *Sciurus carolinensis* (1876), and Reeves' muntjac (1894) for the UK, and the Siberian chipmunk (1850), the American mink (1923), and the raccoon dog (1926) for the Russian Federation (Appendix S4).

Considering the number of countries occupied, the most widespread species was the muskrat (established in 32 countries and with casual presence records in three countries; Appendix S3), followed by the American mink (established in 28, casual in seven), the raccoon dog (established in 27, casual in seven), and the coypu (established in 24, casual in four). However, with respect to the area occupied only by the established species, the order slightly changes, with the raccoon dog becoming the most widespread, followed by the muskrat, the American mink, and the raccoon (Fig. 3).

Fig. 4 illustrates the invasion waves of the four species that invaded most of the European territory (the raccoon dog, the muskrat, the American mink, and the raccoon), including established presence and casual records.

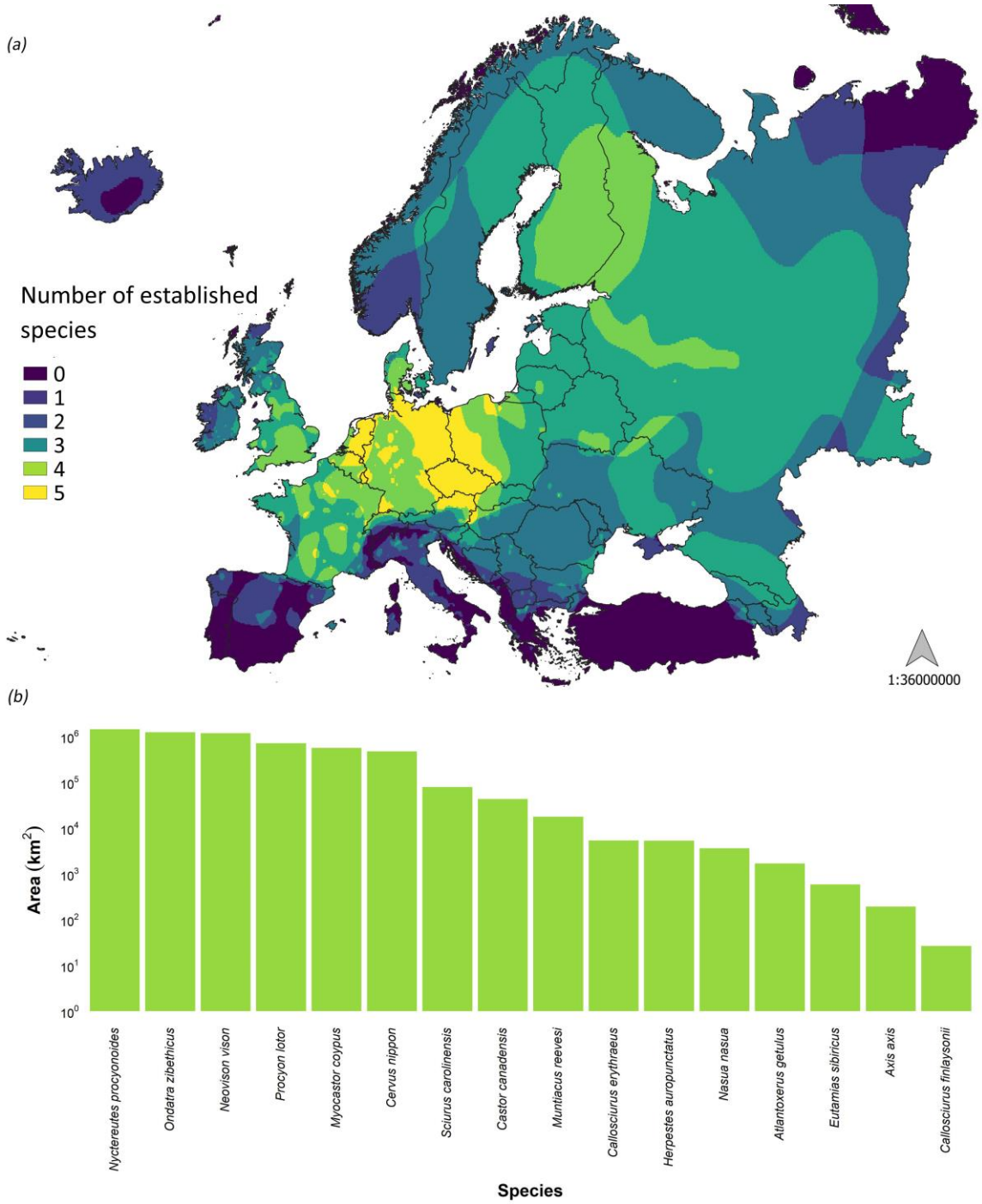

Figure 3. Established presence of the study species in Europe: (a) heat map showing study species' richness in the study area (alien range maps source: Biancolini et al. 2021); (b) area (log scale, km²) occupied by the study species.

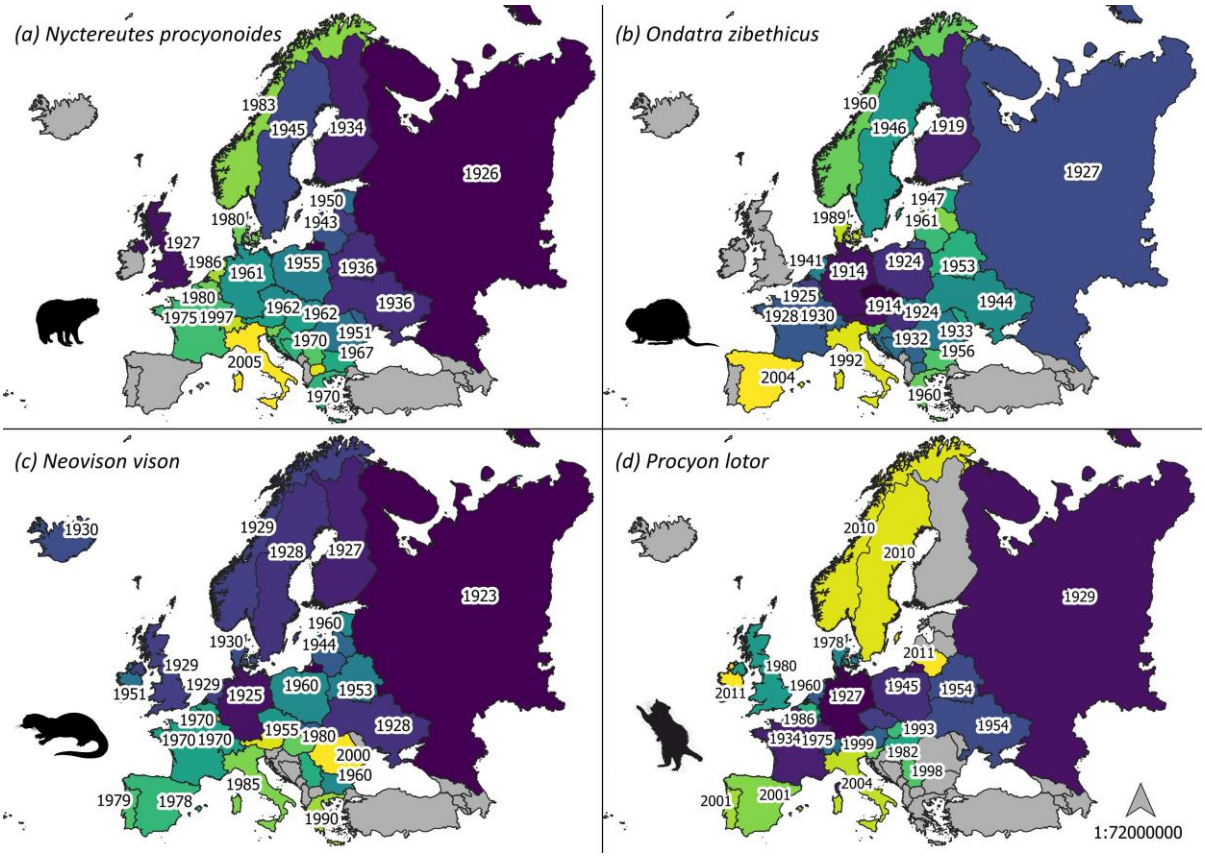

Figure 4. The spread trajectories of the four species that invaded most of the European territory: (a) the raccoon dog, (b) the muskrat, (c) the American mink, and (d) the raccoon. Countries are graded from the country invaded earliest (darker) to the latest (lighter). Year of the first record (when available) is shown. Countries without presence (established or casual) of the species are shown in grey.

Environmental and socio-economic impacts in Europe

Among the publications retrieved during this search process, environmental impacts of invasive mammals have been broadly investigated, as shown by the number of publications issued on this topic (n = 63; Appendix S3). Disease transmission was the most studied sub-topic (30% of the total number of publications related to environmental impacts), followed by predation (24%) and competition (19%). Publications on pathogens of invasive mammals (n = 19) revolved mainly around their helminthofauna (51% of the publications on pathogens; Appendix S3). Some pathogens were introduced in Europe with the study species, such as the nematode *Strongyloides callosciureus*, introduced with Pallas' squirrel *Callosciurus erythraeus* and potentially infecting the native Eurasian red squirrel *Sciurus vulgaris* due to spill-back and spill-over processes (Mazzamuto et al. 2016); and the squirrelpox virus, which can be lethal for red squirrels and was introduced in the UK and Ireland with the Eastern grey squirrel (IUCN 2005, Invasive Species Ireland 2012).

The study species were found to be infected by 224 pathogens, of which 143 (64%) have zoonotic potential; 13 study species serve as potential reservoirs or are implicated in their epidemiological cycle (Fig. 5; Appendix S5). Specifically, regarding the most widespread study species, 49% of the pathogens known to infect the American mink have zoonotic potential; the percentage rises to 67% for the raccoon dog, 78% for the raccoon, and 100% for the muskrat (Fig. 5). Overall, publications on *Echinococcus multilocularis* (14 publications, three species), *Toxoplasma gondii* (nine publications, six species), and *Baylisascaris procyonis* (nine publications, one species) were particularly abundant among the study species (Appendix S5). Prevalence rates presented a high geographical and taxonomical variability: the prevalence of *Echinococcus multilocularis* ranged between 0% (in the raccoon and the raccoon dog in various countries; Kornyushin et al. 2011, Wahlström et al. 2012, EFSA 2015, Karamon et al. 2016, Oksanen et al. 2016, Duscher et al. 2017) and 28% (in the racoon dog in Slovakia; Oksanen et al. 2016); for *Toxoplasma gondii*, it ranged from 0% (in American mink in Spain and the raccoon in the Czech Republic; Criado-Fornelio et al. 2018, Kornacka et al. 2018) to 79% (in American mink in Spain; Ribas et al. 2018); lastly, the prevalence of *Baylisascaris procyonis* in raccoons ranged from 2% in Poland (Karamon et al. 2014) to 80% in Germany (Hohmann et al. 2002). There are recent reports from Denmark and the Netherlands of SARS-CoV-2 infection in mink (Oreshkova et al. 2020).

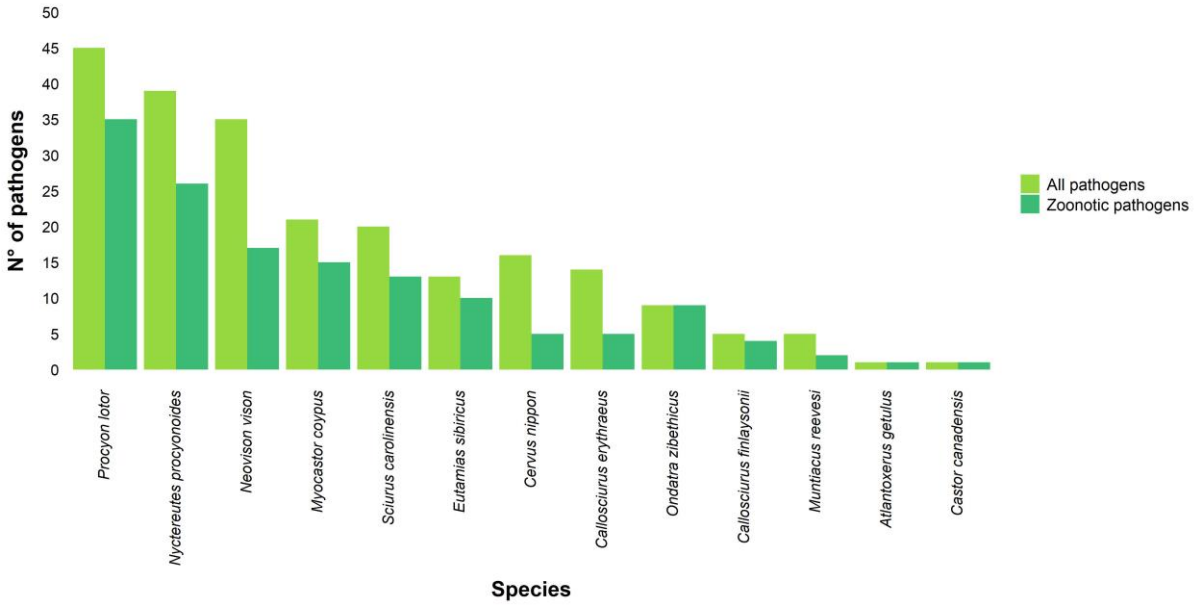

Figure 5. Total number of pathogens known to infect the study species (all pathogens) and pathogens with zoonotic potential (zoonotic pathogens). Species without recorded pathogen infections are not shown.

Regarding the second most investigated sub-topic (predation; n = 15), the majority of publications analysed the predatory effects of American mink (40% of the total number of publications related to predation), raccoon dogs (27%), and Eastern grey squirrels (20%). Of

the publications of predation by American mink, 67% were performed in Poland; all publications of predation by raccoon dogs were performed in Scandinavia, and 67% of publications of predation by Eastern grey squirrels were conducted in the UK. Lastly, regarding competition (n = 12), 75% of the publications investigated how alien squirrels compete with native squirrels. The remaining publications dealing with environmental impacts analysed the sub-topics of habitat alteration (n = 9) and hybridisation (n = 8, comprising only publications on sika deer).

Almost a third of the publications dealt with the health status of the species (n = 46) or with socio-economic impact topics (n = 31), this latter comprising only socio-economic impacts connected to human health. Reviews, datasheets, and risk assessments accounted for 21% of the total publications (n = 54). The remaining publications investigated general ecology of the species (n = 21), genetics aspects (n = 17), population status (n = 13), community ecology (n = 10), ecological modelling (n = 9), management (n = 3), and systematics (n = 3). The least investigated topic was economic impacts (n = 1).

Discussion

The majority of invasive mammals of European Union concern reached Europe as pets that escaped from captivity or were intentionally released. Although introductions of alien mammals have declined in Europe for more than 50 years, many study species are still expanding their alien ranges, colonising neighbouring countries. France is the most invaded country with regard to established presence records, followed by Germany, Italy, and the Russian Federation, and the muskrat, the American mink, the raccoon dog, and the raccoon are the most widespread species. Invasive mammals of Union concern are threatening native biodiversity and human health, and have consequences that were largely overlooked in the past, such as new roles in epidemiological cycles of zoonotic pathogens (Oreshkova et al. 2020).

Literature search

Geographical and impact-related biases emerged from the reviewed literature. Charismatic, widespread, and detrimental species received more attention – in terms of publication numbers – than others, a trend already observed in invasion ecology (Pyšek et al. 2008). Apparently, the documented environmental or social impacts and the geographic range size of the alien species are also related to the number of publications. For instance, species that have localised alien distributions, such as island invaders (the Barbary ground squirrel, the chital, the small Indian mongoose, and the South American coati *Nasua nasua*), have been less well investigated than more widespread species, such as the raccoon and the coypu. The well-acknowledged invasive potential of these localised species urgently calls for additional studies on their impacts and possible future spread. For example, the small Indian mongoose, a devastating island invader globally, could irremediably harm native biota in the Balkans mainland (Ćirović & Toholj 2016).

Our conclusions regarding the recently published literature should be interpreted with caution, as our search did not include 'grey' literature or publications published in languages other than English; this may have generated biases and led to apparent knowledge gaps (Angulo et al. 2021).

Taxonomic characterisation, traits, and native ranges

Humans pose an initial 'filter' to species introduction (Clout & Russell 2008) by selecting mammal species with key traits, such as a large body mass, long reproductive life-span, and large litter size (Blackburn et al. 2017). These last two key traits have been shown also to promote the subsequent phases of establishment and spread, along with many litters per year (Capellini et al. 2015), intraspecific variation in body traits, native range size, and propagule pressure (González-Suárez et al. 2015). The mean adult body mass for our species was high – especially if compared with the mean adult body mass for mammals – but 75% of the study species did not weigh much, and a few of them (i.e., sika deer and chital) heavily skewed the mean. Regarding litter size, the most widespread species in Europe (both in terms of countries and area occupied) had also an above-average litter size, confirming the importance of this trait in the invasion stages consecutive to introduction (Capellini et al. 2015). As for the litters per year, the species that were above average (more than 1.5 litters per year) were mainly rodents. Accordingly, litter size is larger in these socially monogamous species (West & Capellini 2016). Although a longer reproductive life-span promotes introduction and establishment in mammals, the study species with a higher value for this trait have rather localised distributions (the sika deer, the Eastern grey squirrel, and Reeves' muntjac), possibly as an outcome of a low propagule pressure. On the contrary, widespread species (e.g. the muskrat and the American mink) have a short reproductive life-span. The discordance of some study species' traits (adult body mass and reproductive life-span) with what was found previously in the literature could be the result of the relative over-representation in the past of mammals introduced for goods and services (hunting, fur farming, transport; Blackburn et al. 2017), in contrast with more recent introductions of species used as pets (such as squirrels) or for other aesthetic purposes.

With regards to the provenance of the study species, the Palearctic, Sino-Japanese, and Oriental realms were equally relevant. Previous studies (Genovesi et al. 2009, 2012) showed that the Palearctic and the Nearctic were the realms harbouring the native ranges of many introduced mammals. Similarly as for species' traits, the difference could be linked to the over-representation in the past of species introduced to be utilised by humans for goods and services. Contrarily, our study species are mostly used as pets, and originate from eastern realms.

Pathways of introduction to Europe

Overall, the study species were mainly kept in private or public collections or bred for fur, and subsequently escaped or were released. We showed that the pet trade was an important

pathway of introduction to Europe in the last 15 years. For instance, the Siberian chipmunk was first recorded in Ireland in 2007, and was probably released in nature by (or escaped from) private owners (Invasive Species Ireland 2019). Indeed, all the Sciuridae have been introduced at least once for companionship, enjoyment, recreation and/or trading. These species are charismatic and have often been released for 'fauna improvement' in urban parks (as in the case of Siberian chipmunks in Italy; Mori et al. 2018).

Higher rates of establishment and spread are related to multiple releases and, in general, to a higher introduction effort (Clout & Russell 2008, Capellini et al. 2015). However, in the absence of accurate introduction records it is often challenging to distinguish between the natural spread of a species from invasion foci in adjacent countries and a deliberate release (for instance, by private owners) or an escape, especially for highly vagile species such as ungulates and carnivores. For example, recent genetic analyses have shown that new Eastern grey squirrel populations in Italy (which supposedly originated from natural dispersal of individuals) derived in fact from other populations established almost 200 km away (Signorile et al. 2016). Therefore, even in the absence of clear evidence of unaided dispersal, it is inappropriate to assign the unaided pathway of introduction to some species (Pergl et al. 2020).

Temporal trajectories of mammal invasions in Europe

Despite the continuous geographic range expansion of alien mammal species throughout Europe, numbers of first records of alien mammals declined from the 1960s onwards (Fig. 2). This pattern has already been recorded at a global level for this taxon, and it is likely to be influenced by the most recent first records (Seebens et al. 2017). For instance, there were almost no first records of the study species in the last 10 years. However, longer monitoring is needed to assess the reliability of these trends (Seebens et al. 2017), especially to clarify if saturation has been finally reached or if these patterns depend on other factors. The rapid decline in new introduction events can be attributed to the synergistic effects of increased awareness and stricter regulations on alien mammals bred for fur, exploited as game species, or used as pets throughout Europe (Seebens et al. 2017), especially since the implementation of the EU IAS Regulation (EU 2014).

First records in Europe were not evenly distributed among countries, as the UK and the Russian Federation first recorded three study species each. Two of the most common study species (the American mink and the raccoon dog) were first recorded in the Russian Federation, where they were introduced for fur farming. This comes as no surprise, as this country was one of the world's largest producers and consumers of fur (Balakirev & Tinaeva 2001), although now the production has significantly declined (Khusainova & Vorozheykina 2019).

Geographic distribution patterns in Europe

In general, the introduction of a species in a few localities, and subsequent further releases, can rapidly lead to the colonization of large parts of the European territory. We show that, in Europe, the raccoon dog, the muskrat, the American mink, and the raccoon are the most widespread species (in terms of area occupied with established presence), having invaded at least 19 countries each and being present for at least 90 years in the European territory (the most recent invader was the raccoon, introduced in 1927 in Germany). The wide distribution of these species can be attributed to several factors, including their adaptability, capacity to colonize different environments (Birnbaum 2013), wide trophic niches (Bartoszewicz 2011), and high reproduction potentials (Pitra et al. 2010).

It is of paramount importance to monitor the secondary spread (Essl et al. 2020a) of these species in the European territory and to prevent the establishment of new populations of invasive mammals. Secondary spread would foster geographic range expansion for invasive species and would counteract the stringent regulations adopted hitherto to prevent new introductions (and to mitigate IAS impacts). In the EU, changes in the main drivers of potential impacts of biological invasions (trade and transport, climate change, and socio-economics; Essl et al. 2020b) are ongoing (Kovats et al. 2014). This, combined with free circulation of goods and people within the EU (Genovesi et al. 2015), may promote a rise of impacts of IAS.

Environmental and socio-economic impacts in Europe

The wide distribution of alien mammals in the European territory raises many concerns, as these species can transmit diseases to native species, act as disease reservoirs, and introduce zoonotic pathogens. The latter can be hosted by the majority of the study species and, worryingly, some widespread species carry many zoonotic pathogens. Associated infectious diseases, such as echinococcosis, toxoplasmosis, and baylisascariasis, may pose a serious threat to human health. For comparison, only 11% of species on the IUCN list of the 100 World's Worst Invasive Alien Species are known reservoirs for zoonotic pathogens (Vilà et al. 2021).

Publications on *Echinococcus multilocularis* (the pathogen most commonly analysed in all the publications on disease transmission) revolved mainly around the raccoon dog, as it is the definitive host (the host in which the parasite attains sexual maturity; Bagrade et al. 2016). However, the muskrat is an intermediate host (a host in which a parasite passes one or more of its asexual stages), and only two studies (out of 14) investigated the prevalence of the pathogen in this rodent. Dedicated health surveillance, in general of these widespread species of invasive mammals, would be beneficial for many people, as the study species are often found in cities or are bred in captivity for commercial purposes.

In this context, the outbreaks of SARS-CoV-2 reported in the Netherlands and in Denmark in 2020 (Molenaar et al. 2020, Oreshkova et al. 2020) are notable. It is currently unknown which role American mink and other mammals (especially free-ranging ones that are regularly in contact with humans, such as stray cats and their prey) may play in the SARS-CoV-2 cycle.

They may act as wild reservoirs or spread new strains of the virus (mutations affecting the spike protein have already been found in American mink; (Molenaar et al. 2020, Oreshkova et al. 2020, WHO 2020). American mink appear to be very susceptible to the virus, and cases are being reported from other countries such as Spain, Sweden, Italy, and the USA. Following the huge outbreaks of SARS-CoV-2, the mink fur industry in the Netherlands and in Sweden was terminated in 2021 (Humane Society International 2020, 2021), while Italy and Denmark suspended American mink fur farms activity until the end of 2021 (DW 2020, Ministero della Salute 2021).

Large-scale studies investigating the prevalence of zoonotic and non-zoonotic pathogens and the possible roles of invasive mammals of Union concern in their epidemiological cycles are still largely missing. The spread of many pathogens follows invasion stages similar to those described for invasive animals and plants (Vilà et al. 2021), and the unknown role of alien mammals as reservoirs in the wild could easily jeopardise the efforts in place to prevent, manage or eradicate zoonotic diseases. Due to the many analogies between invasion science and human emerging infectious diseases, lessons from the management of IAS can be applied to tackling future human epidemics (Vilà et al. 2021).

Despite their key role in disease epidemiology, predation is probably the most well-known mechanism through which alien mammals can imperil native biodiversity. Through predation, the American mink can exert a negative effect on species such as the Eurasian water vole *Arvicola amphibius* (Rushton et al. 2000, Mori & Mazza 2019) and threaten genetically distinct populations of prey species (Flávio et al. 2021). Heavier egg-predation on ground-nesting birds (compared to previous studies) has recently been reported for the raccoon dog (Dahl & Åhlén 2019), and the muskrat was found to be a major threat to endangered freshwater bivalves in Germany (Stoeckl et al. 2020).

Besides predation and disease transmission, invasive mammals can contribute to native species' extinction through other mechanisms, such as competition (Bertolino & Lurz 2013). The Eurasian red squirrel went extinct in more than half of its range in Italy and was replaced by the Eastern grey squirrel (Bertolino et al. 2016), while the American mink colonised the area occupied by the European mink *Mustela lutreola* and confined this Critically Endangered native mustelid to few areas in Spain (Põdra & Gómez 2018).

IAS can exert a plethora of different impacts on human well-being (e.g., on personal safety, material and immaterial assets, or cultural relations; Bacher et al. 2017). However, the only type of socio-economic impact that emerged prominently from the literature we reviewed was the negative impact on human health. Information regarding economic impacts was not abundant in our results. This is likely to be due to the problems linked to economic data collection (Bradshaw et al. 2016), the specificity of economic sectors (Paini et al. 2016), difficulties in monetising economic damages of IAS (Diagne et al. 2020), or the restricted spatial scales of most studies (Hoffmann & Broadhurst 2016). Until recently, the only exhaustive inventory of economic costs associated with IAS existed solely for insects (Bradshaw et al. 2016, Diagne et al. 2020). Although the InvaCost database (Diagne et al. 2020) is now the most updated datasource for this type of information, the data contained within it for our study species were insufficient for the purpose of this review.

Conclusions

In the European territory, the muskrat, the American mink, and the raccoon dog are the most widespread invasive mammal species, and France, Germany, Italy, and the Russian Federation are the most invaded countries. The 16 species of invasive mammals of European Union concern are threatening native biodiversity and human well-being. The pet trade is still the main pathway of introduction for alien mammals into Europe. It is currently unclear if the recent decline in first records is due to the stricter measures adopted by the European Union or if it is the result of a saturation effect. To explain this decline, longer and more accurate monitoring of first records and of secondary spread of the invasive mammals of Union concern is necessary.

The eradication of those study species with wide distributions is unlikely to be feasible. However, alien species themselves are neither 'bad' nor 'good': it is rather populations of the species that have become invasive, that can be problematic (Simberloff et al. 2013) and that should be managed. In this context, the identification of problematic populations or invaded areas may help to mitigate future impacts.

Funding

The authors appreciate funding by Sapienza University of Rome, the 2017-2018 Belmont Forum and BiodivERsA joint call for research proposals, under the BiodivScen ERA-Net COFUND programme, and with the funding organisations FWF (AlienScenarios, FWF project no I 4011-B32), and the Portuguese National Funds through Fundação para a Ciência e a Tecnologia (CEECIND/02037/2017; UIDB/00295/2020 and UIDP/00295/2020).

Chapter III: Patterns and drivers of range filling of alien mammals in Europe

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Tedeschi L, Lenzner B, Schertler A, Wessely J, Biancolini D, Capinha C, Melone B, Soria CD, Essl F, Rondinini C. Patterns and drivers of range filling of alien mammals in Europe. (*In preparation*)

Abstract

Biological invasions are amongst the main drivers of biodiversity change and decline. Alien mammals are of particular concern in Europe, where their expansion is still unabated, yet the factors that have been driving this spread are still unclear. The well-documented introductions and distributions in this continent provide a unique opportunity to understand how human activities influenced this expansion. We modeled the potential alien ranges of 46 established alien mammals in Europe using species' known introduction localities, residence time, dispersal ability, generation length, and climatic suitability. We compared the potential and observed ranges through three range indices: range filling (portion of potential distribution occupied), range overfilling (portion of observed distribution unexpectedly occupied), and range unfilling (portion of potential distribution currently unoccupied), and we investigated the effects of native range size, introduction pathways, and socio-economic variables on these indices.

We found that range patterns were overall strongly shaped by propagule pressure and markedly differed among species, with many still having wide potential areas unoccupied. Median value of range overfilling was high (68%), suggesting that alien mammal species are spreading outside their potential areas. Conversely, median values of range filling (8%) and range unfilling (0%) were low, confirming how existing information on recorded introductions falls short in elucidating alien mammals' distributions. Human population density showed a consistent, positive influence on all the three range indices, driving range patterns and influencing alien mammals' introduction and establishment. Contrarily, land-use was negatively related to range filling and unfilling, introduction pathways' number and transportation infrastructures to range overfilling, and native range size to range unfilling. These socio-economic factors ultimately depend on human behavior rather than environmental characteristics or species' ecology. Our findings confirm that alien mammals' distribution in Europe is driven also by human agency, highlighting that modifying human behavior and societal norms is key to limit further spread.

Translated abstract

Las invasiones biológicas figuran entre los principales impulsores del cambio y declive de la biodiversidad. Los mamíferos exóticos son particularmente preocupantes en Europa, donde continúan expandiéndose y los factores detrás de esta expansión aún no se han esclarecido. La abundancia de información sobre introducciones y distribuciones en este continente nos brinda una oportunidad única para comprender el papel de la actividad humana en su expansión. Modelizamos la distribución potencial de 46 mamíferos exóticos establecidos en Europa, utilizando puntos de introducción registrados, tiempo de residencia, capacidad dispersiva, duración de una generación e idoneidad climática. Comparamos sus áreas de distribución potencial y observada a través de tres índices: range filling (porción de la distribución potencial ocupada), range overfilling (porción de la distribución observada que está ocupada de forma inesperada) y range unfilling (porción de la distribución potencial sin

ocupar). Además, investigamos el efecto que el tamaño del área de distribución nativa, las vías de introducción y diversas variables socioeconómicas tienen sobre estos índices. Descubrimos que los patrones de distribución estaban fuertemente determinados por la presión de propágulos y diferían notablemente entre especies, muchas de ellas teniendo amplias áreas potenciales aún sin ocupar. El valor mediano de range overfilling fue alto (68%), sugiriendo que las especies de mamíferos exóticos se están expandiendo fuera de sus áreas de distribución potencial. Por el contrario, los valores medianos de range filling (8%) y range unfilling (0%) fueron bajos, confirmando que la información existente sobre introducciones registradas no es suficiente para esclarecer la distribución de mamíferos exóticos. La densidad de población humana tuvo un efecto positivo en los tres índices de introducción, determinando los patrones de distribución, la introducción y el establecimiento de mamíferos exóticos. Por el contrario, los usos del suelo estuvieron negativamente asociados a range filling y unfilling, el número de vías de introducción e infraestructuras de transporte a range overfilling y el tamaño del área de distribución nativa a range unfilling. Estos factores socioeconómicos están en última instancia determinados por el comportamiento humano en lugar de las características ambientales o la ecología de las especies. Nuestros hallazgos confirman que la distribución de mamíferos exóticos en Europa también está guiada por la actividad humana, subrayando la necesidad de cambiar el comportamiento humano y las normas sociales para frenar su expansión.

Keywords: biological invasions, introduction pathways, mammals, potential range, propagule pressure, range filling, socio-economic variables.

Introduction

Biological invasions are one of the most pervasive threats to biodiversity and human well-being (IPBES 2023). The accumulation of alien species shows no signs of saturation (Seebens et al. 2017) and is expected to increase substantially in the coming decades (Seebens et al. 2021), further reshaping biotas, and putting additional pressure on threatened species and economic activities. In Europe, introductions of alien mammals, both unintentional and deliberate (e.g., for food, recreation, pets, conveyance) have been particularly frequent (Long 2003, Genovesi et al. 2012, Tedeschi et al. 2022, Seebens et al. 2023). At least 70 alien mammal species are established in the continent (Biancolini et al. 2021) and, nowadays, ~17% pose significant challenges to species' management and are hence regulated by the European Union (e.g., Regulation (EU) No 1143/2014). Despite new legislation and rising management efforts, alien mammals are still expanding their ranges across Europe (Tsiamis et al. 2019a, Tedeschi et al. 2022), exerting substantial negative environmental and socio-economic impacts (Diagne et al. 2020, Tedeschi et al. 2022, Wang et al. 2023). Worryingly, at least 13 mammal species alien to Europe are implicated in the epidemiological cycle of zoonotic pathogens or act as reservoirs (Tedeschi et al. 2022), and several species are contributing to native species' extinctions (Bellard et al. 2016, Blackburn et al. 2019). Their ongoing spread in Europe

suggests that mammals are not in equilibrium with their new environment, and that they likely still have potentially suitable areas to colonize on the continent (Häkkinen et al. 2023).

The observed distribution of a species is a complex interplay of several biotic and abiotic factors (Wisz et al. 2013), species' environmental preferences, and dispersal ability and limitations (Guisan et al. 2017). In the case of alien species, additional factors related to human agency and invasion history (e.g. timing and duration of species' introductions, species' residence time, secondary spread by human agency; Capinha et al. 2023, Cassey et al. 2018) and their interaction with species spread potential (Simberloff 2009) are crucial for understanding observed species ranges and their relationship with their potential distribution (Bradley et al. 2015). Likely due to the multi-faceted interactions among these factors and to a lack of data, the relationship between observed and potential distributional ranges of alien species has been under-investigated.

Here, we make use of the best available data sources on introduction and distribution of one of the best documented taxonomic groups (alien mammals) in one of the best documented regions (Europe), to disentangle the interplay between introduction history, spread potential, and region climatic suitability on range filling. In particular, we take into account the timing and distribution of known introduction events of alien mammals, and species-specific dispersal ability to reconstruct the over-, un-, and filling of observed and of potential modeled ranges. Specifically, we address the following research questions: i) To which extent have alien mammals filled their potential ranges in Europe? ii) How well does documented propagule pressure (i.e., time-stamped locations of introductions) explain range filling? iii) Which species-specific and anthropogenic factors (that serve as proxies for undocumented aspects of alien mammal species spread, e.g., undocumented secondary spread, region invasibility) explain range filling?

Materials and methods

Study area

We focused on Europe (see Fig. 1) defined as the 46 member States of the Council of Europe, i.e., the 27 European Union countries, the eight candidate countries, Norway, Switzerland, the United Kingdom, the North Atlantic Island territories, and European Russia, but excluding overseas territories (e.g., Guadeloupe, French Guiana).

Box 1

We use the following terms throughout (Fig. 1):

- *Observed range*: the areas where the alien species is extant (i.e., known to occur over the last 20-30 years; Biancolini et al. 2021, IUCN 2021).

- *Potential range*: the maximum climatically suitable area an alien species could have reached spreading from known points of recorded introduction, through natural dispersal, and considering its residence time and generation length.
- *Potential and Observed Alien Range (POAR):* the total potential and observed alien distribution.
- *Range filling*: the portion of the potential range that is currently occupied by the species (i.e., the portion of the potential range that overlaps with the observed range). Similarly, Estrada et al. (2018) defines it as "the proportion of suitable regions where a species has become naturalized".
- *Range overfilling*: the portion of the observed range that is not expected to be occupied by the species, but is occupied (i.e., the portion of the observed range that does not overlap with the potential range).
- *Range unfilling*: the portion of the potential range that is not documented to be occupied by the species (i.e., the portion of the potential range that does not overlap with the observed range).

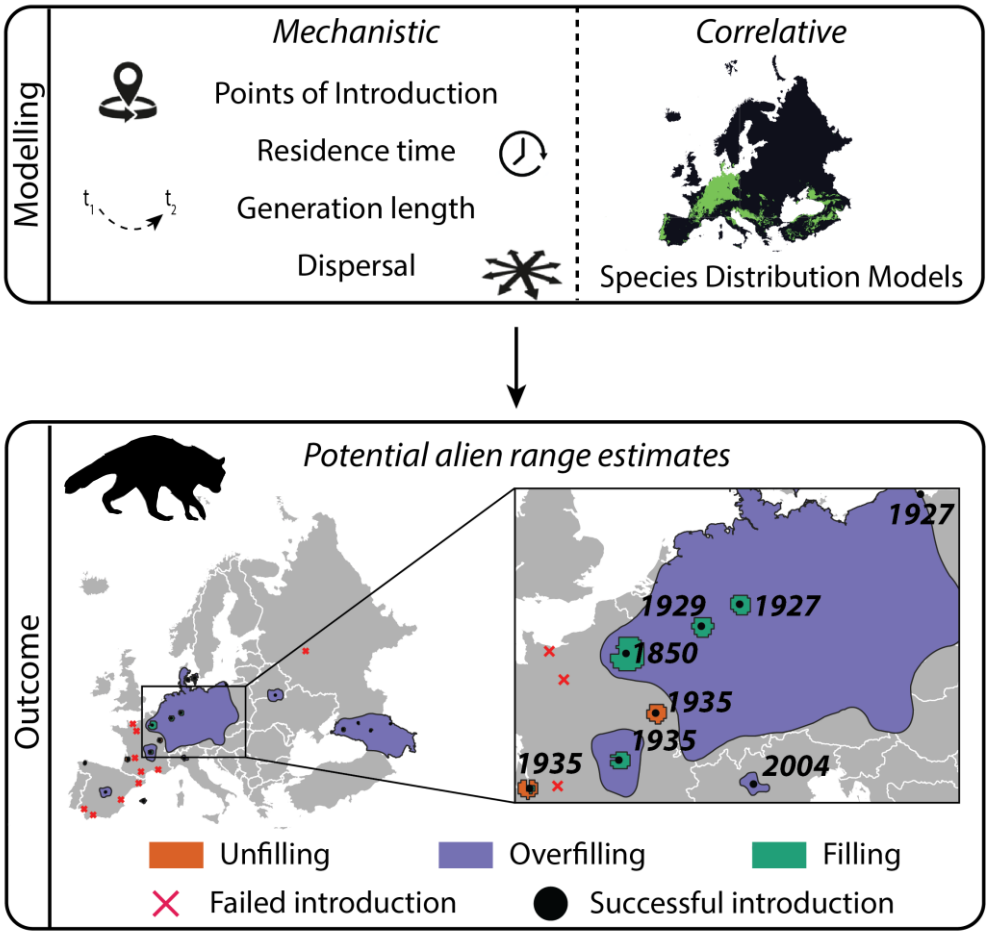

Figure 1: Methodological workflow and terminology used in this paper, using the Northern raccoon *Procyon lotor* as example. The modeling panel at the top shows the hybrid (mechanistic plus correlative) approach used to construct the potential ranges. The bottom panel shows the range patterns (range filling, overfilling, and unfilling). Here, solid green areas represent range filling (areas filled in both ranges), solid purple areas represent range overfilling (areas of the observed ranges outside the potential ones), and orange solid areas represent range unfilling (areas of the potential ranges outside the observed ones). Black dots represent known points of successful (i.e., inside the observed ranges) introduction, while red crosses are points of unsuccessful introductions. Map lines delineate the study area and do not necessarily depict accepted national boundaries.

Species selection and observed ranges

We initially selected the 71 established alien mammals in Europe, for which information on the observed alien range is present in DAMA (Biancolini et al. 2021). We only considered mammal species introduced after 1492 (Kowarik 2010), which marks the onset of the Columbian exchange, meaning that alien ranges and introductions before this date were not considered. Likewise, those without a year of introduction were also excluded (Table S1). We resolved taxonomic inconsistencies and synonyms following the PHYLACINE 1.2 taxonomy (Faurby et al. 2018). In addition, we extracted occurrence data for all species from the Global Biodiversity Information Facility (GBIF; GBIF 2022a) for the construction of ensemble SDMs. We removed species for which we have no record of successful introduction (even if the species is currently established in Europe), domestic species for which it is not possible to discern feral individuals from free-ranging managed ones (e.g., wild goat *Capra aegagrus*), species for which the only alien population was moved to captivity (i.e., llama *Lama glama*, Gargioni et al. 2021), and species with less than 20 occurrences, a commonly acknowledged minimum threshold required to calibrate SDMs (Guisan et al. 2017). This led to a final dataset of 46 study species (Table S2), belonging to five orders, mainly Artiodactyla (33%), followed by Rodentia (30%) and Carnivora (17%).

Potential range calculation

Potential alien ranges for all study species were obtained based on a hybrid approach (Fig. 1), combining i) a mechanistic part, where the potential ranges were calculated based on successful introductions, dispersal distance, generation length, and residence time, and ii) a correlative approach, where SDMs were used to distinguish between climatically suitable and unsuitable regions.

Mechanistic part: introduction points, time since introduction, and species' traits

We gathered records of species introduction events from the global database of mammal introductions. This database, compiled by Blackburn et al. (2017), contains successful and

unsuccessful introductions at the administrative area level. Additional literature was collected through species-specific searches on Scopus (www.scopus.com) and Google Scholar (https://scholar.google.it), using the keywords: "(TITLE - ABS KEY (“Scientific name”) AND TITLE ABS - KEY (“introduc* ”) OR TITLE ABS - KEY (“alien”) OR TITLE ABS - KEY (“invasive”)) AND (LIMIT - TO (SUBJAREA, “AGRI “) OR LIMIT - TO (SUBJAREA, “ENVI”) OR LIMIT - TO (SUBJAREA, “ EART”))". We selected and consulted only the most relevant articles to collect three types of species distribution data: 1) introduction points (coordinates), 2) introduction areas (locations where the species is present, such as range maps or administrative boundaries), and 3) introduction locations (toponyms or other geographic descriptions, e.g., Circeo National Park) following Biancolini et al. (2021). In cases where the introduction was recorded in an area, we used its centroid as the point of introduction. All these spatial operations and georeferencing were performed using QGIS version 3.8 (QGIS.org 2022). Additionally, the involved pathways were assigned to each point of introduction (Biancolini et al., 2021). Points that fell within the observed alien ranges were considered to be successful introductions (i.e., resulting in established, self-sustaining and free-ranging populations), while those outside the observed range were treated as unsuccessful introductions and discarded.

For each study species, we considered dispersal ability (the distance between species’ birth and breeding site, in km) and generation length (the average age of parents of a cohort, in days), derived from the COalesced Mammal dataBase of INtrinsic and Extrinsic traits (COMBINE; Soria et al. 2021), and residence time (number of years since first successful introduction in Europe), derived from DAMA (Biancolini et al. 2021) and additional literature (Melone et al. 2021; Table S3).

To estimate the potential spread of the species from the introduction point(s), we calculated the number of generations a species produced since its introduction by dividing the residence time by the generation length. The total distance each species might have covered following its introduction was calculated by multiplying the species-specific dispersal distance by the number of generations passed (Visconti et al. 2016, Baisero et al. 2020). The potential range of each study species was then represented by the circular space around the introduction point(s) with the radius set to the abovementioned distance. As we are working with terrestrial species, only continuous land area was considered in the calculations.

Correlative part: ensemble Species Distribution Models

To construct ensemble SDMs, we used global species’ presence data points from GBIF (GBIF 2022a), including the native and alien species’ range (Broennimann & Guisan 2008, Jiménez-Valverde et al. 2011, Mainali et al. 2015, Araújo et al. 2019). To be consistent with the temporal span of the bioclimatic variables and, at the same time, retain the highest amount of data possible, we filtered for presences during 1981-2022, excluding fossil records and captive specimens.

Downloaded data was cleaned for evident errors using *CoordinateCleaner* v.2.0-20 (Zizka et al. 2019) using the default settings, and furthermore aggregated to a resolution of 10 x 10 km. In an additional step, following Ficetola et al. (2014), we removed for each species 1% of presences with the farthest distances to native and alien ranges (see Supplementary Methods for further details). To reduce sampling bias, presences were thinned to a 50 km distance (Brown & Carnaval 2019) using *spThin* v. 0.2.0 (Aiello-Lammens et al. 2015). The final dataset comprised 26,677 presences for 46 study species (obtained from the initial 7,262,324 presences; GBIF 2022b), of which 82% were inside range polygons (67% were inside a native range polygon, 15% inside an alien range polygon; Fig. S1, Table S4).

We downloaded bioclimatic variables from CHELSA V2.1 (Karger et al. 2017, 2018) for the period 1981-2010 at 30 arc seconds resolution (≈ 1km) and averaged them to a 10 x 10 km resolution. We checked for collinearity between variables using the Pearson correlation coefficient in *sdmpredictors* v. 0.2.14 (Bosch & Fernandez 2022) and kept those with a correlation ≤ |0.7| (Dormann et al. 2013; Table S5) and that are considered important for projecting species distributions at large scales (Visconti et al. 2016): bio1 (mean annual air temperature), bio3 (isothermality), bio4 (temperature seasonality), bio15 (precipitation seasonality), bio16 (mean monthly precipitation amount of the wettest quarter), and bio17 (mean monthly precipitation amount of the driest quarter). As the study species are terrestrial non-volant mammals, the bioclimatic variables were cropped to the world's landmasses.

Five replicates of pseudo-absences were sampled outside the species' range, where we drew as many of them as presences, but a minimum of 100 (Barbet-Massin et al. 2012). Pseudo-absences were sampled by accounting for major geographical dispersal barriers (Guisan et al. 2014), as well as sampling bias (Phillips et al. 2009). Areas that are theoretically accessible to a species via natural dispersal are those where pseudo-absences are ecologically meaningful (Jiménez-Valverde et al. 2011). We therefore defined the continent(s) where a species occurs as accessible region(s). To account for sampling bias in our presence data, we adopted a target group approach (Phillips et al. 2009, Ranc et al. 2017, Chapman et al. 2019, Pedruzzi et al. 2022; Supplementary Methods; Fig. S3). Pseudo-absences selection was performed using *raster* v. 3.6-14 (Hijmans 2023a) and *terra* v. 1.7-3 (Hijmans 2023b).

We applied an ensemble modeling approach and used six algorithms from *biomod2* v. 3.3-7.1 (Thuiller et al. 2019): two regression methods (Generalised Linear Model and Multivariate Adaptive Regression Splines), a classification method (Flexible Discriminant Analysis), and three machine learning methods (Generalised Boosting Model, also called Boosting Regression Trees, Artificial Neural Network, and Random Forest), with the default settings of *biomod2*. We split species' occurrences in 80% (model calibration) and 20% (model evaluation; Guisan et al. 2017). To account for the stochastic nature of some algorithms, this split sampling approach was repeated three times for each species, resulting in a total of 4,140 models (six models x three runs x five pseudo-absences sets x 46 species).

Single model performance was evaluated using True Skill Statistics (TSS), with a threshold ≥ 0.7 (Guisan et al. 2017) for single models to be included in ensemble modeling. Subsequently, an ensemble model was built for each species as weighted means of the single models, with

the corresponding TSS values as weights. The final ensemble SDMs showed very good predictive performance (Zhang et al. 2015): mean TSS across species = 0.88 ± 0.05, mean sensitivity = 95.38 ± 2.98, and mean specificity = 92.83 ± 2.87 (Table S6). The whole modeling process was documented following the standard protocol ODMAP (Overview, Data, Model, Assessment and Prediction; Zurell et al. 2020), available in the Supplementary Data.

Range patterns and indices

The binary outputs from the SDMs were cropped to Europe and re-projected to ETRS89-extended/LAEA Europe (EPSG:3035) using the nearest neighbour method. For each species, the potential ranges were limited by the climatically suitable areas projected by the SDMs, i.e., unsuitable areas were removed from them. For each species and for each range pattern polygon (filling, overfilling, unfilling) we calculated the area as the number of 10 x 10 km grid cells (see Supplementary Data). Range indices were calculated by dividing the derived values by the total number of available cells (potential + observed range, i.e., POAR) multiplied by 100.

Statistical analyses

We built three generalised linear mixed models (GLMMs; one for each range index), related to the introduction history of the study species and to the socio-economic variables hypothesized to be associated with the range patterns (Table 1). We collected information on the following variables: number of introduction pathways, native range extent, human population density, anthropic land-use, and transportation networks (Table S3, Table S7, Supplementary Methods).

More pathways usually result in multiple introductions (and therefore larger alien ranges; Dyer et al. 2016), and native range extents are indicators of species' niche breadth (González-Suárez et al. 2015). Simple variables describing human pressures (e.g., human population density), rather than composite proxies (such as the Human Footprint Index), have been found to be the better predictors of mammals' geographic range size among human pressure variables (Di Marco & Santini 2015). Moreover, they allow for a better discrimination of individual variables' influence, compared to the use of cumulative measures. Land-use and international trade and transport are amongst the most relevant drivers of biological invasions in the 21st century (Essl et al. 2019, Liu et al. 2023). For land-use, we selected only categories of anthropic environments (pasture, cropland, and urban area), excluding natural land. We refer to this anthropic land-use as "land-use" throughout the manuscript.

Table 1: Variables used in the Generalised Linear Mixed Models (GLMMs). Time span, measurement unit, original variable's resolution, and source are indicated. All variables were transformed to the study resolution (10 x 10 km) and projection (EPSG:3035). Variables available for several individual years were averaged.

Variable	Time span	Unit	Original resolution	Source
Number of introduction pathways	1492-2017	NA	NA	Biancolini et al. (2021)
Native range extent	NA	Number of 10x10 km cells	NA	IUCN (2020)
Human population density	1980, 1990, 2000, 2005	Inhabitants/grid cell	1x1 km	History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011)
Anthropic land-use	1980, 1990, 2000, 2005	Area covered by each anthropic land-use category/km^2	1x1 km	History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011)
Roads and railways	2017	Pressure score (range 0-8; roads mean 2.6, railways mean 0.1)	1x1 km	Williams et al. (2020)

All variables were transformed to the study resolution (10 x 10 km) and coordinate reference system (ETRS89-extended/LAEA Europe–EPSG:3035), averaged across time periods, and calculated for each species as an average value across each species' range filling, overfilling, and unfilling polygon(s) (Supplementary Methods). Continuous variables were scaled to ensure comparability and uniformity, and then checked for collinearity, i.e., Spearman correlation ≤ |0.7| (Dormann et al. 2013; Table S8).

We fitted the GLMMs with a negative binomial error distribution and an offset in *glmmTMB* v. 1.1.7 (Brooks et al. 2017), using the number of 10 x 10 km cells of each polygon of the three range patterns as response variables (Supplementary Data). These models combine the negative binomial distribution (to account for the overdispersion often observed in count data) with species identity as a random effect. To treat a count variable as a rate, we incorporated an offset variable, namely the log of the total area available (POAR). By considering the varying sizes of the POAR for different species, we effectively model the extent of range patterns relative to the available area. After inspecting the data, we accounted for different species' responses to the land-use including a random slope for that variable.

We used *DHARMa* v. 0.4.6 (Hartig 2022) and *performance* v. 0.10.4 (Lüdecke et al. 2021) to check models' performances, and *sjPlot* v. 2.8.14 (Lüdecke 2023)to visualise models' outputs. Spatial analyses were performed in QGIS v. 3.4 (QGIS.org 2022), GRASS GIS v. 7.8.7 (GRASS Development Team 2020), and R v. 4.2.2 (R Core Team 2023). Statistical analyses were performed using R v. 4.0.3 and 4.2.2 (R Core Team 2023).

Results

Our database contained 599 points of successful introduction (ranging from 1 to 112 per species; median = 3) and 162 points of unsuccessful introduction (from 0 to 25 per species; median = 2; Fig. S4, Table S2). Among the discarded points, a total of 104 points across 37 species referred to introductions before 1492, while no year of introduction was available for another 587 points (17 species; Table S1; Fig. S5). The species with most introduction pathways were the sika deer *Cervus nippon* and the aoudad *Ammotragus lervia* (n = 5), while more than half (52%) of the study species were introduced via only one pathway, with the most common one (for 57% of species, n = 26 species) being hunting (Table S3). Native range extent varied between 229 and 658,263 cells (median = 52,364; Table S3).

The median number of occupied cells for the observed alien ranges was 363.5 (equivalent to 36,350 km^2; min = 4 cell, max = 74,463; Fig. 2A, Fig. S6, Table S9), while for the potential alien ranges it was 82 (min = 0, max = 17,285; Fig. 2B, Fig. S6, Table S9). Among the discarded observed alien range polygons, a total of 431 polygons across 28 species referred to introductions before 1492, while no year of introduction was available for 261 polygons (23 species; Table S1). Both observed and potential ranges for the established alien mammals were concentrated in Central Europe, particularly in the Czech Republic (Fig. 2A, 2B). Patterns of range filling were concentrated in Central Europe (e.g., the Czech Republic), as well as in southern United Kingdom (UK) and Sweden (Fig. 2C). Range overfilling closely resembled the currently observed distribution of alien mammals in Europe (Fig. 2D), while species' range unfilling was mainly concentrated in central Germany and Austria, and north-eastern Ireland and France (Fig. 2E).

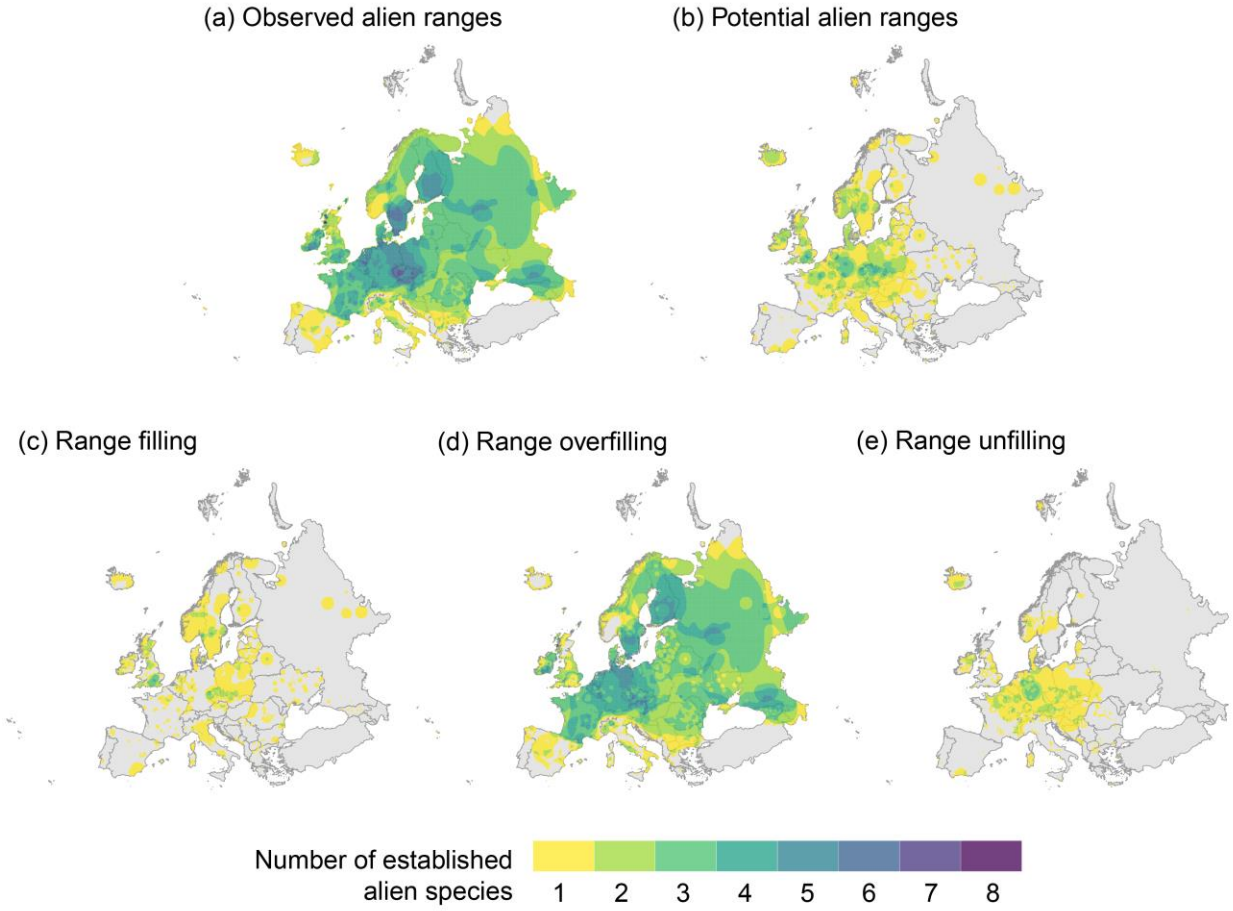

Figure 2: Number of (a) Observed alien ranges (n = 46 species), (b) Climatically suitable potential alien ranges (n = 40), (c) Range filling (n = 39), (d) Range overfilling (n = 44), and (e) Range unfilling (n = 24) patterns of established alien mammal species in Europe. Species for which potential ranges completely resided in climatically unsuitable areas (and thus with a number of cells equal to zero) are not shown. Map lines delineate study areas and do not necessarily depict accepted national boundaries.

The climatically suitable areas identified by the SDMs, on which the potential ranges were cropped, were concentrated mainly in France, Belgium, The Netherlands, Southern Germany, northern Switzerland and Austria, Slovenia, Croatia, and Bosnia, and along some mountainous chains such as the Pyrenees, the Apennines, and the northern coast of Turkey (Fig. S7).

Range patterns and indices

The range indices varied greatly among the study species: at species level, the median number of occupied cells for the range filling was 28 (min = 0, max = 11,419; Fig. S8, Table S9), median

range overfilling was 159 (min = 0, max = 71,980, Fig. S8, Table S9), and median range unfilling was 1.5 (min = 0, max = 15,016; Fig. S8, Table S9). The American mink *Neovison vison* had the wider range filling, while the muskrat *Ondatra zibethicus* and the fallow deer *Dama dama* had, respectively, the wider range overfilling and unfilling (Fig. S8, Table S9).

At a polygon level, median number of occupied cells for range filling was 8 (min = 1, max = 3166; Fig. 3, Supplementary Data), median range overfilling was 4 (min = 1, max = 70,722; Fig. 3, Supplementary Data), and median range unfilling was 3 (min = 1, max = 12,949; Fig. 3, Supplementary Data).

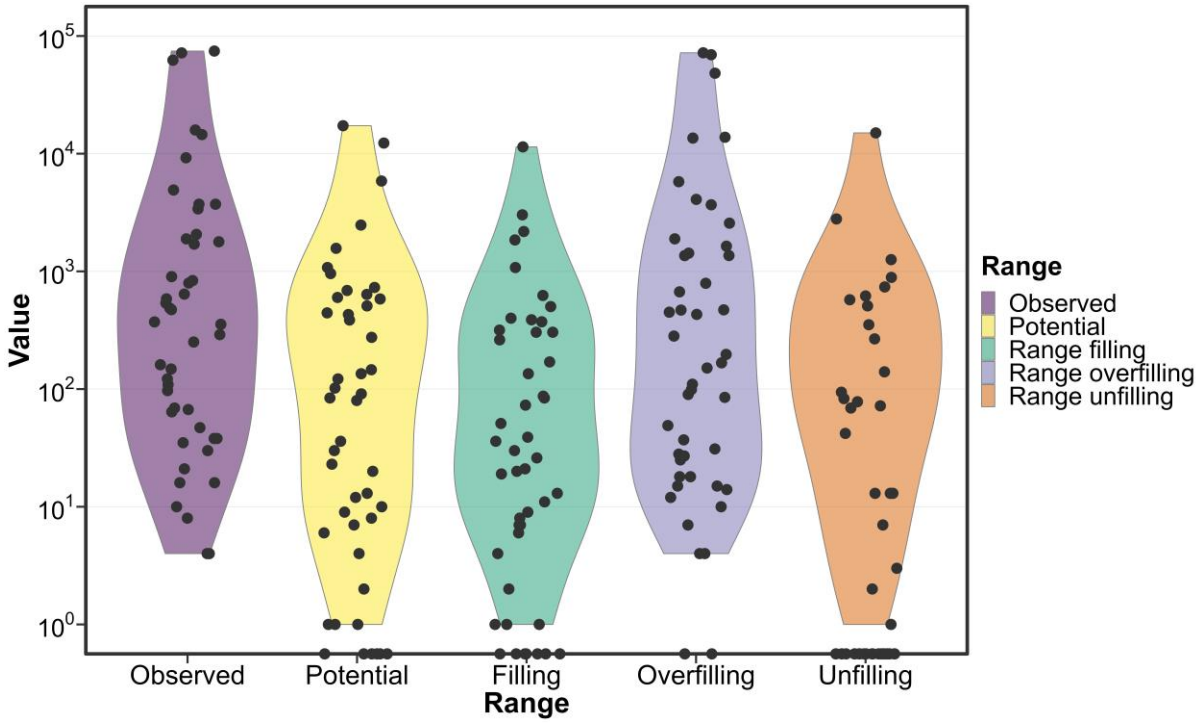

Figure 3: Observed alien range (violet), potential alien range (yellow), range filling (green), range overfilling (purple), and range unfilling (orange) of established alien mammals (n = 46 species) in Europe. For alien ranges and range patterns results are shown at a species level, for numbers of 10 x 10 km cells (log scale).

As for the range percentages, median range filling was 7.7% (min = 0%, max = 68.1%), median range overfilling was 67.6% (min = 0%, max = 100%), and median range unfilling was 0.2% (min = 0%, max = 99.2%; Table S9). The species with the higher cell counts (i.e., wider range pattern areas) were not the ones with the highest percentage. The Bobak marmot *Marmota bobak* had the highest range filling percentage, while the Siberian roe deer *Capreolus pygargus* had a 100% range overfilling (Table S9). It is important to note that this species had potential ranges only in climatically unsuitable areas, and therefore got a potential range's cell count of

zero and a range overfilling of 100%. Lastly, the wapiti *Cervus canadensis* had the highest range unfilling percentage (Table S9).

No species exhibited more than 90% of range filling, while 87% of the species (n = 40) overfilled more than 10% of the total available area (i.e., POAR). Lastly, 10 species (21.7 % of the study species) unfilled more than 10% of the POAR. Other study species as well had potential ranges only in climatically unsuitable areas, and therefore got a potential range's cell count of zero (namely the chital *Axis axis,* Finlayson's squirrel *Callosciurus finlaysonii,* the American beaver *Castor canadensis*, and the Northern white-breasted hedgehog *Erinaceus roumanicus*). Because the resolution of the binary SDMs projections was too coarse to capture very small islands, the red deer *Cervus elaphus,* which was introduced to several European islands and presented a very small potential range in one location, got a cell count of zero for the potential range.

Statistical analyses

Among the statistically significant relationships, human population density was the only variable showing a consistent effect across the three models, being positively associated with all three range indices (Fig. 4, Table S10). Land-use was negatively associated with range filling and unfilling, while total number of introduction pathways and roads and railways were negatively associated with range overfilling (Fig. 4, Table S10). Native range size showed a negative relationship with range unfilling (Fig. 4, Table S10).

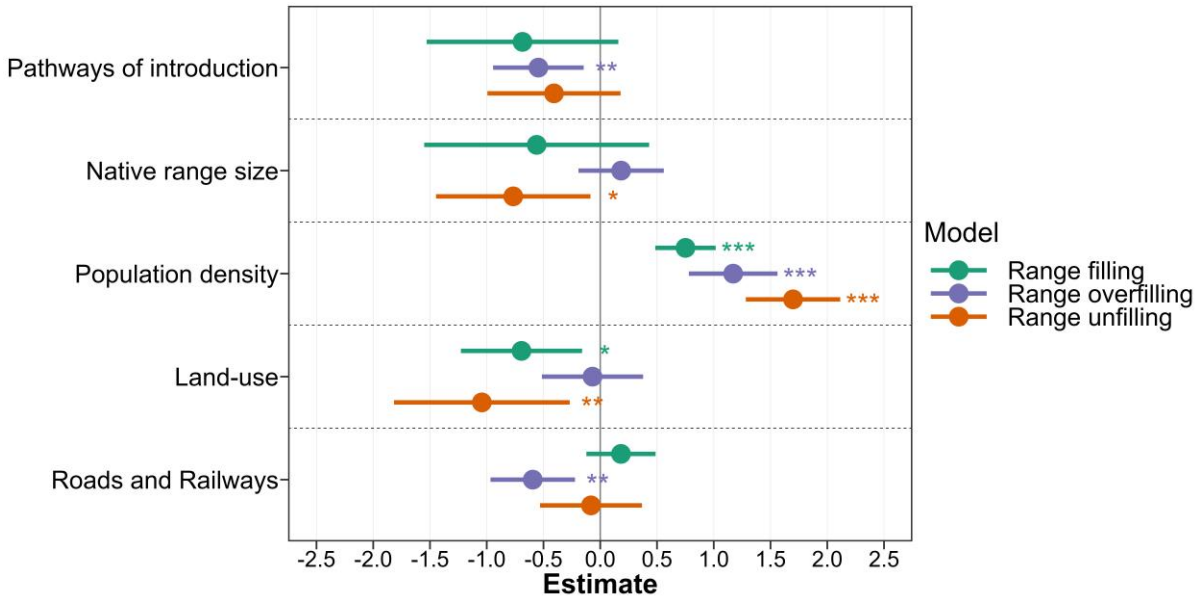

Figure 4: Effects of introduction pathways, native range, human population density, land-use, and roads and railways on the three different range indices (range filling, green; range overfilling, purple; range unfilling, orange) of established alien mammals in Europe.

Estimates (with 95% confidence intervals) of effects were obtained from GLMMs, with species as a random effect, accounting for variations in the response to land-use among species (i.e., random slope). Statistically significant relationships are marked with one or more asterisks based on the strength of the relationship (for the p-value: 0 < *** < 0.001 < ** < 0.01 < * 0.05).

Discussion

Our results show that despite the long-lasting history of mammal introductions into Europe, none of the study species filled more than 90% of the suitable available area, when considering dispersal from the points of introduction. Rather, almost all alien mammals (87%) showed range overfilling by at least 10%, suggesting that those alien species are spreading outside their potential suitable areas. Range unfilling was less commonly observed among our study species; however, 10 species currently do not occupy at least 10% of their potential range in Europe, meaning that a substantial part of the continent is still suitable for invasion. These patterns are primarily driven by human population density, which influences alien mammals' introduction and establishment.

Many alien mammals are still spreading and expanding their ranges

While global mammal introductions seem to be levelling off (Seebens et al. 2017), those alien mammals that are already present are still spreading in their new ranges, as has been observed for Europe (Tsiamis et al. 2019a, Tedeschi et al. 2022). Our results show that this ongoing colonization not only involved climatically suitable areas, but also that many species expanded beyond expected areas.

In this context, the median value for range overfilling we found was almost 70%. Excluding species with a potential range equal to zero, among the species with the higher range overfilling there are some of the most widely distributed alien mammal species in Europe: the muskrat, the Raccoon dog *Nyctereutes procyonoides*, and the Northern raccoon *Procyon lotor*. Those are all species that played or still play an important role in fur farming. Often, large numbers of individuals can escape (or be released) from fur farms (Tedeschi et al. 2022), which may result in a facilitated successful establishment and spread. Such events, if unproperly recorded, may be partially responsible for this high degree of range overfilling. Additionally, to understand this pattern, a clarification on mammals' historical introductions is needed. It is noteworthy that our study specifically targeted data that included precise reference years for the introduction events, ensuring accuracy in our analysis, but also highlighting the substantial discrepancy between the observed distributions and the potential ones based on points of introductions, climatic suitability, and dispersal ability. This proves that numerous unrecorded release events happened in this continent, and it becomes apparent that the existing information alone falls short in elucidating the current distribution of alien mammals. The history of mammal introductions is extensive, as shown by the median introduction year dating back to 1910, considerably earlier than other vertebrates, whose median introduction years dates after 1962 (Seebens et al. 2017). Range overfilling could then be interpreted as a

measure of species' introductions underreporting. This early median, however, may be influenced by the leveling off of mammal introductions in recent years, unlike other taxa (such as birds) which continue to experience numerous recent introductions (Seebens et al. 2017). On the one hand, the fact that so many introductions occurred on average more than a century ago may also imply that mammals were largely introduced when people's ability and willingness to document such introductions, as well as their awareness and knowledge of alien species, were likely significantly lower than today. On the other hand, mammals were often introduced for hunting purposes in the past, and those introductions are among the best documented ones (Biancolini et al. 2021). In any case, mammals had more time to expand in new regions (and eventually overfill their ranges), compared to other alien taxa. Emblematic is the case of the Northern raccoon, with only 18 recorded dated points of successful introduction and a potential range roughly equivalent to Mallorca's Island; however, its current observed range encompasses multiple states in central Europe. This underlying bias has likely driven the underrepresentation of some filling processes: similarly, inventory effort has already been found to affect patterns of range filling (Pouteau et al. 2021).

Contrarily, the median value of range filling for our pool of study species was notably low. This may partially result from limitations in our methodology (see "*Strengths, broader implications, and limitations of the current study*") but, in other instances, the available information was only sporadic yet sufficient to characterize species' range patterns. This is, for instance, the case of the Bobak marmot, which presents only one introduction point in the Russian Federation, and whose potential range closely resembles the observed range, making it the species with the highest range filling index. The spatial patterns that we found can be interpreted also considering species' functional traits (i.e., related to morpho-physio-phenological characteristics influencing specimen growth, reproduction, and survival; Violle et al. 2007). For instance, despite having a habitat breadth below the average of the study species, the American mink (the species with the widest range filling in terms of area occupied) exhibits a broader native range, a more extensive diet breadth, and a lower age at first reproduction compared to the average of the study species (Soria et al. 2021). These characteristics suggest that the American mink is a more versatile and precocious species compared to the others, aligning with the findings of Estrada et al. (2018), who concluded that species displaying generalist traits and early reproductive patterns tend to exhibit greater range filling.

Human activities keep some alien mammals in check

Range unfilling was less commonly observed among our study species, with at least a fifth (21.7%) of them unfilling more than 10% of their range. Our analyses show that human population density accounts as well for this pattern, implying that human activities hampered the spread of some species. This is evident, for example, for the Ungulates displaying the highest proportion of range unfilling (the wapiti, the Alpine ibex *Capra* ibex, and the fallow deer *Dama dama*) and all undergoing human management. The influence of management and containment is clear in the case of the wapiti, which was introduced more than a century ago

in the La Mandria natural park in Northern Italy (Biancolini et al. 2021). Even if the potential range of the species is quite wide—due to the species' high dispersal ability and the climatic suitability of the surrounding area—the deer was effectively confined in the park since then, impeding further species' spread. The observed distribution of the fallow deer is patchy, probably also due to its control as a game species and increasing hunting pressure associated with areas of higher human population density. Contrarily, its potential distribution is continuous and wide, due to the high dispersal ability and extensive climatic suitability. In both cases, the combination of a continuous potential distribution with a patchy observed one probably produced the high degree of range unfilling we found.

Unraveling anthropogenic influence on alien mammal's range patterns

Human population density consistently showed a statistically significant positive association with all range indices, highlighting the role of human intervention in shaping alien distributions. In general, human population density, economic wealth, trade, and anthropogenic impacts have been found to be associated with alien mammals' richness and to drive alien species naturalizations (Pyšek et al. 2010, Dawson et al. 2017, Pouteau et al. 2021, Capinha et al. 2023). Human population density can be interpreted as a proxy of species' introductions and recording effort. The consistent positive association is likely driven by the strong dependence of the range filling and unfilling patterns to the points of introduction, which in turn are strictly connected to human activities and, therefore, population density. Human population density showed a positive effect on range unfilling as well, likely because it is a proxy for undocumented introductions. In other words, without human activity, there would be no recorded introduction points and, consequently, no potential ranges, leading to no range filling or unfilling. We found indeed a consistent positive association between introduction points and human population density, which was evident especially for the range unfilling (Fig. S9). It is therefore important to interpret the positive influence of human population density on range filling and unfilling with caution.

Land-use exhibited a significant negative association with range filling and unfilling across different orders (Fig. S10). This finding is in line with past studies that hypothesized alien mammals to be less dependent on human disturbance for establishment than alien plants and insects (Lozon & MacIsaac 1997). These taxa are frequently found in intensively modified environments, while alien mammals seem to be more distributed in natural ecosystems both in Europe (Pyšek et al. 2010) and at a global scale (Liu et al. 2023). Furthermore, land-use change was recently found to have a negative impact in the native range of ungulates and carnivores (Baisero et al. 2020), to which most of our studied species belong.

Surprisingly, the total number of introduction pathways displayed a significant negative effect on range overfilling. While it might seem intuitive that more introduction pathways would lead to greater colonization success, they may not be equally effective in helping the species to establish and spread, and propagule pressure might differ among pathways as well. Some pathways, like stowaways, result in accidental introductions to either suitable or unsuitable environments, culminating in a mix of failed and successful establishments. On

the flip side, deliberate introduction pathways often go hand in hand with introductions to suitable environments, or even human support in the establishment of a population (Blackburn et al. 2017).

Even if Europe has the highest railways and road density of any continent (Hulme 2009), and road density has been found to be a significant correlate of invasion spatial patterns for some taxa (Urban et al. 2008, Weber & Li 2008, Roques et al. 2009, Benedetti & Morelli 2017), in our study the presence of such transportation networks is negatively correlated with species range overfilling. These infrastructures may be more relevant for species that are accidentally transported (e.g., stowaways), rather than those intentionally released or that escaped from captivity, like mammals (Borda-de-Água et al. 2017), which also rely on efficient autonomous dispersal and spread after first establishment. Only five of our study species have been introduced to Europe as stowaways, with four being micromammals (including the world's known smallest terrestrial mammal by mass, the Etruscan shrew *Suncus etruscus*). In addition, for larger alien mammal species roads and railways may serve as dispersal barriers (hindering the ability to overfill the range), rather than playing a facilitative role, and even act as a gene flow barrier (Frantz et al. 2012).

Lastly, the extent of the native range had a significant negative impact on range unfilling, meaning that species with larger native ranges showed a smaller portion of unoccupied potential range. This is likely because a wider native distribution may indicate also a larger ecological niche (González-Suárez et al. 2015), and therefore higher ability to occupy different environments.

Strengths, broader implications, and limitations of the current study

While some previous studies have explored range filling, none of them have focused on alien mammals using a hybrid model, combining mechanistic and correlative approaches, to identify range unfilling and overfilling as well. We provided a novel framework to study range patterns, which allows us to identify where and to what extent alien mammals (the most extensively studied alien taxonomic group) have expanded beyond their suitable potential range and elucidate the variables shaping these range patterns.

Considering both climatic suitability and anthropogenic activities can improve the estimation of alien species' potential ranges, offering a stronger baseline for management, conservation, and future predictions of species distribution, which is crucial in a time of massive global changes (Pyšek et al. 2020). As managing alien mammals comes also with substantial financial costs (invasive mammals costed US$146 billion in the period 1970-2017; Diagne et al. 2021), those estimations shall be as accurate as possible.

Additionally, time lags between the introduction of alien species and their establishment (and potential negative impacts) characterize a phenomenon called "invasion debt" (Essl et al. 2011). The consequences of the current socio-economic human activities on the extent of biological invasions will not be entirely realised until several future decades (Essl et al. 2011).

In this sense, range unfilling can be of particular interest to pinpoint relevant areas for impacts' prevention and management.

Calculating the potential ranges required several simplifying assumptions aimed to obtain the best result with available data. As we did not aim to investigate alien species expansion *per se*, potential ranges are a scenario of species' spread that can be used for comparison. First, species' spread from points of introduction was homogenous and did not account for functional connectivity or fine scale habitat suitability. In fact, while our potential ranges exclude climatically unsuitable areas, they do not account for land-cover and elevation requirements, which are an essential component of species' Area Of Habitat (Lumbierres et al. 2022). In our study, areas of range unfilling can be interpreted as a mixture of phenomena—including, as mentioned, effective containment actions—but, among others, also unsuitable habitat for the species, or other dispersal barriers not considered in the study.

Another critical point is that the calculation of potential ranges, and in turn the computation of the range indices, strictly depend on the available dated introduction points, which are notoriously underreported and affected by spatial biases (Pyšek et al. 2008). Even though alien mammals have been transported to the continent for a variety of purposes during several centuries, their introduction documentation suffers from gaps known to affect macroecological datasets (Meyer et al. 2015, Seebens et al. 2017). This unavailability of information is reflected in our study data as well: for instance, while the Balkan region harbours several alien mammal species, it lacks introduction records for many countries, meaning that the introductions may have been undocumented, or species secondary spread from adjacent countries (Essl et al. 2020a, Tedeschi et al. 2022). Interestingly, clusters of introduction points undated or dated before 1492 are concentrated mainly on islands (Fig. S5), where mammals were often introduced early on with the purpose of creating wild populations of food reservoir when landfall occurred (Long 2003; Blackburn et al. 2017).

In addition, introduction points needed to be classified as successful and being dated after 1492, further reducing their number. While in the past mammals were introduced often for goods and services (hunting, transport, fur farming; Blackburn et al. 2017; Biancolini et al. 2021), recent introductions of species used as pets or for other aesthetic purposes have been more common (Tedeschi et al. 2022). However, when an accurate reporting of introduction records is lacking, it is arduous to discern what is natural spread from neighboring countries from an escape or a deliberate release, especially if the species has a high mobility as in the case of ungulates and carnivores (Tedeschi et al. 2022), which compose half of our pool of study species.

Lastly, as the potential ranges of some species were in climatically unsuitable areas, their potential ranges resulted to be equal to zero. By adopting a hybrid approach with a correlative part, we also, inevitably, introduced some circularity in our data: to calculate the SDMs for the potential ranges, we used species' occurrences from online biodiversity databases (i.e., GBIF), and we compared those potential ranges to the observed ones (Biancolini et al. 2021) which are also informed by the same set of data. The combination of these reasons, and likely not the inability of the species to spread (e.g., because they had a low dispersal), might have

driven the higher proportion of range overfilling and the lower one of range unfilling in our study.

Conclusions

We show that alien species introduction records are fundamental to understanding their current and potential distribution, emphasising that the existing information alone falls short in explaining the distribution of alien mammals in Europe. Range patterns and indices were strongly shaped and driven by human activities that promoted or hampered alien species' ability to fill their potential ranges, highlighting the pervasive role humans' actions and behaviors have on species' distribution. Our finding that many alien mammals in Europe—despite their long history of introduction—still have not filled their potential range is alarming. Moreover, climatic changes are expected to further increase their suitable conditions (Louppe et al. 2019, 2020, Polaina et al. 2020, Schertler et al. 2020), making it more challenging to anticipate potential spreads, raising concerns. Our results therefore highlight a stronger need for alien mammal monitoring and management in order to avert further spread and associated negative impacts on biodiversity and human livelihoods, in line with existing policy frameworks like the European regulations on alien species (Regulation (EU) No 1143/2014) and the Kunming-Montreal Global Biodiversity Framework.

CrediT

LT, DB, CC, FE, and CR conceptualised the study. DB, BM, CDS, and CR provided the mammal data. LT, BL, AS, and JW conducted the analysis. BL, FE, and CR supervised the study. LT and BL visualised the results. LT wrote the original draft with inputs from BL, AS, DB, CC, FE, and CR. All authors contributed to the overall study design and paper writing.

Funding

CR received funding from the European Union – Next Generation EU as part of the National Biodiversity Future Center. CDS received funding from the European Union (ERC, BEAST, 101044740). AS and FE acknowledge funding from the Austrian Science Foundation FWF (P 34688).

Acknowledgements

We greatly appreciate modeling advice from Stefan Dullinger, Luigi Maiorano, Michela Pacifici, and Riccardo Omenti.

Chapter IV: A synthesis on alien mammals threatened in their native range

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Tedeschi L, Lenzner B, Schertler A, Biancolini D, Essl F, Rondinini C. A synthesis on alien mammals threatened in their native range (*In preparation*)

Abstract

Global changes drive rising extinction and introduction rates for species worldwide. While many alien species are widespread in their native range, some may be threatened, presenting a complex conundrum for conservation invasion science. Species threatened in their native range may become invasive when introduced elsewhere, requiring management. Conversely, some alien populations may aid conservation efforts. To make informed decisions, we must enhance our understanding of these species' ecology in both native and alien ranges. To this end, we conducted an ecological analysis of threatened mammals with alien populations, encompassing their native and alien distributions, introduction pathways, and assessing threats and conservation measures. We also re-assessed their IUCN Red List Category, to evaluate whether the inclusion of the alien populations affect their Red List categorisation.

We identified 41 alien threatened mammals (18% of the total pool of 230 globally established alien mammals), categorised as Critically Endangered (n = 8 species), Endangered (n = 11), and Vulnerable (n = 22). Their native distribution was concentrated in continental and insular Southeast Asia, while alien ranges presented a hotspot in insular Southeast Asia and eastern Australia. Threatened mammals were mainly introduced for hunting purposes, and most exchanges happened within Asia. All the study species are affected by more than one threat, mainly biological resource use, while the most important conservation measure was species management. Lastly, we found that at least 22% of the 41 threatened mammals would shift their IUCN Red List Category if alien populations had been considered in the Red List assessments. Our findings show that many alien mammals are threatened in their native range. Some alien populations may serve as "safety populations", safeguarding species in unforeseen events like fires or demographic declines in native populations, ensuring the preservation of a viable species population. In any case, those decisions are context-specific and shall be carefully evaluated by conservation managers and Red List assessors.

Keywords: alien range, biological invasions, conservation, endangered species, invasive alien species, Red List, threatened alien species

Introduction

Mankind has become the dominant force shaping the surface of the Earth and its biological processes, firing an extinction crisis, with many wild populations declining and an estimated 1 million species facing risk of extinction globally (IPBES 2019). Due to the combination of several drivers (e.g., increased international trade and globalisation), humans have broken down biogeographic barriers, resulting in an unprecedented rise in species moved beyond dispersal obstacles, where an increasing number of them can establish in the new region (Blackburn et al. 2011, IPBES 2023). In recent years, it has become increasingly recognized that species introduced by humans—so-called alien species—play an eminent role in the biodiversity crisis, as they have contributed to at least 60% of extinctions globally (IPBES 2023). Alien species are being introduced throughout the globe at an increasing pace (Seebens et al. 2017, 2023); they can spread and eventually impact human livelihoods and native biotas, becoming invasive alien species (Blackburn et al. 2011, IPBES 2023).

Globally, 230 alien mammal species are known (Biancolini et al. 2021), and several are causing substantial impacts on the environment or human well-being (Tedeschi et al. 2022, IPBES 2023). Many alien mammals are widespread in their native range. However, it remains unknown how many mammals that have become alien are declining in their native range and are ultimately facing the risk of extinction there. Previous research focused mainly on species-specific case studies (Lees & Bell 2008, Garzón-Machado et al. 2012, Cassinello 2018), few species (Marchetti & Engstrom 2016, Gibson & Yong 2017) or countries (Baquero et al. 2023), but an updated global synthesis is still lacking. Alien populations of mammals that are threatened in their native range represent a conservation conundrum as they can be an important resource in conservation efforts (Marchetti & Engstrom 2016). For example, alien populations can provide a substitute for the supply of traded species, thereby curbing demand for native wild populations (Gibson & Yong, 2017).

Here, we jointly use several global data sources on mammals and provide a synthesis on alien mammals threatened in their native range. Specifically, we address the following questions: i) How many mammals threatened in their native range have alien populations, ii) What is their native and alien geographic distribution, iii) What are the introduction pathways of alien populations of mammals threatened in their native range, iv) What are the causes of threat and which conservation measures are undertaken, and v) How would global assessments of extinction risk change if alien populations were included.

Materials and methods

Identification of alien threatened mammals

For identifying alien mammals, we used the Distribution of Alien Mammals database (DAMA; Biancolini et al. 2021). This resource covers 230 alien mammal species with established populations in at least one region of the world. We retrieved the native

distribution and the extinction risk assessment of mammals from the IUCN Red List of Threatened Species (hereafter "Red List", IUCN 2023) on 29.03.2023. After resolving taxonomic differences among both data sources following the IUCN taxonomy (Supplementary Methods), we identified alien mammals that are threatened in their native range (henceforth, "alien threatened mammals") as those classified as Vulnerable (VU), Endangered (EN), Critically Endangered (CR), and Extinct in the Wild (EW; Supplementary Methods) by the Red List.

To test if the proportion of alien threatened mammals statistically differed from the proportion of alien or threatened mammals, we used McNemar's test (McNemar 1947), which tests for difference between correlated proportions. To visualise native and alien ranges, we removed native species range polygons where alien threatened mammals are extinct or with uncertain presence, and those where they are introduced, vagrant, have an uncertain origin, or originate from assisted colonization, keeping the DAMA ranges (Chapter III).

Species characteristics and introduction history

We extracted a range of data important for describing species introduction, threat, and conservation measures for alien threatened mammals. First, information on pathways of introduction for each alien range polygon was extracted from DAMA (Biancolini et al. 2021). This information was retained at a polygon level, as the same species could have had several alien polygons in the same continent, but with different introduction pathways. We used *rredlist* v. 0.7.1 (Gearty & Chamberlain 2022) to extract species' Red List category, countries of occurrence, threats, and conservation measures. For threats and conservation measures, we used the highest hierarchical level provided by IUCN (Level 1; Supplementary Methods; IUCN 2012a, 2022a) and we aggregated all threats of lower levels to the corresponding highest level.

We retrieved world countries and continents (using Natural Earth classification of countries and continents) from *rnaturalearth* v. 0.1.0 (South 2017) and intersected the species' countries of occurrence (native obtained from IUCN, and alien from DAMA) to get the continent(s) of occurrence for each alien threatened mammal species. We used *circlize* v. 0.4.15 (Gu 2014) to produce flow diagrams of species' flows between continents. For this visualisation, each study species introduced to a continent was considered only once, regardless of the number of times the species has been introduced to that continent.

Evaluating global extinction risks of threatened mammals by including alien populations

The assessment of global species extinction risks considers only wild populations inside the native range of a species, and species introductions whose purpose is conservation and that meet specific criteria (Supplementary Methods; IUCN 2022b); accordingly, the other alien populations are excluded from the assessment of extinction risk. To evaluate if including alien populations of threatened mammals would modify the outcomes of global extinction risk

assessments, we applied the Red List assessment criteria (IUCN 2012b, 2022b) but included also alien populations. To do so, we accessed the Red List assessment (https://www.iucnredlist.org/) on 19.12.2023. For each study species, we retrieved data on year of assessment, Red List Category and Criteria used to assess the species, and every other useful information available in the assessment (e.g., information on the introduced population). We then used this data and the information on alien populations from DAMA (Biancolini et al. 2021) to perform Red List assessments for all study species following the IUCN guidelines (IUCN 2022b). We then compared the original Red List assessments of global extinction risks (which do not always include the alien populations) and our re-assessments (based on native plus all alien populations) to illustrate differences in the resulting extinction risk category. Lastly, we used the Red List Index (RLI) calculated based on the formula in Butchart et al. (2007) to quantify this change. The RLI shows trends in the status of taxa: a RLI value of 1 signifies that all species are categorised as LC, indicating they are not expected to become EX in the foreseeable future. Conversely, a RLI value of 0 indicates the scenario where all species have become EX. If the RLI value remains constant over time, it suggests that the overall extinction risk for the group has not changed.

Results

Number, taxonomic distribution, and threat status of alien threatened mammals

We identified 53 alien threatened mammals (Supplementary Results), of which 12 species were introduced only for conservation purposes following Red List Guidelines (IUCN 2022b) and were thus included in Red List assessments (Supplementary Results). According to the Guidelines, those species have been introduced geographically close to the current natural range of the species, in areas where the species could have dispersed naturally in a scenario without human impacts' effects (e.g., fragmentation and habitat loss; IUCN 2022b). Therefore, those introduced populations do not fully represent the classic definition of alien species we adopt (Blackburn et al. 2011) and were removed from subsequent analysis.

We thus analyzed 41 alien threatened mammals, that is, 18% of the total pool of 230 globally established alien mammals (Biancolini et al. 2021), a proportion statistically significantly different from the proportion of alien (not threatened) or threatened (not alien) mammals (McNemar's chi-squared = 820.92, p-value < 0.05).

Alien threatened mammals are distributed across 10 orders, the most numerous one being Artiodactyla (n = 15 species), followed by Primates (n = 11), and Diprotodontia (n = 6) (Figure 1A, Supplementary Results). On the family level, the most important ones were Cercopithecidae (n = 7 species), followed by Bovidae and Cervidae (both n = 6) (Figure 1B, Supplementary Results). A total of 8 study species (20%) is Critically Endangered, 11 species (27%) are Endangered, and 22 species (53%) are Vulnerable (Figure 1); no alien threatened mammals are assigned to other Red List categories.

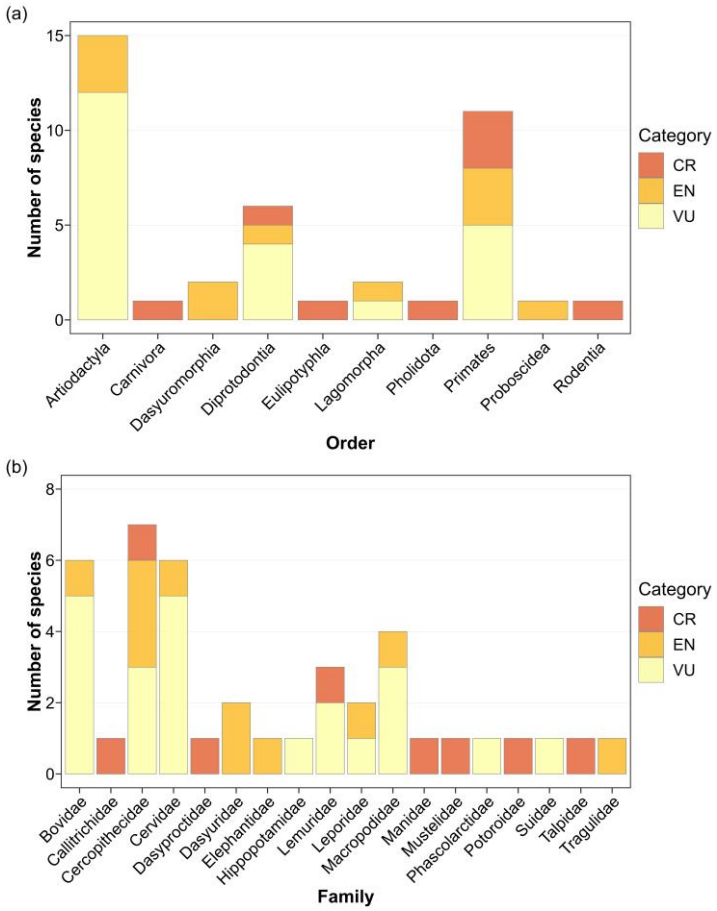

Figure 1: Taxonomic distribution of the 41 alien threatened mammals by (a) order and (b) family. The Red List categories of the species are shown. Red List Categories are indicated with their code: CR (Critically Endangered), EN (Endangered), and VU (Vulnerable).

Distribution, flows among continents, and introduction pathways of alien threatened mammals

The distribution of the native and alien ranges of alien threatened mammals shows distinct patterns. The hotspot of native ranges is located in continental and insular Southeast Asia (Figure 2A), while individual further native ranges are distributed across substantial parts of all other continents with the exception of South America. The hotspot of alien ranges is located in eastern Australia and insular Southeast Asia (Figure 2B), with further individual alien ranges being restricted to Europe, and to small fractions of other continents.

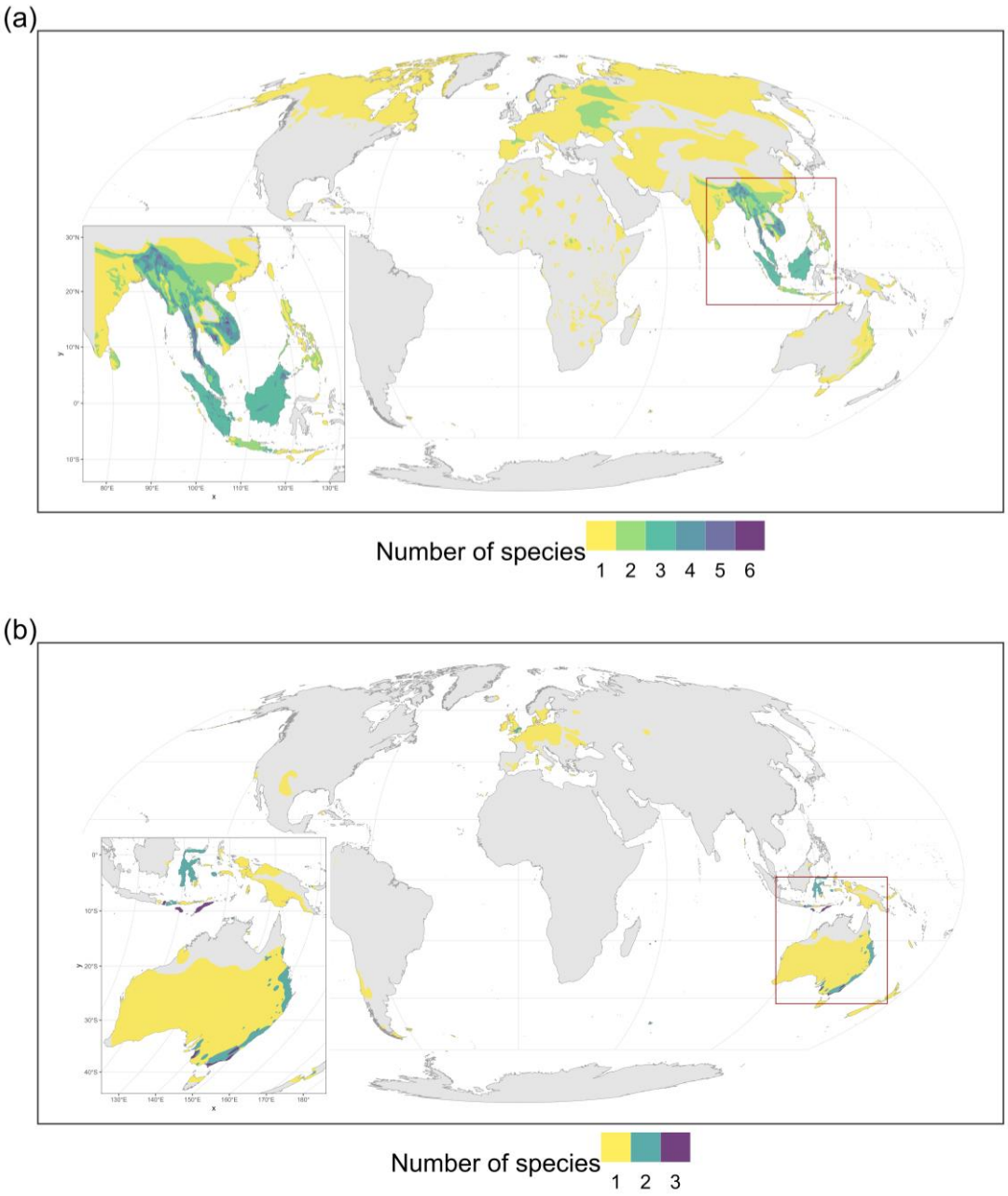

Figure 2: Distribution of (a) the native and (b) alien ranges of alien threatened mammals (n = 41).

The analyses of the flows of species between continents (using native and alien ranges) shows that the most exchanges have occurred within Asia, i.e., species native to Asia became established in other parts of the same continent (n = 15; Figure 3). The second-most important flow is within Oceania and from Asia to Oceania (both n = 7; Figure 3).

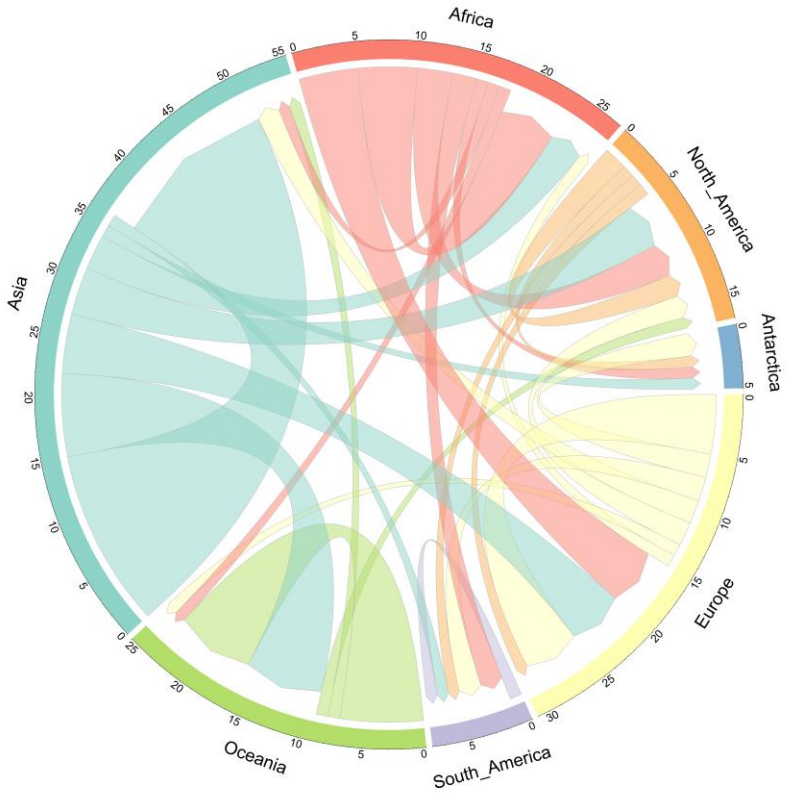

Figure 3: Flows of the 41 alien threatened mammals between donor and receiver continents. The width of the lines indicates the number of species exchanged between donor and receiver continents. Multiple species' introductions to the same continent are counted once. Links attached closer to the circle base indicate species native from that continent and introduced to the continent where the link ends further and with an arrow.

The most important introduction pathways of alien threatened mammals were for hunting purposes (n = 94), followed by farming (n = 38), and by pet trade (n = 27; Supplementary Results).

Causes of threats and conservation measures

All alien threatened mammals are affected by more than one threat. The most important Level 1 threat is biological resource use (n = 67), followed by agriculture and aquaculture (n = 63), and invasive species, genes and diseases (n = 46; Figure 4).

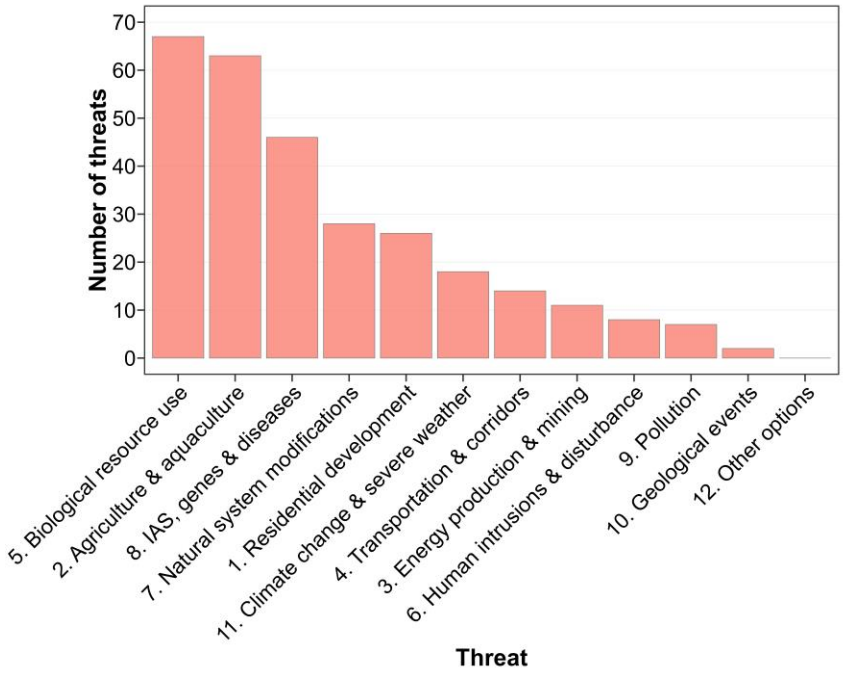

Figure 4: The Level 1 threats to alien threatened mammals (n = 41 species). Each species can be affected by more than one threat. For full names of threats, see Supplementary Results.

Populations in the native range of the study species are subjected to a range of different conservation measures. The most important Level 1 conservation measure is species management (n = 52), followed by land/water management and land/water protection (both n = 43; Figure 5).

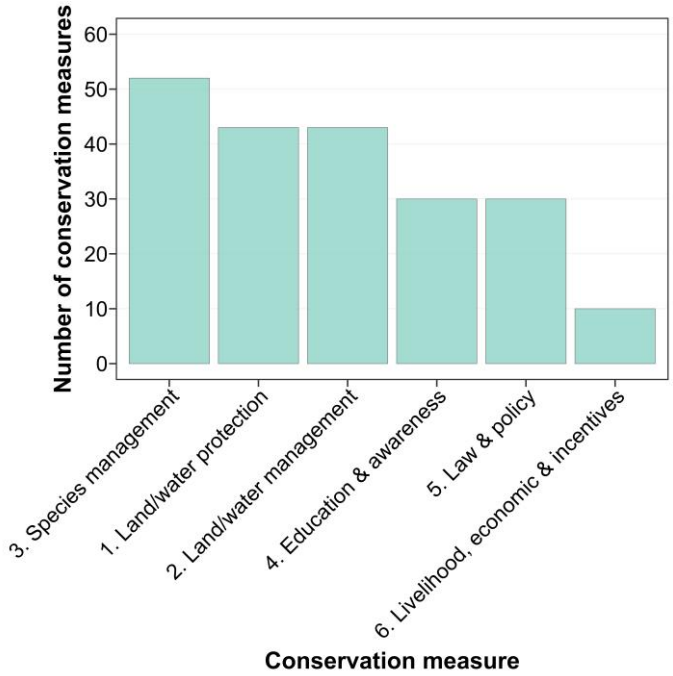

Figure 5: The Level 1 conservation measures applied to populations in the native ranges of alien threatened mammals (n = 41 species). Each species can be affected by more than one conservation measure. For full names of conservation measures, see Supplementary Results.

Considering alien populations in global extinction risk assessments

We found that including alien populations into the study species' global extinction risk assessment resulted in several changes (n = 9 species, which is 22% of the total pool of 41 alien threatened mammals considered in the study) of extinction risk categories. Three species shifted from CR to EN, one species from EN to VU, one species from EN to Least Concern (LC), two species from VU to Near Threatened (NT), and two species from VU to LC (Supplementary Results, Figure 6).

The most notable shifts occurred when a study species changed its classification by two or more levels. Those include the European rabbit (*Oryctolagus cuniculus*), which shifted from EN to LC, and the Javan (*Rusa timorensis*) and Sambar deer (*R. unicolor*), both transitioning from VU to LC. All these species have been introduced in several continents and are scattered across the globe; many alien populations have become invasive and are causing negative impacts. Often those alien populations are showing high population numbers and positive trends, therefore notably increasing the number of mature individuals, or decreasing the population reduction in the native range. Lastly, the calculated RLI for the original assessments was 0.47, while the RLI for our re-assessments was 0.53.

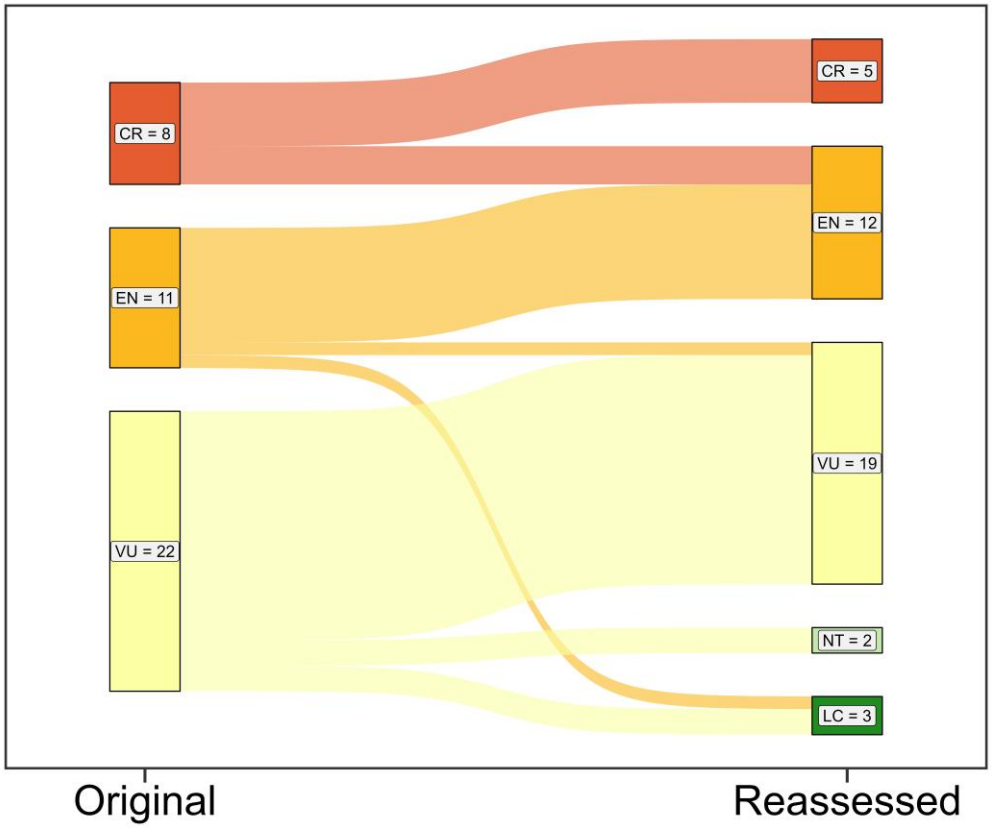

Figure 6: Changes in global IUCN Red List assessments based on original assessments (on the left; IUCN 2023) and our assessment (including alien populations, on the right) of alien threatened mammals (n = 41 species). Red List Categories are indicated with their code: CR (Critically Endangered), EN (Endangered), VU (Vulnerable), Near Threatened (NT), and Least Concern (LC). Assessments are grouped by IUCN Red List Category (CR, EN, VU, NT, LC). Flow colours refer to Red List Categories (red for CR, orange for EN, yellow for VU, light green for NT, forest green for LC). For details, see Supplementary Results.

Discussion

Diversity and geographic distribution of alien threatened mammals

In our study, we found 41 alien threatened mammals, a higher number than what previously reported in the study of Gibson & Yong (2017). This can be attributed to several factors. Firstly, their analysis excluded threatened mammals introduced solely for conservation purposes. In contrast, our analysis considered species introduced through this pathway for which the alien population was not covered in Red List assessments (or with an unclear inclusion status). Moreover, recently a comprehensive database on alien mammals' distributions was released (Biancolini et al. 2021). In the 20 years that passed from the publication of Long (2003), from which Gibson & Yong (2017) study takes information, many more species have been recognized as aliens–including many threatened mammals with alien populations (e.g., the Mexican black agouti *Dasyprocta mexicana*). On the other hand, some mammals listed by Gibson & Yong (2017) are either not threatened anymore (e.g., the greater stick-nest rat *Leporillus conditor*) or do not have alien populations in DAMA (e.g., the Arabian oryx *Oryx leucoryx*; Biancolini et al. 2021)–for instance because the alien population was eradicated or is not viable anymore, or because of a re-evaluation led to the consideration of those populations as not alien.

Many of our study species are native to areas where it is, for various reasons, difficult to assess their threat level and the causes of population declines. Indeed, 14% of all mammals are categorized as Data Deficient in the IUCN Red List (Cazalis et al. 2023, IUCN 2023) highlighting that more research is needed to carefully evaluate endangerment levels in the native range. It is also necessary to assess and evaluate the impacts of the species in the introduced range, to avoid mismatches between regulation and management actions towards threatened species' populations that may actually not be invasive, but that could be a possible resource for conservation actions. Filling these knowledge gaps is essential to make informed decisions, especially in light of rapid global changes and increased extinction and introduction rates.

The importance of introductions within the native continent

It is intriguing to note that a significant number of threatened mammals have been introduced near the native range on the same continent, as happened several times in Asia and Oceania.

For conservation purposes, populations of the species are introduced and established—often in proximity to their native range—in a different location to create a wild population. This is often done in areas where the species is less likely to face the same threats, or where the intensity of these threats is lower.

Importantly, Red List guidelines (IUCN 2022b) refer to introductions within the taxon's current natural range, but they do not refer to historic ranges. In principle, introductions within the historic range may not be considered alien populations, and this could reduce the pool of study species (but also the global pool of mammals that have alien populations). Unfortunately, historic ranges are difficult to obtain, and to date there is no such information for mammals.

Despite several conservation introductions, populations of threatened mammals were primarily introduced for hunting purposes. This trend may also be indicative of historical introductions focused on hunting, whereas contemporary introductions serve various purposes, such as the pet trade (Genovesi et al. 2012, Tedeschi et al. 2022). However, notably, mammals' recorded introductions do not appear to be on the rise (Seebens et al. 2017). Paradoxically, we found that these species are now predominantly at risk due to intentional use, such as bushmeat or trophy hunting. The impact of hunting on mammal populations has been staggering, resulting in a reduction of more than 80% of mammal populations (Benítez-López et al. 2017). The most common conservation approach for threatened mammals involves their management, with many species specifically protected through harvest management, underlying the effort in place to protect them from overexploitation.

Beyond categories: how the inclusion of alien populations reshapes Red List assessments

Including the introduced populations in Red List assessments can have several implications. On the one hand, if this inclusion actually changes the Red List category, the species can be assessed as less threatened and therefore protection and conservation effort may decrease, as well as public awareness and funding. Conversely, thriving alien populations without documented adverse impacts may be useful in conservation efforts.

We excluded from the analysis 12 species of threatened mammals whose populations were already included in Red List assessments, but Interesting is the case of introductions driven by conservation goals but not included in the assessments. This seems to be the case for the European mink (*Mustela lutreola*), for the Northern quoll (*Dasyurus hallucatus*) and for the Tasmanian devil (*Sarcophilus harrisii*), while it is unclear if it happened for the woylie (*Bettongia penicillata*), the Aders' duiker (*Cephalophus adersi*), the Balabac mouse deer (*Tragulus nigricans*) and for the koala (*Phascolarctos cinereus*) as well.

In a couple of cases this is the result of outdated Red List assessments. The European mink was last assessed in 2015 and a personal communication from 2014 reports no established populations on the Kuril Islands (Maran et al. 2016). However, evidence of presence is reported on the islands for the period 2014–2021 (Biancolini et al. 2021, Kisleyko et al. 2021). The Tasmanian devil was last assessed in 2008 (Hawkins et al. 2008), and apparently

successful introductions were carried out in 2012 (Biancolini et al. 2021), which are still not included. Introductions were sometimes mentioned in Red List assessments but were then omitted from the geographic range map (as in the case of the woylie; Woinarski & Burbidge 2016) or from the "conservation actions" sections (e.g., as for the Aders' duiker; IUCN SSC Antelope Specialist Group 2017), challenging the understanding of the alien populations' inclusion in the assessments.

Moreover, in many cases the unavailability of information hindered the possibility of re-assessing the study species. The Mexican black agouti was classified CR in 2008 (Vázquez et al. 2008). The species has recently been reported to be invasive in Western Cuba (Borroto-Páez & Mancina 2017), which possibly implies that the population is either stable or is increasing. Without knowing the population trend of the introduced population, we can only speculate on the conservation relevance of this population. In this and the abovementioned cases, an update assessment of the species is essential to make informed management and conservation decisions.

For other study species, the introduced population is present in an area that is too small to sustain an adequate number of individuals, as in the case of the dusky pademelon (*Thylogale brunii*), introduced on Kai Kecil Island (400 km^2; Leary et al. 2016), or it is known that the abundance of the alien population is low, as for the Balabac mouse deer, which only has 21 alien individuals (Widmann 2015). In those cases, the conservation relevance of the introduced population is likely low.

But there are some instances in which the introduced population could make a difference, as highlighted by the slight increase in the RLI calculated on our re-assessments. The Celebes' crested macaque's (*Macaca nigra*) introduced population probably exceeds that in its native range, and it is likely facing less threats than in the native range (where it is a favoured bushmeat species; Hilser et al. 2013, Lee et al. 2020). The Australian introduced population of banteng (*Bos javanicus*) as well is reported to be thriving (with 6000 alien individuals reported, while the number of wild native mature individuals is reported to be 4000-8000) and likely not facing the same threats as in the native range (Gardner et al. 2016). Lastly, some study species have already been in the spotlight, such as the aoudad (*Ammotragus lervia*; Cassinello 2018) or the European rabbit (Lees & Bell 2008). For all those species, some of the introduced populations (e.g., those thriving or reported to not cause negative environmental or socio-economic impacts) could be protected and act as a backup, a "safety population(s)", which could avoid the extinction in the wild in case of abrupt and drastic native population declines.

Acknowledgements

FE appreciates funding by the Austrian Science Foundation FWF (grant I 5825-B).

Chapter V: General discussion

The common thread of my PhD thesis lies in addressing certain aspects of the ecology of one of the most widespread and impactful taxonomic groups of alien species–mammals. This thesis gathers crucial information on a subset of highly invasive mammals and provides novel findings on the socio-economic drivers of alien mammals' distribution in Europe. Moreover, it thoroughly examines an ambivalent topic (which, due to rapid global changes and increased extinction rates, may become more relevant for other taxonomic groups as well) in invasion science and conservation biology: the paradoxical situation of alien mammals threatened in their native range.

In the last section of the general introduction (Chapter I), I defined the main objectives of each of the analytical chapters included in my thesis (Chapters II, III, and IV). I will now briefly describe how I achieved these objectives in my PhD thesis, discussing and linking the main outcomes of each chapter.

The objective of Chapter II was to review the current knowledge on a subset of highly invasive mammals (those listed in the Union List), to characterise their introduction history, spread dynamics, and environmental impacts. I found that invasive alien species of mammals on the Union List are nowadays primarily introduced by the pet trade, in contrast to past introductions with different purposes (such as hunting, transport, and food; Chapter II). A raised awareness may be one of the reasons why, globally, new records of alien mammals are not on the rise (Chapter II), and a review such as the one I provided in this thesis can effectively inform the general public about the negative impacts of releasing invasive alien species in nature. Given their potential negative impacts, having up-to-date information on IAS of mammals, especially those of Union Concern, is crucial.

Besides, the results presented in Chapter II can help with the identification of problematic populations or invaded areas, helping to mitigate future impacts. This is crucial for human health as well, as I have also demonstrated that 81% of the 16 study species are implicated in the epidemiological cycle of zoonotic pathogens. Alien species, in and of themselves, are neither inherently "bad" nor "good" (Simberloff et al. 2013). The problematic aspect arises when populations of these species become invasive, requiring management (Simberloff et al. 2013). Finally, this review served as a personal foundation to gain expertise in the field, identifying the most prominent datasets where to further gather information for the subsequent analyses in the thesis.

The objective of Chapter III was to explore the role of socio-economic factors in shaping the differences between the observed and potential distributions of established alien mammals in Europe. I found that the range filling patterns of the study species markedly differed from each other, and those patterns were overall strongly shaped by propagule pressure. Notably,

many alien mammals still have wide potential areas unoccupied in Europe. Range unfilling, a spatially explicit measure, is particularly valuable for pinpointing relevant areas for impact prevention and management (Chapter III). This is crucial, especially for alien species, as they can be characterized by a phenomenon called "invasion debt" (Essl et al. 2011), referring to the time lag between their introduction and establishment–including potential negative impacts (Essl et al. 2011). This suggests that the consequences of current socio-economic human activities on the extent of biological invasions may not become fully apparent for several decades (Essl et al. 2011). Additionally, the fact that the distribution of alien mammals in Europe is driven by human agency also reconnects to Chapter II results, where I found that the pet trade is the most common pathway of introduction for some IAS of mammals. It underlines the influence our societal and personal actions and decisions have had and still have on species' distributions, and highlights that modifying our behavior and community norms is key to limiting further species' spread (Chapter III). This is a pivotal consideration given the rapid global changes we are witnessing.

Some species analyzed in Chapter III are either included in the Union List or are prioritized for inclusion (Chapter II). Consequently, the results presented in Chapter III hold significant value. For instance, I found that the American mink (*Neovison vison*) shows the widest range filling, and the muskrat (*Ondatra zibethicus*) the widest range overfilling. These mammals are among the most impactful ones, and identifying the main drivers of their distributions is decisive for preventing negative impacts and managing further spread. Additionally, certain species from Chapter III, characterized by very high values of range overfilling (i.e., they have spread beyond expectations) and recognized invasive potential, may warrant prioritization for further analysis and possible inclusion in the Union List. Examples include the American beaver (*Castor canadensis*) or the Eastern cottontail (*Sylvilagus floridanus*).

Finally, for my last analytical chapter (Chapter IV), I aimed to conduct an analysis of threatened mammals that have been introduced outside their native ranges, encompassing their native and alien distributions, introduction pathways, assessing threats and conservation measures, and re-assessing their IUCN Red List Category. To my knowledge, this is the first study to identify and describe globally alien threatened mammals' ecology using recently updated data (i.e., Biancolini et al. 2021), thus expanding previous studies (e.g., Gibson & Yong, 2017). Due to rapid global changes and increased extinction and introduction rates, the ambivalent situation of threatened species introduced outside their native ranges for purposes other than conservation may become more relevant for various taxonomic groups. In Chapter IV I provided a novel perspective on a challenging and sometimes dividing topic, at the intersection between conservation and management. I suggest that some of these alien populations may serve as "safety populations", safeguarding species in unforeseen events like fires or abrupt demographic declines in other populations (whether native or alien), ensuring the preservation of a viable species population. This can be quantified using standard measures such as the Red List Index (RLI), as performed in Chapter IV, checking whether the inclusion of the alien population can reduce (or not) the overall extinction risk for threatened mammals.

Lastly, some alien threatened mammals identified in Chapter IV (the aoudad *Ammotragus lervia*, the Chinese water deer *Hydropotes inermis*, and the European rabbit *Oryctolagus cuniculus*) have been introduced also to Europe, where they thrive (with their range overfilling index ranging from 27% to 66%, as discussed in Chapter III). For all these species, I estimated a shift to a lower Red List Category. Identifying the suitable areas for these alien threatened mammals and which are the drivers of their distributions is essential. This is not only because they are imperiled in their native ranges, but also because a detailed understanding of species' ecology in both alien and native range is vital for potential future conservation efforts involving these alien populations. Regardless, the decision to use them for conservation purposes should be informed, and context specific.

Limitations of this work

In my thesis, I addressed several aspects of the ecology of different pools (i.e., invasive, alien, and alien threatened) of alien mammals, both at a continental (Europe) and at the global level. To achieve this, I performed a literature review on invasive mammals of Union concern (Chapter II), I calculated potential ranges for alien mammals in Europe (developing a hybrid methodology, accounting both for a mechanistic and a correlative approach) and investigated which socio-economic factors drove species distributions (Chapter III), and I examined which threats and conservation measures are threatened mammals with alien populations experiencing, and how the inclusion of the alien population in the IUCN Red List assessment would potentially change their threat category (Chapter IV). However, each chapter has some limitations, many of which were already addressed in the chapter itself. Below I briefly summarize them, and I discuss additional limitations.

The main limitation of the first analytical chapter (Chapter II) of this thesis is related to the available studies, which is a limiting factor when performing a literature review. The result of a literature review depends on the great and enormous work other researchers do, and on their dissemination on public databases and accessible online resources. Unfortunately, investigating the full spectrum of detrimental impacts (i.e., environmental, social, and economic) of my study species was not entirely possible. Most of the studies I found dealt with environmental impacts and those few studies that investigated social impacts were limited to human health. The main reasons why information on economic impacts is rarely available are discussed in detail in the paragraph "*Environmental and socio-economic impacts in Europe*" (Chapter II). More research on the topic, available in English and on public databases would be needed to overcome those barriers.

The Chapter III of this thesis has several limitations, many related to the available data and others linked to the methodological choices. All of them are thoroughly discussed in the paragraph "*Strengths, broader implications, and limitations of the current study*" of Chapter III.

For that analysis, calculating the potential ranges required several simplifying assumptions aimed to obtain the best result with available data. As I did not aim to investigate alien species expansion *per se*, potential ranges are a scenario of species' spread that can be used for comparison. Species' spread from points of introduction was homogenous and did not account for functional connectivity or fine scale habitat suitability. Another critical point is that the calculation of potential ranges, and in turn the computation of the range indices, strictly depend on the available dated introduction points, which are notoriously underreported and affected by spatial biases (Pyšek et al. 2008). Even though alien mammals have been transported to the European continent for a variety of purposes during several centuries, their introduction documentation suffers from gaps known to affect macroecological datasets (Meyer et al. 2015; Seebens et al. 2017). This unavailability of information is reflected in my study data as well. Moreover, we further reduced introduction points number retaining only successful introductions dated after 1492. Lastly, adopting a hybrid approach with a correlative part inevitably introduces some circularity in my data. To calculate the SDMs for the potential ranges, I used species' occurrences from online biodiversity databases (i.e., GBIF), and I compared those potential ranges to the observed ones (Biancolini et al. 2021) which are also informed by the same set of data.

Similar to Chapter II, my last analytical chapter (Chapter IV) depends on the massive work of other researchers. Many of the study species are elusive, rare, or present in well-known under sampled regions. Having detailed information on their population trends may therefore be challenging, hindering effective analyses. For instance, I could not re-assess the IUCN Red List Category of many threatened mammals, as the information needed on population trends (in native and/or alien ranges) was unavailable. Unfortunately, many threatened mammals are native to areas where it is, for several reasons, difficult to assess their threat level and the causes of population declines. In all these cases, an update assessment of the species, available on online resources, is essential to produce accurate research that can then aid informed management and conservation decisions.

Lastly, it would have been interesting to know whether the introductions of threatened mammals that have been pursued for conservation purposes happened in the historical distributional ranges of the species. Possibly, those populations could have then been considered as native. If so, my pool of alien threatened mammals would have likely considerably shrunk, maybe leading to different outcomes and conclusions. However, as far as I am aware, no complete information on mammals' historical ranges is available yet.

Future perspectives

While pursuing my PhD journey I encountered some topics that captured my attention. My background is in conservation biology and, as a conservationist, I am interested in the causes of biodiversity loss and the possible solutions. Invasive alien species are a prime cause of the decline of native biodiversity, so the connection between those topics comes naturally. Here I

will briefly discuss future areas of research that I find relevant and that can further develop the outcomes of this PhD thesis.

The addition of alien species (especially invasive alien species) to native communities in some delicate and fragile environments such as biodiversity hotspots, islands, or protected areas, which are the cornerstone of biodiversity conservation, can have unforeseen outcomes. It has been found that almost all protected areas have alien species residing near their borders (< 100 km; Liu et al. 2020). It is therefore important to know if protected areas will be suitable for alien species in the future.

Those predictions of suitability are usually made using SDMs, which is a tool I used for the correlative part of Chapter III. They are extensively used and extremely useful, but they also have some flaws, which may hinder SDMs' predictive ability especially when dealing with range-expanding species (Briscoe Runquist et al. 2021), such as many alien ones. The availability of updated databases on alien mammals' distribution compared to previous studies (Biancolini et al. 2021) and the necessity of periodically re-assess predictions of suitability—to avoid underestimation of potential suitable areas (Václavík & Meentemeyer 2012)—make it necessary to perform this type of analysis. Moreover, even if there are some "golden standards" (Araújo et al. 2019), many researchers and teams have their preferences when it comes to modeling: it is similar to the famous *ragù alla Bolognese* recipe, where each family has its own and, similarly, those different procedures can lead to different predictions (Gould et al. 2023).

Furthermore, global changes (such as climate and land-use changes) will likely impact alien species' distribution and ability to spread in the future (Bellard et al. 2016) and shall thus be considered in these predictions. However, the only study I am aware of (Liu et al. 2020) does not project suitability to the future accounting for global changes. It is indeed recommended to adopt multiple drivers in SDMs, to obtain more accurate future predictions for the management of IAS (Di Febbraro et al. 2019). Therefore, project SDMs outputs to the future under different scenarios of global changes to evaluate protected areas' suitability for alien mammals can be a further and valuable advance in the field.

Additionally, the recent development of updated databases on mammals' traits (Soria et al. 2021) allows researchers to investigate ecological questions that previously required extensive data collection. By first identifying which protected areas will be suitable for alien mammals in the future under different scenarios, and then a set of key traits that may influence their abilities to colonize those areas, management efforts can be optimized and targeted on specific species and areas.

Chapter VI: Scientific outputs and activities

Key research outputs

Tedeschi L, Biancolini D, Capinha C, Rondinini C, Essl F (2022) Introduction, spread, and impacts of invasive alien mammal species in Europe. *Mammal Review* **52**: 252–266.

Tedeschi L, Lenzner B, Schertler A, Wessely J, Biancolini D, Capinha C, Melone B, Soria CD, Essl F, Rondinini C. Patterns and drivers of range filling of alien mammals in Europe. (*In preparation*)

Tedeschi L, Lenzner B, Schertler A, Biancolini D, Essl F, Rondinini C. A synthesis on alien mammals threatened in their native range (*In preparation*)

Collaborative research outputs

Vincent C, Cristiano A, Cuadros-Casanova I, Pacifici M, Soria CD, **Tedeschi L**, Beekmann M, D'alessio A, Lucas PM, Nania D, Rondinini C. The war in Ukraine is changing plausible future socioeconomic scenarios leading to an unexplored outlook for biodiversity. (*Accepted in Conservation Science and Practice*)

Lenzner B, Colling G, Dullinger S, Fugger J, García-Rodríguez A, Glaser M, Hennenfeind JH, Kaplan E, Liu D, Omer A, Pauchard A, Roy HE, Schernhammer T, Schertler A, Stoett P, **Tedeschi L**, Vorstenbosch T, Wessely J, Essl F. Hidden in plain sight: the neglected importance of biological invasions for sustainable development (*Resubmitted to One Earth*)

Schertler A, **Tedeschil** L, Essl F. Reeves' muntjac (*Muntiacus reveesi*) in Austria (*Resubmitted to BioInvasions Records*)

Moshobane MC, Ravhuanzwo F, **Tedeschi L**, Zungu MM. A retrospective onto the environmental and socio-economic impacts associated with NEM: BA regulated invasive mammal species in South Africa. (*In review in Mammal Review*)

Conference contributions and organizations

February 2023 – now: member of the Local Organizing Committee of the European Congress on Conservation Biology (ECCB) 2024, Bologna, Italy.

July 2023: oral talk "Filling the range: how propagule pressure shaped alien mammal's distribution in Europe" at the 31st International Congress of Conservation Biology (ICCB), Kigali, Rwanda.

April 2023: poster presentation "Identify and classify mammal species responding to human-induced environmental changes and their impacts" at Challenging Conservation: Adattarsi al Cambiamento conference, Rome, Italy.

March 2022 – April 2023: Chair of the Organizing Committee of "Challenging Conservation: Adattarsi al Cambiamento", the first Italian conference of the Society for Conservation Biology (SCB) Italian Chapter, Sapienza University of Rome, Rome, Italy.

September 2022: oral talk "The role of (un)recorded introductions in explaining current alien mammals' distribution in Europe" at NeoBiota conference, Tartu, Estonia.

August 2022: oral talk "The role of socio-economic factors in range filling of European alien mammals" at the 6th European Congress on Conservation Biology (ECCB), Prague, Czech Republic.

March 2022: poster presentation "Introduction, spread, and impacts of invasive alien mammals in Europe" at the Student Conference on Conservation Science (SCCS), Cambridge, United Kingdom.

March 2022: oral talk "Alien amphibians and where to find them" for the Global Water Day, at Accademia dei Lincei, Rome, Italy.

December 2021: online oral talk "Introduction, spread, and impacts of invasive alien mammal species in Europe" at the 30th International Congress of Conservation Biology (ICCB), Kigali, Rwanda.

Grants and awards

December 2023: Italian Knowledge Leaders Legacy award.

February 2023: Sapienza University of Rome PhD Individual mobility grant (amount: €2100; role: principal investigator).

November 2022: Sapienza University of Rome Starting Research grant (amount: €1800; role: principal investigator; evaluation: 23/24).

February 2022: Sapienza University of Rome Start to the Third Mission grant (amount: €9750; role: project component; evaluation: 78/100).

December 2021: Sapienza University of Rome PhD Individual mobility grant (amount: €2800; role: principal investigator).

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Supplementary material

Chapter II: Supplementary material

Appendix S1

Process of literature search and keywords used.

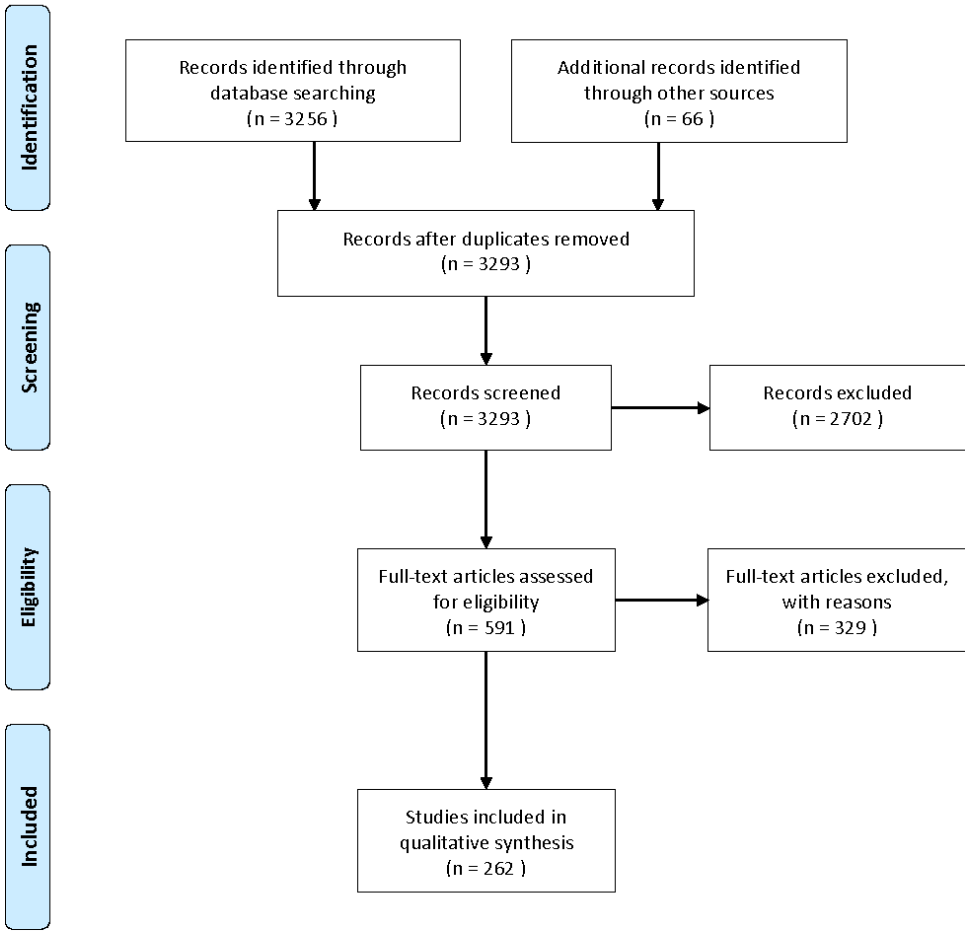

Fig. S1. The flowchart illustrating the process of literature search and review, based on PRISMA guidelines, conducted in August and September 2020 (adapted from Moher et al. 2009).

Scopus and Web of Science search terms used to review the literature for each study species in the study area.

Atlantoxerus getulus

(TITLE-ABS-KEY ("Atlantoxerus getulus" OR "Barbary ground squirrel") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Spain OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English"))

Axis axis

(TITLE-ABS-KEY ("Axis axis" OR "Indian spotted deer" OR chital* OR "Spotted deer" OR "Axis deer") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Croatia OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English"))

Callosciurus erythraeus

(TITLE-ABS-KEY ("Callosciurus erythraeus" OR "Pallas's squirrel") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR France OR Germany OR Italy OR Netherlands OR "The Netherlands" OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014))

Callosciurus finlaysonii

(TITLE-ABS-KEY ("Callosciurus finlaysonii " OR "Variable squirrel" OR "Finlayson's squirrel") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Italy OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history

trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018))

Castor canadensis

[excluding] WEB OF SCIENCE CATEGORIES: (ANTHROPOLOGY OR MATERIALS SCIENCE MULTIDISCIPLINARY OR MATHEMATICAL COMPUTATIONAL BIOLOGY OR OPHTHALMOLOGY OR ORTHOPEDICS OR LINGUISTICS OR PHYSICS FLUIDS PLASMAS OR THERMODYNAMICS OR MATHEMATICS APPLIED OR COMPUTER SCIENCE ARTIFICIAL INTELLIGENCE OR ENGINEERING ELECTRICAL ELECTRONIC OR COMPUTER SCIENCE SOFTWARE ENGINEERING OR DENTISTRY ORAL SURGERY MEDICINE OR HISTORY OR HUMANITIES MULTIDISCIPLINARY OR MECHANICS OR LANGUAGE LINGUISTICS OR EMERGENCY MEDICINE OR COMPUTER SCIENCE INTERDISCIPLINARY APPLICATIONS OR PHYSICS MATHEMATICAL OR COMPUTER SCIENCE THEORY METHODS OR SURGERY OR ART OR CARDIAC CARDIOVASCULAR SYSTEMS OR HEALTH CARE SCIENCES SERVICES OR HISTORY PHILOSOPHY OF SCIENCE OR MATHEMATICS INTERDISCIPLINARY APPLICATIONS OR COMPUTER SCIENCE INFORMATION SYSTEMS OR EDUCATION EDUCATIONAL RESEARCH OR EDUCATION SCIENTIFIC DISCIPLINES OR ENERGY FUELS OR INSTRUMENTS INSTRUMENTATION OR INTERNATIONAL RELATIONS OR HOSPITALITY LEISURE SPORT TOURISM OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH) (TITLE-ABS-KEY ("Castor canadensis" OR beaver* OR “American beaver”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR Finland OR France OR Germany OR Luxembourg OR Russia OR “Russian Federation” OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010))

Cervus nippon

(TITLE-ABS-KEY ("Cervus nippon" OR “Sika deer”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Austria OR Czechia OR “Czech Republic” OR Denmark OR Finland OR France OR Germany OR Hungary OR Ireland OR Lithuania OR Poland OR Russia OR “Russian Federation” OR Switzerland OR “United Kingdom” OR UK OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation"

OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009))

Eutamias sibiricus

(TITLE-ABS-KEY ("Eutamias sibiricus" OR “Tamias sibiricus” OR "Siberian chipmunk") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR Denmark OR France OR Germany OR Ireland OR Italy OR Netherlands OR “The Netherlands” OR Russia OR “Russian Federation” OR Spain OR Switzerland OR “United Kingdom” OR UK OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English"))

Herpestes auropunctatus

(TITLE-ABS-KEY ("Herpestes javanic*" OR "Herpestes auropunctat*" OR "Urva javanic*" OR "Urva auropunctat*" OR "Small Indian mongoose") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Albania OR “Bosnia and Herzegovina” OR “Bosnia-Herzegovina” OR Croatia OR Montenegro OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015))

Muntiacus reevesi

(TITLE-ABS-KEY ("Muntiacus reevesi" OR “Reeves’ muntjac” OR "Reeves muntjac") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR Denmark OR Ireland OR

Netherlands OR “The Netherlands” OR “United Kingdom” OR UK OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR “Union List” OR "Europe* IAS regulation" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English"))

Myocastor coypus

(TITLE-ABS-KEY ("Myocastor coypus" OR “coypu*” OR “nutria”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Austria OR Belarus OR Belgium OR Bulgaria OR Croatia OR Czechia OR “Czech Republic” OR Denmark OR France OR Germany OR Greece OR Hungary OR Ireland OR Italy OR Luxembourg OR Macedonia OR Montenegro OR Netherlands OR “The Netherlands” OR Norway OR Poland OR Romania OR Serbia OR Slovakia OR Slovenia OR Spain OR Sweden OR Switzerland OR “United Kingdom” OR UK OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014))

Nasua nasua

(TITLE-ABS-KEY ("Nasua nasua" OR “South American coati” OR “ring-tailed coati”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR France OR Germany OR Spain OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015))

Neovison vison

(TITLE-ABS-KEY ("Neovison vison" OR “American mink”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Albania OR Andorra OR Austria OR Belarus OR Belgium OR Czechia OR “Czech Republic” OR Denmark OR Estonia OR Finland OR France OR Germany OR Greece OR Hungary OR Iceland OR Ireland OR Italy OR Latvia OR Lithuania OR Luxembourg OR Macedonia OR “North Macedonia” OR Montenegro OR Netherlands OR “The Netherlands” OR Norway OR Poland OR Portugal OR Romania OR Russia OR “Russian federation” OR Slovakia OR Slovenia OR Serbia OR Spain OR Sweden OR Switzerland OR “United Kingdom” OR UK OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016))

Nyctereutes procyonoides

(TITLE-ABS-KEY ("Nyctereutes procyonoides" OR “Racoon dog*”) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Albania OR Austria OR Belarus OR Belgium OR “Bosnia and Herzegovina” OR “Bosnia-Herzegovina” OR Bulgaria OR Croatia OR Czechia OR “Czech Republic” OR Denmark OR Estonia OR Finland OR France OR Germany OR Greece OR Hungary OR Italy OR Latvia OR Liechtenstein OR Lithuania OR Luxembourg OR Macedonia OR “North Macedonia” OR Moldova OR Montenegro OR Netherlands OR “The Netherlands” OR Norway OR Poland OR Romania OR Russia OR “Russian Federation” OR Serbia OR Slovakia OR Slovenia OR Sweden OR Switzerland OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR “Union List” OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015))

Ondatra zibethicus

(TITLE-ABS-KEY ("Ondatra zibethicus" OR muskrat*) AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Andorra OR Austria OR Belarus OR Belgium OR “Bosnia and Herzegovina” OR “Bosnia-Herzegovina” OR Bulgaria OR Croatia OR Czechia OR “Czech Republic” OR Denmark OR Estonia OR Finland OR France OR Germany OR Greece OR Hungary OR Ireland OR Italy OR Latvia OR Liechtenstein OR Lithuania OR Luxembourg OR Moldova OR Montenegro OR Netherlands OR “The Netherlands” OR Norway OR Poland OR Romania OR Russia OR “Russian Federation” OR Serbia OR Slovakia OR Slovenia OR Spain OR Sweden OR Switzerland OR “United

Kingdom" OR UK OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015))

Procyon lotor

(TITLE-ABS-KEY ("Procyon lotor" OR raccoon* OR "Northern raccoon" AND NOT "raccoon dog") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Austria OR Belarus OR Belgium OR Croatia OR Czechia OR "Czech Republic" OR Denmark OR Estonia OR France OR Germany OR Hungary OR Ireland OR Italy OR Liechtenstein OR Lithuania OR Luxembourg OR Netherlands OR "The Netherlands" OR Poland OR Romania OR Russia OR "Russian Federation" OR Serbia OR Slovakia OR Slovenia OR Spain OR Switzerland OR Ukraine OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011))

Sciurus carolinensis

(TITLE-ABS-KEY ("*Sciurus carolinensis*" OR "Eastern gr*y squirrel" OR "American gr*y squirrel" OR "gr*y squirrel") AND TITLE-ABS-KEY (europe* OR "european union" OR EU OR Belgium OR Germany OR Ireland OR Italy OR Netherlands OR "The Netherlands" OR "United Kingdom" OR UK OR introduc* OR invasi* OR establish* OR alien OR invasive OR ias OR allochthonous OR exotic OR "Aichi target 9" OR "EU biodiversity strategy" OR "europe* biodiversity strategy" OR "EU IAS regulation" OR "Europe* IAS regulation" OR "Union List" OR "propagule pressure" OR "colonization pressure" OR "life-history trait*" OR "life history trait*" OR trait* OR "risk assessment*" OR "impact assessment*" OR "environmental impact*" OR "socio-economic impact*" OR "socio economic impact*" OR "economic impact*")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "EART")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-

TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015))

Appendix S2

List of the papers obtained through the literature search process for each study species in Europe

Atlantoxerus getulus

1. Gangoso, L., Donázar, J. A., Scholz, S., Palacios, C. J., & Hiraldo, F. (2006). Contradiction in conservation of island ecosystems: Plants, introduced herbivores and avian scavengers in the Canary Islands. Biodiversity and Conservation, 15(7), 2231–2248. https://doi.org/10.1007/s10531-004-7181-4
2. Nogales, M., Rodríguez-Luengo, J. L., & Marrero, P. (2006). Ecological effects and distribution of invasive non-native mammals on the Canary Islands. Mammal Review, 36(1), 49–65. https://doi.org/10.1111/j.1365-2907.2006.00077.x
3. Lorenzo-Morales, J., López-Darias, M., Martínez-Carretero, E., & Valladares, B. (2007). Isolation of potentially pathogenic strains of Acanthamoeba in wild squirrels from the Canary Islands and Morocco. Experimental Parasitology, 117(1), 74–79. https://doi.org/10.1016/j.exppara.2007.03.014
4. López-Darias, M., Lobo, J. M., & Gouat, P. (2008). Predicting potential distributions of invasive species: The exotic Barbary ground squirrel in the Canarian archipelago and the west Mediterranean region. Biological Invasions, 10(7), 1027–1040. https://doi.org/10.1007/s10530-007-9181-2
5. López-Darias, M., & Nogales, M. (2008). Effects of the invasive Barbary ground squirrel (*Atlantoxerus getulus*) on seed dispersal systems of insular xeric environments. Journal of Arid Environments, 72(6), 926–939. https://doi.org/10.1016/j.jaridenv.2007.12.006
6. Traveset, A., Nogales, M., Alcover, J. A., Delgado, J. D., López-Darias, M., Godoy, D., Igual, J. M., & Bover, P. (2009). A review on the effects of alien rodents in the Balearic (western Mediterranean sea) and Canary islands (eastern Atlantic ocean). Biological Invasions, 11(7), 1653–1670. https://doi.org/10.1007/s10530-008-9395-y
7. Nogales, M., Nieves, C., Illera, J. C., Padilla, D. P., & Traveset, A. (2014). Effect of native and alien vertebrate frugivores patterns of *Rubia fruticosa* viability and germination in the eastern Canary Islands (Rubiaceae). Functional Ecology, 19, 429–436. https://doi.org/10.1111/j.1365-2435.2005.00975.x
8. Di Febbraro, M., Martinoli, A., Russo, D., Preatoni, D., & Bertolino, S. (2016). Modelling the effects of climate change on the risk of invasion by alien squirrels. Hystrix, 27(1), 1–8. https://doi.org/10.4404/hystrix-27.1-11776

Axis axis

9. Centore, L., Ugarković, D., Scaravelli, D., Safner, T., Pandurić, K., & Sprem, N. (2018). Locomotor activity pattern of two recently introduced non-native ungulate species in a Mediterranean habitat. Folia Zoologica, 67(1), 17–24. https://doi.org/10.25225/fozo.v67.i1.a1.2018

10. Šprem, N., & Zachos, F. E. (2020). Axis Deer *Axis axis* Erxleben, 1777. In K. Hackländer & F. E. Zachos (Eds.), Handbook of the Mammals of Europe (pp. 1–9). Springer Nature Switzerland. https://doi.org/10.1007/978-3-319-65038-8_22-2

Callosciurus erythraeus

11. Tamura, N. (2009). Datasheet on *Callosciurus erythraeus*. Wallingford (UK): CAB International, Invasive Species Compendium. Available from: http://www.cabi.org/isc.
12. Bertolino, S., & Lurz, P. W. W. (2013). Callosciurus squirrels: Worldwide introductions, ecological impacts and recommendations to prevent the establishment of new invasive populations. Mammal Review, 43(1), 22–33. https://doi.org/10.1111/j.1365-2907.2011.00204.x
13. Mazzamuto, M. V., Wauters, L., Martinoli, A., & Bertolino, S. (2014). EU NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME - *Callosciurus erythraeus*.
14. Adriaens, T., Baert, K., Breyne, P., Casaer, J., Devisscher, S., Onkelinx, T., Pieters, S., & Stuyck, J. (2015). Successful eradication of a suburban Pallas's squirrel *Callosciurus erythraeus* (Pallas 1779) (Rodentia, Sciuridae) population in Flanders (northern Belgium). Biological Invasions, 17(9), 2517–2526. https://doi.org/10.1007/s10530-015-0898-z
15. Dozières, A., Pisanu, B., Kamenova, S., Bastelica, F., Gerriet, O., & Chapuis, J. L. (2015). Range expansion of Pallas's squirrel (*Callosciurus erythraeus*) introduced in southern France: Habitat suitability and space use. Mammalian Biology, 80(6), 518–526. https://doi.org/10.1016/j.mambio.2015.08.004
16. Hofmannová, L., Romeo, C., Štohanzlová, L., Jirsová, D., Mazzamuto, M. V., Wauters, L. A., Ferrari, N., & Modrý, D. (2016). Diversity and host specificity of coccidia (Apicomplexa: Eimeriidae) in native and introduced squirrel species. European Journal of Protistology, 56, 1–14. https://doi.org/10.1016/j.ejop.2016.04.008
17. Mazzamuto, M. V., Pisanu, B., Romeo, C., Ferrari, N., Preatoni, D., Wauters, L. A., Chapuis, J. L., & Martinoli, A. (2016). Poor Parasite Community of an Invasive Alien Species: Macroparasites of Pallas's Squirrel in Italy. Annales Zoologici Fennici, 53(1–2), 103–112. https://doi.org/10.5735/086.053.0209
18. Mazzamuto, M. V., Morandini, M., Panzeri, M., Wauters, L. A., Preatoni, D. G., & Martinoli, A. (2017a). Space invaders: effects of invasive alien Pallas's squirrel on home range and body mass of native red squirrel. Biological Invasions, 19(6), 1863–1877. https://doi.org/10.1007/s10530-017-1396-2
19. Mazzamuto, M. V., Bisi, F., Wauters, L. A., Preatoni, D. G., & Martinoli, A. (2017b). Interspecific competition between alien Pallas's squirrels and Eurasian red squirrels reduces density of the native species. Biological Invasions, 19(2), 723–735. https://doi.org/10.1007/s10530-016-1310-3
20. Prediger, J., Horčičková, M., Hofmannová, L., Sak, B., Ferrari, N., Mazzamuto, M. V., Romeo, C., Wauters, L. A., McEvoy, J., & Kváč, M. (2017). Native and introduced squirrels in Italy host different Cryptosporidium spp. European Journal of Protistology, 61, 64–75. https://doi.org/10.1016/j.ejop.2017.09.007
21. Schilling, A. K., Avanzi, C., Ulrich, R. G., Busso, P., Pisanu, B., Ferrari, N., Romeo, C., Mazzamuto, M. V., McLuckie, J., Shuttleworth, C. M., Del-Pozo, J., Lurz, P. W. W., Escalante-Fuentes, W. G., Ocampo-Candiani, J., Vera-Cabrera, L., Stevenson, K., Chapuis, J. L., Meredith, A. L., & Cole, S. T. (2019). British red squirrels remain the only known wild rodent host for leprosy bacilli. Frontiers in Veterinary Science, 6(FEB), 6–11. https://doi.org/10.3389/fvets.2019.00008

Callosciurus finlaysonii

22. Lurz, P. (2014). Datasheet on *Callosciurus finlaysonii*. Wallingford (UK): CAB International, Invasive Species Compendium. Available from: http://www.cabi. org/isc.
23. Mori, E., Mazzoglio, P. J., Rima, P. C., Aloise, G., & Bertolino, S. (2016a). Bark-stripping damage by *Callosciurus finlaysonii* introduced into Italy. Mammalia, 80(5), 507–514. https://doi.org/10.1515/mammalia-2015-0107
24. Bertolino, S., Adriaens, T., Verzelen, Y., Rabitsch, W., Robertson, P., Kettunen, M., Chapman, D., & Scalera, R. (2018). Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention (*Callosciurus finlaysonii*).

Castor canadensis

25. Aldridge, V. (2009). Datasheet on *Castor canadensis*. Wallingford (UK): CAB International, Invasive Species Compendium. Available from: http://www.cabi. org/isc.
26. Nummi, P. (2010). NOBANIS - Invasive Alien Species Fact Sheet: *Castor canadensis*. https://doi.org/10.3732/ajb.1000402
27. Dewas, M., Herr, J., Schley, L., Angst, C., Manet, B., Landry, P., & Catusse, M. (2012). Recovery and status of native and introduced beavers *Castor fiber* and *Castor canadensis* in France and neighbouring countries. Mammal Review, 42(2), 144–165. https://doi.org/10.1111/j.1365-2907.2011.00196.x
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Appendix S3

Figures illustrating the trends in the published literature, species' taxonomy, traits, native zoogeographic realms, and pathogens classification

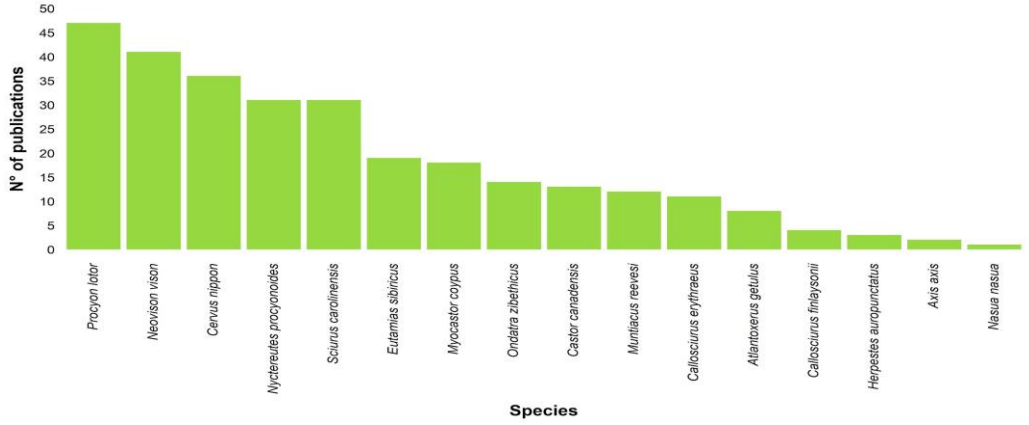

Fig. S2. The number of publications resulting from the literature search process collected for each study species in Europe (n = 291).

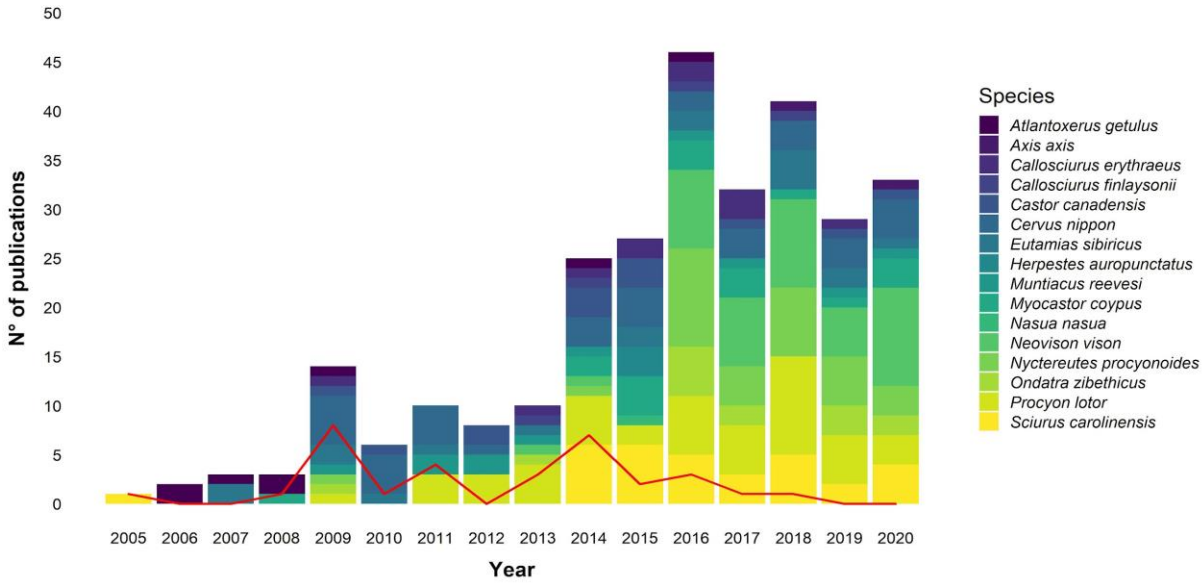

Fig. S3. The number of published studies per year for each study species (with duplicates) from 2005 to 2020 (n = 290; one publication has no date). The line shows the overall temporal trend of the published datasheets.

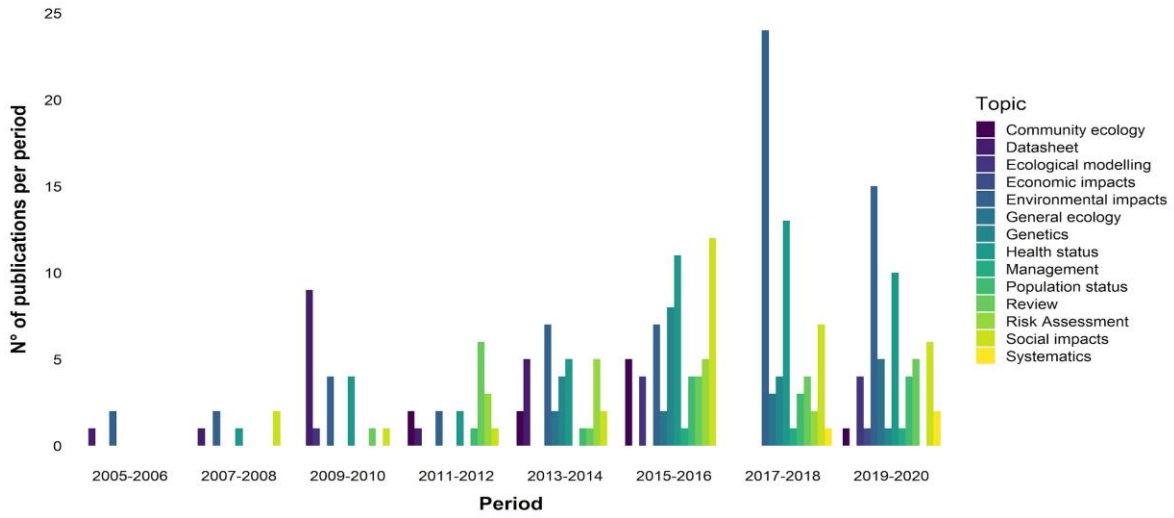

Fig. S4. The number of publications for each topic over a two-year period from 2005 to 2020 (n = 261; one publication has no date).

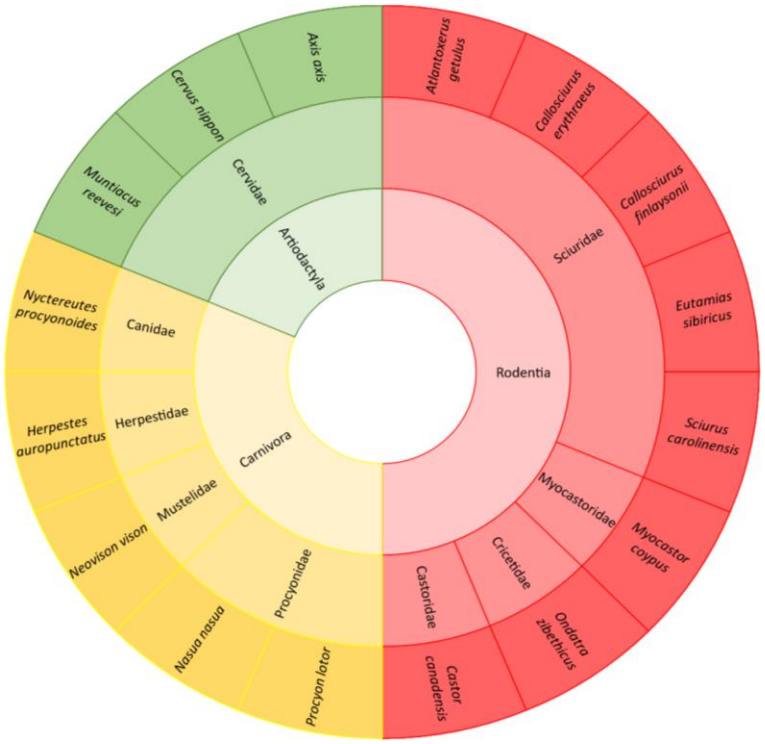

Fig. S5. Taxonomic assignment of the study species (n = 16). The inner circle represents the orders, the middle circle the families and the outer circle the species.

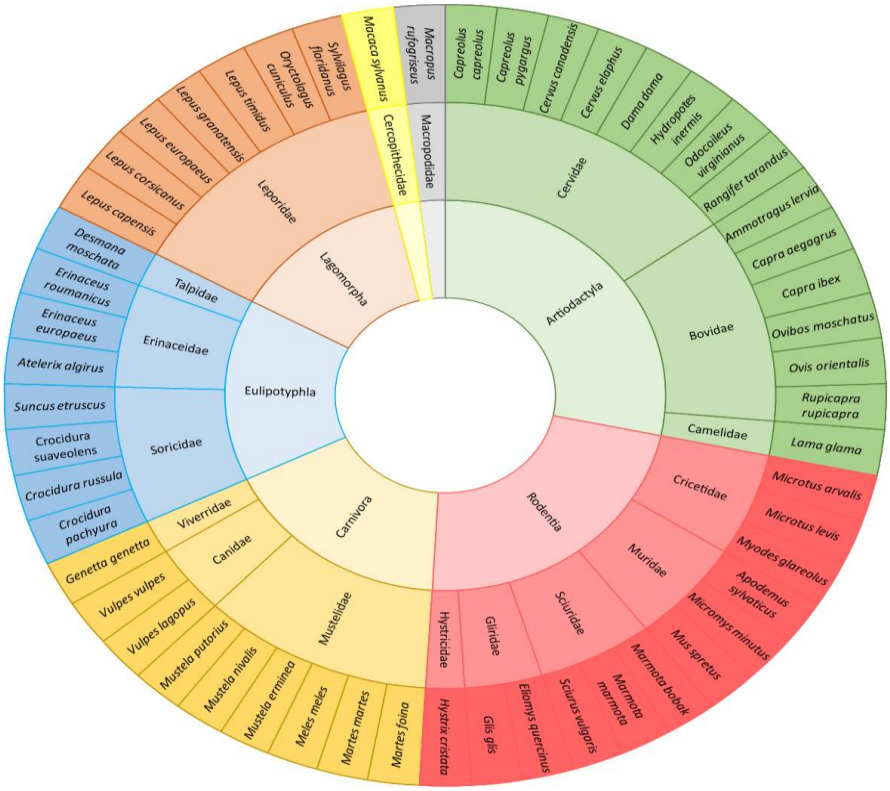

Fig. S6. Taxonomic assignment of all the introduced mammals established in Europe (n = 53). The inner circle represents the orders, the middle circle the families and the outer circle the species.

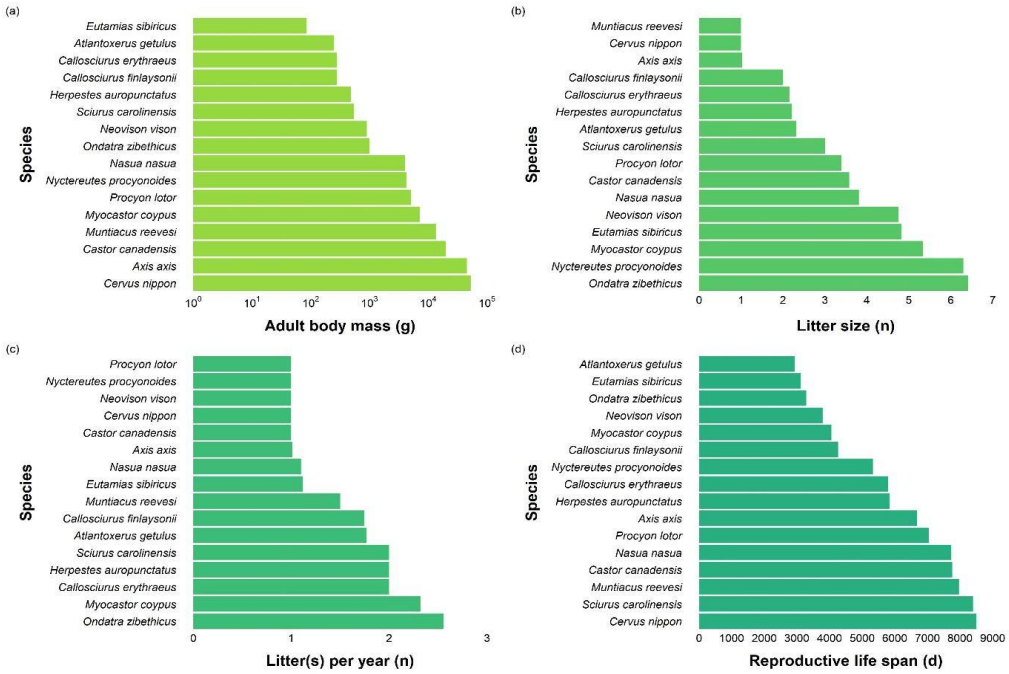

Fig. S7. Traits favouring the introduction, establishment, and spread (Capellini et al. 2015; Blackburn et al. 2017) of the study species: (a) adult body mass (log scale, in grams), (b) litter size, (c) litter(s) per year, and (d) generation length (in days).

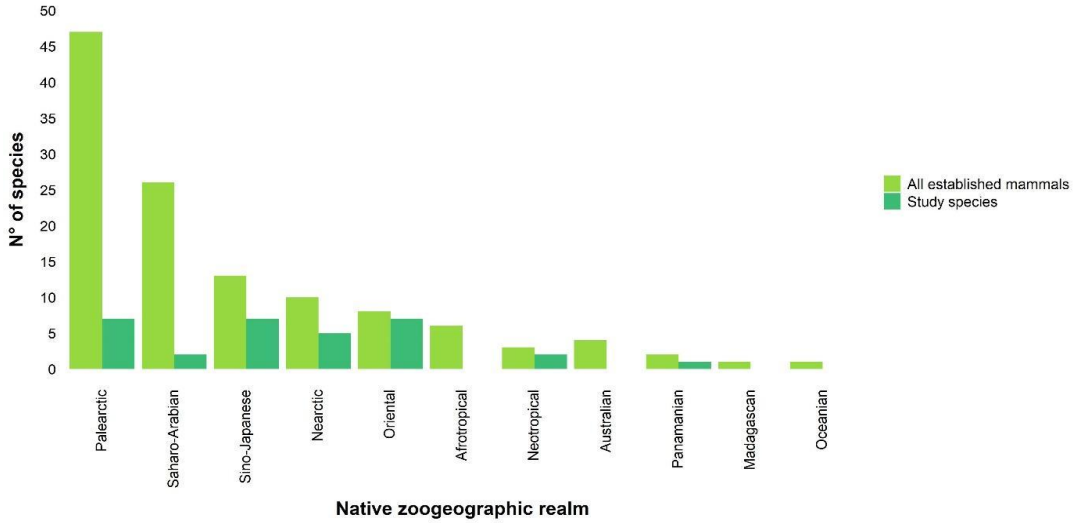

Fig. S8. Native zoogeographic realms (Holt et al. 2013) of all the introduced mammals established in Europe (n = 119) and of the study species (n = 31).

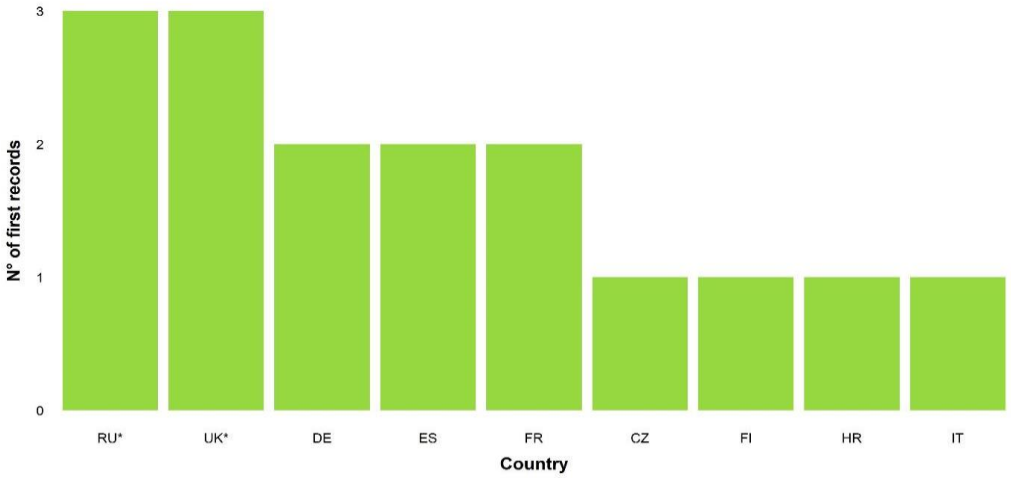

Fig. S9. First continental records in the countries of Europe (n = 16). Countries without invasive mammal species are not shown. Countries marked with an asterisk (*) are not Member States of the EU.

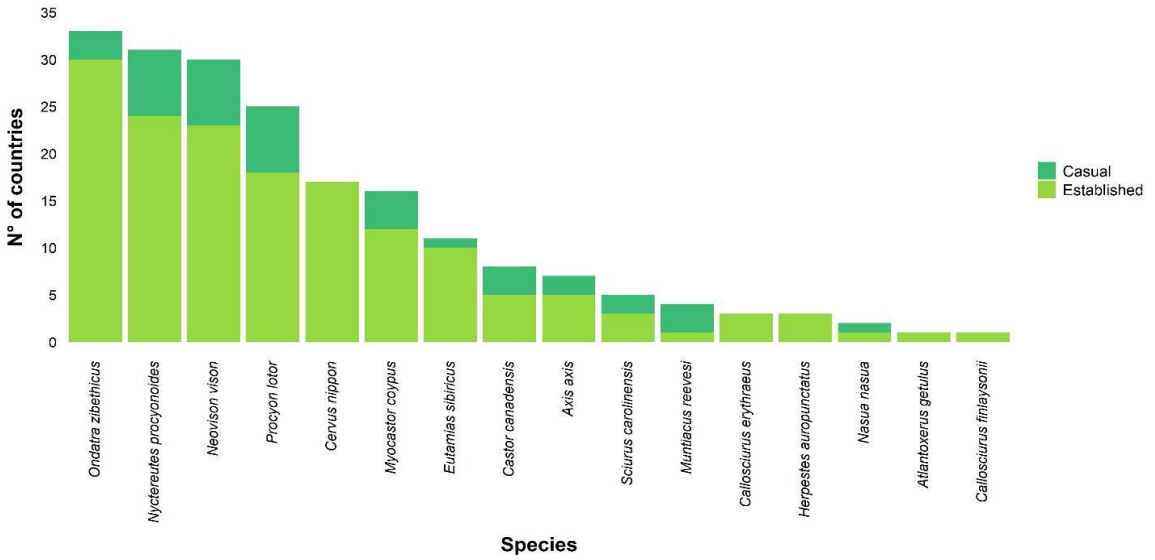

Fig. S10. Number of countries in Europe with established and casual presences (n = 197) of the study species.

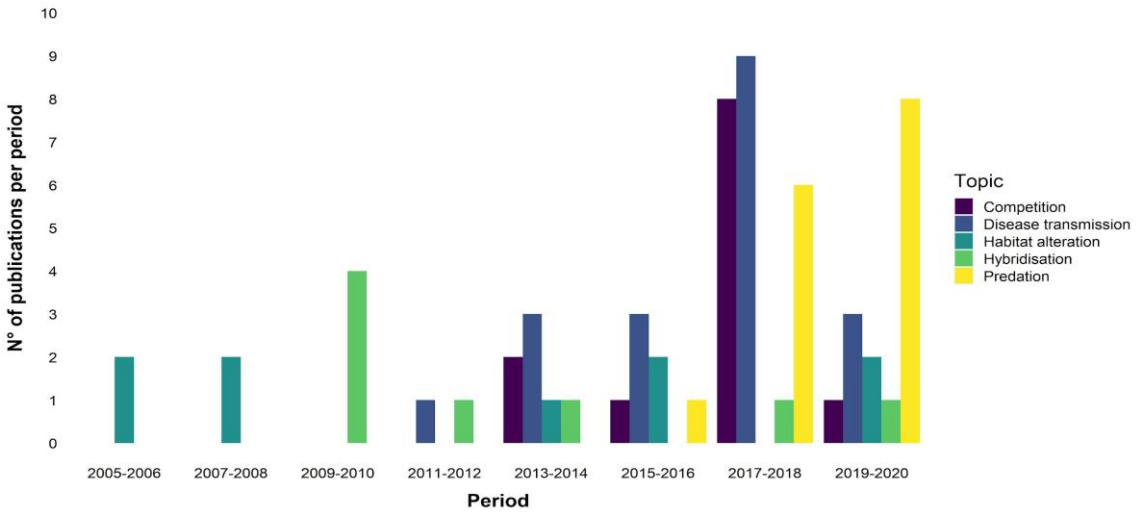

Fig. S11. The number of published papers (n = 63) regarding environmental impacts of invasive mammal species in Europe, divided per impact categories (following Blackburn et al. 2014).

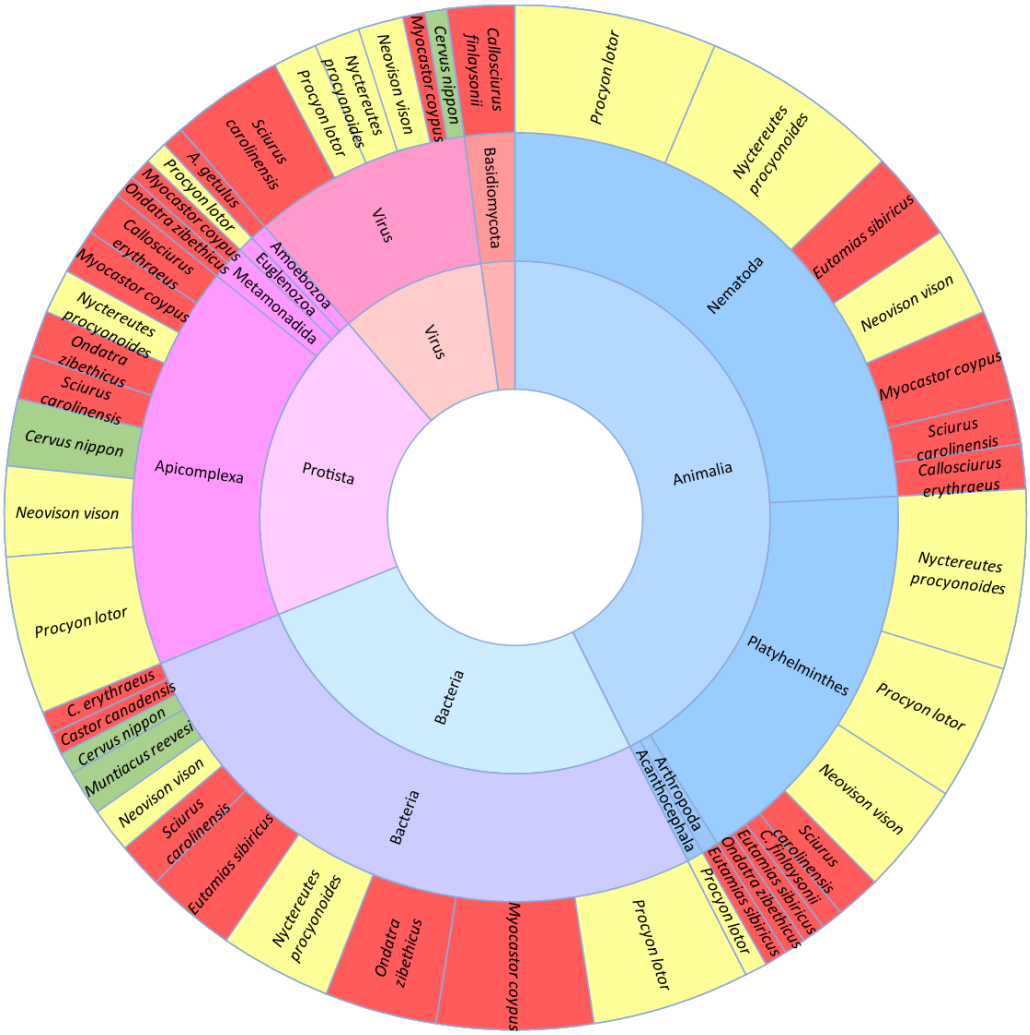

Fig. S12. Taxonomic assignments of the pathogens (n = 141) and study species (n = 13) known to be infected by them. The inner circle represents the Domain or the Kingdom, the middle circle the phyla, and the outer circle the species know to be infected. Species pertaining to the same order are indicated with the same colour (yellow for Carnivora, red for Rodentia, green for Artiodactyla).

Appendix S4

Year of first record and presences of the study species in Europe

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Species	Family	Order	Country	Present_Status	First_Record	Reference
Atlantoxerus getulus	Sciuridae	Rodentia	Spain	established	1965	Piero Genovesi
Axis axis	Cervidae	Artiodactyla	Croatia	established	1911	Piero Genovesi
Axis axis	Cervidae	Artiodactyla	Germany	casual	1750	Piero Genovesi
Axis axis	Cervidae	Artiodactyla	Ireland	casual	1850	Piero Genovesi
Callosciurus erythraeus	Sciuridae	Rodentia	France	established	1974	Piero Genovesi
Callosciurus erythraeus	Sciuridae	Rodentia	Italy	established	2007	Mazzamuto et al. 2016
Callosciurus erythraeus	Sciuridae	Rodentia	Netherlands	established	1998	Piero Genovesi
Callosciurus finlaysonii	Sciuridae	Rodentia	Italy	established	1981	Piero Genovesi
Castor canadensis	Castoridae	Rodentia	Belgium	established	1998	Parker et al. 2012
Castor canadensis	Castoridae	Rodentia	Finland	established	1935	Piero Genovesi
Castor canadensis	Castoridae	Rodentia	France	established	1975	Biancolini et al. 2021
Castor canadensis	Castoridae	Rodentia	Germany	alien	1966	Nehring & Rabitsch 2015
Castor canadensis	Castoridae	Rodentia	Hungary	alien	1990	Piero Genovesi
Castor canadensis	Castoridae	Rodentia	Luxembourg	established	2006	Parker et al. 2012
Castor canadensis	Castoridae	Rodentia	Norway	alien	2001	Sandvik et al. 2020
Castor canadensis	Castoridae	Rodentia	Russia	established	1950	César Capinha
Castor canadensis	Castoridae	Rodentia	United Kingdom	established	2002	Halley et al. 2020
Cervus nippon	Cervidae	Artiodactyla	Austria	established	1907	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Belarus	established	1954	Long, 2003
Cervus nippon	Cervidae	Artiodactyla	Czech Republic	established	1891	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Denmark	established	1900	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Estonia	established	1956	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	France	established	1890	Long 2003
Cervus nippon	Cervidae	Artiodactyla	Germany	established	1893	Long 2003
Cervus nippon	Cervidae	Artiodactyla	Hungary	established	1910	Markovic 1988
Cervus nippon	Cervidae	Artiodactyla	Ireland	established	1860	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Latvia	established	1954	Long 2003
Cervus nippon	Cervidae	Artiodactyla	Lithuania	established	1954	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Moldova	established	1954	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Poland	established	1895	Biedrzycka et al. 2012
Cervus nippon	Cervidae	Artiodactyla	Russia	established	1933	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Slovakia	established	1977	Piero Genovesi
Cervus nippon	Cervidae	Artiodactyla	Ukraine	established	1909	Bartos 2009
Cervus nippon	Cervidae	Artiodactyla	United Kingdom	established	1860	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	Belgium	established	1970	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	Denmark	established	1990	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	France	established	1970	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	Germany	established	1969	Piero Genovesi

Eutamias sibiricus	Sciuridae	Rodentia	Ireland	established	2007	Invasive Species Ireland 2019
Eutamias sibiricus	Sciuridae	Rodentia	Italy	established	1970	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	Netherlands	established	1972	Dijkstra & Dekker 2008
Eutamias sibiricus	Sciuridae	Rodentia	Norway	alien	1940	Sandvik et al. 2020
Eutamias sibiricus	Sciuridae	Rodentia	Russia	established	1850	Long 2003
Eutamias sibiricus	Sciuridae	Rodentia	Switzerland	established	1975	Piero Genovesi
Eutamias sibiricus	Sciuridae	Rodentia	United Kingdom	established	2005	Piero Genovesi
Herpestes auropunctatus	Herpestidae	Carnivora	Albania	established	-	Biancolini et al. 2021
Herpestes auropunctatus	Herpestidae	Carnivora	Bosnia and Herzegovina	established	1910	Piero Genovesi
Herpestes auropunctatus	Herpestidae	Carnivora	Croatia	established	1910	Piero Genovesi
Herpestes auropunctatus	Herpestidae	Carnivora	Montenegro	established	1988	Piero Genovesi
Muntiacus reevesi	Cervidae	Artiodactyla	Belgium	casual	2008	O'Flynn et al. 2014
Muntiacus reevesi	Cervidae	Artiodactyla	Ireland	casual	2007	O'Flynn et al. 2014
Muntiacus reevesi	Cervidae	Artiodactyla	Netherlands	casual	1998	Piero Genovesi
Muntiacus reevesi	Cervidae	Artiodactyla	United Kingdom	established	1894	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Albania	established	1995	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Austria	established	1935	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Belarus	casual	1997	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Belgium	established	1963	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Bulgaria	established	1953	Gruychev 2017
Myocastor coypus	Myocastoridae	Rodentia	Croatia	established	1966	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Czech Republic	established	1924	Nechybová et al. 2018
Myocastor coypus	Myocastoridae	Rodentia	Denmark	casual	1930	Piero Genovesi
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Myocastor coypus	Myocastoridae	Rodentia	Germany	established	1926	Long 2003
Myocastor coypus	Myocastoridae	Rodentia	Greece	established	1965	Ehrlich 1967
Myocastor coypus	Myocastoridae	Rodentia	Hungary	established	1966	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Ireland	established	2010	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Italy	established	1928	Long 2003
Myocastor coypus	Myocastoridae	Rodentia	Luxembourg	established	-	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Macedonia	established	1965	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Montenegro	established	-	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Netherlands	established	1935	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Poland	casual	1940	Piero Genovesi
Myocastor coypus	Myocastoridae	Rodentia	Romania	established	1988	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Russia	established	1926	Bertolino 2008
Myocastor coypus	Myocastoridae	Rodentia	San Marino	established	-	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Serbia	established	1970	Piero Genovesi

Myocastor coypus	Myocastoridae	Rodentia	Slovakia	established	-	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Slovenia	established	-	Biancolini et al. 2021
Myocastor coypus	Myocastoridae	Rodentia	Spain	established	1970	Piero Genovesi
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Myocastor coypus	Myocastoridae	Rodentia	Ukraine	established	-	Biancolini et al. 2021
Nasua nasua	Procyonidae	Carnivora	Spain	established	2003	Piero Genovesi
Nasua nasua	Procyonidae	Carnivora	Norway	alien	1961	Sandvik et al. 2020
Neovison vison	Mustelidae	Carnivora	Albania	established	-	Biancolini et al. 2021
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Neovison vison	Mustelidae	Carnivora	Denmark	established	1930	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Estonia	established	1960	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Finland	established	1927	Palazón 2014
Neovison vison	Mustelidae	Carnivora	France	established	1970	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Germany	established	1925	Nehring & Rabitsch 2015
Neovison vison	Mustelidae	Carnivora	Greece	established	1990	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Hungary	casual	1980	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Iceland	established	1930	Palazón 2014
Neovison vison	Mustelidae	Carnivora	Ireland	established	1951	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Italy	established	1985	Piero Genovesi
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Neovison vison	Mustelidae	Carnivora	Lithuania	established	1940	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Luxembourg	casual	1993	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Macedonia	established	-	Biancolini et al. 2021
Neovison vison	Mustelidae	Carnivora	Netherlands	casual	1929	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Norway	established	1929	Palazón 2014
Neovison vison	Mustelidae	Carnivora	Poland	established	1960	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Portugal	established	1979	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Romania	established	2000	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Russia	alien	1923	César Capinha
Neovison vison	Mustelidae	Carnivora	Serbia	casual	1974	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Slovakia	casual	1940	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	Slovenia	established	-	Biancolini et al. 2021
Neovison vison	Mustelidae	Carnivora	Spain	established	1978	Palazón 2014
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Neovison vison	Mustelidae	Carnivora	Switzerland	established	1970	Biancolini et al. 2021

Neovison vison	Mustelidae	Carnivora	Ukraine	established	1928	Piero Genovesi
Neovison vison	Mustelidae	Carnivora	United Kingdom	established	1929	Palazón 2014
Nyctereutes procyonoides	Canidae	Carnivora	Albania	established	-	Biancolini et al. 2021
Nyctereutes procyonoides	Canidae	Carnivora	Austria	established	1962	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Belarus	established	1936	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Belgium	established	1980	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Bosnia and Herzegovina	established	1970	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Bulgaria	established	1967	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Croatia	established	1970	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Czech Republic	established	1959	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Denmark	established	1980	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Estonia	established	1950	Piero Genovesi
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Nyctereutes procyonoides	Canidae	Carnivora	France	casual	1975	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Germany	established	1961	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Greece	alien	1970	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Hungary	established	1962	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Italy	casual	2005	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Latvia	established	1943	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Liechtenstein	established	-	Biancolini et al. 2021
Nyctereutes procyonoides	Canidae	Carnivora	Lithuania	established	1948	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Luxembourg	established	-	Biancolini et al. 2021
Nyctereutes procyonoides	Canidae	Carnivora	Macedonia	casual	2002	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Moldova	established	1949	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Netherlands	established	1986	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Norway	established	1983	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Poland	established	1955	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Romania	established	1951	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Russia	established	1926	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Serbia	established	1978	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Slovakia	established	1959	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Slovenia	casual	1980	Piero Genovesi
Nyctereutes procyonoides	Canidae	Carnivora	Sweden	established	1945	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Switzerland	casual	1997	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	Ukraine	established	1936	Kahuala 2009
Nyctereutes procyonoides	Canidae	Carnivora	United Kingdom	alien	1927	Zierits et al. 2016
Ondatra zibethicus	Cricetidae	Rodentia	Andorra	established	-	Biancolini et al. 2021
Ondatra zibethicus	Cricetidae	Rodentia	Austria	established	1914	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Belarus	alien	1953	Long 2003

Ondatra zibethicus	Cricetidae	Rodentia	Belgium	established	1925	Triplet 2009
Ondatra zibethicus	Cricetidae	Rodentia	Bosnia and Herzegovina	established	1932	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Bulgaria	established	1956	Triplet 2009
Ondatra zibethicus	Cricetidae	Rodentia	Croatia	established	1932	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Czech Republic	established	1905	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Denmark	established	1989	Birnbaum 2013
Ondatra zibethicus	Cricetidae	Rodentia	Estonia	established	1947	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Finland	established	1919	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	France	established	1928	Triplet 2009
Ondatra zibethicus	Cricetidae	Rodentia	Germany	established	1914	Nehring & Rabitsch 2015
Ondatra zibethicus	Cricetidae	Rodentia	Greece	casual	1960	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Hungary	established	1924	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Italy	alien	1992	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Latvia	established	1961	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Liechtenstein	established	1980	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Lithuania	established	1954	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Luxembourg	established	1960	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Macedonia	established	1932	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Moldova	established	1947	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Montenegro	established	-	Biancolini et al. 2021
Ondatra zibethicus	Cricetidae	Rodentia	Netherlands	established	1941	Long 2003
Ondatra zibethicus	Cricetidae	Rodentia	Norway	established	1960	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Poland	established	1924	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Romania	established	1933	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Russia	established	1927	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Serbia	established	1930	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Slovakia	established	1933	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Slovenia	established	1960	Piero Genovesi
Ondatra zibethicus	Cricetidae	Rodentia	Spain	established	2004	Muñoz-Mas & García-Berthou 2020
Ondatra zibethicus	Cricetidae	Rodentia	Sweden	established	1946	Triplet 2009
Ondatra zibethicus	Cricetidae	Rodentia	Switzerland	established	1930	Triplet 2009
Ondatra zibethicus	Cricetidae	Rodentia	Ukraine	established	1944	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Austria	established	1974	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Belarus	established	1954	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Belgium	established	1986	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Czech Republic	established	1952	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Denmark	casual	1978	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	France	established	1934	Piero Genovesi

Procyon lotor	Procyonidae	Carnivora	Germany	established	1927	Nehring & Rabitsch, 2015
Procyon lotor	Procyonidae	Carnivora	Hungary	established	1982	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Ireland	casual	2011	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Italy	established	2004	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Liechtenstein	established	1977	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Lithuania	established	2011	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Luxembourg	established	1979	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Netherlands	established	1960	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Norway	alien	2010	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Poland	established	1945	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Portugal	established	2001	Ascensão et al. 2021
Procyon lotor	Procyonidae	Carnivora	Russia	established	1929	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Serbia	casual	1998	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Slovakia	established	1993	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Slovenia	alien	1999	Piero Genovesi
Procyon lotor	Procyonidae	Carnivora	Spain	established	2001	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Sweden	casual	2010	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Switzerland	established	1975	Salgado 2018
Procyon lotor	Procyonidae	Carnivora	Ukraine	established	1954	Biancolini et al. 2021
Procyon lotor	Procyonidae	Carnivora	United Kingdom	casual	1980	Salgado 2018
Sciurus carolinensis	Sciuridae	Rodentia	Ireland	established	1911	IUCN/SSC ISSG 2005
Sciurus carolinensis	Sciuridae	Rodentia	Italy	established	1948	Piero Genovesi
Sciurus carolinensis	Sciuridae	Rodentia	Netherlands	casual	1990	NOBANIS
Sciurus carolinensis	Sciuridae	Rodentia	Norway	alien	1831	Sandvik et al. 2020
Sciurus carolinensis	Sciuridae	Rodentia	United Kingdom	established	1876	Piero Genovesi

Appendix S5

List of pathogens known to have been recorded to infect the study species in Europe and list of additional references

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Atlantoxerus getulus	*Acanthamoeba* spp.	YES	ES	23.50%	Lorenzo-Morales et al. 2007	
Callosciurus erythraeus	Capillariinae	YES	IT	1%	Mazzamuto et al. 2016	
	Ceratophyllus s. sciurorum	NO	IT	50%	Mazzamuto et al. 2016	
	Cryptosporidium spp.	YES	IT	2.80%	Prediger et al. 2017	
	Ctenophtalmus agyrtes sardiniensis	NO	IT	1%	Mazzamuto et al. 2016	
	Ctenophtalmus sp.	NO	IT	1%	Mazzamuto et al. 2016	
	Eimeria spp.	YES	IT	4.10%	Hofmannová et al. 2016	
	Ixodes ricinus		IT	47%	Mazzamuto et al. 2016	
	Mycobacterium leprae	YES	IT	0%	Schilling et al. 2019	
	Mycobacterium leprae	YES	FR	0%	Schilling et al. 2019	
	Spiruridae	NO	IT	1%	Mazzamuto et al. 2016	
	Strongyloides callosciureus	NO	IT	1%	Mazzamuto et al. 2016	
	Strongyloides sp.	YES	IT	1%	Mazzamuto et al. 2016	
	Trichuris muris	NO	IT	4%	Mazzamuto et al. 2016	
	Trombiculidae	NO	IT	7%	Mazzamuto et al. 2016	
	Trypanoxyuris sciuri	NO	IT	5%	Mazzamuto et al. 2016	
Callosciurus finlaysonii	*Cryptococcus neoformans*	YES	IT	5.60%	Iatta et al. 2015	
	Debaryomyces hansenii	YES	IT	0.80%	Iatta et al. 2015	
	Dicrocoelium dendriticum	YES	IT	33.30%	d'Ovidio et al. 2014	
	Hanseniaspora thailandica	NO	IT	3.20%	Iatta et al. 2015	
Callosciurus finlaysonii	*Meyerozyma guilliermondii*	YES	IT	0.80%	Iatta et al. 2015	
Castor canadensis	*Francisella tularensis*	YES	SE		Sissonen et al. 2015	Samples analysed were already infected.
Cervus nippon	*Anaplasma phagocytophilum*	YES	UK	50%	Robinson et al. 2009	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
	Ashworthius sidemi	NO	RU		Panova et al. 2017	Probably introduced in Europe with *C. nippon.*
	Babesia spp.	YES	CZ	21.90%	Hrazdilová et al. 2020	
	BlueTongue Virus (BTV)	NO	IE	0%	Graham et al. 2017	Pooled prevalence: sika + fallow + red deer.
	Border Disease Virus (BDV)	NO	CZ	0%	Sedlak et al. 2009	
	Bovine HerpesVirus-1 (BoHV-1)	NO	IE	1.80%	Graham et al. 2017	Pooled prevalence: sika + fallow + red deer.
	Bovine Viral Diarrhoea Virus (BVDV)	NO	CZ	0%	Sedlak et al. 2009	
	Bovine Viral Diarrhoea Virus (BVDV)	NO	IE	1.50%	Graham et al. 2017	Pooled prevalence: sika + fallow + red deer.
	Hepatitis E Virus (HEV)	YES	DE	0%	Trojnar et al. 2020	
	Hepatitis E Virus (HEV)	YES	PL	0%	Larska et al. 2015	
	Hepatitis E Virus (HEV)	YES	CZ	0%	Kubankova et al. 2015	
	Lipoptena fortisetosa	NO	EE		Mihalca et al. 2019	Probably introduced in Europe with *C. nippon.*
	Onchocerca flexuosa	NO	CZ	16.70%	Dykova & Blazek, 1972	Can be a host.
	Sarcocystis spp.	YES	LT	100%	Prakas et al. 2016	Farm bred animals.
	Sarcocystis spp.	YES	LT	92%	Rudaitytė-Lukošienė et al. 2018	
	Schmallenberg Virus (SBV)	NO	IE	9.70%	Graham et al. 2017	Pooled prevalence: sika + fallow + red deer.
	Toxoplasma gondii	YES	CZ	50%	Lorencova et al. 2015	Antibodies. DNA prevalence: 0%.
	Trichuris discolor	NO	CZ	5.20%	Nechybová et al. 2018	
	Trichuris ovis	NO	CZ	1.70%	Nechybová et al. 2018	
	Wehrdickmansia cervipedis	NO	CZ	16.70%	Dykova & Blazek, 1972	
Eutamias sibiricus	*Aonchotheca annulosa*	NO	FR	47%	Pisanu et al. 2007	
	Aonchotheca annulosa	NO	FR	40.50%	Pisanu et al. 2009	
	Ascaroidea	YES	FR	2.40%	Pisanu et al. 2009	
	Borrelia burgdoferi sensu lato	YES	FR	33.30%	Vourc'h et al. 2007	
	Borrelia burgdoferi sensu lato	YES	FR	35%	Marsot et al. 2011	
	Borrelia burgdoferi sensu lato	YES	FR	5%-60%	Marsot et al. 2013	
	Borrelia lusitaniae	YES	IT		Mori et al. 2018b	*B. lusitaniae* and *R. monacensis* were present in ticks of the chipmunks.
	Brevistriata skrjabini		FR	90.5%	Pisanu et al. 2009	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Eutamias sibiricus	*Brevistriata skrjabini*		FR	87%	Pisanu et al. 2007	
	Hymenolepis spp.	YES	IT	0%	d'Ovidio et al. 2015	
	Mycobacterium leprae	YES	FR	0%	Schilling et al. 2019	
	Oxyuridea	YES	FR	2.40%	Pisanu et al. 2009	
	Rickettsia monacensis	YES	IT		Mori et al. 2018b	*B. lusitaniae* and *R. monacensis* were present in ticks of the chipmunks.
	Strongyloides callosciureus	NO	FR	19%	Pisanu et al. 2009	
	Trichostrongyloidea sp.	YES	FR	7.10%	Pisanu et al. 2009	
	Trichuris sp.	YES	FR	9.50%	Pisanu et al. 2009	
Muntiacus reevesi	*Anaplasma phagocytophilum*	YES	UK	1%	Duscher et al. 2020	
	Bovine Viral Diarrhoea Virus (BVDV)	NO	IE		McKillen et al. 2017	Can act as a reservoir. Preliminary study.
	Foot and Mouth Disease Virus (FMDV)	NO	UK		Gibbs et al. 1975	Samples analysed were already infected.
	Ixodes ricinus		UK		GB Non-Native Species Secretariat, 2011	
	Mycobacterium bovis	YES	UK		Ward & Smith, 2012	Can act as a host.
Myocastor coypus	*Cryptosporidium* spp.	YES	IT	0%	Zanzani et al. 2016	
	Cryptosporidium spp.	YES	CZ	0%	Kellnerová et al. 2017	
	Eimeria coypi	NO	CZ	37%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
Myocastor coypus	*Eimeria coypi*	NO	CZ	60%	Nechybová et al. 2018	Faecal analysis of wild animals.
	Eimeria coypi	NO	IT	86.30%	Zanzani et al. 2016	
	Eimeria myopotami	NO	CZ	5%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
	Eimeria nutriae	NO	CZ	45%	Nechybová et al. 2018	Faecal analysis of wild animals.
	Eimeria nutriae	NO	CZ	23%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
	Eimeria seideli	NO	CZ	26%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
	Eimeria seideli	NO	IT	6.80%	Zanzani et al. 2016	
	Escherichia coli	YES	IT	4.50%	Zanzani et al. 2016	
	Francisella tularensis	YES	DE	0%	Schulze et al. 2016	
	Giardia duodenalis (Giardia lamblia)	YES	IT	0%	Zanzani et al. 2016	
	Hepatitis E Virus (HEV)	YES	IT	0%	Serracca et al. 2015	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Myocastor coypus	*Leptospira interrogans*	YES	IT	44.90%	Zanzani et al. 2016	Antibodies. Humans are accidental hosts.
	Leptospira spp.	YES	IT	32.90%	Bertelloni et al. 2019	
	Leptospira spp.	YES	IT	44.90%	Zanzani et al. 2016	
	Leptospira spp.	YES	IT	27.90%	Fratini et al. 2015	Antibodies. Prevalence 9.8% by PCR, 0% by bacteriological examination.
	Leptospira spp.	YES	FR	64%-76%	Vein et al. 2014	Antibodies.
	Leptospira spp.	YES	FR	42%	Ayral et al. 2020	Antibodies.
	Leptospira spp.	YES	FR	16.50%-66%	Michel et al. 2001	Antibodies.
	Salmonella spp.	YES	IT	0%	Zanzani et al. 2016	
	Staphylococcus aureus	YES	IT	10.10%	Zanzani et al. 2016	
	Streptococcus spp.	YES	IT	3.40%	Zanzani et al. 2016	
	Strongyloides myopotami	YES	CZ	25%	Nechybová et al. 2018	Necropsy on farm-bred animals.
	Strongyloides myopotami	YES	IT	63.40%	Zanzani et al. 2016	
	Strongyloides sp.	YES	CZ	30%	Nechybová et al. 2018	Faecal analysis of wild animals.
	Strongyloides sp.	YES	CZ	11.50%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
	Toxoplasma gondii	YES	IT	28.9%	Zanzani et al. 2016	Antibodies.
	Toxoplasma gondii	YES	IT	59.40%	Nardoni et al. 2011	Antibodies. Prevalence 52.2% by PCR.
	Trichostrongylus duretteae	NO	IT	28.10%	Zanzani et al. 2016	
	Trichostrongylus sp.	YES	CZ	4%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
	Trichuris myocastoris		CZ	40%	Nechybová et al. 2018	Necropsy on farm-bred animals.
	Trichuris sp.	YES	CZ	5%	Nechybová et al. 2018	Faecal analysis of wild animals.
	Trichuris sp.	YES	CZ	57%	Nechybová et al. 2018	Faecal analysis of farm-bred animals.
Neovison vison	*Aelurostrongylus* spp.	NO	ES	2%	Martínez-Rondán et al. 2017	
	Alaria alata	YES	LT	7.60%	Nugaraitė et al. 2018	Mesocercariae.
	Aleutian Disease Virus (ADV)	NO	ES		Mañas et al. 2001	ADV DNA was detected by PCR in 28.57% of the carcasses tested.
	Angiostrongylus daskalovi	NO	ES	6%	Martínez-Rondán et al. 2017	
	Angiostrongylus vasorum	NO	DK	0.80%	Lemming et al. 2020	
	Aonchotheca annulosa	NO	ES	8%	Martínez-Rondán et al. 2017	
	Aonchotheca putorii	YES	ES	54%	Martínez-Rondán et al. 2017	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Neovison vison	*Aonchotheca putorii*	YES	LT	33.30%-50%	Nugaraitė et al. 2018	
	Canine ParvoVirus (CPV)	NO	PT	0%	Miranda et al. 2017	
	Capillaria plica (Pearsonema plica)	NO	DK	0%	Petersen et al. 2018b	
	Crenosoma melesi		ES	10%	Martínez-Rondán et al. 2017	
	Crenosoma schachmatovae		LT	10.20%-15%	Nugaraitė et al. 2018	
	Crenosoma vulpis	NO	DK	5.70%	Lemming et al. 2020	
	Cryptosporidium spp.	YES	CZ	1%	Kellnerová et al. 2017	
	Cystoisospora spp.	YES	DK	11%	Petersen et al. 2020	
	Echinococcus spp.	YES	PL	14.20%	Kołodziej-Sobocińska et al. 2020	
	Ehrlichia canis	YES	ES	0%	Criado-Fornelio et al. 2018	
	Eucoleus aerophilus	YES	LT	10%-15.30%	Nugaraitė et al. 2018	
	Francisella tularensis	YES	DE	0%	Schulze et al. 2016	
	Hepatozoon spp.	NO	ES	0%	Criado-Fornelio et al. 2018	
	Influenza A Viruses (IAV)	YES	ES	2.20%	Gholipour et al. 2017	
	Isthmiophora melis	NO	LT	75%	Nugaraitė et al. 2017	
	Isthmiophora melis	NO	LT	70%-77%	Nugaraitė et al. 2018	
	Mesocestoides spp.	YES	LT	5%-7.60%	Nugaraitė et al. 2018	
	Molineus patens	NO	LT	12.80%-20%	Nugaraitė et al. 2018	
	Molineus patens	NO	ES	68%	Martínez-Rondán et al. 2017	
	Pseudamphistomum truncatum	YES	LT	17.90%-30%	Nugaraitė et al. 2018	
	Sarcosystis lutrae	NO	LT	13.60%	Prakas et al. 2018	
	SARS-CoV-2	YES	NL	19.40%	Oreshkova et al. 2020	Dead mink positive for viral RNA. Prevalence 100% of the throat swabs of dead animals.
	Skrjabingylus nasicola	NO	DE	53.30%	Heddergott et al. 2016	
	Staphylococcus aureus methicillin-resistant (LA-MRSA)	YES	DK	34%-40%	Hansen et al. 2017	
	Strigea strigis		LT	28.20%-30%	Nugaraitė et al. 2018	Metacercariae.
	Taenia martis	YES	LT	2.50%	Nugaraitė et al. 2018	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Neovison vison	*Toxocara* spp.	YES	PL	21.70%	Kołodziej-Sobocińska et al. 2020	
	Toxoplasma gondii	YES	PL	25%	Sroka et al. 2019	
	Toxoplasma gondii	YES	ES	78.80%	Ribas et al. 2018	
	Toxoplasma gondii	YES	ES	0%	Criado-Fornelio et al. 2018	
	Trichinella spp.	YES	PL	3.30%	Hurníková et al. 2016	
	Troglotrema acutum		ES	2%	Martínez-Rondán et al. 2017	
	Unidentified trematode		ES	2%	Martínez-Rondán et al. 2017	
Nyctereutes procyonoides	*Aelurostrongylus abstrusus*	NO	DK	0%	Lemming et al. 2020	
	Alaria alata	YES	AT	30%	Duscher et al. 2017	
	Alaria alata	YES	EE	13.30%	Laurimaa et al. 2016	Metacercariae.
	Alaria alata	YES	EE	68.30%	Laurimaa et al. 2016	
	Alaria alata	YES	PL	94.30%	Karamon et al. 2016	
	Anaplasmataceae	YES	AT	0%	Duscher et al. 2017	
	Angiostrongylus vasorum	NO	EE	1.30%	Laurimaa et al. 2016	
	Angiostrongylus vasorum	NO	DK	3.20%	Lemming et al. 2020	
	Aonchotheca putorii	YES	EE	3.60%	Laurimaa et al. 2016	
	Apophallus spp.	YES	PL	15.10%	Karamon et al. 2016	
	Babesia cf microti	YES	AT	62.50%	Duscher et al. 2017	
	Borrelia spp.	YES	PL	25%	Wodecka et al. 2016	
	Candidatus Neoerlichia sp.	YES	PL	30%	Hildebrand et al. 2018	
	Capillaria aerophila (Eucoleus aerophilus)	YES	DK	1.90%	Lemming et al. 2020	
	Capillaria plica (Pearsonema plica)	NO	DK	0.50%	Petersen et al. 2018b	
	Chlamydia spp.	YES	UA	0%	Ksyonz et al. 2019	
	Crenosoma vulpis	NO	EE	15%	Laurimaa et al. 2016	
	Crenosoma vulpis	NO	DK	5.30%	Lemming et al. 2020	
	Dipylidium caninum	NO	AT	20%	Duscher et al. 2017	
	Echinococcus multilocularis	YES	AT	10%	Duscher et al. 2017	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Nyctereutes procyonoides	*Echinococcus multilocularis*	YES	DK	0.70%	Petersen et al. 2018a	
	Echinococcus multilocularis	YES	EE	1.60%	Laurimaa et al. 2016	
	Echinococcus multilocularis	YES	NL	11.10%	Maas et al. 2016	PCR.
	Echinococcus multilocularis	YES	DK	0%	Oksanen et al. 2016	Pooled prevalence from Enemark, 2013; Al-Sabi et al. 2013; EFSA, 2015.
	Echinococcus multilocularis	YES	DE	2.50%	Oksanen et al. 2016	Pooled prevalence from Thiess et al. 2001; Thiess, 2004; Schwarz et al. 2011.
	Echinococcus multilocularis	YES	NL	0%	EFSA, 2015	
	Echinococcus multilocularis	YES	FI	0%	Oksanen et al. 2016	Pooled prevalence from EFSA, 2013, 2014, 2015.
	Echinococcus multilocularis	YES	PL	10.40%	Oksanen et al. 2016	Pooled prevalence from Machnicka-Rowińska et al. 2002; Machnicka et al. 2003; EFSA, 2015.
	Echinococcus multilocularis	YES	PL	0%	Karamon et al. 2016	
	Echinococcus multilocularis	YES	SE	0%	Wahlström et al. 2011	
	Echinococcus multilocularis	YES	SK	28%	Oksanen et al. 2016	Pooled prevalence from Letková et al. 2008; Hurníková et al. 2009; EFSA, 2015.
	Echinococcus multilocularis	YES	LV	8.10%	Bagrade et al. 2016	
	Echinococcus multilocularis	YES	LV	21%	Bagrade et al. 2008	
	Echinococcus multilocularis	YES	LT	8.20%	Bružinskaitė-Schmidhalter et al. 2012	
	Echinococcus multilocularis	YES	UA	0%	Kornyushin et al. 2011	
	Echinostomatidae	YES	PL	18.90%	Karamon et al. 2016	
	Eucoleus aerophilus	YES	EE	30%	Laurimaa et al. 2016	
	Francisella tularensis	YES	DE	16.70%	Schulze et al. 2016	
	Hepatitis E Virus (HEV)	YES	DE	34.30%	Dahnert et al. 2018	
	Hookworms	YES	PL	83%	Karamon et al. 2016	
	Isthmiophora melis	NO	AT	20%	Duscher et al. 2017	
	Isthmiophora melis	NO	EE	6%	Laurimaa et al. 2016	
	Ixodes ricinus		PL		Wodecka et al. 2016	Raccoon dogs harbor seven-fold more ticks than badgers.
	Mesocestoides spp.	YES	AT	40%	Duscher et al. 2017	
	Mesocestoides spp.	YES	EE	21.30%	Laurimaa et al. 2016	*M. lineatus, M. litteratus*
	Metorchis bilis	YES	EE	19.50%	Laurimaa et al. 2016	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Nyctereutes procyonoides	*Molineus patens*	NO	EE	13.70%	Laurimaa et al. 2016	
	Molineus spp.	NO	AT	30%	Duscher et al. 2017	
	Molineus spp.	NO	PL	41.50%	Karamon et al. 2016	
	Pearsonema plica	NO	EE	10.80%	Laurimaa et al. 2016	
	Plagiorchis elegans	NO	EE	0.80%	Laurimaa et al. 2016	
	Pygidiopsis summa	YES	DK	3%	Al-Sabi et al. 2013	
	Taenia policantha	NO	EE	8.40%	Laurimaa et al. 2016	
	Taenia spp.	YES	AT	20%	Duscher et al. 2017	
	Tick-Borne Encephalitis Virus (TBEV)	YES	FI		Uusitalo et al. 2020	Has a role in the cycle.
	Toxocara canis	YES	AT	20%	Duscher et al. 2017	
	Toxocara leonina	YES	AT	10%	Duscher et al. 2017	
	Toxocara spp.	YES	EE	8%	Laurimaa et al. 2016	*T. canis, T. leonina*
	Toxocara spp.	YES	PL	15.10%	Karamon et al. 2016	
	Toxoplasma gondii	YES	PL	7.70%	Sroka et al. 2019	
	Trichinella spp.	YES	AT	0%	Duscher et al. 2017	
	Trichinella spp.	YES	EE	57.50%	Kärssin et al. 2017	
	Trichinella spp.	YES	NL	11.10%	Maas et al. 2016	
	Trichinella spp.	YES	PL	39.80%	Cybulska et al. 2019	
	Uncinaria stenocephala	YES	AT	40%	Duscher et al. 2017	
	Uncinaria stenocephala	YES	EE	97.60%	Laurimaa et al. 2016	
	Unidentified lungworm		DK	0.80%	Lemming et al. 2020	
Ondatra zibethicus	*Bartonella* spp.	YES	BE		Krügel et al. 2020	Detection in a by-caught specimen.
	Chlamydia spp.	YES	UA	33.30%	Ksyonz et al. 2019	
	Cryptosporidium spp.	YES	DE		Petri et al. 1997	Muskrat can contaminate waters.
	Echinococcus multilocularis	YES	BE	11.20%	Hanosset et al. 2008	
	Echinococcus multilocularis	YES	NL	0.10%	Borgsteede et al. 2003	
	Francisella tularensis	YES	DE	0%	Schulze et al. 2016	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Ondatra zibethicus	*Giardia duodenalis (Giardia lamblia)*	YES	RO	100%	Adriana et al. 2016	One sample analysed.
	Leptospira spp.	YES	DE	5.90%	Hurd et al. 2017	
	Toxoplasma gondii	YES	PL	6.30%	Sroka et al. 2019	
	Yersinia pestis	YES			Anon., 1940	Appears to be susceptible to plague.
Procyon lotor	*Acanthocephala*	YES	PL	1.90%	Karamon et al. 2014	
	Alaria alata	YES	AT	0%	Duscher et al. 2017	
	Alaria alata	YES	DE	33.30%	Rentería-Solís et al. 2013	
	Anaplasma phagocytophilum	YES	PL	0.80%	Hildebrand et al. 2018	
	Anaplasmataceae	YES	AT	0%	Duscher et al. 2017	
	Ancylostoma spp.	YES	PL	4.40%	Popiołek et al. 2011	
	Babesia cf microti	YES	AT	0%	Duscher et al. 2017	
	Baylisascaris procyonis	YES	DE	43.60%	Heddergott et al. 2020b	
	Baylisascaris procyonis	YES	DE	76.20%	Rentería-Solís et al. 2018	
	Baylisascaris procyonis	YES	DE	39%	Winter, 2005	
	Baylisascaris procyonis	YES	DE	71.40%	Gey, 1998	
	Baylisascaris procyonis	YES	DE	80%	Hohmann et al. 2002	
	Baylisascaris procyonis	YES	DK	11%	Al-Sabi et al. 2016	
	Baylisascaris procyonis	YES	PL	3.30%	Popiołek et al. 2011	
	Baylisascaris procyonis	YES	PL	1.90%	Karamon et al. 2014	
Procyon lotor	*Baylisascaris procyonis*	YES	PL	3.70%	Bartoszewicz et al. 2008	
	Canine Adenovirus 1 (CAdV-1)	NO	DE	0%	Schulze et al. 2019	
	Canine Adenovirus 1 (CAdV-1)	NO	DE	0%	Hechinger et al. 2017	
	Canine Adenovirus 1 (CAdV-2)	NO	DE	0%	Schulze et al. 2019	
	Canine Distemper Virus (CDV)	NO	DE	10.80%	Wibbelt et al. 2008	
	Canine Distemper Virus (CDV)	NO	DE	46%	Hechinger et al. 2017	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Procyon lotor	*Canine Distemper Virus* (CDV)	NO	DE	76.30%	Rentería-Solís et al. 2014b	
	Capillaria spp.	YES	PL	25.50%	Karamon et al. 2014	
	Capillaridae	YES	PL	33.30%	Popiołek et al. 2011	
	Cryptosporidium spp.	YES	LU	12.40%	Heddergott et al. 2020a	
	Cryptosporidium spp.	YES	PL	34.70%	Leśniańska et al. 2016	
	Cryptosporidium spp.	YES	DE	34.70%	Leśniańska et al. 2016	
	Dipylidium caninum	NO	AT	0%	Duscher et al. 2017	
	Echinococcus multilocularis	YES	AT	0%	Duscher et al. 2017	
	Echinostoma sp.	YES	PL	2.20%	Popiołek et al. 2011	
	Echinostomatidae	YES	PL	34.50%	Karamon et al. 2014	
	Ehrlichia canis	YES	ES	2.60%	Criado-Fornelio et al. 2018	
	Eimeria spp.	YES	DE	1.50%	Gey, 1998	
	Eimeria spp.	YES	DE	1.80%	Winter, 2005	
	Enterocytozoon bieneusi	YES	PL	4.10%	Leśniańska et al. 2016	
	Francisella tularensis	YES	DE	0%	Schulze et al. 2016	
	Hepatitis E Virus (HEV)	YES	DE	53.80%	Dahnert et al. 2018	
	Hepatozoon canis	NO	ES	2.60%	Criado-Fornelio et al. 2018	
	Isthmiophora melis	NO	AT	0%	Duscher et al. 2017	
	Leishmania infantum	YES	ES	0%	Risueño et al. 2018	
	Listeria spp.	YES	PL	7.10%	Nowakiewicz et al. 2016	
	Lyssavirus rabies	YES	Europe		The Rabies Information System of the WHO Collaboration Centre for Rabies Surveillance and Research	142 cases reported in Europe. http://rbe.fli.bund.de/Default.aspx
	Mesocestoides spp.	YES	AT	0%	Duscher et al. 2017	
	Mesocestoides spp.	YES	PL	67.30%	Karamon et al. 2014	
	Molineus spp.	NO	AT	13%	Duscher et al. 2017	
	Neospora caninum	NO	CZ	17.60%	Kornacka et al. 2018	Antibodies. Prevalence 0% by PCR.
	Neospora caninum	NO	DE	16.70%	Kornacka et al. 2018	Antibodies. Prevalence 0% by PCR.
	Neospora caninum	NO	PL	13.30%	Kornacka et al. 2018	Antibodies. Prevalence 0% by PCR.

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Procyon lotor	*Placoconus lotoris*	NO	PL	4.40%	Popiołek et al. 2011	
	Salmonella spp.	YES	PL	5.70%	Nowakiewicz et al. 2016	
	Sarcocystis spp.	YES	DE	4.40%	Stolte et al. 1996	
	Sarcocystis spp.		DE		Rentería-Solís et al. 2014	Cross-transmission of *S. scabiei* mites has been recorded.
	Spirocerca lupi	NO	PL	8.80%	Popiołek et al. 2011	
	Staphylococcus coagulase-positive	YES	PL	35.70%	Nowakiewicz et al. 2016	
	Strongyloides procyonis	YES	PL	14.80%	Bartoszewicz et al. 2008	
	Strongyloides procyonis	YES	PL	11%	Popiołek et al. 2011	
	Taenia spp.	YES	AT	0%	Duscher et al. 2017	
	Toxocara canis	YES	AT	0%	Duscher et al. 2017	
	Toxocara leonina	YES	AT	0%	Duscher et al. 2017	
	Toxoplasma gondii	YES	CZ	0%	Kornacka et al. 2018	Antibodies. Prevalence 47.1% by PCR.
	Toxoplasma gondii	YES	DE	26%	Gey, 1998	
	Toxoplasma gondii	YES	DE	33.30%	Kornacka et al. 2018	Antibodies. Prevalence 33.3% by PCR.
	Toxoplasma gondii	YES	DE	38.30%	Heddergot et al. 2017	Antibodies.
	Toxoplasma gondii	YES	LU	19%	Heddergot et al. 2017	Antibodies.
	Toxoplasma gondii	YES	PL	13.10%	Sroka et al. 2019	
	Toxoplasma gondii	YES	PL	13.30%	Kornacka et al. 2018	Antibodies. Prevalence 40% by PCR.
	Toxoplasma gondii	YES	ES	3.60%	Criado-Fornelio et al. 2018	
	Trichinella spp.	YES	AT	0%	Duscher et al. 2017	
	Trichinella spp.	YES	CZ	9.10%	Cybulska et al. 2018	
	Trichinella spp.	YES	DE	0%	Cybulska et al. 2018	
	Trichinella spp.	YES	PL	6%	Cybulska et al. 2018	
	Uncinaria stenocephala	YES	AT	0%	Duscher et al. 2017	
	Yersinia spp.	YES	PL	4.30%	Nowakiewicz et al. 2016	
Sciurus carolinensis	*Adenoviridae*	YES	IT	0.90%	Romeo et al. 2014b	
	Aonchotheca annulosa	NO	IT	1.50%	Romeo et al. 2014a	
	Borrelia burgdoferi sensu lato	YES	UK	11.90%	Millins et al. 2015	

Species	Pathogen	Zoonotic	Country	Prevalence	Reference	Notes
Sciurus carolinensis	*Cryptosporidium* spp.	YES	IT	3.70%	Prediger et al. 2017	
	Eimeria spp.	YES	IT	95.70%	Hofmannová et al. 2016	Plus the successful introduction of *E. lancasterensis.*
	Hymenolepididae	YES	IT	0.40%	Romeo et al. 2014a	
	Hymenolepis spp.	YES	IT	0%	d'Ovidio et al. 2015	
	Ljungan Virus (LV)	YES	IT	0%	Romeo et al. 2014b	
	Mycobacterium leprae	YES	IT	0%	Schilling et al. 2019	
	Mycobacterium leprae	YES	UK	0%	Schilling et al. 2019	
	Oxyurida	YES	IT	0.90%	Romeo et al. 2014a	
	Squirrelpox poxvirus (SQPV)	NO	IE	29%	Stritch et al. 2015	
	Squirrelpox poxvirus (SQPV)	NO	IE	25%	Collins et al. 2014	Antibodies. Prevalence 10% by PCR.
	Strongylida	YES	IT	4.40%	Romeo et al. 2014a	
	Strongyloides robustus	NO	IT	56.50%	Romeo et al. 2014a	
	Tick-Borne Encephalitis Virus (TBEV)	YES	IT	1.90%-2.50%	Romeo et al. 2018	
	Trichostrongylus calcaratus	NO	IT	6.50%	Romeo et al. 2014a	
	Trichostrongylus retortaeformis	NO	IT	0.80%	Romeo et al. 2014a	
	Trichuris muris	NO	IT	4.20%	Romeo et al. 2014a	
	Trypanoxyuris sciuri	NO	IT	2.30%	Romeo et al. 2014a	
	Usutu Virus (USUV)	YES	IT	3.20%-3.80%	Romeo et al. 2018	
	West Nile Virus (WNV)	YES	IT	0.60%	Romeo et al. 2018	

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Chapter III: Supplementary material

Supplementary methods

Extended methodological description for the correlative part on ensemble Species Distribution Models (SDMs)

To construct ensemble SDMs, we used global species' presence data points from GBIF (GBIF 2022a), including the native and alien species' range (Broennimann et al. 2008, Jiménez-Valverde et al. 2011, Mainali et al. 2015, Araújo et al. 2019). To be consistent with the temporal span of the bioclimatic variables and, at the same time, retain the highest amount of data possible, we filtered for presences during 1981-2022, excluding fossil records and captive specimens.

Using *CoordinateCleaner* v. 2.0-20 (Zizka et al. 2019), we removed i) presences with a coordinate precision smaller than 0.01 (but retained those with missing coordinate precision), ii) presences with coordinate uncertainty above 10 km or with a large default value (i.e., 9999 m), iii) presences with latitude or longitude equal to zero, iv) country, capital, and zoo centroids in a radius within two km, v) presences in the sea, and vi) duplicated presences (i.e., with the same coordinates). The initial search on GBIF for presence data retrieved a total of 7,262,324 presences for 71 study species (GBIF 2022b). After cleaning and aggregating (at a 10 x 10 km resolution), 259,506 presences were retained. These data were then used to identify the species having more than 20 records.

Following Ficetola et al. (2014), we performed a spatial intersection analysis for each study species, using species' native and alien ranges and the aggregated presence data, to i) determine the number of presences included in any range polygon, and ii) remove presences in the upper 1% quantile of distances from any polygon distribution. As IUCN species' ranges discriminate between native and alien range polygons, to improve accuracy and avoid an overlap with DAMA we removed IUCN range polygons where the study species are extinct or with uncertain presence, and those where the study species are introduced, vagrant, have an uncertain origin, or originate from assisted colonisation. A total of 2596 presences were farther from any polygon than the defined threshold and were thus removed from the analysis.

To reduce spatial autocorrelation, occurrences were thinned to a 50 km distance (Brown & Carnaval 2019), using *spThin* v. 0.2.0 (Aiello-Lammens et al. 2015). The final dataset comprised 26,677 presences for 46 study species, of which 82% were inside range polygons (67% were inside a native range polygon, 15% inside an alien range polygon; Fig. S1, Table S5). Mean distance of presences from any range polygon was 19 km. Remarkably, 14,664 presences were in Europe, of which 79% were inside any range polygon (63% were inside a native range polygon, 16% inside an alien range polygon; Fig. S1, Table S4).

We downloaded bioclimatic variables from Chelsa V2.1 (Karger et al. 2017, 2018) for the period 1981-2010 at 30 arc seconds resolution (≈ 1km) and averaged them to a 10 x 10 km resolution. We checked for collinearity between variables using the Pearson correlation coefficient in *sdmpredictors* v. 0.2.14 (Bosch & Fernandez 2022) and kept those with a correlation ≤ |0.7|

(Dormann et al. 2013; Table S5) and that are considered important for predicting species distributions at large scales (Visconti et al. 2016): bio1 (mean annual air temperature), bio3 (isothermality), bio4 (temperature seasonality), bio15 (precipitation seasonality), bio16 (mean monthly precipitation amount of the wettest quarter), and bio17 (mean monthly precipitation amount of the driest quarter). As the study species are all terrestrial non-volant mammals, the bioclimatic variables were cropped to the world's landmasses.

Five replicates of pseudo-absences were sampled outside the species' range, where we drew as many of them as presences, but a minimum of 100 (Barbet-Massin et al. 2012). Pseudo-absences were sampled by accounting for major geographical dispersal barriers (Guisan et al. 2014), as well as sampling bias (Phillips et al. 2009). Areas that are theoretically accessible to a species via natural dispersal are those where pseudo-absences are ecologically meaningful (Jiménez-Valverde et al. 2011). We therefore defined the continent(s) where a species occurs as accessible region(s). To account for sampling bias in our presence data, we adopted a target group approach (Phillips et al. 2009, Ranc et al. 2017, Chapman et al. 2019, Pedruzzi et al. 2022; Fig. S3). We sampled pseudo-absences with a probability based on the estimates on the completeness of digitally accessible information for mammals from Meyer et al. (2015), assuming that this reflects the sampling bias for the study species (Chapman et al. 2019) and thus, can be used as a probability surface (a "biasfile"). As Meyer et al. (2015) do not include the Arctic and Antarctic, while some of our study species occur there, we merged those areas to the biasfile, assigning them the minimum value possible. Pseudo-absences selection was performed using *raster* v. 3.6-14 (Hijmans 2023a) and *terra* v. 1.7-3 (Hijmans 2023b).

We applied an ensemble modeling approach and used six algorithms from *biomod2* v. 3.3-7.1 (Thuiller et al. 2019): two regression methods (Generalised Linear Model and Multivariate Adaptive Regression Splines), a classification method (Flexible Discriminant Analysis), and three machine learning methods (Generalised Boosting Model, also called Boosting Regression Trees, Artificial Neural Network, and Random Forest) with the default settings of *biomod2*. We split species' occurrences in 80% (model calibration) and 20% (model evaluation; Guisan et al. 2017). To account for the stochastic nature of some algorithms, each model was run three times for each species, resulting in a total of 4140 models (six models x three runs x five pseudo-absences sets x 46 species).

Single model performance was evaluated using True Skill Statistics (TSS), with a threshold ≥ 0.7 (Guisan et al. 2017) for single models to be included in ensemble modeling. The final ensemble SDMs showed very good predictive performance (Zhang et al. 2015): mean TSS across species = 0.88 ± 0.05, mean sensitivity = 95.38 ± 2.98, and mean specificity = 92.83 ± 2.87 (Table S6). The whole modeling process was implemented following the standard protocol ODMAP (Overview, Data, Model, Assessment and Prediction; Zurell et al. 2020), available in the Supplementary Data.

Extended methodological description of models' variables

To test the role of propagule pressure and other socio-economic factors in explaining the observed range patterns, we built three models (one for each range index), related to the introduction history of the study species and to the socio-economic variables hypothesized to be associated with range patterns.

After initial consideration of adult body mass from COMBINE (Soria et al. 2021) as a candidate predictor, representing a proxy of species detectability, we opted not to include this predictor in our analysis. Larger species could be easier to detect and therefore can have both higher numbers of species' presence records (used in the SDMs) and introduction records. However, our decision was based on the high correlation (Spearman correlation = 0.84) between adult body mass and dispersal ability, as well as circularity that would have been introduced to our analysis, as dispersal was calculated using the formula from Santini et al. (2013) — which factors in body mass and trophic level. Hence, we decided against adult body mass inclusion.

We collected information on the total number of introduction pathways, as more pathways usually result in multiple introductions (and therefore larger alien ranges; Dyer et al. 2016), from DAMA (Biancolini et al. 2021; Table S3). We collected native range extents (an indicator of species niche breadth; González-Suárez et al. 2015) from IUCN (IUCN 2020): data were rasterized at 10x10 km resolution, and area was calculated as number of 10x10 km raster cells.

Simple variables describing human pressures, rather than composite proxies (such as the Human Footprint Index), have been found to be the better predictor of mammals' geographic range size among human pressure variables (Di Marco & Santini 2015). Moreover, they allow for a better discrimination of individual variables' influence, compared to the use of cumulative measures. We downloaded population density data from the History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011), for the decades 1980-2000, and the year 2005. Data were in the form of raster maps, with each decade represented as inhabitants/grid cell. We log-transformed population density, which was strongly skewed.

Land-use is one of the most relevant drivers for biological invasions in the 21st century (Essl et al. 2019). We downloaded land-use data from the History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011), for the decades 1980-2000, and the year 2005. We selected only categories of anthropic environments (pasture, cropland, and urban area), excluding natural land, and produced a raster per each category with the area covered per cell in km^2. We then summed all categories to obtain a single anthropic land-use variable describing the amount of anthropised environments per cell. For simplicity, we refer to this anthropic land-use as "land-use" throughout the manuscript.

International trade and transport are as well among the most relevant drivers of biological invasions in the 21st century (Essl et al 2019), hence we selected roads and railways from Williams et al. (2020) for the year 2017. If available as vector maps, data were rasterized.

All variables were transformed to the study resolution (10 x 10 km) and projection (EPSG:3035), averaged across time periods, and calculated for each species as an average value across each species' range filling, overfilling, and unfilling polygon(s) (Supplementary Data). Continuous variables were scaled to ensure comparability and uniformity and checked for collinearity, i.e., Spearman correlation ≤ |0.7| (Dormann et al. 2013; Table S8).

Supplementary information

Table S1: Points of introduction and polygons dated before 1492 or without a date of introduction for the initial pool of study species (n = 71) at European level. Species that only

had points of introduction dated before 1492 or without a date of introduction were excluded from the analysis.

Species	Points undated or dated before 1492	Polygons undated or dated before 1492	TOTAL
Ammotragus lervia	1	0	1
Apodemus sylvaticus	65	62	127
Atelerix algirus	6	7	13
Atlantoxerus getulus	0	0	0
Axis axis	0	0	0
Callosciurus erythraeus	0	0	0
Callosciurus finlaysonii	0	0	0
Capra aegagrus	5	6	11
Capra ibex	2	1	3
Capreolus capreolus	0	0	0
Capreolus pygargus	0	0	0
Castor canadensis	0	0	0
Cervus canadensis	0	0	0
Cervus elaphus	0	0	0
Cervus nippon	0	0	0
Crocidura pachyura	4	5	9
Crocidura russula	2	0	2
Crocidura suaveolens	9	9	18
Dama dama	47	34	81
Desmana moschata	0	0	0
Eliomys quercinus	5	6	11
Erinaceus europaeus	46	41	87
Erinaceus roumanicus	1	2	3
Eutamias sibiricus	1	0	1
Gazella subgutturosa	1	1	2
Genetta genetta	6	4	10
Glis glis	5	6	11
Herpestes auropunctatus	0	0	0
Hydropotes inermis	6	6	12
Hystrix cristata	12	2	14
Lama glama	0	0	0
Lepus capensis	3	4	7
Lepus corsicanus	2	3	5
Lepus europaeus	13	15	28
Lepus granatensis	1	1	2
Lepus timidus	0	0	0
Macaca sylvanus	0	1	1
Macropus rufogriseus	0	0	0
Marmota bobak	0	0	0
Marmota marmota	0	0	0
Martes foina	5	6	11

Species	Points undated or dated before 1492	Polygons undated or dated before 1492	TOTAL
Martes martes	4	4	8
Meles meles	1	1	2
Micromys minutus	1	0	1
Microtus arvalis	6	1	7
Microtus levis	0	0	0
Muntiacus reevesi	6	6	12
Mus spretus	2	3	5
Mustela erminea	2	2	4
Mustela nivalis	13	14	27
Mustela putorius	19	10	29
Myocastor coypus	0	0	0
Myodes glareolus	0	0	0
Nasua nasua	1	0	1
Neovison vison	55	21	76
Nyctereutes procyonoides	0	0	0
Odocoileus virginianus	0	0	0
Ondatra zibethicus	12	0	12
Oryctolagus cuniculus	275	353	628
Ovibos moschatus	0	0	0
Ovis orientalis	12	15	27
Procyon lotor	5	12	17
Rangifer tarandus	0	0	0
Rupicapra rupicapra	0	0	0
Sciurus anomalus	0	0	0
Sciurus carolinensis	0	0	0
Sciurus vulgaris	0	0	0
Suncus etruscus	9	6	15
Sylvilagus floridanus	10	7	17
Vulpes lagopus	0	0	0
Vulpes vulpes	10	11	21
TOTAL	**691**	**688**	**1379**

Table S2: The 46 alien mammal species included in this study. Order, scientific name, common name, year of first alien record in Europe, points of successful introduction (i.e., inside the alien ranges, that led to the establishment of an alien population), and points of unsuccessful introduction (i.e., outside the alien ranges, that did not lead to the establishment of an alien population) at European level are indicated.

Order	Scientific name	Common name	Year of first record in Europe	Points of successful introduction	Points of unsuccessful introduction
Carnivora	*Herpestes auropunctatus*	Small Indian Mongoose	1910	7	1
	Martes martes	Pine Marten	1986	1	0
	Mustela erminea	Stoat	1650	3	1
	Mustela putorius	Western Polecat/Ferret	1933	4	0
	Neovison vison	American Mink	1925	112	9
	Nyctereutes procyonoides	Raccoon Dog	1936	35	0
	Procyon lotor	Northern Raccoon	1850	18	10
	Vulpes lagopus	Arctic Fox	1926	1	2
Artiodactyla	*Ammotragus lervia*	Aoudad	1970	2	2
	Axis axis	Chital	1974	2	3
	Capra ibex	Alpine Ibex	1936	4	1
	Capreolus capreolus	European Roe Deer	2011	2	2
	Capreolus pygargus	Siberian Roe Deer	1955	1	1
	Cervus canadensis	Wapiti	1865	1	0
	Cervus elaphus	Red Deer	1845	1	12
	Cervus nippon	Sika Deer	1860	67	25
	Dama dama	Fallow Deer	1577	30	12
	Hydropotes inermis	Chinese Water Deer	1900	5	2
	Muntiacus reevesi	Reeves' Muntjac	1910	2	1
	Odocoileus virginianus	White-tailed Deer	1934	9	0
	Ovibos moschatus	Muskox	1932	1	4
	Rangifer tarandus	Reindeer	1787	2	6
	Rupicapra rupicapra	Alpine Chamois	1937	2	5
Eulipotyphla	*Crocidura russula*	White-toothed Shrew	2001	1	3
	Erinaceus europaeus	Western European Hedgehog	1801	12	5
	Erinaceus roumanicus	Northern White-breasted Hedgehog	1890	3	0
	Suncus etruscus	Pygmy White-toothed Shrew	1955	2	0
Lagomorpha	*Lepus europaeus*	European Hare	1810	21	6
	Lepus granatensis	Granada Hare	1975	2	0
	Lepus timidus	Mountain Hare	1818	38	5
	Oryctolagus cuniculus	European Rabbit	1550	71	5
	Sylvilagus floridanus	Eastern Cottontail	1966	2	3
Rodentia	*Callosciurus erythraeus*	Pallas's Squirrel	1965	5	0
	Callosciurus finlaysonii	Finlayson's Squirrel	1985	1	1
	Castor canadensis	American Beaver	1937	2	3

Order	Scientific name	Common name	Year of first record in Europe	Points of successful introduction	Points of unsuccessful introduction
Rodentia	*Eutamias sibiricus*	Siberian Chipmunk	1965	16	2
	Glis glis	Edible Dormouse	1902	1	0
	Hystrix cristata	Crested Porcupine	1808	3	0
	Marmota bobak	Bobak Marmot	1934	1	0
	Marmota marmota	Alpine Marmot	1948	7	4
	Micromys minutus	Eurasian Harvest Mouse	1985	2	0
	Myocastor coypus	Coypu	1928	52	9
	Myodes glareolus	Bank Vole	1950	1	0
	Ondatra zibethicus	Muskrat	1905	18	0
	Sciurus carolinensis	Gray Squirrel	1828	15	1
	Sciurus vulgaris	Eurasian Red Squirrel	1937	11	16
TOTAL				**599**	**162**

Table S3: Species' traits used in the calculation of the potential alien ranges, species-specific variables used to explain the different range patterns in the GLMMs, their rationale, and the sources, for each study species (n = 46). Dispersal is indicated as the distance between species' birth and breeding site (in km) and generation length is the average age of parents of a cohort (in days), both derived from the COalesced Mammal dataBase of INtrinsic and Extrinsic traits (COMBINE; Soria et al. 2021). Earliest residence time is indicated as the number of years since the first successful introduction in Europe (Biancolini et al. 2021, Melone et al. 2021).

Species-specific explanatory variables		**Rationale**	**Reference/Source**	**Species**		
				Ammotragus lervia	*Axis axis*	*Callosciurus erythraeus*
Traits	**Generation length (days)**	A species with a shorter generation length may have been able to produce more generations in its residence time, and thus be able to colonize wider environments (= wider PAR)	COMBINE (Soria et al., 2021)	1825	3650	1696.563
	Dispersal (km)	A species with a higher dispersal distance may have been able to colonize wider environments in its residence time (= wider PAR)	COMBINE (Soria et al., 2021)	12.785	8.654	0.524
Residence time (days)		A species with a longer residence time (time since introduction) may have been able to colonize wider environments (= wider PAR)	DAMA (Biancolini et al., 2021)	17155	15695	18980
Pathway(s) of introduction	**Biological control**	Different pathways, as well as the total number of pathways of introduction, can influence the PARs	DAMA (Biancolini et al., 2021)	0	0	0
	Conservation			1	0	0
	Farming			0	0	0
	Fauna improvement			1	0	0
	Fur farming			0	0	0
	Hunting			1	1	0
	Ornamental purposes			1	0	0
	Pet			0	0	1
	Stowaway			0	0	0
	Wild fur			0	0	0
	Zoo			1	0	0
	TOTAL			**5**	**1**	**1**
Native range extent (10 X 10 km cells)		A species with a larger native range can attain broader alien ranges (González-Suárez et al., 2015)	IUCN	10314	20535	36175
Points of introduction		Contributes to the extent of alien range (Dyer et al., 2016)	DAMA (Biancolini et al., 2021); Biancolini & Rondinini, Melone et al. (2021)	2	2	5

Species-specific explanatory variables		Species									
		Callosciurus finlaysonii	*Capra ibex*	*Capreolus capreolus*	*Capreolus pygargus*	*Castor canadensis*	*Cervus canadensis*	*Cervus elaphus*	*Cervus nippon*	*Crocidura russula*	*Dama dama*
Traits	**Generation length (days)**	1595.763	2958.933	2335.392	3063.803	2657.6	5209.452	5209.452	3499.206	448.652	3286.095
	Dispersal (km)	0.524	11.558	5.754	5.754	5.496	17.291	17.291	9.411	0.7	10.405
Residence time (days)		11680	29565	2190	22630	29200	55480	62780	57305	5840	160600
Pathway(s) of introduction	**Biological control**	0	0	0	0	0	0	0	0	0	0
	Conservation	0	1	0	0	1	0	0	0	0	1
	Farming	0	0	0	0	0	0	0	1	0	0
	Fauna improvement	0	0	0	0	0	1	0	1	0	1
	Fur farming	0	0	0	0	0	0	0	0	0	0
	Hunting	0	1	1	1	0	0	1	1	0	1
	Ornamental purposes	0	0	0	0	0	0	0	1	0	1
	Pet	1	0	0	0	0	0	0	0	0	0
	Stowaway	0	0	0	0	0	0	0	0	1	0
	Wild fur	0	0	0	0	0	0	0	0	0	0
	Zoo	0	0	0	0	1	0	0	1	0	0
	TOTAL	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**5**	**1**	**4**
Native range extent (10 X 10 km cells)		6175	229	84339	151277	196228	71669	53216	3564	21318	2053
Points of introduction		1	4	2	1	2	1	1	67	1	30

Species-specific explanatory variables		Species								
		Erinaceus europaeus	*Erinaceus roumanicus*	*Eutamias sibiricus*	*Glis glis*	*Herpestes auropunctatus*	*Hydropotes inermis*	*Hystrix cristata*	*Lepus europaeus*	*Lepus granatensis*
Traits	**Generation length (days)**	1608.523	1172.132	1311.522	1152.94	1472.701	2190	2793.545	730	1021.934
	Dispersal (km)	5.748	5.722	0.273	0.36	5.737	4.301	5.379	2.168	1.686
Residence time (days)		78840	46355	18980	41975	39055	42705	76285	75555	15330
Pathway(s) of introduction	**Biological control**	1	1	0	0	1	0	0	0	0
	Conservation	0	0	0	0	0	0	0	0	0
	Farming	0	0	0	0	0	0	0	0	0
	Fauna improvement	0	0	1	1	0	1	0	0	0
	Fur farming	0	0	0	0	0	0	0	0	0
	Hunting	1	1	0	1	0	1	1	1	1
	Ornamental purposes	0	0	0	0	0	1	0	0	0
	Pet	1	1	1	0	0	0	0	0	0
	Stowaway	0	0	0	0	0	0	0	0	0
	Wild fur	0	0	0	0	0	0	0	0	0
	Zoo	0	0	1	0	0	0	0	0	0
	TOTAL	**3**	**3**	**3**	**2**	**1**	**3**	**1**	**1**	**1**
Native range extent (10 X 10 km cells)		51512	78949	215806	44643	31161	1743	44966	133306	5590
Points of introduction		12	3	16	1	7	5	3	21	2

Species-specific explanatory variables		Species									
		Lepus timidus	*Marmota bobak*	*Marmota marmota*	*Martes martes*	*Micromys minutus*	*Muntiacus reevesi*	*Mustela erminea*	*Mustela putorius*	*Myocastor coypus*	*Myodes glareolus*
Traits	**Generation length (days)**	1306.156	1095	2506.497	2100.94	502.66	2931.795	1078.778	1652.464	1311.715	577.751
	Dispersal (km)	1.949	3.163	2.111	1.225	0.07	4.436	2.207	5.859	3.127	0.126
Residence time (days)		72635	30295	25185	11315	11680	39055	133955	30660	32485	24455
Pathway(s) of introduction	**Biological control**	0	0	0	0	0	0	1	1	0	0
	Conservation	0	0	1	0	0	0	0	0	0	0
	Farming	0	0	0	0	0	0	0	0	0	0
	Fauna improvement	0	0	0	0	0	1	0	0	0	0
	Fur farming	0	0	0	0	0	0	0	0	1	0
	Hunting	1	1	1	1	0	1	0	0	0	0
	Ornamental purposes	0	0	0	0	0	1	0	0	0	0
	Pet	0	0	0	0	0	0	1	1	0	0
	Stowaway	0	0	0	1	1	0	0	0	0	1
	Wild fur	0	1	0	1	0	0	0	0	0	0
	Zoo	0	0	0	0	0	0	0	0	0	0
	TOTAL	**1**	**2**	**2**	**3**	**1**	**3**	**2**	**2**	**1**	**1**
Native range extent (10 X 10 km cells)		334900	10077	2187	137677	228915	20466	658263	80073	38364	124958
Points of introduction		38	1	7	1	2	2	3	4	52	1

Species-specific explanatory variables		Species									
		Neovison vison	*Nyctereutes procyonoides*	*Odocoileus virginianus*	*Ondatra zibethicus*	*Oryctolagus cuniculus*	*Ovibos moschatus*	*Procyon lotor*	*Rangifer tarandus*	*Rupicapra rupicapra*	*Sciurus carolinensis*
Traits	**Generation length (days)**	1473.65	2091.937	2713.883	1317.65	1515.354	3567.388	2703.919	1825	3650	2778.38
	Dispersal (km)	6.172	2.344	10.558	1.059	1.509	24.973	2.59	13.436	7.536	0.756
Residence time (days)		33580	29565	30295	40880	170455	31025	60955	83950	29200	68985
Pathway(s) of introduction	**Biological control**	0	0	0	0	0	0	0	0	0	0
	Conservation	0	0	0	0	0	0	0	0	0	0
	Farming	0	0	0	0	1	0	0	0	0	0
	Fauna improvement	0	0	0	0	0	0	0	0	0	1
	Fur farming	1	1	0	1	0	0	0	0	0	0
	Hunting	0	0	1	0	1	0	0	1	1	0
	Ornamental purposes	0	0	0	0	0	0	0	0	0	0
	Pet	0	1	0	0	1	0	1	0	0	1
	Stowaway	0	0	0	0	0	0	0	0	0	0
	Wild fur	1	1	0	1	0	0	1	0	0	0
	Zoo	0	0	0	0	0	1	1	0	0	0
	TOTAL	**2**	**3**	**1**	**2**	**3**	**1**	**3**	**1**	**1**	**2**
Native range extent (10 X 10 km cells)		194822	65982	149345	476299	6734	46223	123973	347681	2362	43312
Points of introduction		112	35	9	18	71	1	18	2	2	15

Species-specific explanatory variables		Species			
		Sciurus vulgaris	*Suncus etruscus*	*Sylvilagus floridanus*	*Vulpes lagopus*
Traits	**Generation length (days)**	1612.753	590.755	1107.051	1871.187
	Dispersal (km)	0.575	0.336	1.16	12.176
Residence time (days)		29200	22630	18615	33215
Pathway(s) of introduction	**Biological control**	0	0	0	0
	Conservation	0	0	0	0
	Farming	0	0	0	0
	Fauna improvement	0	0	0	0
	Fur farming	0	0	0	0
	Hunting	1	0	1	0
	Ornamental purposes	0	0	0	0
	Pet	0	0	0	0
	Stowaway	0	1	0	0
	Wild fur	0	0	0	1
	Zoo	0	0	0	0
	TOTAL	**1**	**1**	**1**	**1**
Native range extent (10 X 10 km cells)		300984	31913	68337	242272
Points of introduction		11	2	2	1

Table S4: Total thinned (50 x 50 km) GBIF points, and their distribution inside native and alien range polygons for each study species (n = 46), both globally and at European level.

Species	Total GBIF points at 50 x 50 km thinning	GBIF points (inside the range polygons) at 50 x 50 km thinning			
		Global		Europe	
		Native	Alien	Native	Alien
Ammotragus lervia	66	5	37	1	7
Axis axis	157	65	56	0	1
Callosciurus erythraeus	119	72	6	0	3
Callosciurus finlaysonii	60	33	0	0	0
Capra ibex	58	9	0	9	0
Capreolus capreolus	1170	1001	0	1001	0
Capreolus pygargus	139	129	1	44	1
Castor canadensis	1351	1201	34	0	19
Cervus canadensis	477	284	0	0	0
Cervus elaphus	915	575	89	575	0
Cervus nippon	220	27	80	0	70
Crocidura russula	299	256	6	256	6
Dama dama	712	13	505	13	374
Erinaceus europaeus	994	753	51	753	5
Erinaceus roumanicus	478	418	0	415	0
Eutamias sibiricus	210	164	1	24	1
Glis glis	326	293	2	293	2
Herpestes auropunctatus	39	10	12	0	2
Hydropotes inermis	18	1	10	0	10
Hystrix cristata	111	50	13	33	13
Lepus europaeus	1310	755	382	752	108
Lepus granatensis	102	92	3	92	3
Lepus timidus	629	510	0	440	0
Marmota bobak	83	17	5	10	5
Marmota marmota	73	43	11	43	11
Martes martes	783	673	4	670	4
Micromys minutus	389	328	10	319	10
Muntiacus reevesi	97	12	41	0	40
Mustela erminea	1236	1028	33	634	1
Mustela putorius	565	410	31	410	15
Myocastor coypus	696	154	416	0	294
Myodes glareolus	754	666	4	666	4
Neovison vison	596	85	376	0	372
Nyctereutes procyonoides	353	28	277	0	277
Odocoileus virginianus	1834	1650	40	0	33
Ondatra zibethicus	1464	1258	59	425	51
Oryctolagus cuniculus	1527	114	1039	114	324

Species	Total GBIF points at 50 x 50 km thinning	GBIF points (inside the range polygons) at 50 x 50 km thinning			
		Global		Europe	
		Native	Alien	Native	Alien
Ovibos moschatus	109	35	28	8	11
Procyon lotor	1916	1460	158	0	147
Rangifer tarandus	426	174	9	42	5
Rupicapra rupicapra	155	49	8	49	1
Sciurus carolinensis	975	708	100	0	67
Sciurus vulgaris	1433	1228	18	1112	18
Suncus etruscus	90	65	4	63	2
Sylvilagus floridanus	1025	857	16	0	12
Vulpes lagopus	138	78	0	28	0
TOTAL	**26,677**	**17,836**	**3975**	**9294**	**2329**

Table S5: Correlation matrix of the Chelsa bioclimatic variables aggregated at 10 x 10 km. Correlations between selected pairs of bioclimatic variables are shown in bold.

	bio1	**bio2**	**bio3**	**bio4**	**bio5**	**bio6**	**bio7**	**bio8**	**bio9**	**bio10**	**bio11**	**bio12**	**bio13**	**bio14**	**bio15**	**bio16**	**bio17**	**bio18**	**bio19**
bio1	1.00																		
bio2	-0.08	1.00																	
bio3	**0.52**	0.24	1.00																
bio4	**-0.65**	0.49	**-0.52**	1.00															
bio5	0.94	0.18	0.46	-0.36	1.00														
bio6	0.97	-0.27	0.53	-0.81	0.83	1.00													
bio7	-0.55	0.69	-0.37	0.97	-0.24	-0.74	1.00												
bio8	0.95	0.00	0.44	-0.45	0.96	0.87	-0.36	1.00											
bio9	0.94	-0.15	0.54	-0.77	0.83	0.96	-0.67	0.81	1.00										
bio10	0.97	0.05	0.45	-0.45	0.99	0.88	-0.34	0.98	0.87	1.00									
bio11	0.98	-0.19	0.56	-0.78	0.86	1.00	-0.70	0.89	0.96	0.91	1.00								
bio12	0.51	-0.28	0.56	-0.55	0.38	0.57	-0.52	0.44	0.52	0.43	0.55	1.00							
bio13	0.55	-0.17	0.55	-0.50	0.46	0.58	-0.45	0.50	0.54	0.49	0.58	0.91	1.00						
bio14	0.32	-0.34	0.39	-0.45	0.18	0.39	-0.47	0.25	0.34	0.23	0.37	0.82	0.55	1.00					
bio15	**0.32**	0.44	**0.17**	**0.10**	0.45	0.20	0.21	0.38	0.22	0.40	0.24	-0.16	0.14	-0.48	1.00				
bio16	**0.55**	-0.18	**0.56**	**-0.51**	0.45	0.58	-0.46	0.49	0.54	0.48	0.57	0.93	0.99	0.59	**0.10**	1.00			
bio17	**0.34**	-0.34	**0.40**	**-0.46**	0.20	0.41	-0.48	0.27	0.36	0.25	0.39	0.85	0.59	0.99	**-0.47**	**0.62**	1.00		
bio18	0.49	-0.22	0.46	-0.43	0.41	0.52	-0.41	0.48	0.44	0.44	0.51	0.86	0.84	0.67	-0.03	0.84	0.70	1.00	
bio19	0.38	-0.26	0.47	-0.49	0.25	0.45	-0.48	0.29	0.43	0.29	0.43	0.85	0.70	0.78	-0.28	0.73	0.80	0.55	1.00

Table S6: Species Distribution Models for the study species (n = 46). Number of modeled GBIF points, sensitivity, specificity, and True Skill Statistics (TSS) are indicated.

Species	Modeled presences	Sensitivity	Specificity	TSS
Ammotragus lervia	64	96.875	91.8	0.887
Axis axis	144	97.222	92.357	0.897
Callosciurus erythraeus	107	87.85	93.277	0.813
Callosciurus finlaysonii	51	94.118	98	0.921
Capra ibex	56	98.214	89.178	0.874
Capreolus capreolus	1051	95.528	94.192	0.897
Capreolus pygargus	138	99.275	95.108	0.944
Castor canadensis	1319	89.992	91.897	0.819
Cervus canadensis	469	92.964	85.025	0.78
Cervus elaphus	837	97.969	91.178	0.891
Cervus nippon	182	92.857	90.636	0.835
Crocidura russula	276	97.826	92.838	0.907
Dama dama	656	96.189	91.195	0.874
Erinaceus europaeus	853	98.007	91.339	0.894
Erinaceus roumanicus	449	94.878	93.512	0.882
Eutamias sibiricus	206	93.689	95.143	0.888
Glis glis	314	92.357	94.53	0.869
Herpestes auropunctatus	29	100	95.6	0.956
Hydropotes inermis	16	100	96.8	0.968
Hystrix cristata	100	89	89.189	0.784
Lepus europaeus	1188	94.444	92.072	0.865
Lepus granatensis	96	100	98.627	0.986
Lepus timidus	545	94.679	95.158	0.898
Marmota bobak	83	100	96.6	0.966
Marmota marmota	69	95.652	94.188	0.898
Martes martes	707	97.313	92.707	0.9
Micromys minutus	355	95.775	91.971	0.878
Muntiacus reevesi	86	95.349	94	0.893
Mustela erminea	1100	97.364	93.999	0.914
Mustela putorius	509	97.25	93.759	0.91
Myocastor coypus	647	93.663	89.394	0.831
Myodes glareolus	689	97.533	93.408	0.909
Neovison vison	496	94.153	88.676	0.828
Nyctereutes procyonoides	324	91.049	96.992	0.88
Odocoileus virginianus	1755	92.877	93.836	0.867
Ondatra zibethicus	1398	91.488	91.359	0.829
Oryctolagus cuniculus	1313	91.775	91.966	0.838
Ovibos moschatus	87	95.402	90.826	0.862

Species	Modeled presences	Sensitivity	Specificity	TSS
Procyon lotor	1787	95.803	91.787	0.876
Rangifer tarandus	363	98.898	88.826	0.877
Rupicapra rupicapra	148	96.622	90.839	0.875
Sciurus carolinensis	920	94.457	92.885	0.874
Sciurus vulgaris	1320	95.909	87	0.829
Suncus etruscus	80	93.75	97.194	0.909
Sylvilagus floridanus	979	92.441	93.056	0.856
Vulpes lagopus	85	98.824	96.377	0.952
TOTAL OR MEAN ± SD	**24,446**	**95.38 ± 2.98**	**92.83 ± 2.87**	**0.88 ± 0.05**

Table S7: Variables used in the Generalised Linear Mixed Models (GLMMs). Rationale, time span, measurement unit, original variable's resolution, processing methods, processed data resolution, statistical processing, and source are indicated. Variables available for several individual years were averaged.

Variable	Rationale	Time span	Unit	Spatial raw data resolution	Spatial processing methods	Spatial processed data resolution	Statistical processing	Source
Number of introduction pathways	More pathways usually result in multiple introductions, and therefore larger alien ranges (Dyer et al. 2016).	1492-2022	NA	NA	NA	NA		Biancolini et al. (2021)
Native range extent	An indicator of species niche breadth (González-Suárez et al. 2015).	NA	Number of 10x10 km cells	NA	NA	NA	Scaled.	IUCN (2020)
Human population density	Simple variables describing human pressures, rather than composite proxies (such as the Human Footprint Index), have been found to be the better predictor of mammals' geographic range size among human pressure variables (Di Marco & Santini 2015). They also allow for a better discrimination of individual variables' influence, compared to the use of cumulative measures.	1980, 1990, 2000, 2005	Inhabitants/grid cell	1x1 km	Resampled (gdalwarp); averaged across time (r.series).	10x10 km	Scaled; log transformed.	History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011)
Anthropic land-use	One of the most relevant drivers for biological invasions in the 21st century (Essl et al. 2019).	1980, 1990, 2000, 2005	Area covered by each land-use category/km^2	1x1 km	Retained only pasture, cropland, and urban area; resampled (gdalwarp); averaged across time (r.series);	10x10 km	Scaled.	History Database of the Global Environment (HYDE) 3.1 (Klein Goldewijk et al. 2011)

					summed across space (r.series).			
Roads and railways	One of the most relevant drivers for biological invasions in the 21st century (Essl et al. 2019).	2017	Pressure score (range 0-8; roads mean 2.6, railways mean 0.1)	1x1 km	Resampled (gdalwarp); summed across space (r.series).	10x10 km	Scaled.	Williams et al. (2020)

Table S8: Correlation matrix of the variables used in the three (one for each filling pattern: range filling, overfilling, and unfilling) Generalised Linear Mixed Models.

RANGE FILLING	Pathways of introduction	Native range size	Population density	Land-use	Roads and Railways
Pathways of introduction	1				
Native range size	-0.59	1			
Population density	0.06	-0.10	1		
Land-use	0.10	-0.16	0.48	1	
Roads and Railways	0.20	-0.22	0.41	0.24	1

RANGE OVERFILLING	Pathways of introduction	Native range size	Population density	Land-use	Roads and Railways
Pathways of introduction	1				
Native range size	-0.54	1			
Population density	0.11	-0.21	1		
Land-use	0.17	-0.24	0.47	1	
Roads and Railways	0.10	-0.21	0.47	0.32	1

RANGE UNFILLING	Pathways of introduction	Native range size	Population density	Land-use	Roads and Railways
Pathways of introduction	1				
Native range size	-0.54	1			
Population density	0.23	-0.08	1		
Land-use	0.28	0.00	0.46	1	
Roads and Railways	0.21	-0.01	0.56	0.21	1

Table S9: Observed alien range (Obs.), potential alien range (Pot.), and the total area available for each species (Potential + Observed Alien Range, POAR) of established alien mammals (n = 46) in Europe. For alien ranges and range index, results are shown, at a species level, for numbers of 10 x 10 km cells. Range percentage columns show the percentage of range filling (fil.), overfilling (ove.), and unfilling (unf.) compared to the total area available (POAR).

Species	Alien Ranges (10x10 km)			Range index (10x10 km)			Range percentage (%)		
	Obs.	Pot.	POAR	Fil.	Ove.	Unf.	Fil.	Ove.	Unf.
Ammotragus lervia	902	430	944	388	471	42	41.10	49.89	4.45
Axis axis	16	0	16	0	4	0	0.00	25.00	0.00
Callosciurus erythraeus	97	1	97	1	90	0	1.03	92.78	0.00
Callosciurus finlaysonii	8	0	8	0	7	0	0.00	87.50	0.00
Capra ibex	38	600	612	26	12	574	4.25	1.96	93.79
Capreolus capreolus	16	6	16	6	10	0	37.50	62.50	0.00
Capreolus pygargus	1889	0	1889	0	1889	0	0.00	100.00	0.00
Castor canadensis	3724	0	3724	0	3679	0	0.00	98.79	0.00
Cervus canadensis	4	509	513	0	4	509	0.00	0.78	99.22
Cervus elaphus	4	0	4	0	0	0	0.00	0.00	0.00
Cervus nippon	9233	5855	12065	3023	5779	2790	25.06	47.90	23.12
Crocidura russula	161	9	161	9	151	0	5.59	93.79	0.00
Dama dama	3721	17285	18825	2181	1362	15016	11.59	7.24	79.77
Erinaceus europaeus	148	12	149	11	49	1	7.38	32.89	0.67
Erinaceus roumanicus	10	0	10	0	0	0	0.00	0.00	0.00
Eutamias sibiricus	38	10	41	7	31	3	17.07	75.61	7.32
Glis glis	35	8	35	8	27	0	22.86	77.14	0.00
Herpestes auropunctatus	122	146	217	51	28	94	23.50	12.90	43.32
Hydropotes inermis	486	444	626	304	167	140	48.56	26.68	22.36
Hystrix cristata	30	7	30	7	15	0	23.33	50.00	0.00
Lepus europaeus	3394	688	3682	400	2568	267	10.86	69.74	7.25
Lepus granatensis	109	23	111	21	85	2	18.92	76.58	1.80
Lepus timidus	290	20	290	20	99	0	6.90	34.14	0.00
Marmota bobak	372	275	385	262	110	13	68.05	28.57	3.38
Marmota marmota	355	80	362	73	282	7	20.17	77.90	1.93
Martes martes	21	1	21	1	15	0	4.76	71.43	0.00
Micromys minutus	836	1	836	1	792	0	0.12	94.74	0.00
Muntiacus reevesi	1704	135	1704	135	1363	0	7.92	79.99	0.00
Mustela erminea	47	2	47	2	18	0	4.26	38.30	0.00
Mustela putorius	641	102	656	87	450	13	13.26	68.60	1.98
Myocastor coypus	15894	2474	16519	1849	13563	618	11.19	82.11	3.74
Myodes glareolus	538	4	538	4	469	0	0.74	87.17	0.00
Neovison vison	62290	12313	63184	11419	48286	889	18.07	76.42	1.41
Nyctereutes procyonoides	71858	1078	71858	1078	69317	0	1.50	96.46	0.00

Species	Alien Ranges (10x10 km)			Range index (10x10 km)			Range percentage (%)		
	Obs.	**Pot.**	**POAR**	**Fil.**	**Ove.**	**Unf.**	**Fil.**	**Ove.**	**Unf.**
Odocoileus virginianus	2062	583	2143	502	1428	78	23.43	66.64	3.64
Ondatra zibethicus	74463	637	74476	624	71980	13	0.84	96.65	0.02
Oryctolagus cuniculus	4912	1570	6178	304	4088	1258	4.92	66.17	20.36
Ovibos moschatus	584	730	941	373	197	352	39.64	20.94	37.41
Procyon lotor	14535	386	14604	317	13797	69	2.17	94.47	0.47
Rangifer tarandus	251	958	1039	170	37	737	16.36	3.56	70.93
Rupicapra rupicapra	64	122	147	39	25	83	26.53	17.01	56.46
Sciurus carolinensis	796	91	868	19	670	72	2.19	77.19	8.29
Sciurus vulgaris	1785	84	1785	84	1637	0	4.71	91.71	0.00
Suncus etruscus	69	13	69	13	14	0	18.84	20.29	0.00
Sylvilagus floridanus	473	30	473	30	431	0	6.34	91.12	0.00
Vulpes lagopus	67	36	67	36	18	0	53.73	26.87	0.00
MEDIAN	**363.5**	**82**	**525.5**	**28**	**159**	**1.5**	**7.65**	**67.62**	**0.24**

Table S10: Coefficient estimates, standard error, z-value and Pr(>|z|) of the three GLMMs. Significant values are marked in bold.

RANGE FILLING				
	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	-2.29	0.94	-2.42	**0.01**
Introduction pathways	-0.68	0.43	-1.59	0.11
Native range	-0.56	0.51	-1.11	0.27
Population density	0.75	0.14	5.53	**0.001**
Land-use	-0.69	0.27	-2.55	**0.01**
Roads and Railways	0.18	0.16	1.17	0.24
RANGE OVERFILLING				
	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	-1.64	0.47	-3.51	**0.001**
Introduction pathways	-0.54	0.20	-2.68	**0.007**
Native range	0.18	0.19	0.96	0.34
Population density	1.17	0.20	5.88	**0.001**
Land-use	-0.07	0.23	-0.30	0.76
Roads and Railways	-0.59	0.19	-3.13	**0.002**
RANGE UNFILLING				
	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	-3.73	0.79	-4.74	**0.001**
Introduction pathways	-0.41	0.30	-1.36	0.17
Native range	-0.77	0.35	-2.21	**0.03**
Population density	1.70	0.21	8.00	**0.001**
Land-use	-1.04	0.39	-2.64	**0.008**
Roads and Railways	-0.08	0.23	-0.36	0.73

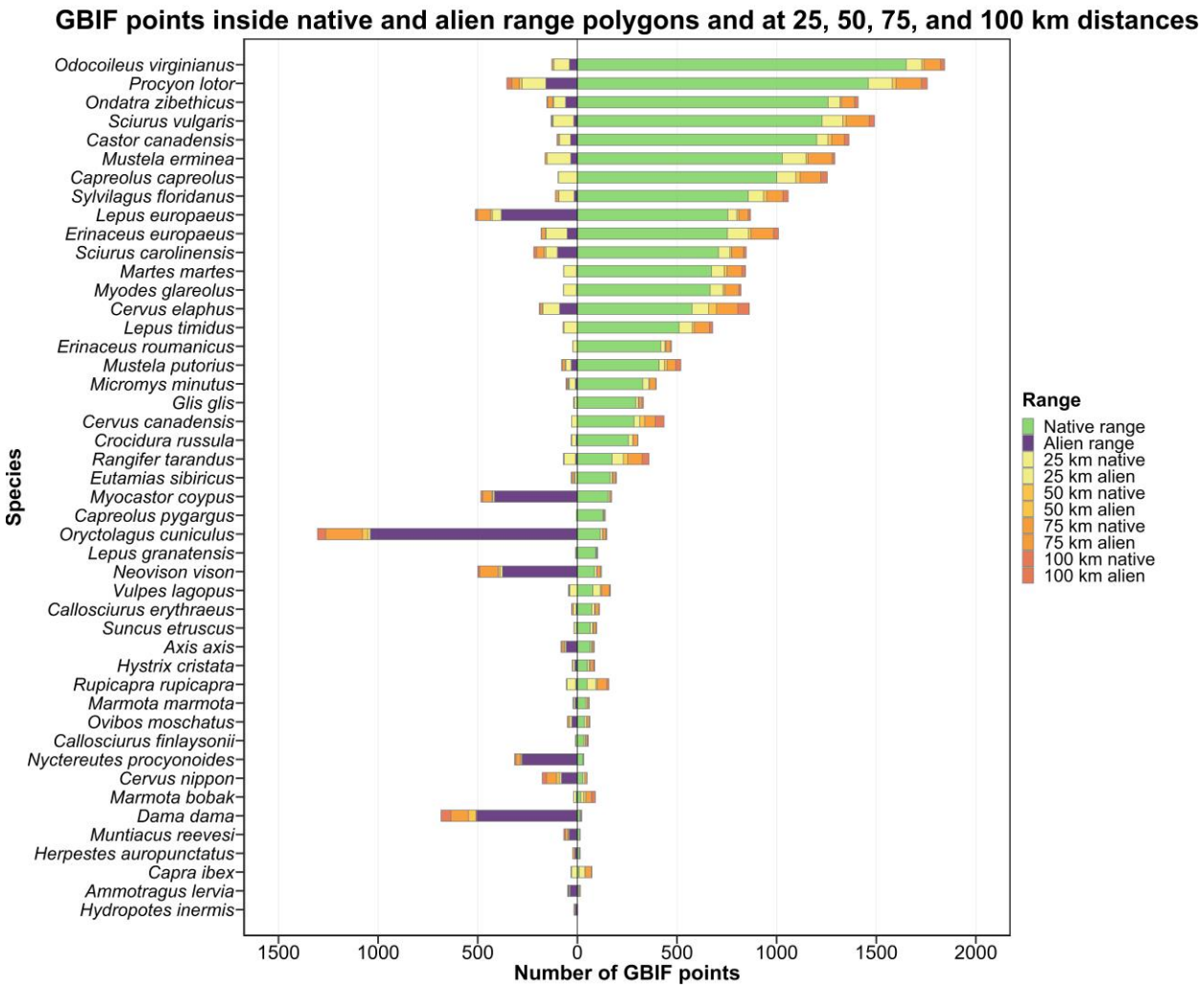

Figure S1: Global distribution of GBIF points inside native (green) and alien (violet) polygons, and at different distances (25, 59, 75, and 100 km) from the polygons, for the study species (n = 46).

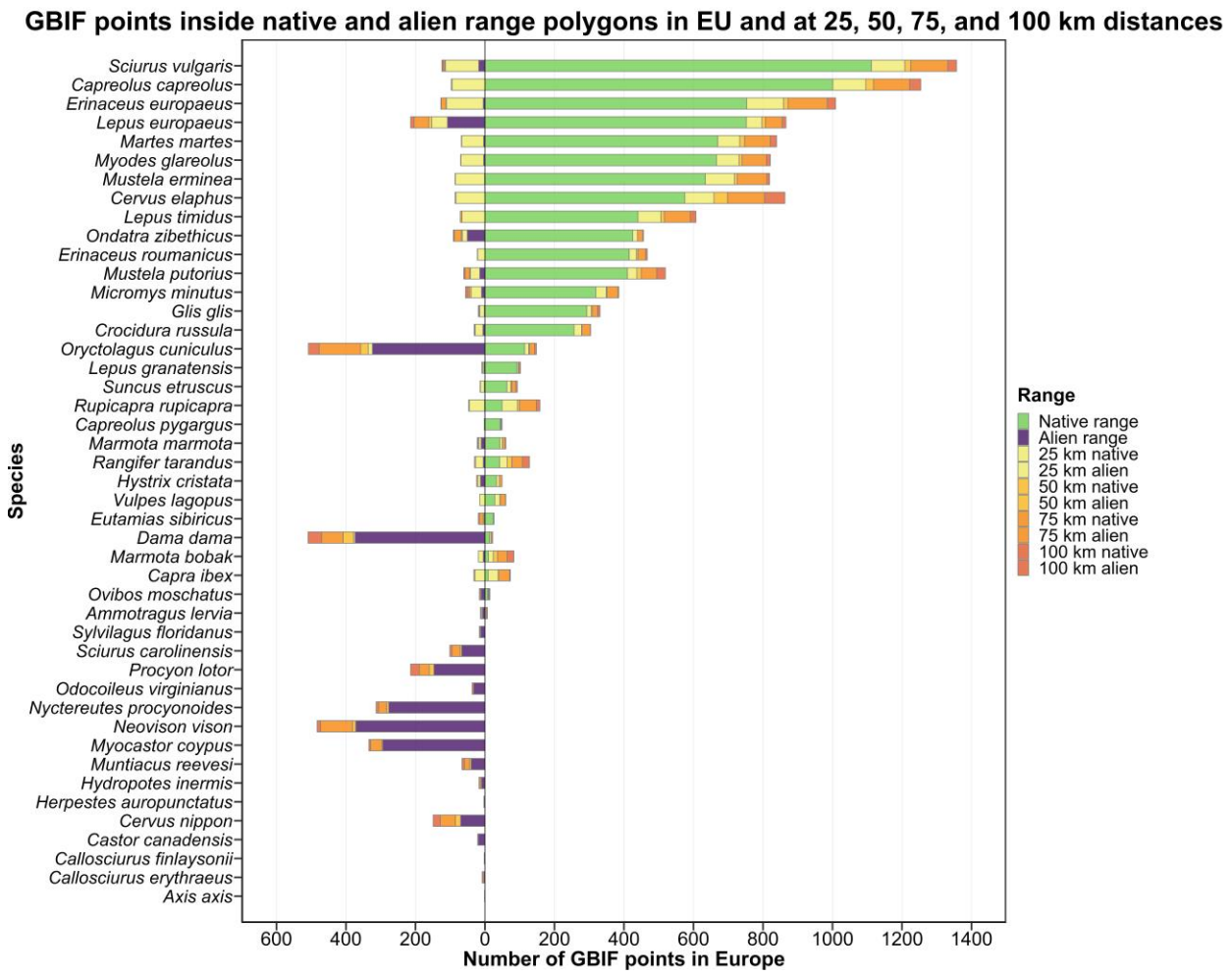

Figure S2: European distribution of GBIF points inside native (green) and alien (violet) polygons, and at different distances (25, 59, 75, and 100 km) from the polygons, for the study species (n = 46).

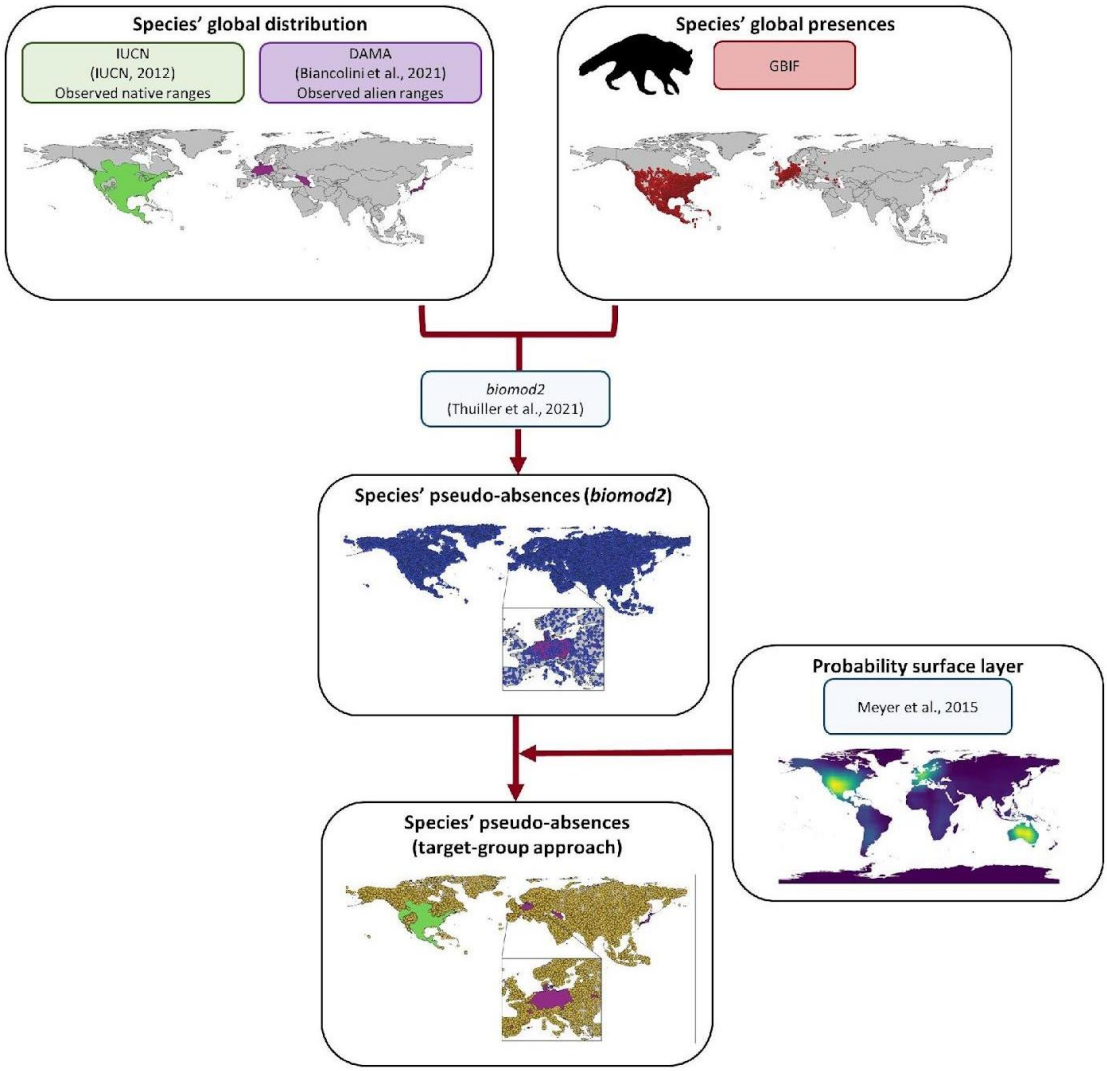

Figure S3: Example of PAs selection at a global level, using the Northern raccoon *Procyon lotor*. On the top left, the Northern raccoon's native (green) and alien (violet) ranges, with the continents where the species has its ranges as a background. On the top right panel, the Northern raccoon's presences (red). In the central panel, pseudo-absences (blue) drawn randomly in the whole world (including species' ranges) by *biomod2*. On the central-right panel, the biasfile, used as a background to re-sample the pseudo-absences. On the bottom panel, pseudo-absences (blue), replaced with a weighted sample based on the biasfile, excluding the species' ranges. Map lines delineate study areas and do not necessarily depict accepted national boundaries.

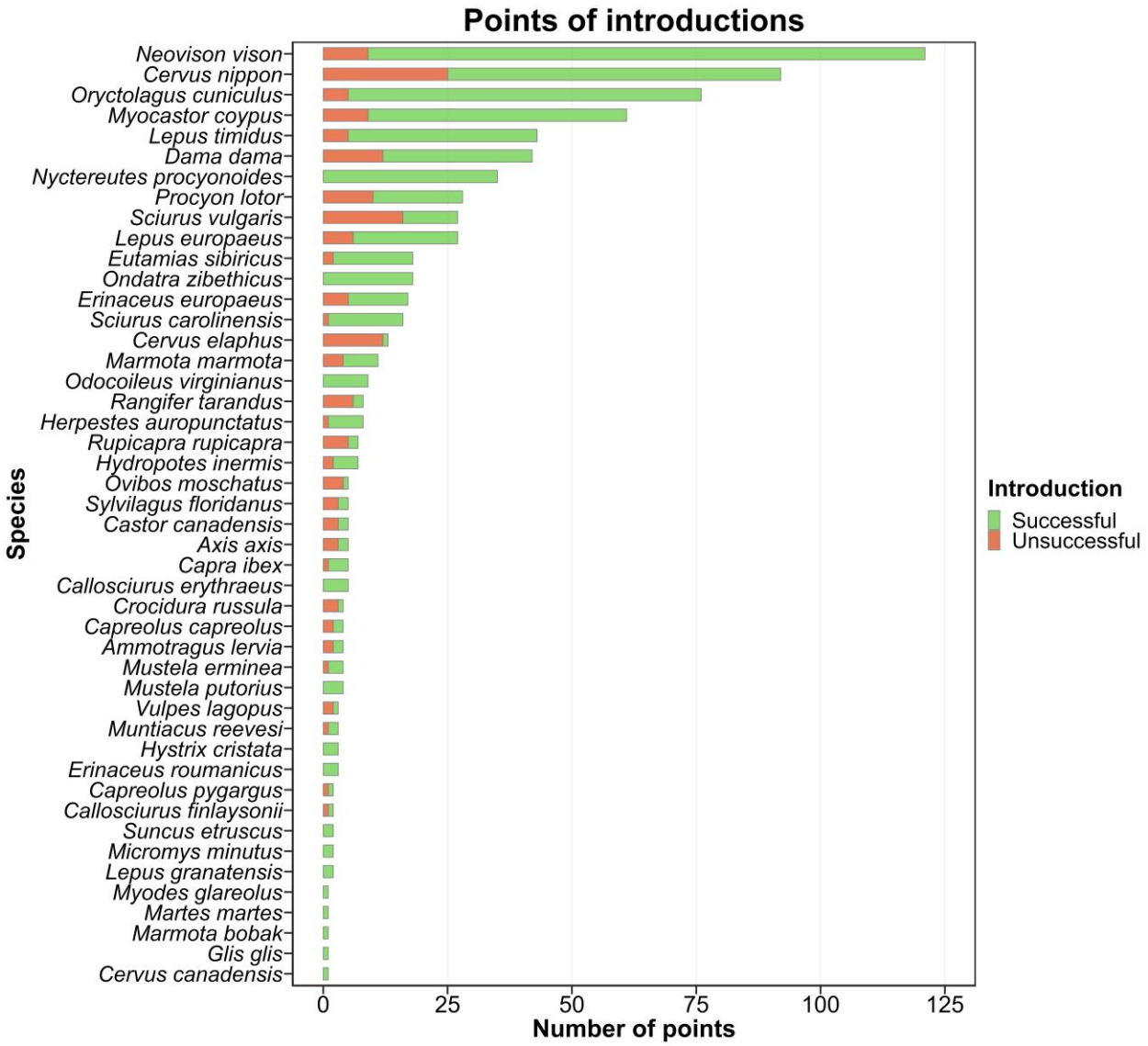

Figure S4: Points of successful (green; n = 599) and unsuccessful introduction (red; n = 162) extracted from literature for the study species (n = 46) at European level.

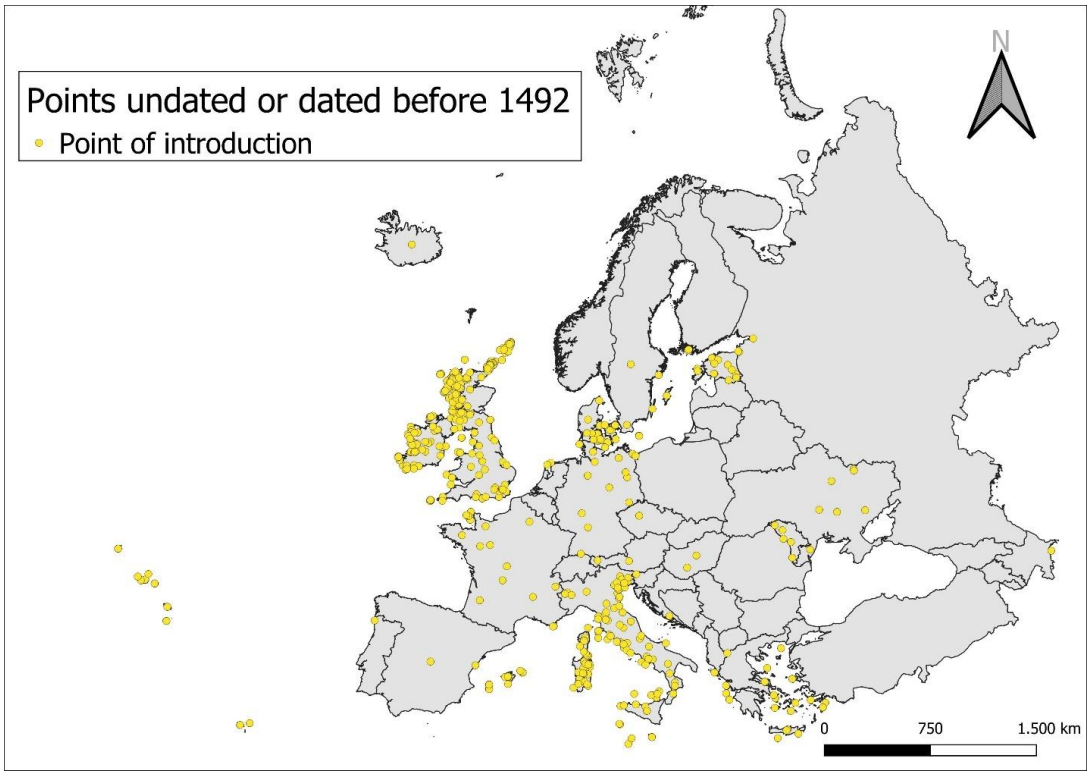

Figure S5: Points of introduction without a year or dated before 1492 (n = 41). Map lines delineate study areas and do not necessarily depict accepted national boundaries.

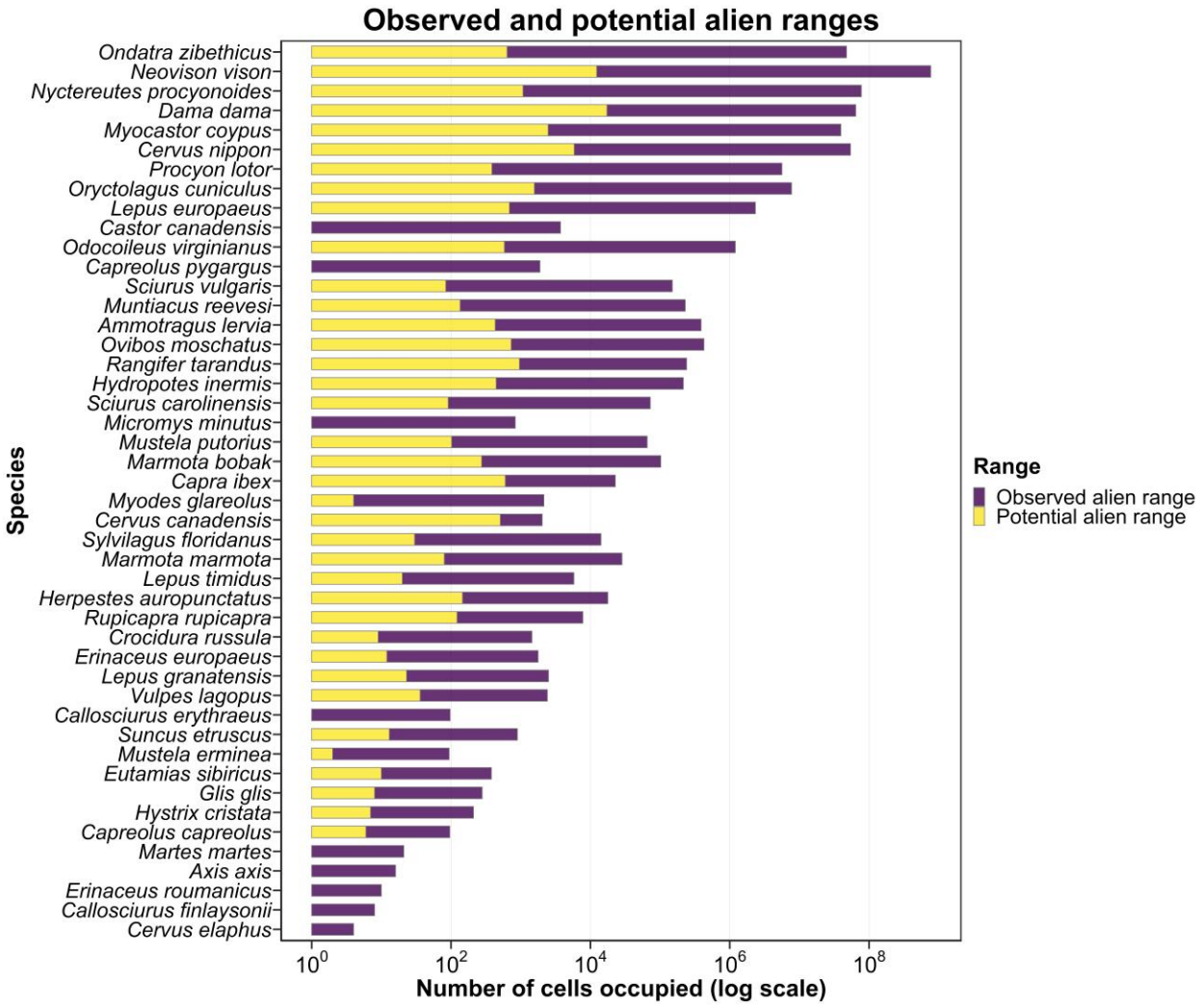

Figure S6: Number of occupied 10 x 10 km raster cells (logarithmic scale) for the study species (n = 46) in Europe for the observed (violet) and potential alien range (yellow). Species are in descending order based on their observed alien range extent.

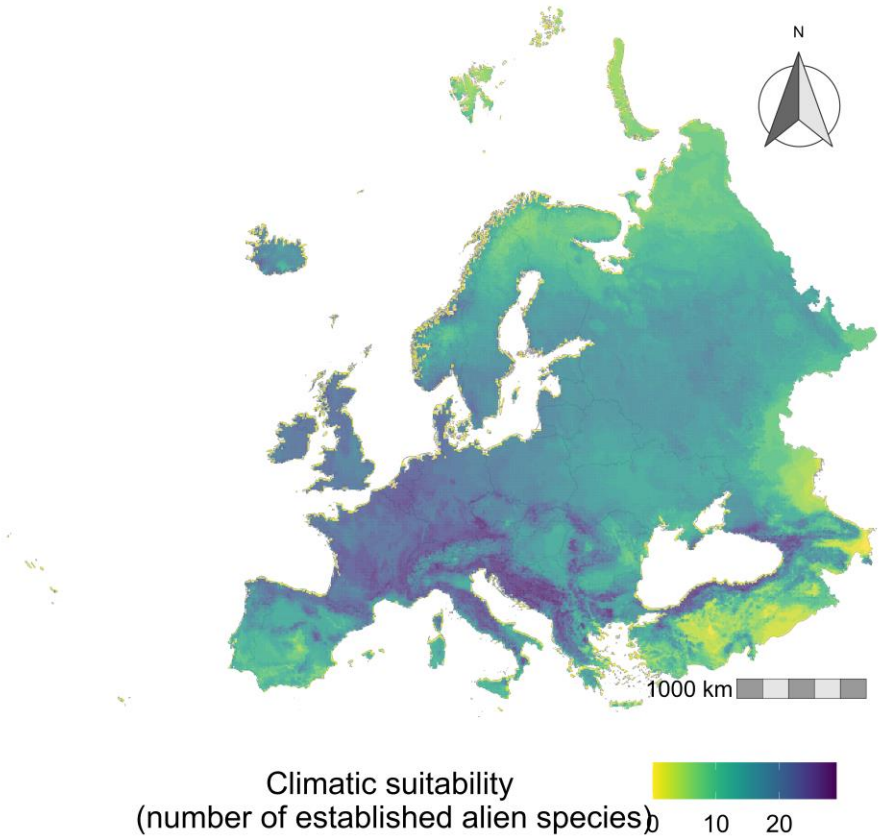

Figure S7: Predicted alien mammals species richness (n = 46) across Europe. Map lines delineate study areas and do not necessarily depict accepted national boundaries.

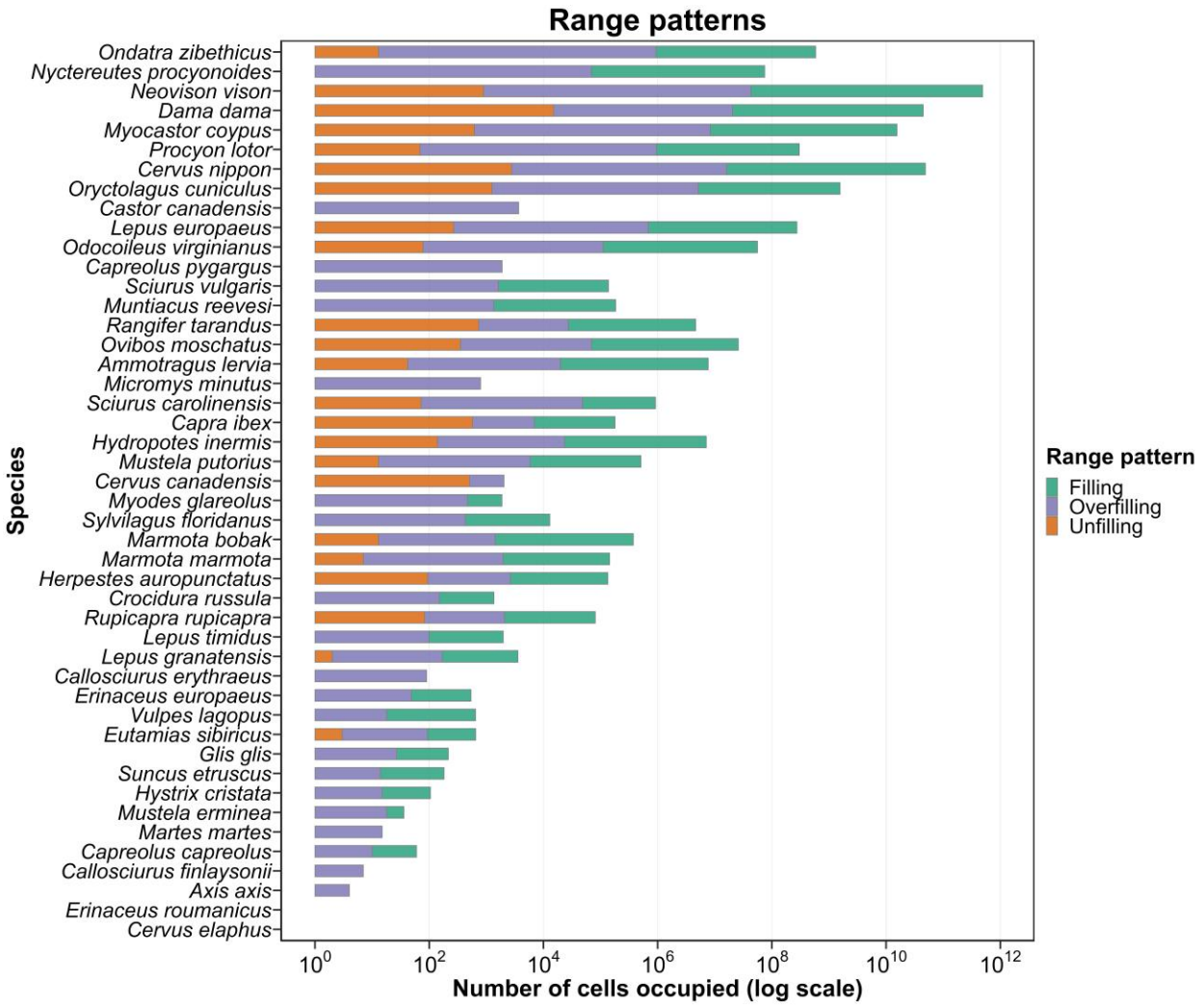

Figure S8: Number of occupied 10 x 10 km raster cells (logarithmic scale) for the study species (n = 46) in Europe for the three range patterns: filling (green), overfilling (purple), and unfilling (orange). Species are in descending order based on their range overfilling extent.

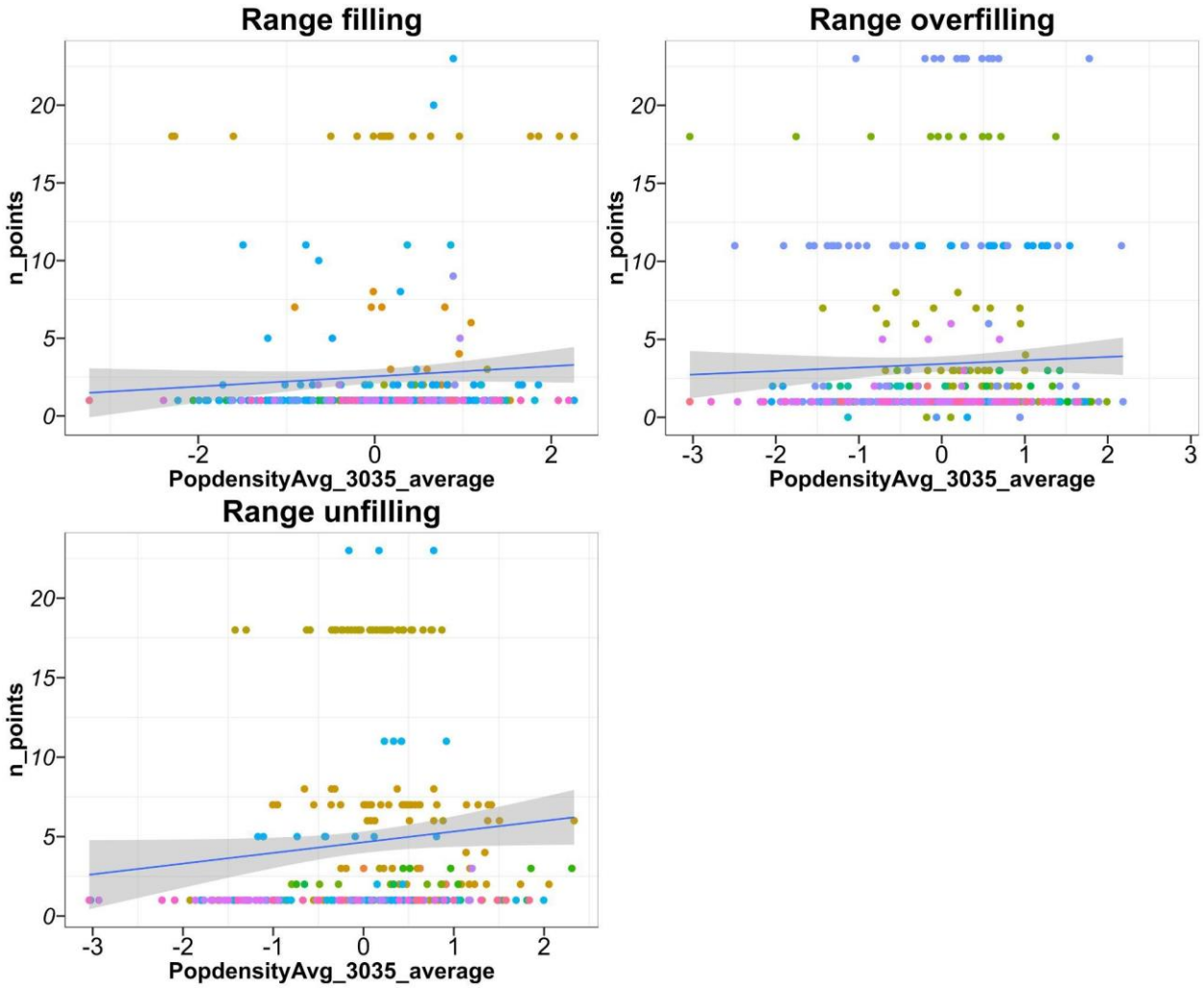

Figure S9: Simple linear regression between number of introduction points that originated each range pattern polygons, and human population density, for the study species (n = 46). Here, successful introduction points are the response variable and human population density is predictor variable. Each species is represented by a different colour.

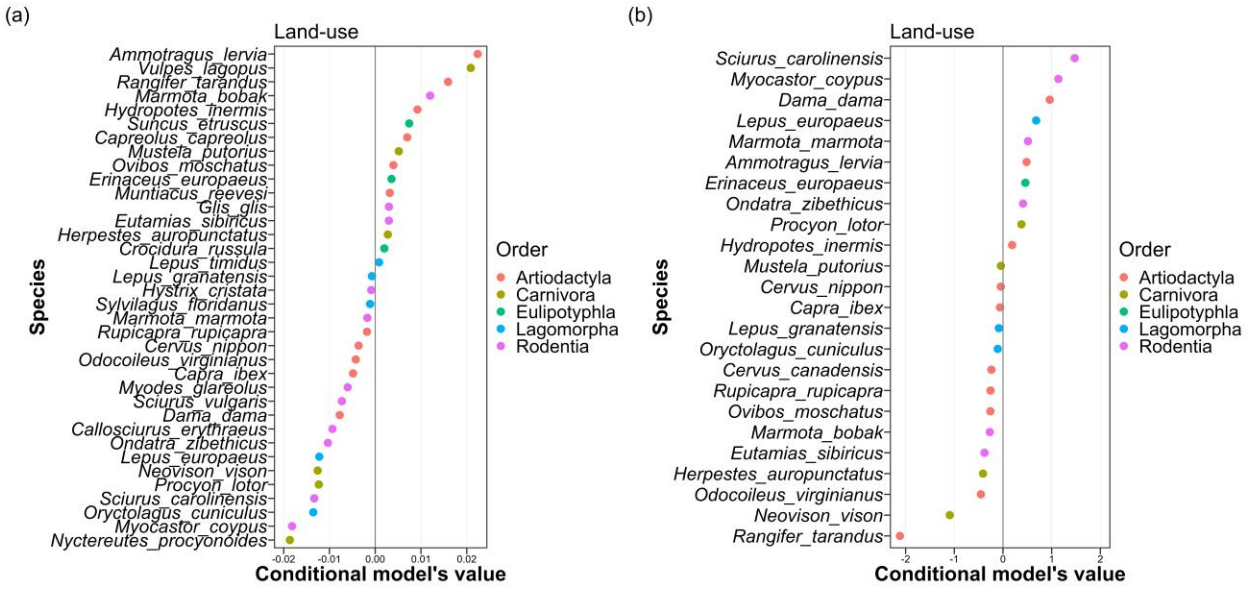

Figure S10: Random effect (land-use) extracted from the fitted model with: (a) Range filling and (b) Range unfilling as a response variables. Each Order is represented by a different colour.

Supplementary data

For each of the three range patterns (range filling, overfilling, unfilling) a dedicated table with: species' Order, scientific name (Binomial), number of 10x10 km cell for observed range, for potential range, for total area available (potential + observed, POAR), for each polygon of the considered range pattern (i.e., range filling, overfilling, unfilling), filling percentage, and polygon-level values for the variables considered in the GLMMs: total number of pathways of introduction, human population density, land-use, roads and railways.

ODMAP: Overview, Data, Model, Assessment and Prediction (Zurell et al. 2020) protocol for SDMs.

Range filling

Order	Binomial	OAR	PAR	POAR	Range_filling	Filling_ratio	Pathways_tot	Native_range	PopdensityAvg	landuseHAvg	infrastructuresAvg
Artiodactyla	*Ammotragus_lervia*	902	430	944	388	41.10	5.00	10314.00	76.86	45.35	6.76
Rodentia	*Callosciurus_erythraeus*	97	1	97	1	1.03	1.00	36175.00	286.48	13.80	16.00
Artiodactyla	*Capra_ibex*	38	600	612	2	0.33	2.00	229.00	20.72	12.53	8.00
Artiodactyla	*Capra_ibex*	38	600	612	2	0.33	2.00	229.00	25.84	14.52	0.76
Artiodactyla	*Capra_ibex*	38	600	612	2	0.33	2.00	229.00	7.03	1.44	8.00
Artiodactyla	*Capra_ibex*	38	600	612	20	3.27	2.00	229.00	6.06	19.63	4.59
Artiodactyla	*Capreolus_capreolus*	16	6	16	4	25.00	1.00	84339.00	120.40	34.81	4.00
Artiodactyla	*Capreolus_capreolus*	16	6	16	2	12.50	1.00	84339.00	11.06	32.22	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	270.07	41.25	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	40	0.33	5.00	3564.00	133.00	25.52	9.20
Artiodactyla	*Cervus_nippon*	9233	5855	12065	89	0.74	5.00	3564.00	45.96	36.93	7.63
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	4.36	19.00	NA
Artiodactyla	*Cervus_nippon*	9233	5855	12065	48	0.40	5.00	3564.00	40.59	18.54	7.50
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	1.38	20.23	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	2.87	14.87	NA
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	13.38	18.27	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	301	2.49	5.00	3564.00	28.37	27.30	5.28
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	51.03	29.00	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	6.36	29.21	5.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	42.48	22.29	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	84	0.70	5.00	3564.00	30.65	33.93	8.29
Artiodactyla	*Cervus_nippon*	9233	5855	12065	7	0.06	5.00	3564.00	21.78	21.02	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	12.61	34.18	6.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	71	0.59	5.00	3564.00	40.57	36.61	8.09
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	26.07	37.63	10.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	78.35	42.53	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	9.63	29.54	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	202.42	36.99	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	13.74	11.18	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	27.78	41.18	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	25	0.21	5.00	3564.00	343.91	36.37	8.96
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	52.13	46.15	8.00

Artiodactyla	*Cervus_nippon*	9233	5855	12065	8	0.07	5.00	3564.00	44.00	35.35	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	20.28	20.59	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	12.00	31.26	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	35.62	40.46	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	155	1.28	5.00	3564.00	362.55	35.22	8.62
Artiodactyla	*Cervus_nippon*	9233	5855	12065	286	2.37	5.00	3564.00	108.50	29.99	8.14
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	14.53	27.47	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	18.40	34.79	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	37	0.31	5.00	3564.00	63.92	38.74	7.57
Artiodactyla	*Cervus_nippon*	9233	5855	12065	7	0.06	5.00	3564.00	33.82	31.59	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	54.03	45.28	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	25	0.21	5.00	3564.00	195.02	40.45	7.04
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	37.74	47.63	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	24.07	41.71	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	15	0.12	5.00	3564.00	74.00	38.59	9.07
Artiodactyla	*Cervus_nippon*	9233	5855	12065	10	0.08	5.00	3564.00	13.15	35.53	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	18.70	39.36	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	17.95	50.06	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	37	0.31	5.00	3564.00	356.98	31.78	9.51
Artiodactyla	*Cervus_nippon*	9233	5855	12065	13	0.11	5.00	3564.00	42.92	50.32	1.96
Artiodactyla	*Cervus_nippon*	9233	5855	12065	18	0.15	5.00	3564.00	402.34	31.08	8.89
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	146.21	48.05	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	77.17	50.17	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	68	0.56	5.00	3564.00	122.40	44.82	8.25
Artiodactyla	*Cervus_nippon*	9233	5855	12065	441	3.66	5.00	3564.00	575.83	41.53	9.18
Artiodactyla	*Cervus_nippon*	9233	5855	12065	125	1.04	5.00	3564.00	211.07	22.30	9.15
Artiodactyla	*Cervus_nippon*	9233	5855	12065	44	0.36	5.00	3564.00	91.93	24.35	8.73
Artiodactyla	*Cervus_nippon*	9233	5855	12065	18	0.15	5.00	3564.00	88.65	38.80	8.44
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	107.85	37.77	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	10	0.08	5.00	3564.00	52.28	32.67	9.60
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	19.79	26.39	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	60	0.50	5.00	3564.00	328.39	29.87	9.07
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	36.16	28.29	8.00

Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	41.05	34.05	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	41.39	12.37	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	152.20	44.50	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	18	0.15	5.00	3564.00	124.16	14.99	8.89
Artiodactyla	*Cervus_nippon*	9233	5855	12065	17	0.14	5.00	3564.00	47.26	42.09	9.41
Artiodactyla	*Cervus_nippon*	9233	5855	12065	130	1.08	5.00	3564.00	95.85	20.76	9.29
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	6.61	14.84	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	198	1.64	5.00	3564.00	606.49	39.80	9.27
Artiodactyla	*Cervus_nippon*	9233	5855	12065	30	0.25	5.00	3564.00	225.88	41.32	7.73
Artiodactyla	*Cervus_nippon*	9233	5855	12065	27	0.22	5.00	3564.00	33.50	32.41	8.89
Artiodactyla	*Cervus_nippon*	9233	5855	12065	159	1.32	5.00	3564.00	145.57	25.15	9.16
Artiodactyla	*Cervus_nippon*	9233	5855	12065	36	0.30	5.00	3564.00	76.99	38.97	9.56
Artiodactyla	*Cervus_nippon*	9233	5855	12065	119	0.99	5.00	3564.00	241.47	24.22	9.82
Artiodactyla	*Cervus_nippon*	9233	5855	12065	45	0.37	5.00	3564.00	29.37	37.21	9.07
Artiodactyla	*Cervus_nippon*	9233	5855	12065	18	0.15	5.00	3564.00	52.22	24.91	8.44
Artiodactyla	*Cervus_nippon*	9233	5855	12065	38	0.31	5.00	3564.00	38.16	26.34	8.84
Artiodactyla	*Cervus_nippon*	9233	5855	12065	16	0.13	5.00	3564.00	34.31	41.61	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	9	0.07	5.00	3564.00	23.15	23.45	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	16.60	17.88	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	23	0.19	5.00	3564.00	37.60	27.26	9.04
Eulipotyphla	*Crocidura_russula*	161	9	161	9	5.59	1.00	21318.00	19.93	41.49	9.78
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	NA
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	4.09	17.73	NA
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	5.16	23.98	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	13	0.07	4.00	2053.00	1561.04	28.78	11.69
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	918.97	40.38	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	32	0.17	4.00	2053.00	299.79	29.28	8.50
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	133.30	18.97	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	45.36	17.42	12.00
Artiodactyla	*Dama_dama*	3721	17285	18825	50	0.27	4.00	2053.00	123.46	30.15	7.76
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	8.16	7.29	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	17	0.09	4.00	2053.00	15.30	17.13	6.92
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	119.37	50.96	8.00

Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	12.00	27.51	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	67	0.36	4.00	2053.00	46.57	20.51	5.44
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	25.72	41.62	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	0.00	9.92	5.33
Artiodactyla	*Dama_dama*	3721	17285	18825	50	0.27	4.00	2053.00	65.97	16.80	6.84
Artiodactyla	*Dama_dama*	3721	17285	18825	361	1.92	4.00	2053.00	69.74	35.99	6.97
Artiodactyla	*Dama_dama*	3721	17285	18825	16	0.08	4.00	2053.00	45.30	20.06	6.85
Artiodactyla	*Dama_dama*	3721	17285	18825	7	0.04	4.00	2053.00	116.91	45.46	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	82.88	49.99	6.00
Artiodactyla	*Dama_dama*	3721	17285	18825	134	0.71	4.00	2053.00	104.67	26.93	5.74
Artiodactyla	*Dama_dama*	3721	17285	18825	110	0.58	4.00	2053.00	43.74	46.26	6.95
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	71.12	29.00	10.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	132.95	45.96	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	6.14	9.62	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	8	0.04	4.00	2053.00	18.09	10.64	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	50.73	15.02	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	25	0.13	4.00	2053.00	17.43	33.18	8.32
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	18.37	7.27	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1243	6.60	4.00	2053.00	56.12	9.22	7.20
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	2272.83	17.45	16.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	1	0.67	3.00	51512.00	NA	NA	NA
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	2	1.34	3.00	51512.00	11.35	13.69	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	3	2.01	3.00	51512.00	1.38	20.23	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	1	0.67	3.00	51512.00	NA	NA	8.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	2	1.34	3.00	51512.00	225.76	28.93	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	2	1.34	3.00	51512.00	NA	NA	0.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	1997.11	23.89	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	62.40	21.55	4.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	200.67	23.42	16.00
Rodentia	*Eutamias_sibiricus*	38	10	41	4	9.76	3.00	215806.00	293.14	22.68	8.00
Rodentia	*Glis_glis*	35	8	35	3	8.57	2.00	44643.00	398.25	44.21	10.67
Rodentia	*Glis_glis*	35	8	35	5	14.29	2.00	44643.00	644.36	39.94	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	50	23.04	1.00	31161.00	91.43	37.36	7.30

Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	112.96	37.09	8.00
Artiodactyla	*Hydropotes_inermis*	486	444	626	25	3.99	3.00	1743.00	44.58	43.20	8.96
Artiodactyla	*Hydropotes_inermis*	486	444	626	6	0.96	3.00	1743.00	120.81	44.83	9.33
Artiodactyla	*Hydropotes_inermis*	486	444	626	273	43.61	3.00	1743.00	372.20	43.26	9.30
Rodentia	*Hystrix_cristata*	30	7	30	1	3.33	1.00	44966.00	10.18	0.34	8.00
Rodentia	*Hystrix_cristata*	30	7	30	6	20.00	1.00	44966.00	50.73	15.02	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	NA	NA	NA
Lagomorpha	*Lepus_europaeus*	3394	688	3682	180	4.89	1.00	133306.00	24.79	3.49	7.47
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	1.38	20.23	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	2	0.05	1.00	133306.00	0.76	20.29	4.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	NA	NA	NA
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	4.09	17.73	NA
Lagomorpha	*Lepus_europaeus*	3394	688	3682	2	0.05	1.00	133306.00	236.50	18.83	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	2	0.05	1.00	133306.00	19.58	21.34	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	127.79	43.29	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	84.19	34.88	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	12	0.33	1.00	133306.00	55.78	41.37	9.33
Lagomorpha	*Lepus_europaeus*	3394	688	3682	19	0.52	1.00	133306.00	63.44	34.26	6.50
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	26.01	2.72	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	58	1.58	1.00	133306.00	14.68	7.03	6.08
Lagomorpha	*Lepus_europaeus*	3394	688	3682	114	3.10	1.00	133306.00	441.93	31.50	8.58
Lagomorpha	*Lepus_granatensis*	109	23	111	20	18.02	1.00	5590.00	236.77	39.61	9.00
Lagomorpha	*Lepus_granatensis*	109	23	111	1	0.90	1.00	5590.00	159.81	13.64	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	NA	NA	NA
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	NA	NA	NA
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	NA	NA	NA
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	10.19	15.93	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	3	1.03	1.00	334900.00	5.22	24.66	0.85
Lagomorpha	*Lepus_timidus*	290	20	290	2	0.69	1.00	334900.00	11.35	13.69	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	3	1.03	1.00	334900.00	1.38	20.23	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	2	0.69	1.00	334900.00	0.76	20.29	4.00
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	NA	NA	NA
Lagomorpha	*Lepus_timidus*	290	20	290	3	1.03	1.00	334900.00	4.09	17.73	NA

Lagomorpha	*Lepus_timidus*	290	20	290	2	0.69	1.00	334900.00	19.58	21.34	8.00
Rodentia	*Marmota_bobak*	372	275	385	262	68.05	2.00	10077.00	102.95	33.30	5.37
Rodentia	*Marmota_marmota*	355	80	362	10	2.76	2.00	2187.00	14.22	24.91	8.80
Rodentia	*Marmota_marmota*	355	80	362	9	2.49	2.00	2187.00	25.18	19.06	8.00
Rodentia	*Marmota_marmota*	355	80	362	6	1.66	2.00	2187.00	25.49	17.85	8.00
Rodentia	*Marmota_marmota*	355	80	362	8	2.21	2.00	2187.00	23.55	14.23	8.00
Rodentia	*Marmota_marmota*	355	80	362	8	2.21	2.00	2187.00	63.38	10.66	8.00
Rodentia	*Marmota_marmota*	355	80	362	32	8.84	2.00	2187.00	31.74	25.66	6.57
Carnivora	*Martes_martes*	21	1	21	1	4.76	3.00	137677.00	NA	NA	NA
Rodentia	*Micromys_minutus*	836	1	836	1	0.12	1.00	228915.00	NA	NA	8.00
Artiodactyla	*Muntiacus_reevesi*	1704	135	1704	135	7.92	3.00	20466.00	557.85	41.57	9.66
Carnivora	*Mustela_erminea*	47	2	47	1	2.13	2.00	658263.00	NA	NA	NA
Carnivora	*Mustela_erminea*	47	2	47	1	2.13	2.00	658263.00	NA	NA	NA
Carnivora	*Mustela_putorius*	641	102	656	1	0.15	2.00	80073.00	NA	NA	NA
Carnivora	*Mustela_putorius*	641	102	656	3	0.46	2.00	80073.00	4.09	17.73	NA
Carnivora	*Mustela_putorius*	641	102	656	59	8.99	2.00	80073.00	49.47	39.69	8.14
Carnivora	*Mustela_putorius*	641	102	656	24	3.66	2.00	80073.00	105.24	36.24	8.01
Rodentia	*Myocastor_coypus*	15894	2474	16519	11	0.07	1.00	38364.00	137.28	33.07	7.64
Rodentia	*Myocastor_coypus*	15894	2474	16519	5	0.03	1.00	38364.00	19.20	40.34	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	5	0.03	1.00	38364.00	45.83	33.22	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	25	0.15	1.00	38364.00	38.75	23.96	8.96
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	499.89	36.68	10.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	164	0.99	1.00	38364.00	303.54	29.18	8.45
Rodentia	*Myocastor_coypus*	15894	2474	16519	169	1.02	1.00	38364.00	328.35	26.44	9.35
Rodentia	*Myocastor_coypus*	15894	2474	16519	99	0.60	1.00	38364.00	403.90	26.53	9.94
Rodentia	*Myocastor_coypus*	15894	2474	16519	34	0.21	1.00	38364.00	252.73	30.82	9.18
Rodentia	*Myocastor_coypus*	15894	2474	16519	16	0.10	1.00	38364.00	104.94	49.48	9.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	72.14	12.44	12.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	14	0.08	1.00	38364.00	85.43	43.47	7.43
Rodentia	*Myocastor_coypus*	15894	2474	16519	28	0.17	1.00	38364.00	334.09	47.31	6.49
Rodentia	*Myocastor_coypus*	15894	2474	16519	17	0.10	1.00	38364.00	42.77	33.25	6.59
Rodentia	*Myocastor_coypus*	15894	2474	16519	31	0.19	1.00	38364.00	25.75	46.76	6.59
Rodentia	*Myocastor_coypus*	15894	2474	16519	9	0.05	1.00	38364.00	21.79	45.13	2.73

Rodentia	*Myocastor_coypus*	15894	2474	16519	12	0.07	1.00	38364.00	169.07	34.78	6.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	105	0.64	1.00	38364.00	67.34	45.38	6.36
Rodentia	*Myocastor_coypus*	15894	2474	16519	12	0.07	1.00	38364.00	57.56	40.30	6.08
Rodentia	*Myocastor_coypus*	15894	2474	16519	16	0.10	1.00	38364.00	514.32	42.48	3.77
Rodentia	*Myocastor_coypus*	15894	2474	16519	901	5.45	1.00	38364.00	176.40	37.88	8.22
Rodentia	*Myocastor_coypus*	15894	2474	16519	15	0.09	1.00	38364.00	65.32	47.41	7.47
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	51.07	47.86	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	37	0.22	1.00	38364.00	31.34	35.26	6.32
Rodentia	*Myocastor_coypus*	15894	2474	16519	5	0.03	1.00	38364.00	55.68	56.68	7.20
Rodentia	*Myocastor_coypus*	15894	2474	16519	20	0.12	1.00	38364.00	61.71	41.44	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	8	0.05	1.00	38364.00	51.91	45.84	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	51.54	47.89	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	27	0.16	1.00	38364.00	103.88	26.72	7.70
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	20.76	41.68	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	70.05	12.46	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	200.06	35.06	2.67
Rodentia	*Myocastor_coypus*	15894	2474	16519	41	0.25	1.00	38364.00	65.47	32.64	8.10
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	6.70	42.06	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	22.43	46.20	2.73
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	200.01	60.69	8.00
Rodentia	*Myodes_glareolus*	538	4	538	4	0.74	1.00	124958.00	182.31	40.72	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	0.00	0.41	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	0.00	10.76	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	2275.58	4.70	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	2.31	0.95	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	8.74	7.97	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	5.16	23.98	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	115	0.18	2.00	194822.00	30.13	25.83	7.18
Carnivora	*Neovison_vison*	62290	12313	63184	178	0.28	2.00	194822.00	435.96	34.56	8.48
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	281.71	42.81	16.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	13.15	30.53	8.00

Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	17.30	35.31	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	23.79	15.94	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	31.67	24.56	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	367.75	55.52	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	88.52	50.42	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	16	0.03	2.00	194822.00	10.09	38.84	6.81
Carnivora	*Neovison_vison*	62290	12313	63184	280	0.44	2.00	194822.00	1.11	0.00	1.96
Carnivora	*Neovison_vison*	62290	12313	63184	19	0.03	2.00	194822.00	72.67	11.54	7.42
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	2.65	16.88	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	2.19	0.14	1.36
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	0.00	0.00	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	363	0.57	2.00	194822.00	24.32	0.12	1.79
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	1.07	6.88	2.00
Carnivora	*Neovison_vison*	62290	12313	63184	326	0.52	2.00	194822.00	0.53	9.79	3.14
Carnivora	*Neovison_vison*	62290	12313	63184	52	0.08	2.00	194822.00	1.36	0.02	3.51
Carnivora	*Neovison_vison*	62290	12313	63184	237	0.38	2.00	194822.00	16.43	1.23	3.02
Carnivora	*Neovison_vison*	62290	12313	63184	26	0.04	2.00	194822.00	114.83	7.15	7.20
Carnivora	*Neovison_vison*	62290	12313	63184	51	0.08	2.00	194822.00	4.74	1.67	6.59
Carnivora	*Neovison_vison*	62290	12313	63184	313	0.50	2.00	194822.00	3.76	0.37	3.13
Carnivora	*Neovison_vison*	62290	12313	63184	372	0.59	2.00	194822.00	27.25	16.22	5.46
Carnivora	*Neovison_vison*	62290	12313	63184	49	0.08	2.00	194822.00	8.50	2.10	8.16
Carnivora	*Neovison_vison*	62290	12313	63184	609	0.96	2.00	194822.00	7.83	0.50	5.90
Carnivora	*Neovison_vison*	62290	12313	63184	362	0.57	2.00	194822.00	63.09	22.28	4.68
Carnivora	*Neovison_vison*	62290	12313	63184	2066	3.27	2.00	194822.00	11.43	1.84	5.08
Carnivora	*Neovison_vison*	62290	12313	63184	51	0.08	2.00	194822.00	43.89	10.88	7.61
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	4.21	3.92	2.86
Carnivora	*Neovison_vison*	62290	12313	63184	15	0.02	2.00	194822.00	26.38	8.25	5.71
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	1.38	20.23	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	11	0.02	2.00	194822.00	1.85	8.11	7.27
Carnivora	*Neovison_vison*	62290	12313	63184	17	0.03	2.00	194822.00	14.50	15.17	7.53
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	4.09	17.73	NA
Carnivora	*Neovison_vison*	62290	12313	63184	57	0.09	2.00	194822.00	112.86	14.32	7.93
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	10.01	25.19	2.00

Carnivora	*Neovison_vison*	62290	12313	63184	302	0.48	2.00	194822.00	132.45	31.87	7.34
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	5.47	25.45	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	119.71	20.83	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	45	0.07	2.00	194822.00	55.65	24.87	8.36
Carnivora	*Neovison_vison*	62290	12313	63184	382	0.60	2.00	194822.00	62.52	22.64	7.54
Carnivora	*Neovison_vison*	62290	12313	63184	376	0.60	2.00	194822.00	78.30	21.51	7.31
Carnivora	*Neovison_vison*	62290	12313	63184	187	0.30	2.00	194822.00	32.47	36.46	7.98
Carnivora	*Neovison_vison*	62290	12313	63184	635	1.01	2.00	194822.00	87.19	26.90	8.30
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	364.26	46.63	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	254	0.40	2.00	194822.00	719.64	40.64	9.10
Carnivora	*Neovison_vison*	62290	12313	63184	94	0.15	2.00	194822.00	120.49	45.26	8.27
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	80.28	38.85	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	123.17	33.53	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	101.69	46.63	10.67
Carnivora	*Neovison_vison*	62290	12313	63184	10	0.02	2.00	194822.00	50.80	38.01	9.60
Carnivora	*Neovison_vison*	62290	12313	63184	3166	5.01	2.00	194822.00	131.11	30.60	8.89
Carnivora	*Neovison_vison*	62290	12313	63184	113	0.18	2.00	194822.00	215.19	31.31	9.56
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	43.80	17.74	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	9	0.01	2.00	194822.00	9.47	14.93	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	78	0.12	2.00	194822.00	62.26	14.82	8.21
Carnivora	*Neovison_vison*	62290	12313	63184	16	0.03	2.00	194822.00	87.77	49.21	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	11.50	45.77	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	37	0.06	2.00	194822.00	8.72	14.09	7.17
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	11.30	43.86	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	84.73	9.03	12.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	17.37	18.86	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	33	0.05	2.00	194822.00	5.06	33.20	6.11
Carnivora	*Neovison_vison*	62290	12313	63184	17	0.03	2.00	194822.00	6.40	41.21	6.51
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	1	0.00	3.00	65982.00	5.65	2.48	NA
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	26	0.04	3.00	65982.00	57.25	10.16	4.63
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	57	0.08	3.00	65982.00	16.95	9.87	6.95
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	18	0.03	3.00	65982.00	9.39	8.08	5.88
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	3	0.00	3.00	65982.00	7.03	5.76	8.00

Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	31	0.04	3.00	65982.00	8.62	8.03	6.45
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	128	0.18	3.00	65982.00	15.20	10.85	7.51
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	38	0.05	3.00	65982.00	33.13	16.09	8.21
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	4	0.01	3.00	65982.00	144.84	36.74	8.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	26	0.04	3.00	65982.00	121.58	22.01	6.46
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	49	0.07	3.00	65982.00	112.66	35.20	5.86
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	48	0.07	3.00	65982.00	143.36	39.51	6.58
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	45	0.06	3.00	65982.00	454.63	40.47	7.68
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	51	0.07	3.00	65982.00	158.82	47.08	7.94
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	55	0.08	3.00	65982.00	778.45	35.51	7.78
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	51	0.07	3.00	65982.00	124.50	46.77	6.31
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	49	0.07	3.00	65982.00	40.69	35.00	5.98
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	48	0.07	3.00	65982.00	169.74	34.33	7.83
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	52	0.07	3.00	65982.00	422.83	42.19	7.03
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	48	0.07	3.00	65982.00	144.85	36.70	7.92
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	49	0.07	3.00	65982.00	80.55	40.62	6.16
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	97	0.13	3.00	65982.00	285.43	40.14	6.33
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	6	0.01	3.00	65982.00	10.17	46.40	6.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	71	0.10	3.00	65982.00	203.26	38.54	5.60
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	27	0.04	3.00	65982.00	337.69	42.46	7.70
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	3.78	15.04	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	3	0.14	1.00	149345.00	2.97	11.32	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	59	2.75	1.00	149345.00	15.40	3.63	7.66
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	437	20.39	1.00	149345.00	21.58	1.54	7.05
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	2	0.09	1.00	149345.00	168.14	32.47	12.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	35	0.05	2.00	476299.00	1.82	0.00	3.47
Rodentia	*Ondatra_zibethicus*	74463	637	74476	21	0.03	2.00	476299.00	405.56	11.50	6.23
Rodentia	*Ondatra_zibethicus*	74463	637	74476	32	0.04	2.00	476299.00	31.89	48.28	4.25
Rodentia	*Ondatra_zibethicus*	74463	637	74476	31	0.04	2.00	476299.00	352.09	25.13	8.77
Rodentia	*Ondatra_zibethicus*	74463	637	74476	33	0.04	2.00	476299.00	164.72	41.44	8.12
Rodentia	*Ondatra_zibethicus*	74463	637	74476	98	0.13	2.00	476299.00	192.93	36.13	9.71
Rodentia	*Ondatra_zibethicus*	74463	637	74476	2	0.00	2.00	476299.00	78.24	18.96	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	8	0.01	2.00	476299.00	22.72	55.34	8.00

Rodentia	*Ondatra_zibethicus*	74463	637	74476	2	0.00	2.00	476299.00	80.03	60.62	0.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	362	0.49	2.00	476299.00	186.33	30.29	9.44
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	6.54	2.08	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	48	0.78	3.00	6734.00	34.69	6.51	7.09
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	74	1.20	3.00	6734.00	62.28	5.49	6.54
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2	0.03	3.00	6734.00	11.35	13.69	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	11	0.18	3.00	6734.00	17.52	16.08	7.27
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	35	0.57	3.00	6734.00	161.67	32.67	9.45
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	12	0.19	3.00	6734.00	112.68	37.62	6.67
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	32.73	35.58	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2	0.03	3.00	6734.00	56.66	30.95	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	41.22	44.65	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	117	1.89	3.00	6734.00	217.13	9.04	7.69
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	3.02	0.13	1.63
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	1.30	0.00	4.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	371	39.43	1.00	46223.00	2.32	0.10	3.57
Carnivora	*Procyon_lotor*	14535	386	14604	1	0.01	3.00	123973.00	270.99	29.84	8.00
Carnivora	*Procyon_lotor*	14535	386	14604	19	0.13	3.00	123973.00	86.07	34.22	9.33
Carnivora	*Procyon_lotor*	14535	386	14604	12	0.08	3.00	123973.00	112.68	37.62	6.67
Carnivora	*Procyon_lotor*	14535	386	14604	43	0.29	3.00	123973.00	114.02	20.26	8.37
Carnivora	*Procyon_lotor*	14535	386	14604	44	0.30	3.00	123973.00	203.34	24.86	9.45
Carnivora	*Procyon_lotor*	14535	386	14604	4	0.03	3.00	123973.00	86.06	50.12	6.15
Carnivora	*Procyon_lotor*	14535	386	14604	115	0.79	3.00	123973.00	110.76	39.34	9.25
Carnivora	*Procyon_lotor*	14535	386	14604	4	0.03	3.00	123973.00	126.45	44.97	7.00
Carnivora	*Procyon_lotor*	14535	386	14604	1	0.01	3.00	123973.00	85.90	46.09	8.00
Carnivora	*Procyon_lotor*	14535	386	14604	26	0.18	3.00	123973.00	345.25	40.59	6.22
Carnivora	*Procyon_lotor*	14535	386	14604	35	0.24	3.00	123973.00	82.27	26.61	8.46
Carnivora	*Procyon_lotor*	14535	386	14604	7	0.05	3.00	123973.00	63.87	36.88	9.14
Carnivora	*Procyon_lotor*	14535	386	14604	2	0.01	3.00	123973.00	28.01	11.45	8.00
Carnivora	*Procyon_lotor*	14535	386	14604	4	0.03	3.00	123973.00	28.68	53.87	10.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	170	16.36	1.00	347681.00	0.36	8.52	1.95
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	3	2.04	1.00	2362.00	174.27	27.90	8.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	36	24.49	1.00	2362.00	48.03	12.11	8.44

Rodentia	*Sciurus_carolinensis*	796	91	868	9	1.04	2.00	43312.00	24.68	39.00	10.67
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	489.68	39.45	0.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	963.38	30.43	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	2038.08	18.50	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	439.74	51.73	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	3	0.35	2.00	43312.00	2253.20	18.36	10.67
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	227.40	55.12	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	146.29	48.01	8.00
Rodentia	*Sciurus_vulgaris*	1785	84	1785	9	0.50	1.00	300984.00	18.68	18.96	4.83
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	3.39	16.34	2.76
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	2.74	14.61	1.18
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	21.38	17.45	6.41
Rodentia	*Sciurus_vulgaris*	1785	84	1785	9	0.50	1.00	300984.00	66.85	38.44	8.00
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	59.72	26.13	9.00
Rodentia	*Sciurus_vulgaris*	1785	84	1785	15	0.84	1.00	300984.00	702.08	40.08	8.27
Rodentia	*Sciurus_vulgaris*	1785	84	1785	3	0.17	1.00	300984.00	1642.31	29.22	5.33
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	177.54	36.99	8.00
Rodentia	*Sciurus_vulgaris*	1785	84	1785	8	0.45	1.00	300984.00	24.34	28.92	2.78
Eulipotyphla	*Suncus_etruscus*	69	13	69	13	18.84	1.00	31913.00	95.66	53.59	7.38
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	21	4.44	1.00	68337.00	173.84	53.62	9.14
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	9	1.90	1.00	68337.00	226.87	46.02	7.56
Carnivora	*Vulpes_lagopus*	67	36	67	35	52.24	1.00	242272.00	0.00	0.08	0.00
Carnivora	*Vulpes_lagopus*	67	36	67	1	1.49	1.00	242272.00	NA	NA	NA

Range overfilling

Order	Binomial	OAR	PAR	POAR	Range_overfilling	Filling_ratio	Pathways_tot	Native_range	PopdensityAvg	landuseHAvg	infrastructuresAvg
Artiodactyla	*Ammotragus_lervia*	902	430	944	12	1.27	5.00	10314.00	338.75	28.50	9.33
Artiodactyla	*Ammotragus_lervia*	902	430	944	6	0.64	5.00	10314.00	131.45	52.18	5.36
Artiodactyla	*Ammotragus_lervia*	902	430	944	1	0.11	5.00	10314.00	9.28	55.49	8.00
Artiodactyla	*Ammotragus_lervia*	902	430	944	122	12.92	5.00	10314.00	56.69	45.29	8.10
Artiodactyla	*Ammotragus_lervia*	902	430	944	321	34.00	5.00	10314.00	27.33	42.43	6.49
Artiodactyla	*Ammotragus_lervia*	902	430	944	4	0.42	5.00	10314.00	73.72	28.65	8.00

Artiodactyla	*Ammotragus_lervia*	902	430	944	1	0.11	5.00	10314.00	18.96	37.01	8.00
Artiodactyla	*Ammotragus_lervia*	902	430	944	2	0.21	5.00	10314.00	28.59	49.66	4.00
Artiodactyla	*Ammotragus_lervia*	902	430	944	2	0.21	5.00	10314.00	NA	NA	4.00
Artiodactyla	*Axis_axis*	16	0	16	4	25.00	1.00	20535.00	20.39	17.70	0.00
Rodentia	*Callosciurus_erythraeus*	97	1	97	42	43.30	1.00	36175.00	274.77	23.86	8.29
Rodentia	*Callosciurus_erythraeus*	97	1	97	12	12.37	1.00	36175.00	929.08	22.57	9.33
Rodentia	*Callosciurus_erythraeus*	97	1	97	1	1.03	1.00	36175.00	28.43	8.28	8.00
Rodentia	*Callosciurus_erythraeus*	97	1	97	1	1.03	1.00	36175.00	172.90	5.82	8.00
Rodentia	*Callosciurus_erythraeus*	97	1	97	7	7.22	1.00	36175.00	1933.62	14.97	10.29
Rodentia	*Callosciurus_erythraeus*	97	1	97	27	27.84	1.00	36175.00	221.23	33.07	8.30
Rodentia	*Callosciurus_finlaysonii*	8	0	8	1	12.50	1.00	6175.00	132.21	52.89	8.00
Rodentia	*Callosciurus_finlaysonii*	8	0	8	6	75.00	1.00	6175.00	152.26	16.70	4.00
Artiodactyla	*Capra_ibex*	38	600	612	8	1.31	2.00	229.00	20.77	15.15	8.00
Artiodactyla	*Capra_ibex*	38	600	612	1	0.16	2.00	229.00	435.92	33.43	8.00
Artiodactyla	*Capra_ibex*	38	600	612	3	0.49	2.00	229.00	17.65	16.84	3.96
Artiodactyla	*Capreolus_capreolus*	16	6	16	2	12.50	1.00	84339.00	273.51	43.19	8.00
Artiodactyla	*Capreolus_capreolus*	16	6	16	2	12.50	1.00	84339.00	54.43	42.06	12.00
Artiodactyla	*Capreolus_capreolus*	16	6	16	4	25.00	1.00	84339.00	303.94	38.88	8.00
Artiodactyla	*Capreolus_capreolus*	16	6	16	2	12.50	1.00	84339.00	61.28	37.49	8.00
Artiodactyla	*Capreolus_pygargus*	1889	0	1889	841	44.52	1.00	151277.00	163.11	29.76	7.26
Artiodactyla	*Capreolus_pygargus*	1889	0	1889	1048	55.48	1.00	151277.00	35.28	46.35	3.86
Rodentia	*Castor_canadensis*	3724	0	3724	3575	96.00	2.00	196228.00	9.43	2.29	5.70
Rodentia	*Castor_canadensis*	3724	0	3724	104	2.79	2.00	196228.00	119.10	25.74	9.31
Artiodactyla	*Cervus_canadensis*	4	509	513	4	0.78	1.00	71669.00	1375.36	33.56	10.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	9	0.07	5.00	3564.00	115.92	39.32	6.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	13.35	13.71	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	8.57	13.54	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	31.47	21.41	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	8.45	29.95	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	38.14	38.50	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	56	0.46	5.00	3564.00	4.72	22.80	3.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1469	12.18	5.00	3564.00	31.98	20.66	5.65
Artiodactyla	*Cervus_nippon*	9233	5855	12065	12	0.10	5.00	3564.00	202.87	27.03	8.00

Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	32.40	35.12	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	21	0.17	5.00	3564.00	2.42	13.73	0.86
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	0.00	17.45	NA
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	24.27	30.78	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	152.90	36.70	6.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	15	0.12	5.00	3564.00	3.79	14.94	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	97.91	41.51	9.60
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	38	0.31	5.00	3564.00	34.68	23.22	5.45
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	92.53	30.01	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	27.52	34.50	9.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	41	0.34	5.00	3564.00	50.51	20.76	5.49
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	38.45	25.39	11.20
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	13.12	40.93	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	9.22	28.86	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	NA	NA	NA
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	10.26	20.82	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	59.56	15.22	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	10.47	33.05	5.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	43	0.36	5.00	3564.00	22.47	24.79	7.81
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	21.12	32.32	3.20
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	280.45	30.55	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	125.25	39.05	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	28.09	28.89	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	49.71	38.98	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	31.38	47.52	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	254.09	44.45	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	23.22	31.19	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	NA	NA	10.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	42	0.35	5.00	3564.00	108.37	30.42	6.80
Artiodactyla	*Cervus_nippon*	9233	5855	12065	87	0.72	5.00	3564.00	241.81	29.08	8.10

Artiodactyla	*Cervus_nippon*	9233	5855	12065	43	0.36	5.00	3564.00	46.45	33.17	8.56
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	52.50	46.24	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	121.35	30.30	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	42.67	27.59	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	15.25	22.07	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	7	0.06	5.00	3564.00	717.01	32.53	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	229	1.90	5.00	3564.00	113.18	26.40	8.45
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	76.85	24.92	6.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	19	0.16	5.00	3564.00	43.39	47.43	3.59
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	18.74	39.91	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	5.92	24.39	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	NA	NA	NA
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	8.66	25.02	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	13.85	27.21	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	126.17	39.64	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	7	0.06	5.00	3564.00	45.92	26.93	1.14
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	12.23	41.09	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	8	0.07	5.00	3564.00	130.39	46.96	3.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	11	0.09	5.00	3564.00	36.50	46.11	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	15	0.12	5.00	3564.00	187.96	36.49	10.13
Artiodactyla	*Cervus_nippon*	9233	5855	12065	68	0.56	5.00	3564.00	606.35	38.27	8.71
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	208.34	45.71	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	19	0.16	5.00	3564.00	151.18	45.31	9.26
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	184.85	42.47	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	197.97	48.65	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	128.41	38.44	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	71	0.59	5.00	3564.00	241.68	43.60	8.23
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	NA	NA	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	149.24	28.19	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	285.84	33.54	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	158.94	42.37	10.67

Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	67.62	35.66	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	266.07	45.27	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	18	0.15	5.00	3564.00	90.43	46.53	9.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	61.45	31.82	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	15	0.12	5.00	3564.00	91.16	35.71	8.53
Artiodactyla	*Cervus_nippon*	9233	5855	12065	227	1.88	5.00	3564.00	141.52	25.54	9.15
Artiodactyla	*Cervus_nippon*	9233	5855	12065	17	0.14	5.00	3564.00	142.30	47.45	6.59
Artiodactyla	*Cervus_nippon*	9233	5855	12065	13	0.11	5.00	3564.00	50.85	36.09	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	25.07	40.14	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	30	0.25	5.00	3564.00	66.10	42.54	9.60
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2795	23.17	5.00	3564.00	80.63	40.62	6.04
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	50.77	43.66	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	34.23	48.27	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	12.74	31.15	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	52	0.43	5.00	3564.00	124.07	27.11	8.62
Artiodactyla	*Cervus_nippon*	9233	5855	12065	13	0.11	5.00	3564.00	65.15	44.86	6.46
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	18.33	27.86	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	19	0.16	5.00	3564.00	34.54	50.57	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	19	0.16	5.00	3564.00	253.16	38.19	8.42
Artiodactyla	*Cervus_nippon*	9233	5855	12065	13	0.11	5.00	3564.00	84.42	36.84	9.23
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	16.42	23.23	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	55	0.46	5.00	3564.00	103.64	21.88	8.29
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	56.41	28.89	10.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	17	0.14	5.00	3564.00	59.50	27.46	9.41
Eulipotyphla	*Crocidura_russula*	161	9	161	7	4.35	1.00	21318.00	27.39	36.54	9.14
Eulipotyphla	*Crocidura_russula*	161	9	161	144	89.44	1.00	21318.00	48.49	40.52	8.42
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	9.53	6.94	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	42.57	22.03	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	235.03	51.60	8.00

Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.48	33.21	0.85
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	3647.23	25.72	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	11	0.06	4.00	2053.00	3.45	1.75	8.73
Artiodactyla	*Dama_dama*	3721	17285	18825	7	0.04	4.00	2053.00	34.98	10.38	3.20
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	154.42	9.59	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	15	0.08	4.00	2053.00	8.22	10.88	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	4.23	7.19	10.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	1009.05	16.53	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	82.85	21.61	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	12	0.06	4.00	2053.00	4.16	13.82	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	766.90	29.37	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	30	0.16	4.00	2053.00	70.13	6.02	6.96
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	74.13	34.94	10.00
Artiodactyla	*Dama_dama*	3721	17285	18825	5	0.03	4.00	2053.00	51.53	31.16	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	NA	NA	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	312.37	24.94	16.00
Artiodactyla	*Dama_dama*	3721	17285	18825	5	0.03	4.00	2053.00	2436.63	16.36	9.60
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	101.21	16.50	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	59.83	28.90	6.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	53.75	38.37	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	35.25	21.02	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	181	0.96	4.00	2053.00	123.90	30.85	6.35
Artiodactyla	*Dama_dama*	3721	17285	18825	41	0.22	4.00	2053.00	143.16	40.05	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	11	0.06	4.00	2053.00	26.32	23.19	5.82
Artiodactyla	*Dama_dama*	3721	17285	18825	10	0.05	4.00	2053.00	160.80	36.59	6.80
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	0.09	27.56	3.21
Artiodactyla	*Dama_dama*	3721	17285	18825	51	0.27	4.00	2053.00	131.00	50.54	5.73
Artiodactyla	*Dama_dama*	3721	17285	18825	23	0.12	4.00	2053.00	159.52	46.76	8.35
Artiodactyla	*Dama_dama*	3721	17285	18825	192	1.02	4.00	2053.00	102.90	43.51	5.90
Artiodactyla	*Dama_dama*	3721	17285	18825	9	0.05	4.00	2053.00	250.63	40.25	8.44
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	951.90	28.05	6.95
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	35.99	44.67	2.73
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	3443.21	13.43	12.00

Artiodactyla	*Dama_dama*	3721	17285	18825	34	0.18	4.00	2053.00	292.92	46.21	6.32
Artiodactyla	*Dama_dama*	3721	17285	18825	610	3.24	4.00	2053.00	114.85	43.63	6.45
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	78.73	44.65	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	8	0.04	4.00	2053.00	1265.06	16.59	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	378.18	31.29	12.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	31.15	31.27	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	34.91	8.07	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	7	0.04	4.00	2053.00	46.67	8.04	6.86
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	269.05	22.43	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	15	0.08	4.00	2053.00	25.90	28.83	6.40
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	13	8.72	3.00	51512.00	17.68	10.71	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	8	5.37	3.00	51512.00	11.38	19.52	8.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	7	4.70	3.00	51512.00	13.54	15.20	4.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	8	5.37	3.00	51512.00	3.45	11.60	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	1	0.67	3.00	51512.00	NA	NA	0.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	2	1.34	3.00	51512.00	0.00	14.97	4.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	3	2.01	3.00	51512.00	644.71	38.54	8.00
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	7	4.70	3.00	51512.00	NA	NA	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	8	19.51	3.00	215806.00	43.84	33.54	8.50
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	128.25	37.09	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	239.55	31.47	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	328.68	40.06	16.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	75.59	41.47	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	1272.58	29.41	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	401.18	39.74	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	4	9.76	3.00	215806.00	195.00	41.16	12.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	788.43	44.98	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	1333.72	23.26	16.00
Rodentia	*Eutamias_sibiricus*	38	10	41	2	4.88	3.00	215806.00	542.81	43.95	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	178.29	49.66	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	6	14.63	3.00	215806.00	137.43	24.94	6.74
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	111.43	55.68	1.16
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	9821.64	0.00	8.00

Rodentia	*Glis_glis*	35	8	35	27	77.14	2.00	44643.00	842.06	39.71	9.78
Carnivora	*Herpestes_auropunctatus*	122	146	217	2	0.92	1.00	31161.00	323.29	42.31	NA
Carnivora	*Herpestes_auropunctatus*	122	146	217	5	2.30	1.00	31161.00	81.64	41.88	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	3	1.38	1.00	31161.00	NA	NA	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	29.83	34.23	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	12	5.53	1.00	31161.00	79.68	44.18	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	194.51	38.38	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	36.76	25.22	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	3	1.38	1.00	31161.00	75.24	37.83	8.00
Artiodactyla	*Hydropotes_inermis*	486	444	626	102	16.29	3.00	1743.00	155.56	41.39	6.82
Artiodactyla	*Hydropotes_inermis*	486	444	626	56	8.95	3.00	1743.00	345.25	42.96	9.21
Artiodactyla	*Hydropotes_inermis*	486	444	626	1	0.16	3.00	1743.00	644.71	38.54	8.00
Artiodactyla	*Hydropotes_inermis*	486	444	626	7	1.12	3.00	1743.00	514.93	41.82	9.14
Artiodactyla	*Hydropotes_inermis*	486	444	626	1	0.16	3.00	1743.00	NA	NA	8.00
Rodentia	*Hystrix_cristata*	30	7	30	8	26.67	1.00	44966.00	263.90	12.81	9.00
Rodentia	*Hystrix_cristata*	30	7	30	5	16.67	1.00	44966.00	61.93	24.70	8.00
Rodentia	*Hystrix_cristata*	30	7	30	2	6.67	1.00	44966.00	NA	NA	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	7	0.19	1.00	133306.00	11.38	19.52	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	12	0.33	1.00	133306.00	3.45	11.60	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	0.00	18.67	4.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	12	0.33	1.00	133306.00	4.16	13.82	0.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	18.95	16.06	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	42.46	24.02	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	4	0.11	1.00	133306.00	22.24	25.59	10.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1747	47.45	1.00	133306.00	49.23	7.32	7.29
Lagomorpha	*Lepus_europaeus*	3394	688	3682	3	0.08	1.00	133306.00	32.92	10.35	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	26.38	3.55	16.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	6	0.16	1.00	133306.00	30.75	3.19	7.33
Lagomorpha	*Lepus_europaeus*	3394	688	3682	11	0.30	1.00	133306.00	40.05	4.95	5.14
Lagomorpha	*Lepus_europaeus*	3394	688	3682	320	8.69	1.00	133306.00	186.71	31.69	8.22
Lagomorpha	*Lepus_europaeus*	3394	688	3682	2	0.05	1.00	133306.00	656.57	11.61	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	2	0.05	1.00	133306.00	NA	NA	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	432	11.73	1.00	133306.00	163.57	36.13	7.50

Lagomorpha	*Lepus_granatensis*	109	23	111	1	0.90	1.00	5590.00	37.23	41.40	8.00
Lagomorpha	*Lepus_granatensis*	109	23	111	3	2.70	1.00	5590.00	77.71	38.87	8.00
Lagomorpha	*Lepus_granatensis*	109	23	111	14	12.61	1.00	5590.00	52.06	24.94	8.29
Lagomorpha	*Lepus_granatensis*	109	23	111	67	60.36	1.00	5590.00	70.31	11.34	7.24
Lagomorpha	*Lepus_timidus*	290	20	290	8	2.76	1.00	334900.00	11.21	0.45	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	5	1.72	1.00	334900.00	20.37	11.53	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	4	1.38	1.00	334900.00	4.23	6.58	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	8	2.76	1.00	334900.00	11.38	19.52	8.00
Lagomorpha	*Lepus_timidus*	290	20	290	20	6.90	1.00	334900.00	39.09	21.33	1.84
Lagomorpha	*Lepus_timidus*	290	20	290	8	2.76	1.00	334900.00	13.54	15.20	4.00
Lagomorpha	*Lepus_timidus*	290	20	290	4	1.38	1.00	334900.00	NA	NA	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	17	5.86	1.00	334900.00	2.59	12.04	1.00
Lagomorpha	*Lepus_timidus*	290	20	290	9	3.10	1.00	334900.00	4.56	15.33	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	1	0.34	1.00	334900.00	0.00	17.45	NA
Lagomorpha	*Lepus_timidus*	290	20	290	4	1.38	1.00	334900.00	2.17	6.27	0.00
Lagomorpha	*Lepus_timidus*	290	20	290	3	1.03	1.00	334900.00	18.95	16.06	8.00
Lagomorpha	*Lepus_timidus*	290	20	290	8	2.76	1.00	334900.00	36.60	35.86	9.00
Rodentia	*Marmota_bobak*	372	275	385	56	14.55	2.00	10077.00	84.13	26.78	4.47
Rodentia	*Marmota_bobak*	372	275	385	1	0.26	2.00	10077.00	17.59	37.78	8.00
Rodentia	*Marmota_bobak*	372	275	385	1	0.26	2.00	10077.00	18.06	29.88	4.00
Rodentia	*Marmota_bobak*	372	275	385	5	1.30	2.00	10077.00	10.48	33.86	4.80
Rodentia	*Marmota_bobak*	372	275	385	1	0.26	2.00	10077.00	10.10	37.25	2.73
Rodentia	*Marmota_bobak*	372	275	385	46	11.95	2.00	10077.00	35.57	33.48	4.33
Rodentia	*Marmota_marmota*	355	80	362	2	0.55	2.00	2187.00	22.29	26.25	8.00
Rodentia	*Marmota_marmota*	355	80	362	31	8.56	2.00	2187.00	37.34	33.73	8.52
Rodentia	*Marmota_marmota*	355	80	362	42	11.60	2.00	2187.00	49.79	18.76	8.38
Rodentia	*Marmota_marmota*	355	80	362	1	0.28	2.00	2187.00	24.67	31.19	8.00
Rodentia	*Marmota_marmota*	355	80	362	3	0.83	2.00	2187.00	14.25	8.86	8.00
Rodentia	*Marmota_marmota*	355	80	362	1	0.28	2.00	2187.00	77.89	34.22	8.00
Rodentia	*Marmota_marmota*	355	80	362	1	0.28	2.00	2187.00	16.30	9.98	8.00
Rodentia	*Marmota_marmota*	355	80	362	14	3.87	2.00	2187.00	30.88	21.27	8.00
Rodentia	*Marmota_marmota*	355	80	362	2	0.55	2.00	2187.00	696.62	35.80	8.00
Rodentia	*Marmota_marmota*	355	80	362	3	0.83	2.00	2187.00	26.93	14.03	6.67

Rodentia	*Marmota_marmota*	355	80	362	182	50.28	2.00	2187.00	14.83	17.94	6.66
Carnivora	*Martes_martes*	21	1	21	1	4.76	3.00	137677.00	0.00	17.45	NA
Carnivora	*Martes_martes*	21	1	21	14	66.67	3.00	137677.00	4.15	14.47	0.00
Rodentia	*Micromys_minutus*	836	1	836	17	2.03	1.00	228915.00	2.14	0.14	4.24
Rodentia	*Micromys_minutus*	836	1	836	677	80.98	1.00	228915.00	22.48	5.33	6.38
Rodentia	*Micromys_minutus*	836	1	836	2	0.24	1.00	228915.00	11.52	13.09	8.00
Rodentia	*Micromys_minutus*	836	1	836	96	11.48	1.00	228915.00	64.00	34.07	8.25
Artiodactyla	*Muntiacus_reevesi*	1704	135	1704	11	0.65	3.00	20466.00	595.65	34.88	8.73
Artiodactyla	*Muntiacus_reevesi*	1704	135	1704	1345	78.93	3.00	20466.00	336.64	39.71	8.64
Artiodactyla	*Muntiacus_reevesi*	1704	135	1704	7	0.41	3.00	20466.00	139.24	42.98	0.00
Carnivora	*Mustela_erminea*	47	2	47	6	12.77	2.00	658263.00	20.37	11.53	0.00
Carnivora	*Mustela_erminea*	47	2	47	5	10.64	2.00	658263.00	4.23	6.58	0.00
Carnivora	*Mustela_erminea*	47	2	47	7	14.89	2.00	658263.00	11.38	19.52	8.00
Carnivora	*Mustela_putorius*	641	102	656	12	1.83	2.00	80073.00	17.68	10.71	0.00
Carnivora	*Mustela_putorius*	641	102	656	14	2.13	2.00	80073.00	4.16	13.82	0.00
Carnivora	*Mustela_putorius*	641	102	656	3	0.46	2.00	80073.00	9.43	20.54	4.00
Carnivora	*Mustela_putorius*	641	102	656	421	64.18	2.00	80073.00	71.92	38.30	8.16
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	20.46	37.48	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	13.02	37.56	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	9.21	17.11	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	3.25	32.80	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	NA	NA	NA
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	168.90	30.61	0.44
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	87.89	3.88	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	42.02	14.79	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	2.26	23.79	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	12.89	36.13	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	0.59	44.38	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	NA	NA	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	18.74	36.07	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	35.23	43.36	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	12025	72.79	1.00	38364.00	161.77	30.44	8.91
Rodentia	*Myocastor_coypus*	15894	2474	16519	14	0.08	1.00	38364.00	113.26	48.49	4.86

Rodentia	*Myocastor_coypus*	15894	2474	16519	6	0.04	1.00	38364.00	104.93	14.16	9.33
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	33.05	23.61	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	5	0.03	1.00	38364.00	24.51	12.31	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	7	0.04	1.00	38364.00	191.68	26.53	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	74.36	59.61	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	48	0.29	1.00	38364.00	82.39	29.15	9.83
Rodentia	*Myocastor_coypus*	15894	2474	16519	133	0.81	1.00	38364.00	68.71	32.59	4.67
Rodentia	*Myocastor_coypus*	15894	2474	16519	9	0.05	1.00	38364.00	103.75	45.32	1.33
Rodentia	*Myocastor_coypus*	15894	2474	16519	13	0.08	1.00	38364.00	221.10	26.22	7.08
Rodentia	*Myocastor_coypus*	15894	2474	16519	288	1.74	1.00	38364.00	341.01	35.47	8.07
Rodentia	*Myocastor_coypus*	15894	2474	16519	8	0.05	1.00	38364.00	420.39	41.93	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	7	0.04	1.00	38364.00	301.28	51.25	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	235	1.42	1.00	38364.00	100.15	38.54	6.60
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	113.81	55.65	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	816.53	40.16	14.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	20.41	54.75	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	6	0.04	1.00	38364.00	360.12	45.29	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	103	0.62	1.00	38364.00	117.24	36.91	6.90
Rodentia	*Myocastor_coypus*	15894	2474	16519	15	0.09	1.00	38364.00	66.70	50.87	8.53
Rodentia	*Myocastor_coypus*	15894	2474	16519	44	0.27	1.00	38364.00	138.94	40.84	8.55
Rodentia	*Myocastor_coypus*	15894	2474	16519	139	0.84	1.00	38364.00	69.13	50.29	6.89
Rodentia	*Myocastor_coypus*	15894	2474	16519	8	0.05	1.00	38364.00	160.28	47.07	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	30.43	20.98	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	16	0.10	1.00	38364.00	1173.33	46.79	7.75
Rodentia	*Myocastor_coypus*	15894	2474	16519	214	1.30	1.00	38364.00	302.11	33.60	8.44
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	11.66	51.16	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	NA	NA	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	54	0.33	1.00	38364.00	61.72	30.59	5.94
Rodentia	*Myocastor_coypus*	15894	2474	16519	22	0.13	1.00	38364.00	153.04	29.83	6.91
Rodentia	*Myocastor_coypus*	15894	2474	16519	90	0.54	1.00	38364.00	51.95	19.73	8.09
Rodentia	*Myocastor_coypus*	15894	2474	16519	14	0.08	1.00	38364.00	12.16	51.50	4.42
Rodentia	*Myodes_glareolus*	538	4	538	469	87.17	1.00	124958.00	34.56	37.43	8.08
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	5.76	0.00	2.73

Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	913.27	0.18	1.63
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	0.00	0.00	0.44
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	1.64	5.12	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	1.80	0.31	1.16
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	1.60	1.31	0.76
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	1.16
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	0.82	0.00	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	1.05	3.25	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	6.24	4.54	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	10.31	3.53	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	2.73
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	16.54	1.19	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	99.77	17.67	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	30.30	40.30	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	19	0.03	2.00	194822.00	2.32	16.33	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	157.09	21.27	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	5.76	26.11	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	254.09	44.45	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	NA
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1016	1.61	2.00	194822.00	234.34	39.60	8.55
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	644.71	38.54	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	192.30	47.36	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	70.11	45.37	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	NA	NA	NA
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	91.00	25.45	8.00

Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	3.56	44.69	0.59
Carnivora	*Neovison_vison*	62290	12313	63184	25	0.04	2.00	194822.00	3.75	0.28	3.13
Carnivora	*Neovison_vison*	62290	12313	63184	38601	61.09	2.00	194822.00	26.31	14.78	4.64
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	2.95	0.00	4.11
Carnivora	*Neovison_vison*	62290	12313	63184	80	0.13	2.00	194822.00	1.34	7.74	1.62
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	3.29	0.35	1.63
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	2.90	26.74	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	7.80	16.29	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	69.58	32.20	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	207.56	26.64	1.54
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	250.95	48.96	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	36	0.06	2.00	194822.00	8.35	46.73	7.12
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	7.46	21.98	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	3.07	38.67	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	72	0.11	2.00	194822.00	472.11	40.92	8.04
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	3.18	0.64	2.84
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	544.95	0.00	0.29
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	3.42	0.00	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	2.32	0.00	1.51
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	0.83	0.00	0.27
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	3.80	0.00	5.27
Carnivora	*Neovison_vison*	62290	12313	63184	22	0.03	2.00	194822.00	92.53	0.25	1.78
Carnivora	*Neovison_vison*	62290	12313	63184	9	0.01	2.00	194822.00	5.87	9.34	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	0.48	7.00	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	12	0.02	2.00	194822.00	7.32	7.91	3.77
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	6.89	7.35	1.64
Carnivora	*Neovison_vison*	62290	12313	63184	28	0.04	2.00	194822.00	0.48	12.84	3.82
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	1.95	0.61	1.63
Carnivora	*Neovison_vison*	62290	12313	63184	334	0.53	2.00	194822.00	1.36	8.31	3.44
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	4.89	1.03	2.73
Carnivora	*Neovison_vison*	62290	12313	63184	20	0.03	2.00	194822.00	2.71	1.20	4.78
Carnivora	*Neovison_vison*	62290	12313	63184	16	0.03	2.00	194822.00	3.25	2.52	2.50
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	2.26	0.10	8.00

Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	10.87	0.71	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	12	0.02	2.00	194822.00	5.83	0.95	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	8.85	0.00	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	10.96	1.12	7.68
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	2.79	3.63	1.16
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	13.42	0.81	1.74
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	6.54	1.70	6.24
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	1.81	0.01	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	2.67	0.02	6.57
Carnivora	*Neovison_vison*	62290	12313	63184	49	0.08	2.00	194822.00	70.59	2.84	3.18
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	28.43	9.58	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	614.27	3.37	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	10	0.02	2.00	194822.00	1.90	4.33	3.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	NA	NA	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	19	0.03	2.00	194822.00	8.26	5.92	7.47
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	0.19	2.98	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	12.26	2.78	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	187.12	12.89	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	5.28	2.48	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	6.82	14.96	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	8.34	6.09	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	2.93	3.64	5.33
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	4.23	7.19	10.00
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	50.59	40.16	9.60
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	2785.50	0.00	NA
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	21.84	28.27	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	164	0.26	2.00	194822.00	17.43	22.98	3.97
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	8.27	18.08	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	182.96	21.62	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	159.85	14.97	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	28.13	30.74	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	554	0.88	2.00	194822.00	65.84	37.66	8.12
Carnivora	*Neovison_vison*	62290	12313	63184	12	0.02	2.00	194822.00	11.04	31.89	4.00

Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	12.30	29.78	1.63
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	32.76	22.77	4.57
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	1050.73	29.20	11.20
Carnivora	*Neovison_vison*	62290	12313	63184	13	0.02	2.00	194822.00	19.76	25.01	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	11	0.02	2.00	194822.00	1459.13	21.43	10.18
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	19.47	40.61	12.00
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	60.44	33.83	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	66.65	22.90	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	67	0.11	2.00	194822.00	61.39	28.31	7.38
Carnivora	*Neovison_vison*	62290	12313	63184	624	0.99	2.00	194822.00	439.36	28.48	8.78
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	64.49	51.11	2.67
Carnivora	*Neovison_vison*	62290	12313	63184	12	0.02	2.00	194822.00	946.08	30.77	10.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	163.88	47.89	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	128.41	38.44	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	184.85	42.47	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	9	0.01	2.00	194822.00	139.24	42.98	0.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	56.06	37.10	9.33
Carnivora	*Neovison_vison*	62290	12313	63184	1347	2.13	2.00	194822.00	174.67	27.40	9.02
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	200.28	30.84	9.33
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	37.07	37.34	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	790	1.25	2.00	194822.00	94.43	39.67	8.51
Carnivora	*Neovison_vison*	62290	12313	63184	811	1.28	2.00	194822.00	89.89	29.68	8.46
Carnivora	*Neovison_vison*	62290	12313	63184	20	0.03	2.00	194822.00	51.64	48.38	9.60
Carnivora	*Neovison_vison*	62290	12313	63184	16	0.03	2.00	194822.00	32.21	14.57	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	6	0.01	2.00	194822.00	208.13	30.71	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	134	0.21	2.00	194822.00	231.42	35.97	7.72
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	46.24	43.96	5.71
Carnivora	*Neovison_vison*	62290	12313	63184	55	0.09	2.00	194822.00	143.59	42.54	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	760	1.20	2.00	194822.00	53.52	29.99	8.16
Carnivora	*Neovison_vison*	62290	12313	63184	296	0.47	2.00	194822.00	140.82	12.46	7.81
Carnivora	*Neovison_vison*	62290	12313	63184	26	0.04	2.00	194822.00	902.54	22.68	8.92
Carnivora	*Neovison_vison*	62290	12313	63184	477	0.75	2.00	194822.00	144.79	25.38	7.69
Carnivora	*Neovison_vison*	62290	12313	63184	11	0.02	2.00	194822.00	1873.26	39.74	7.27

Carnivora	*Neovison_vison*	62290	12313	63184	1247	1.97	2.00	194822.00	71.09	40.44	7.59
Carnivora	*Neovison_vison*	62290	12313	63184	108	0.17	2.00	194822.00	34.33	44.90	6.57
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	28.19	17.11	6.67
Carnivora	*Neovison_vison*	62290	12313	63184	19	0.03	2.00	194822.00	34.81	24.77	9.05
Carnivora	*Neovison_vison*	62290	12313	63184	4	0.01	2.00	194822.00	10.39	15.84	8.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	10	0.01	3.00	65982.00	258.96	11.72	10.40
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	3	0.00	3.00	65982.00	NA	NA	4.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	1	0.00	3.00	65982.00	NA	NA	4.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	2	0.00	3.00	65982.00	962.21	4.74	8.00
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	69256	96.38	3.00	65982.00	66.93	25.87	6.12
Carnivora	*Nyctereutes_procyonoides*	71858	1078	71858	45	0.06	3.00	65982.00	18.10	7.06	6.82
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	8	0.37	1.00	149345.00	13.68	15.08	4.05
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	4	0.19	1.00	149345.00	38.61	10.16	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	1.43	7.94	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1159	54.08	1.00	149345.00	28.72	5.77	7.11
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	21	0.98	1.00	149345.00	179.98	36.15	8.38
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	109	5.09	1.00	149345.00	282.17	29.40	9.32
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	126	5.88	1.00	149345.00	159.60	38.40	9.33
Rodentia	*Ondatra_zibethicus*	74463	637	74476	4	0.01	2.00	476299.00	3.42	0.00	0.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	98	0.13	2.00	476299.00	12.14	18.70	4.05
Rodentia	*Ondatra_zibethicus*	74463	637	74476	4	0.01	2.00	476299.00	5.01	4.81	NA
Rodentia	*Ondatra_zibethicus*	74463	637	74476	3	0.00	2.00	476299.00	51.21	35.51	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	2	0.00	2.00	476299.00	61.41	15.77	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	1	0.00	2.00	476299.00	7.37	42.41	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	2	0.00	2.00	476299.00	18.22	52.24	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	70722	94.96	2.00	476299.00	63.02	23.66	5.73
Rodentia	*Ondatra_zibethicus*	74463	637	74476	1137	1.53	2.00	476299.00	13.31	29.12	3.93
Rodentia	*Ondatra_zibethicus*	74463	637	74476	7	0.01	2.00	476299.00	207.56	26.64	1.54
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	27	0.44	3.00	6734.00	443.70	13.81	7.68
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	25.89	0.00	NA
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	8	0.13	3.00	6734.00	28.46	8.21	2.67
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	8	0.13	3.00	6734.00	11.38	19.52	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	NA	NA	NA

Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	9.53	6.94	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	NA	NA	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	6	0.10	3.00	6734.00	154.42	9.59	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	26	0.42	3.00	6734.00	32.74	21.95	1.80
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	8	0.13	3.00	6734.00	13.54	15.20	4.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	18	0.29	3.00	6734.00	2.13	15.16	1.20
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2	0.03	3.00	6734.00	21.84	28.27	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	6	0.10	3.00	6734.00	7.84	13.18	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	19	0.31	3.00	6734.00	4.15	14.47	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	7	0.11	3.00	6734.00	19.20	18.17	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	7	0.11	3.00	6734.00	104.26	21.47	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	NA	NA	NA
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	NA	NA	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	5	0.08	3.00	6734.00	39.72	26.02	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	14	0.23	3.00	6734.00	138.25	28.39	4.67
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1400	22.66	3.00	6734.00	48.85	8.41	7.40
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	8	0.13	3.00	6734.00	36.60	35.86	9.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	4	0.06	3.00	6734.00	27.20	18.74	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2	0.03	3.00	6734.00	NA	NA	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	3	0.05	3.00	6734.00	68.26	19.16	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2	0.03	3.00	6734.00	NA	NA	NA
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	21	0.34	3.00	6734.00	74.30	29.55	6.74
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	6	0.10	3.00	6734.00	121.70	21.77	9.33
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	4	0.06	3.00	6734.00	44.58	18.58	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	3	0.05	3.00	6734.00	5.89	4.95	NA
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	2870.93	2.15	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	2358	38.17	3.00	6734.00	78.89	43.13	6.12
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	109	1.76	3.00	6734.00	53.97	28.03	5.93
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	3.79	0.00	0.85
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	0.00	0.00	0.59
Artiodactyla	*Ovibos_moschatus*	584	730	941	71	7.55	1.00	46223.00	1.68	1.92	5.49
Artiodactyla	*Ovibos_moschatus*	584	730	941	2	0.21	1.00	46223.00	3.83	0.00	4.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	5	0.53	1.00	46223.00	1.65	0.19	4.00

Artiodactyla	*Ovibos_moschatus*	584	730	941	2	0.21	1.00	46223.00	2.13	0.00	4.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	3.60	0.00	0.32
Artiodactyla	*Ovibos_moschatus*	584	730	941	2	0.21	1.00	46223.00	2.32	1.61	4.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	112	11.90	1.00	46223.00	31.73	0.38	5.09
Carnivora	*Procyon_lotor*	14535	386	14604	1	0.01	3.00	123973.00	NA	NA	NA
Carnivora	*Procyon_lotor*	14535	386	14604	55	0.38	3.00	123973.00	350.84	26.54	7.67
Carnivora	*Procyon_lotor*	14535	386	14604	3	0.02	3.00	123973.00	68.26	19.16	8.00
Carnivora	*Procyon_lotor*	14535	386	14604	13	0.09	3.00	123973.00	91.31	31.94	8.00
Carnivora	*Procyon_lotor*	14535	386	14604	358	2.45	3.00	123973.00	20.22	24.24	6.16
Carnivora	*Procyon_lotor*	14535	386	14604	8412	57.60	3.00	123973.00	190.87	28.88	9.01
Carnivora	*Procyon_lotor*	14535	386	14604	4263	29.19	3.00	123973.00	66.19	34.89	4.65
Carnivora	*Procyon_lotor*	14535	386	14604	67	0.46	3.00	123973.00	498.43	49.34	8.72
Carnivora	*Procyon_lotor*	14535	386	14604	351	2.40	3.00	123973.00	56.84	33.47	8.75
Carnivora	*Procyon_lotor*	14535	386	14604	29	0.20	3.00	123973.00	85.33	18.62	8.28
Carnivora	*Procyon_lotor*	14535	386	14604	220	1.51	3.00	123973.00	192.85	49.30	7.46
Carnivora	*Procyon_lotor*	14535	386	14604	25	0.17	3.00	123973.00	142.79	47.38	6.72
Artiodactyla	*Rangifer_tarandus*	251	958	1039	3	0.29	1.00	347681.00	NA	NA	0.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	2	0.19	1.00	347681.00	0.48	11.91	8.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	3	0.29	1.00	347681.00	0.86	10.20	8.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	12	1.15	1.00	347681.00	0.07	7.23	4.58
Artiodactyla	*Rangifer_tarandus*	251	958	1039	7	0.67	1.00	347681.00	0.00	9.13	0.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	5	0.48	1.00	347681.00	11.23	14.22	0.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	1	0.10	1.00	347681.00	NA	NA	NA
Artiodactyla	*Rangifer_tarandus*	251	958	1039	3	0.29	1.00	347681.00	NA	NA	1.63
Artiodactyla	*Rangifer_tarandus*	251	958	1039	1	0.10	1.00	347681.00	NA	NA	NA
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	3	2.04	1.00	2362.00	284.21	27.54	10.67
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	17	11.56	1.00	2362.00	51.63	22.65	8.94
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	1	0.68	1.00	2362.00	981.58	28.88	8.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	2	1.36	1.00	2362.00	57.88	9.92	12.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	2	1.36	1.00	2362.00	10.66	6.92	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	131.85	5.83	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	95.72	23.31	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	28.76	35.01	8.00

Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	13.68	32.83	0.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	22.10	32.32	4.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	15.76	42.64	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	94.99	25.28	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	2474.37	16.46	0.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	50.99	41.15	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	104.16	41.05	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	34.87	37.56	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	NA
Rodentia	*Sciurus_carolinensis*	796	91	868	3	0.35	2.00	43312.00	60.66	17.90	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	54.11	36.04	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	6.74	5.41	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	63.26	30.02	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	115.06	45.81	4.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	378.80	43.85	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	448.94	7.15	NA
Rodentia	*Sciurus_carolinensis*	796	91	868	4	0.46	2.00	43312.00	532.05	45.49	4.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	72.81	27.68	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	1541.42	28.08	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	165.03	46.07	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	197.97	48.65	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	644.71	38.54	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	3	0.35	2.00	43312.00	135.09	16.41	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	239.38	41.46	0.00
Rodentia	*Sciurus_carolinensis*	796	91	868	55	6.34	2.00	43312.00	855.74	39.60	8.87
Rodentia	*Sciurus_carolinensis*	796	91	868	13	1.50	2.00	43312.00	549.19	48.31	9.23
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	NA	NA	NA
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	194.84	56.29	8.00
Rodentia	*Sciurus_carolinensis*	796	91	868	6	0.69	2.00	43312.00	7.80	16.29	4.00

Rodentia	*Sciurus_carolinensis*	796	91	868	514	59.22	2.00	43312.00	68.34	38.44	8.23
Rodentia	*Sciurus_carolinensis*	796	91	868	1	0.12	2.00	43312.00	229.22	47.60	0.00
Rodentia	*Sciurus_carolinensis*	796	91	868	33	3.80	2.00	43312.00	407.00	44.14	7.88
Rodentia	*Sciurus_vulgaris*	1785	84	1785	97	5.43	1.00	300984.00	130.30	35.33	6.31
Rodentia	*Sciurus_vulgaris*	1785	84	1785	1	0.06	1.00	300984.00	30.46	42.46	16.00
Rodentia	*Sciurus_vulgaris*	1785	84	1785	1539	86.22	1.00	300984.00	55.45	24.87	4.60
Eulipotyphla	*Suncus_etruscus*	69	13	69	10	14.49	1.00	31913.00	323.62	28.81	4.44
Eulipotyphla	*Suncus_etruscus*	69	13	69	4	5.80	1.00	31913.00	61.55	56.71	8.00
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	418	88.37	1.00	68337.00	295.64	36.59	8.06
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	8	1.69	1.00	68337.00	29.30	34.85	8.00
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	3	0.63	1.00	68337.00	79.63	31.68	8.00
Lagomorpha	*Sylvilagus_floridanus*	473	30	473	2	0.42	1.00	68337.00	7266.01	0.00	12.00
Carnivora	*Vulpes_lagopus*	67	36	67	3	4.48	1.00	242272.00	NA	NA	0.00
Carnivora	*Vulpes_lagopus*	67	36	67	13	19.40	1.00	242272.00	3.47	0.00	0.00
Carnivora	*Vulpes_lagopus*	67	36	67	2	2.99	1.00	242272.00	0.00	0.00	0.00

Range unfilling

Order	Binomial	OAR	PAR	POAR	Range_unfilling	Filling_ratio	Pathways_tot	Native_range	PopdensityAvg	landuseHAvg	infrastructuresAvg
Artiodactyla	*Ammotragus_lervia*	902	430	944	42	4.45	5.00	10314.00	67.61	46.20	6.30
Artiodactyla	*Capra_ibex*	38	600	612	554	90.52	2.00	229.00	103.65	21.64	7.63
Artiodactyla	*Capra_ibex*	38	600	612	13	2.12	2.00	229.00	27.10	23.57	5.06
Artiodactyla	*Capra_ibex*	38	600	612	1	0.16	2.00	229.00	1.57	7.24	8.00
Artiodactyla	*Capra_ibex*	38	600	612	1	0.16	2.00	229.00	29.50	33.06	8.00
Artiodactyla	*Capra_ibex*	38	600	612	1	0.16	2.00	229.00	1.20	3.18	2.73
Artiodactyla	*Capra_ibex*	38	600	612	1	0.16	2.00	229.00	3.01	22.90	8.00
Artiodactyla	*Capra_ibex*	38	600	612	3	0.49	2.00	229.00	3.78	25.00	1.16
Artiodactyla	*Cervus_canadensis*	4	509	513	1	0.19	1.00	71669.00	4.62	1.04	8.00
Artiodactyla	*Cervus_canadensis*	4	509	513	1	0.19	1.00	71669.00	6.08	19.28	8.00
Artiodactyla	*Cervus_canadensis*	4	509	513	8	1.56	1.00	71669.00	116.59	15.12	9.00
Artiodactyla	*Cervus_canadensis*	4	509	513	499	97.27	1.00	71669.00	47.38	21.09	6.09
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	32.68	33.75	8.00

Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	61.80	39.53	13.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	0.56	1.82	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	61.91	25.52	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	273	2.26	5.00	3564.00	210.24	28.95	8.78
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	91.23	49.10	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	21.39	28.45	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	19.93	39.80	10.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	8.89	20.33	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	35.89	35.86	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	12	0.10	5.00	3564.00	16.87	30.78	8.67
Artiodactyla	*Cervus_nippon*	9233	5855	12065	53	0.44	5.00	3564.00	414.85	33.61	8.91
Artiodactyla	*Cervus_nippon*	9233	5855	12065	115	0.95	5.00	3564.00	134.26	36.77	8.66
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	39.08	39.49	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	9	0.07	5.00	3564.00	33.25	27.46	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	15.73	34.04	9.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	36.28	41.95	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	295	2.45	5.00	3564.00	61.86	39.51	8.27
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	19.11	42.96	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	18.44	40.53	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	14	0.12	5.00	3564.00	35.38	35.21	7.71
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	94.75	30.47	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	22.95	29.83	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	33.35	37.81	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	10	0.08	5.00	3564.00	54.88	32.20	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	12.93	51.47	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	33.60	37.24	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	80.72	40.82	9.33
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	46.97	22.72	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	22.78	51.48	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	20.84	52.02	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	12.01	47.05	2.73
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	24.84	39.92	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	54	0.45	5.00	3564.00	647.94	37.07	10.15

Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	7.84	42.88	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	6	0.05	5.00	3564.00	16.79	47.91	2.59
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	20.92	51.28	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	62.44	48.07	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	19.34	52.02	1.63
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	30.04	46.44	6.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	403.61	40.95	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	138	1.14	5.00	3564.00	285.78	28.07	9.22
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	43.00	40.11	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	823.43	41.05	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	1492.25	23.77	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	281.71	42.81	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	314.72	48.59	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	54	0.45	5.00	3564.00	161.76	43.28	7.48
Artiodactyla	*Cervus_nippon*	9233	5855	12065	240	1.99	5.00	3564.00	390.59	27.75	9.50
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	230.59	49.06	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	13	0.11	5.00	3564.00	76.07	45.81	6.77
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	239.38	41.46	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	65.13	48.30	0.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	122.83	14.05	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	260	2.15	5.00	3564.00	79.70	29.03	9.12
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	19.04	17.87	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	130.42	45.90	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	73.65	39.29	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	655.43	39.13	16.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	106.85	33.36	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	16	0.13	5.00	3564.00	88.31	46.45	8.50
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	105.52	42.21	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	0.00	4.50	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	418	3.46	5.00	3564.00	263.80	25.83	9.36
Artiodactyla	*Cervus_nippon*	9233	5855	12065	5	0.04	5.00	3564.00	45.60	18.74	9.60
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	45.76	39.34	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	50.53	41.38	16.00

Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	47.45	33.63	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	17.63	54.26	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	86.58	42.58	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	54.17	46.07	12.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	31.13	53.84	4.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	19.21	24.93	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	74	0.61	5.00	3564.00	176.45	23.18	8.97
Artiodactyla	*Cervus_nippon*	9233	5855	12065	74	0.61	5.00	3564.00	60.00	13.30	8.76
Artiodactyla	*Cervus_nippon*	9233	5855	12065	3	0.02	5.00	3564.00	19.96	29.82	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	366	3.03	5.00	3564.00	95.09	38.47	8.69
Artiodactyla	*Cervus_nippon*	9233	5855	12065	24	0.20	5.00	3564.00	368.72	33.33	9.83
Artiodactyla	*Cervus_nippon*	9233	5855	12065	9	0.07	5.00	3564.00	39.38	23.32	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	19.71	26.85	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	24	0.20	5.00	3564.00	97.57	28.34	10.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	2	0.02	5.00	3564.00	92.91	33.69	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	1	0.01	5.00	3564.00	8.62	24.76	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	4	0.03	5.00	3564.00	61.42	30.07	8.00
Artiodactyla	*Cervus_nippon*	9233	5855	12065	63	0.52	5.00	3564.00	38.43	29.10	8.44
Artiodactyla	*Cervus_nippon*	9233	5855	12065	67	0.56	5.00	3564.00	24.22	20.59	8.06
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.99	0.00	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	10.51	12.31	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.00	0.71	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.53	1.96	0.33
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	46.97	22.72	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	NA	NA	16.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	32.57	50.10	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	21.06	11.59	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.41	0.59	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	16.10	0.03	0.40
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	1.02	43.05	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	36.08	11.70	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	7.21	17.46	1.63
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	22.43	8.26	2.73

Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	16.84	3.62	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	10.47	27.46	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	15.22	34.52	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	10.78	12.39	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	38	0.20	4.00	2053.00	1.48	0.04	2.34
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	0.00	0.00	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	2.26	1.64	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	1	0.01	4.00	2053.00	163.70	45.48	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	17.42	18.95	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	21.89	38.30	6.24
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	46.84	5.00	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	17	0.09	4.00	2053.00	1.06	0.08	4.97
Artiodactyla	*Dama_dama*	3721	17285	18825	1139	6.05	4.00	2053.00	18.48	2.47	6.14
Artiodactyla	*Dama_dama*	3721	17285	18825	29	0.15	4.00	2053.00	71.90	9.86	7.17
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	5.92	4.10	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	9	0.05	4.00	2053.00	1.31	5.19	4.00
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	51.03	29.00	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	173	0.92	4.00	2053.00	33.22	15.61	6.56
Artiodactyla	*Dama_dama*	3721	17285	18825	3	0.02	4.00	2053.00	45.27	29.38	10.67
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	43.02	15.88	0.00
Artiodactyla	*Dama_dama*	3721	17285	18825	12949	68.79	4.00	2053.00	158.20	30.61	8.75
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	8.40	3.76	1.16
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	240.24	15.15	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	0.86	3.58	6.00
Artiodactyla	*Dama_dama*	3721	17285	18825	10	0.05	4.00	2053.00	16.14	19.24	6.40
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	20.49	6.55	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	14.53	18.35	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	13	0.07	4.00	2053.00	3.14	1.93	3.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	12.00	25.36	6.00
Artiodactyla	*Dama_dama*	3721	17285	18825	96	0.51	4.00	2053.00	59.17	23.22	7.71
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	126.50	14.88	2.81
Artiodactyla	*Dama_dama*	3721	17285	18825	4	0.02	4.00	2053.00	53.35	17.13	8.29
Artiodactyla	*Dama_dama*	3721	17285	18825	69	0.37	4.00	2053.00	55.15	28.92	6.99

Artiodactyla	*Dama_dama*	3721	17285	18825	5	0.03	4.00	2053.00	92.05	20.09	5.26
Artiodactyla	*Dama_dama*	3721	17285	18825	16	0.08	4.00	2053.00	68.36	47.95	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	2	0.01	4.00	2053.00	38.50	30.77	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	5	0.03	4.00	2053.00	88.27	22.47	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	20	0.11	4.00	2053.00	139.37	34.70	9.60
Artiodactyla	*Dama_dama*	3721	17285	18825	6	0.03	4.00	2053.00	16.11	40.53	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	137	0.73	4.00	2053.00	43.14	23.78	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	9	0.05	4.00	2053.00	110.24	19.30	8.00
Artiodactyla	*Dama_dama*	3721	17285	18825	208	1.10	4.00	2053.00	150.32	45.78	7.28
Eulipotyphla	*Erinaceus_europaeus*	148	12	149	1	0.67	3.00	51512.00	566.25	19.44	8.00
Rodentia	*Eutamias_sibiricus*	38	10	41	2	4.88	3.00	215806.00	109.91	23.07	12.00
Rodentia	*Eutamias_sibiricus*	38	10	41	1	2.44	3.00	215806.00	171.92	21.83	8.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	7.10	37.41	0.33
Carnivora	*Herpestes_auropunctatus*	122	146	217	1	0.46	1.00	31161.00	13.22	31.45	0.33
Carnivora	*Herpestes_auropunctatus*	122	146	217	12	5.53	1.00	31161.00	23.21	37.26	7.00
Carnivora	*Herpestes_auropunctatus*	122	146	217	78	35.94	1.00	31161.00	54.09	26.31	6.92
Carnivora	*Herpestes_auropunctatus*	122	146	217	2	0.92	1.00	31161.00	6.95	31.61	8.00
Artiodactyla	*Hydropotes_inermis*	486	444	626	12	1.92	3.00	1743.00	1105.68	36.65	8.67
Artiodactyla	*Hydropotes_inermis*	486	444	626	81	12.94	3.00	1743.00	273.82	40.48	9.38
Artiodactyla	*Hydropotes_inermis*	486	444	626	34	5.43	3.00	1743.00	2337.42	29.06	9.76
Artiodactyla	*Hydropotes_inermis*	486	444	626	12	1.92	3.00	1743.00	316.56	39.43	9.33
Artiodactyla	*Hydropotes_inermis*	486	444	626	1	0.16	3.00	1743.00	191.26	48.62	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	4.69	22.02	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	1	0.03	1.00	133306.00	8.89	20.33	4.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	15	0.41	1.00	133306.00	88.51	41.75	8.00
Lagomorpha	*Lepus_europaeus*	3394	688	3682	250	6.79	1.00	133306.00	55.18	37.14	8.38
Lagomorpha	*Lepus_granatensis*	109	23	111	1	0.90	1.00	5590.00	235.04	54.81	8.00
Lagomorpha	*Lepus_granatensis*	109	23	111	1	0.90	1.00	5590.00	942.07	39.17	8.00
Rodentia	*Marmota_bobak*	372	275	385	1	0.26	2.00	10077.00	37.89	41.42	8.00
Rodentia	*Marmota_bobak*	372	275	385	12	3.12	2.00	10077.00	19.24	32.02	2.70
Rodentia	*Marmota_marmota*	355	80	362	3	0.83	2.00	2187.00	10.95	12.80	8.00
Rodentia	*Marmota_marmota*	355	80	362	1	0.28	2.00	2187.00	44.88	4.27	8.00
Rodentia	*Marmota_marmota*	355	80	362	1	0.28	2.00	2187.00	21.32	18.02	8.00

Rodentia	*Marmota_marmota*	355	80	362	2	0.55	2.00	2187.00	3.05	19.37	8.00
Carnivora	*Mustela_putorius*	641	102	656	1	0.15	2.00	80073.00	23.85	41.55	8.00
Carnivora	*Mustela_putorius*	641	102	656	7	1.07	2.00	80073.00	54.50	36.13	10.29
Carnivora	*Mustela_putorius*	641	102	656	5	0.76	2.00	80073.00	19.20	38.65	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	102	0.62	1.00	38364.00	109.21	30.24	9.10
Rodentia	*Myocastor_coypus*	15894	2474	16519	74	0.45	1.00	38364.00	41.83	27.11	8.16
Rodentia	*Myocastor_coypus*	15894	2474	16519	14	0.08	1.00	38364.00	76.89	43.14	8.86
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	4.03	9.16	2.18
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	44.57	16.77	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	42.91	11.66	10.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	174.52	14.95	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	61.42	52.82	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	218	1.32	1.00	38364.00	69.85	49.06	7.19
Rodentia	*Myocastor_coypus*	15894	2474	16519	33	0.20	1.00	38364.00	47.71	12.90	7.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	5.39	30.67	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	14.29	30.53	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	176.93	25.48	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	1.93	9.64	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	109.23	41.86	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	70.65	39.98	5.49
Rodentia	*Myocastor_coypus*	15894	2474	16519	16	0.10	1.00	38364.00	32.53	31.51	5.26
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	2.74	28.74	0.85
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	750.36	47.50	16.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	2	0.01	1.00	38364.00	89.72	49.97	2.24
Rodentia	*Myocastor_coypus*	15894	2474	16519	32	0.19	1.00	38364.00	56.32	25.41	7.63
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	60.38	55.76	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	4	0.02	1.00	38364.00	24.12	41.97	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	61	0.37	1.00	38364.00	39.66	45.50	7.52
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	6.71	51.29	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	84.17	35.91	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	0.93	45.79	4.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	25.63	18.65	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	7	0.04	1.00	38364.00	46.50	10.95	6.86

Rodentia	*Myocastor_coypus*	15894	2474	16519	8	0.05	1.00	38364.00	16.42	13.79	7.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	1	0.01	1.00	38364.00	6.19	28.06	8.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	8	0.05	1.00	38364.00	220.19	52.82	9.00
Rodentia	*Myocastor_coypus*	15894	2474	16519	3	0.02	1.00	38364.00	1336.65	43.21	5.33
Carnivora	*Neovison_vison*	62290	12313	63184	166	0.26	2.00	194822.00	0.00	2.70	1.62
Carnivora	*Neovison_vison*	62290	12313	63184	7	0.01	2.00	194822.00	22.68	28.58	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	42.65	49.78	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	57	0.09	2.00	194822.00	160.75	38.00	9.26
Carnivora	*Neovison_vison*	62290	12313	63184	5	0.01	2.00	194822.00	15.52	34.94	9.60
Carnivora	*Neovison_vison*	62290	12313	63184	176	0.28	2.00	194822.00	128.74	33.20	9.43
Carnivora	*Neovison_vison*	62290	12313	63184	59	0.09	2.00	194822.00	161.86	25.66	9.08
Carnivora	*Neovison_vison*	62290	12313	63184	143	0.23	2.00	194822.00	324.64	39.59	9.45
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	23.86	34.05	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	21.30	27.35	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	10	0.02	2.00	194822.00	17.29	28.72	6.80
Carnivora	*Neovison_vison*	62290	12313	63184	34	0.05	2.00	194822.00	21.36	32.37	8.82
Carnivora	*Neovison_vison*	62290	12313	63184	13	0.02	2.00	194822.00	12.43	20.39	8.92
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	13.47	46.95	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	65.19	10.75	16.00
Carnivora	*Neovison_vison*	62290	12313	63184	23	0.04	2.00	194822.00	42.44	42.59	9.74
Carnivora	*Neovison_vison*	62290	12313	63184	22	0.03	2.00	194822.00	28.02	21.23	8.36
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	12.79	24.82	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	15	0.02	2.00	194822.00	39.24	20.70	9.60
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	99.68	9.38	10.67
Carnivora	*Neovison_vison*	62290	12313	63184	3	0.00	2.00	194822.00	6.10	3.84	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	98.21	3.16	8.47
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	24.72	16.80	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	13.86	15.49	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	8	0.01	2.00	194822.00	13.19	8.83	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	62	0.10	2.00	194822.00	19.34	19.68	7.56
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	4.59	50.71	4.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	2.66	32.66	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	1	0.00	2.00	194822.00	3.67	33.24	8.00

Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	1.91	32.89	0.59
Carnivora	*Neovison_vison*	62290	12313	63184	2	0.00	2.00	194822.00	11.52	38.62	8.00
Carnivora	*Neovison_vison*	62290	12313	63184	27	0.04	2.00	194822.00	142.36	25.24	8.89
Carnivora	*Neovison_vison*	62290	12313	63184	40	0.06	2.00	194822.00	47.30	11.06	7.03
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	4.61	23.29	2.73
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	0.77	2.21	0.76
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	2.83	5.66	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	0.00	3.44	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	2	0.09	1.00	149345.00	164.08	22.68	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	1	0.05	1.00	149345.00	78.76	24.15	8.00
Artiodactyla	*Odocoileus_virginianus*	2062	583	2143	71	3.31	1.00	149345.00	2.93	5.28	7.51
Rodentia	*Ondatra_zibethicus*	74463	637	74476	1	0.00	2.00	476299.00	109.95	19.39	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	1	0.00	2.00	476299.00	42.50	49.33	8.00
Rodentia	*Ondatra_zibethicus*	74463	637	74476	8	0.01	2.00	476299.00	29.85	46.51	4.50
Rodentia	*Ondatra_zibethicus*	74463	637	74476	3	0.00	2.00	476299.00	23.35	50.77	4.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	5.16	23.98	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	3	0.05	3.00	6734.00	45.80	31.01	0.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	159	2.57	3.00	6734.00	278.98	40.40	9.58
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	23	0.37	3.00	6734.00	286.74	32.95	9.74
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1060	17.16	3.00	6734.00	299.15	25.80	9.43
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	1	0.02	3.00	6734.00	3.83	33.36	4.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	5	0.08	3.00	6734.00	6.17	33.41	8.00
Lagomorpha	*Oryctolagus_cuniculus*	4912	1570	6178	6	0.10	3.00	6734.00	36.35	43.27	8.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	3	0.32	1.00	46223.00	1.26	0.00	2.89
Artiodactyla	*Ovibos_moschatus*	584	730	941	4	0.43	1.00	46223.00	0.81	0.02	5.36
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	1.00	0.00	2.73
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	3.15	0.00	8.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	3	0.32	1.00	46223.00	1.23	0.02	1.65
Artiodactyla	*Ovibos_moschatus*	584	730	941	2	0.21	1.00	46223.00	1.64	1.91	1.16
Artiodactyla	*Ovibos_moschatus*	584	730	941	2	0.21	1.00	46223.00	2.31	0.42	8.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	2.63	0.43	4.00
Artiodactyla	*Ovibos_moschatus*	584	730	941	260	27.63	1.00	46223.00	2.07	0.07	3.52
Artiodactyla	*Ovibos_moschatus*	584	730	941	38	4.04	1.00	46223.00	2.16	0.15	6.93

Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	1.34	0.00	0.85
Artiodactyla	*Ovibos_moschatus*	584	730	941	1	0.11	1.00	46223.00	11.56	0.00	1.63
Artiodactyla	*Ovibos_moschatus*	584	730	941	35	3.72	1.00	46223.00	2.91	0.21	2.99
Carnivora	*Procyon_lotor*	14535	386	14604	39	0.27	3.00	123973.00	65.20	34.54	8.41
Carnivora	*Procyon_lotor*	14535	386	14604	30	0.21	3.00	123973.00	281.80	23.20	8.67
Artiodactyla	*Rangifer_tarandus*	251	958	1039	1	0.10	1.00	347681.00	0.00	8.30	0.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	8	0.77	1.00	347681.00	0.00	7.43	1.07
Artiodactyla	*Rangifer_tarandus*	251	958	1039	1	0.10	1.00	347681.00	2.13	6.58	4.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	2	0.19	1.00	347681.00	0.00	7.79	8.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	4	0.38	1.00	347681.00	0.50	15.57	2.68
Artiodactyla	*Rangifer_tarandus*	251	958	1039	3	0.29	1.00	347681.00	0.00	0.00	0.00
Artiodactyla	*Rangifer_tarandus*	251	958	1039	92	8.85	1.00	347681.00	0.00	0.00	0.04
Artiodactyla	*Rangifer_tarandus*	251	958	1039	626	60.25	1.00	347681.00	0.50	7.49	2.90
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	10	6.80	1.00	2362.00	154.99	33.37	11.20
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	2	1.36	1.00	2362.00	44.76	28.86	8.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	25	17.01	1.00	2362.00	142.73	26.78	9.60
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	21	14.29	1.00	2362.00	19.80	14.85	8.38
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	1	0.68	1.00	2362.00	4.49	13.05	4.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	10	6.80	1.00	2362.00	14.68	9.77	8.00
Artiodactyla	*Rupicapra_rupicapra*	64	122	147	14	9.52	1.00	2362.00	352.60	31.73	10.29
Rodentia	*Sciurus_carolinensis*	796	91	868	10	1.15	2.00	43312.00	989.99	30.04	10.40
Rodentia	*Sciurus_carolinensis*	796	91	868	14	1.61	2.00	43312.00	92.73	40.61	6.31
Rodentia	*Sciurus_carolinensis*	796	91	868	13	1.50	2.00	43312.00	594.73	35.47	8.92
Rodentia	*Sciurus_carolinensis*	796	91	868	6	0.69	2.00	43312.00	583.15	41.04	9.33
Rodentia	*Sciurus_carolinensis*	796	91	868	15	1.73	2.00	43312.00	383.53	44.65	9.60
Rodentia	*Sciurus_carolinensis*	796	91	868	6	0.69	2.00	43312.00	3648.69	10.37	12.00
Rodentia	*Sciurus_carolinensis*	796	91	868	2	0.23	2.00	43312.00	3385.91	14.93	16.00
Rodentia	*Sciurus_carolinensis*	796	91	868	6	0.69	2.00	43312.00	142.10	49.17	10.67

Section	Subsection	Element	Value
Overview	Authorship	Study title	Patterns and drivers of range filling of alien mammals in Europe
		Author names	Lisa Tedeschi, Bernd Lenzner, Anna Schertler, Johannes Wessely, Dino Biancolini, César Capinha, Beatrice Melone, Carmen Soria, Franz Essl, Carlo Rondinini
		Contact	lias.tedeschi@uniroma1.it
		Study link	Will be first submitted to Global Change Biology
	Model objective	Model objective	Inference and explanation
	Focal Taxon	Focal Taxon	Mammals aliens to Europe
	Location	Location	Europe, global (training regions for SDMs)
	Scale of Analysis	Spatial extent	-160, 160, -90, 90 (xmin, xmax, ymin, ymax)
		Spatial resolution	10
		Temporal extent	Climate: 1981-2010, occurrence data: 1980-2022
		Temporal resolution	
		Boundary	political
	Biodiversity data	Observation type	GBIF
		Response data type	presence/pseudo-absences
	Predictors	Predictor types	climatic
	Hypotheses	Hypotheses	Climatic variables recognized to influence mammals' spatial distribution
	Assumptions	Model assumptions	Equilibrium
	Algorithms	Modelling techniques	glm; mars; brt; ann; fda; randomForest
		Model complexity	Balance different algorithms' performances
		Model averaging	Ensemble modeling based on the TSS of each model
	Workflow	Model workflow	Framework: i) presences were downloaded from GBIF, then cleaned, aggregated, and thinned at 50 x 50 km resolution; ii) global bioclimatic variables were downloaded from Chelsa V2.1 (Karger et al. 2017, 2018), and aggregated (using the mean) to a 10 x 10 km resolution, and we selected only bioclimatic variables with a correlation < |0.7|; iii) pseudo-absences (PAs) were sampled by accounting for major geographical dispersal barriers (Guisan et al. 2014), as well as sampling bias,

			adopting a target-group approach (Phillips et al. 2009, Ranc et al. 2017, Chapman et al. 2019, Pedruzzi et al. 2022) and sampling five replicates of PAs outside the species' range, where we drew as many PAs as presences, but a minimum of 100 (Barbet-Massin et al. 2012); iv) we applied an ensemble modeling approach and used six algorithms from biomod2 v. 3.3-7.1 (Thuiller et al. 2019); v) we split species' occurrences in 80% (model calibration) and 20% (model evaluation; Guisan et al. 2017); vi) single model performance of the six algorithms was assessed with TSS; vii) we used a threshold of > 0.7 (Guisan et al. 2017) for single models to be included in ensemble modeling; viii) we obtained binary outputs of climatic suitability.
	Software	Software	Modeling platforms: R version 4.0.3 and 4.2.2 (R Core Team 2023), GRASS GIS version 7.8.7 (GRASS Development Team 2020). R packages used: *CoordinateCleaner* v. 2.0-20 (Zizka et al. 2019), *spThin* v. 0.2.0 (Aiello-Lammens et al. 2015), *sdmpredictors* v. 0.2.14 (Bosch & Fernandez 2022), *raster* v. 3.6-14 (Hijmans 2023a), *terra* v. 1.7-3 (Hijmans 2023b), *biomod2* v. 3.3-7.1 (Thuiller et al. 2019).
		Code availability	Available from the corresponding author on reasonable request (will be uploaded on a repository)
		Data availability	Available from the corresponding author on reasonable request
Data	Biodiversity data	Taxon names	Initially, 71 species of established alien mammals in Europe: *Ammotragus lervia, Apodemus sylvaticus, Atelerix algirus, Atlantoxerus getulus, Axis axis, Callosciurus erythraeus, Callosciurus finlaysonii, Capra aegagrus, Capra ibex, Capreolus capreolus, Capreolus pygargus, Castor canadensis, Cervus canadensis, Cervus elaphus, Cervus nippon, Crocidura pachyura, Crocidura russula, Crocidura suaveolens, Dama dama, Desmana moschata, Eliomys quercinus, Erinaceus europaeus, Erinaceus roumanicus, Eutamias sibiricus, Gazella subgutturosa, Genetta genetta, Glis glis, Herpestes auropunctatus, Hydropotes inermis, Hystrix cristata, Lama glama, Lepus capensis, Lepus corsicanus, Lepus europaeus, Lepus granatensis, Lepus timidus, Macaca sylvanus, Macropus rufogriseus, Marmota bobak, Marmota marmota, Martes foina, Martes martes, Meles meles, Micromys minutus, Microtus arvalis, Microtus levis, Muntiacus reevesi, Mus spretus, Mustela erminea, Mustela nivalis, Mustela putorius, Myocastor coypus, Myodes glareolus, Nasua nasua, Neovison vison, Nyctereutes procyonoides, Odocoileus virginianus, Ondatra zibethicus, Oryctolagus cuniculus, Ovibos moschatus, Ovis orientalis, Procyon lotor, Rangifer tarandus, Rupicapra rupicapra, Sciurus anomalus, Sciurus carolinensis, Sciurus vulgaris, Suncus etruscus, Sylvilagus floridanus, Vulpes lagopus, Vulpes vulpes*
		Taxonomic reference system	PHYLACINE: doi:10.5281/zenodo.3690867
		Ecological level	species
		Data sources	Data from 4125 datasets collected through Global Biodiversity Information Facility (GBIF): https://doi.org/10.15468/dl.m24wws

		Sampling design	Varies according to species (e.g., opportunistic, volunteer-based recording schemes, atlases)
		Sample size	Varies according to species. After thinning at 50x50km:
		Clipping	
		Scaling	Spatial aggregation (at a 10 x 10 km resolution), spatial intersection analysis (using species' native and alien ranges and the aggregated point data) to remove points in the upper 1% quantile of distances from any polygon distribution, spatial thinning (50 x 50 km resolution).
		Cleaning	We removed i) points with a coordinate precision smaller than 0.01 (but retained points with missing coordinate precision), ii) points with coordinate uncertainty larger than 10 km and with a large default value (i.e., 9999 m), iii) points with latitude or longitude equal to zero, iv) country, capital, and zoo centroids in a radius within two km, v) points in the seas (Waller 2021), and vi) duplicated points (i.e., with the same locality).
		Absence data	No absence data used
		Background data	Pseudo-absences (PAs) were sampled by accounting for major geographical dispersal barriers (Guisan et al. 2014), as well as sampling bias (Phillips et al. 2009). We defined the continent(s) where a species occurs as accessible region(s). To account for sampling bias in our presence data, we adopted a target group approach (Phillips et al. 2009, Ranc et al. 2017, Chapman et al. 2019, Pedruzzi et al. 2022). We sampled PAs with a probability based on the estimates on the completeness of digitally accessible information for mammals from Meyer et al. (2015), assuming that this reflects the sampling bias for the study species (Chapman et al. 2019) and can be used as a probability surface (a 'biasfile'). Five replicates of PAs were sampled outside the species' range, where we drew as many PAs as presences, but a minimum of 100 (Barbet-Massin et al. 2012).
		Errors and biases	To minimize the risk of including incorrect species' observations, a spatial intersection analysis was performed to discard the farthest (from native or alien range) 1% of occurrences.
	Predictor variables	Predictor variables	bio1 (mean annual air temperature), bio3 (isothermality), bio4 (temperature seasonality), bio15 (precipitation seasonality), bio16 (mean monthly precipitation amount of the wettest quarter), and bio17 (mean monthly precipitation amount of the driest quarter).
		Data sources	Chelsa V2.1 (Karger et al. 2017, 2018) https://doi.org/10.1038/sdata.2017.122 http://dx.doi.org/doi:10.5061/dryad.kd1d4
		Spatial extent	-160, 160, -90, 90 (xmin, xmax, ymin, ymax)
		Spatial resolution	1 km
		Coordinate reference system	EPSG:4326

		Temporal extent	1981-2010
		Temporal resolution	NA
		Data processing	First, we manually set the scale and offset for the variables, first multiplying the raster values with the 'scale' value and then adding the 'offset' value (following CHELSA V2.1: Technical specification, 2021) in R software. Then we resampled at a coarser resolution (10 x 10 km) through *r.resamp.stats* function in GRASS GIS software.
		Errors and biases	NA
		Dimension reduction	NA
	Transfer data	Spatial extent	-160, 160, -90, 90 (xmin, xmax, ymin, ymax)
		Spatial resolution	10km
		Temporal extent	1981-2010
		Temporal resolution	NA
Model	Variable pre-selection	Variable pre-selection	Among climatic variables with a correlation < |0.7|, we selected those recognized to have an importance for mammals at a global scale (based on Visconti et al. 2016)
	Multicollinearity	Multicollinearity	We checked for collinearity between variables using the Pearson correlation coefficient in *sdmpredictors* v. 0.2.14 (Bosch & Fernandez 2022) and selected bioclimatic variables with a correlation <|0.7| (Dormann et al. 2013; Table S5) that are usually considered important for SDMs at a global scale (Visconti et al. 2016)
	Model settings	Model settings (fitting)	glm: family (binomial(link = "logit")), notes (default settings of biomod2), type (quadratic), interaction.level (0), mustart (0.5), test (AIC); mars: penalty (2), nk (NULL), thresh (0.001), pmethod ("backward"), notes (default settings of biomod2), type (simple), interaction.level (0); brt: distribution ("bernoulli"), nTrees (2500), interactionDepth (7), shrinkage (0.001), bagFraction (0.5), trainFraction (1), notes (default settings of biomod2), n.minobsinnode (5), cv.folds (3), perf.method ("cv"), n.cores (1); ann: size (NULL), decay (NULL), NbCV (5), rang (0.1), maxit (200); fda: method ("mars"); randomForest: ntree (500), mtry ("default"), maxnodes (NULL), notes (default settings of biomod2), nodesize (5)
	Model estimates	Coefficients	NA
		Parameter uncertainty	NA

		Variable importance	Three permutations were done for each variable to estimate variable importance.
	Model selection - model averaging - ensembles	Model selection	NA
		Model averaging	NA
		Model ensembles	TSS > 0.7
	Analysis and Correction of non-independence	Spatial autocorrelation	NA
		Temporal autocorrelation	NA
		Nested data	No nested data
Assessment	Performance statistics	Performance on training data	TSS
	Plausibility check	Response shapes	

Chapter IV: Supplementary material

Supplementary methods

Table S1: Summary of the criteria used by IUCN to classify species as Vulnerable (VU), Endangered (EN), Critically Endangered (CR), or Extinct in the wild (EW).

Category	Criteria
Vulnerable (VU)	A species is considered VU, EN, or CR when the best available evidence indicates that it meets any of the criteria A to E for, respectively, the categories VU, EN, or CR, and it is therefore considered to be facing a high risk of extinction in the wild.
Endangered (EN)	
Critically Endangered (CR)	
Extinct in the Wild (EW)	A species is EW when it is known only to survive in captivity or as an alien, and it is presumed to be EW when exhaustive surveys in known and/or expected habitat, at appropriate times, throughout its historic range have failed to record any specimens.

Taxonomy

In our study we followed the taxonomy provided by IUCN (IUCN 2023). When comparing the list of native threatened mammals (IUCN 2023) to the list of alien mammals (Biancolini et al. 2021) we found the following inconsistencies. Nine species (of genus Macropus, Microtus, and Myodes, plus the mouflon) were reclassified recently, and the taxonomy of DAMA is different from the taxonomy of IUCN. However, all of those species are LC or NT, and therefore are in any case excluded from our study. Three species (water buffalo, camel, and llama) are present in DAMA, but IUCN does not assess them (nor map their distribution) as they are considered domestic species and are therefore excluded from our study. Lastly, one species (arctic fox) does not have distribution data in IUCN, but it's assessed as LC and is excluded from our study.

Table S2: Taxonomic species' names used in IUCN, in DAMA, common names, and reason to not include the species in our study.

IUCN Taxonomy	DAMA Taxonomy	Common name	Rationale for exclusion from the study
NA	*Bubalus bubalis*	Water buffalo	*Bubalus arnee* is the wild water buffalo, while *Bubalus bubalis* is not present in IUCN because it's the domestic form.
NA	*Camelus dromedarius*	Camel	Domesticated, thus not present in IUCN.
NA	*Lama glama*	Llama	Domesticated, thus not present in IUCN.

IUCN Taxonomy	DAMA Taxonomy	Common name	Rationale for exclusion from the study
Notamacropus agilis	*Macropus agilis*	Agile wallaby	Classified as LC in IUCN.
Notamacropus eugenii	*Macropus eugenii*	Tammar wallaby	Classified as LC in IUCN.
Notamacropus parma	*Macropus parma*	Parma wallaby	Classified as NT in IUCN.
Notamacropus rufogriseus	*Macropus rufogriseus*	Red-necked wallaby	Classified as LC in IUCN.
Microtus mystacinus	*Microtus levis*	East European vole	Classified as LC in IUCN.
Clethrionomys gapperi	*Myodes gapperi*	Southern Red-backed vole	Classified as LC in IUCN.
Clethrionomys glareolus	*Myodes glareolus*	Bank vole	Classified as LC in IUCN.
Clethrionomys rutilus	*Myodes rutilus*	Northern Red-backed vole	Classified as LC in IUCN.
Ovig gmelini	*Ovis orientalis*	Mouflon	Classified as NT in IUCN.
Vulpes lagopus	*Vulpes lagopus*	Arctic fox	Distribution range not mapped, but species classified as LC in IUCN.

Hierarchical structure of threats and conservation measures

IUCN provides a hierarchical structure of causes of threats and applied conservation measures composed by three levels, and assessors are asked to indicate the threats/conservation measures that triggered the listing of the species at the lowest level possible (IUCN 2016). The adoption of a level can be interpreted as a measure of accuracy in the assessment Assessors make of the threats/conservation measures to the species. The more certain information they have, the more likely they chose a lower (i.e., more specific) hierarchical level. Here, we aggregate all threats and conservation measures at lower levels to the corresponding highest level (Level 1).

The hierarchical structure of threat types includes 12 major threats: 1) Residential & commercial development, 2) Agriculture & aquaculture, 3) Energy production & mining, 4) Transportation & service corridors, 5) Biological resource use, 6) Human intrusions & disturbance, 7) Natural system modifications, 8) Invasive & other problematic species, genes & diseases, 9) Pollution, 10) Geological event, 11) Climate change & severe weather, and 12) Other options (IUCN 2022a). Those major threats are further divided in sub-categories, for instance 2) Agriculture & Aquaculture is divided into 2.1.) Annual & perennial non-timber crops, 2.2.) Wood & pulp plantations, etc. (IUCN 2022a). These are divided again into other sub-categories, for example 2.1.) Annual & perennial non-timber crops are further divided into 2.1.1.) Shifting agriculture, 2.1.2.) Small-holder farming, and so on

(IUCN 2022a). For simplicity, we refer to "Level 1 threats", "Level 2 threats", and "Level 3 threats" throughout.

Among the Level 1 threat category 8) Invasive & other problematic species, genes & diseases, we retained the following Level 2 and Level 3 threats: invasive non-native/alien species/diseases, introduced genetic material, problematic species/diseases of unknown origin, and diseases of unknown cause. We assumed a species/disease of unknown origin or cause to be introduced.

Table S3: Example of hierarchical structure used by IUCN. In our study, we describe only the highest level (Level 1), and we aggregate all threats at lower levels to the corresponding highest level.

Variable	Level 1	Level 2	Level 3
Habitat	1. Forest & Woodland	1.1. Boreal forest	
		1.2. Subarctic forest	
		…	
	2. Savanna	2.1. Dry savanna	
		2.2. Moist savanna	
	3. Shrubland	3.1. Subarctic shrubland	
		3.2. Subantarctic shrubland	
		…	
	…	…	
Threats	1. Residential & commercial development	1.1. Housing & urban areas	
		…	
	2. Agriculture & aquaculture	2.1. Annual & perennial non-timber crops	2.1.1. Shifting agriculture
			2.1.2. Small-holder farming
			…
	…	…	…
Conservation measures	1. Land/water protection	1.1. Site/area protection	
		1.2. Resource & habitat protection	
	2. Land/water management	2.1. Site/area protection	
		…	
	3. Species management	3.1. Species management	3.1.1. Harvest management
			3.1.2. Trade management
			…
	…	…	…

IUCN Red List re-assessments

The IUCN Red List categorization process should also be applied to wild subpopulations resulting from introductions outside the natural range (also termed benign introductions or translocations), if all of the following conditions are met (IUCN 2022b):

(a) The known or likely intent of the introduction was to reduce the extinction risk of the taxon being introduced.

(b) The introduced subpopulation is geographically close to the natural range of the taxon. What is considered to be geographically close enough is determined by the assessor.

(c) The introduced subpopulation has produced viable offspring (i.e., offspring that have reached maturity or are likely to do so).

(d) At least five years have passed since the introduction.

Moreover, those criteria should be applied as well to established (i.e., self-sustaining) translocated or re-introduced subpopulations (within the taxon's natural range), regardless of the original goal of such translocations or re-introductions (IUCN 2022b).

Supplementary results

Table S4: The 53 alien mammals threatened in their native ranges we first identified. Order, family, scientific name, and IUCN threat category are given. Species not included in the study (because they were introduced only for conservation purposes and are included in Red List assessments) are marked with an asterisk (*).

Order	Family	Scientific name	Common name	Category
Carnivora	Mustelidae	*Mustela lutreola*	European Mink	CR
Artiodactyla	Bovidae	*Ammotragus lervia*	Aoudad	VU
		*Beatragus hunteri**	Hirola	CR
		Bos javanicus	Banteng	EN
		Cephalophus adersi	Aders' Duiker	VU
		Gazella subgutturosa	Goitered Gazelle	VU
		Nanger soemmerringii	Soemmerring's Gazelle	VU
		Tragelaphus derbianus	Giant Eland	VU
	Cervidae	*Axis porcinus*	Hog Deer	EN
		Hydropotes inermis	Chinese Water Deer	VU
		Rangifer tarandus	Reindeer	VU
		Rusa marianna	Philippine Deer	VU
		Rusa timorensis	Javan Deer	VU
		Rusa unicolor	Sambar Deer	VU
	Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	VU
	Suidae	*Babyrousa babyrussa*	Babirusa	VU
	Tragulidae	*Tragulus nigricans*	Balabac Mouse Deer	EN
Dasyuromorphia	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	EN
		*Parantechinus apicalis**	Dibbler	EN

Order	Family	Scientific name	Common name	Category
Dasyuromorphia	Dasyuridae	*Sarcophilus harrisii*	Tasmanian Devil	EN
Diprotodontia	Macropodidae	*Dendrolagus matschiei*	Huon Tree-Kangaroo	EN
		*Lagorchestes hirsutus**	Rufous Hare Wallaby	VU
		*Lagostrophus fasciatus**	Banded Hare Wallaby	VU
		*Petrogale lateralis**	Pearson Island Rock-Wallaby	VU
		Petrogale penicillata	Brush-Tailed Rock Wallaby	VU
		*Petrogale persephone**	Proserpine Rock Wallaby	EN
		Thylogale browni	New Guinea Pademelon	VU
		Thylogale brunii	Dusky Pademelon	VU
	Phascolarctidae	*Phascolarctos cinereus*	Koala	VU
	Potoroidae	*Bettongia penicillata*	Woylie	CR
		*Potorous gilbertii**	Gilbert's Potoroo	CR
Eulipotyphla	Talpidae	*Desmana moschata*	Russian Desman	CR
Lagomorpha	Leporidae	*Lepus corsicanus*	Corsican Hare	VU
		Oryctolagus cuniculus	European Rabbit	EN
Pholidota	Manidae	*Manis culionensis*	Philippine Pangolin	CR
Primates	Callitrichidae	*Saguinus Oedipus*	Cotton-Top Tamarins	CR
	Cercopithecidae	*Macaca arctoides*	Stump-Tailed Macaque	VU
		Macaca fascicularis	Nicobar Crab-eating Macaque	EN
		Macaca leonina	Northern Pig-Tailed Macaque	VU
		Macaca nemestrina	Southern Pig-tailed Macaque	EN
		Macaca nigra	Celebes Crested Macaque	CR
		Macaca sylvanus	Barbary Ape	EN
		*Piliocolobus kirkii**	Zanzibar Red Colobus	EN
		Trachypithecus auratus	Javan Lutung	VU
	Daubentoniidae	*Daubentonia madagascariensis**	Aye-aye	EN
	Lemuridae	*Eulemur albifrons*	White-Fronted Lemur	VU
		Eulemur fulvus	Brown Lemur	VU
		Eulemur mongoz	Mongoose Lemur	CR
		*Varecia variegata**	Black-and-white Ruffed Lemur	CR
Proboscidea	Elephantidae	*Elephas maximus*	Asian Elephant	EN
Rodentia	Capromyidae	*Geocapromys ingrahami**	Bahaman Hutia	VU

Order	Family	Scientific name	Common name	Category
Rodentia	Dasyproctidae	*Dasyprocta mexicana*	Mexican Black Agouti	CR
	Muridae	*Pseudomys fieldi**	Djoongari	VU

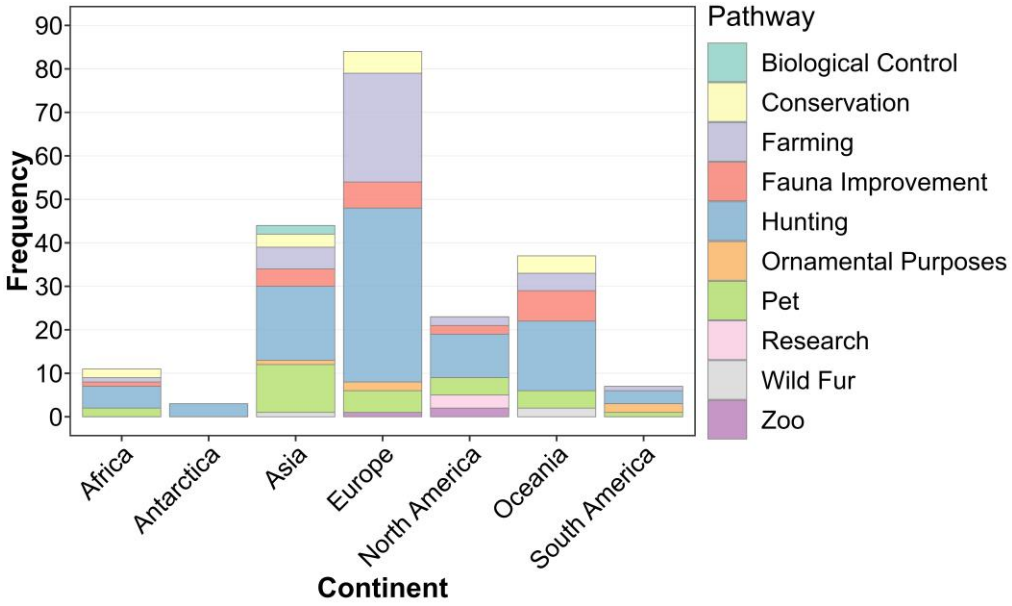

Figure S1: Pathways of introduction of alien threatened mammals (n = 41 species). The same species could have been introduced to the same continent through different pathways, and vice versa (i.e., the same species could have been introduced through the same pathway into different continents).

Additional figures description

In Figure 4 of the main text, shortened IUCN Level 1 threats are indicated as follow: Residential & commercial development: "Residential development", Transportation & service corridors: "Transportation & corridors", Invasive & other problematic species, genes & diseases: "IAS, genes & diseases".

In Figure 5 of the main text, shortened IUCN Level 1 conservation measures are indicated as follow: Livelihood, economic & other incentives: "Livelihood, economic & incentives".

Considering alien populations in global extinction risk assessments

CRITICALLY ENDANGERED

Mustela lutreola

There is an introduced population for conservation purposes on Kuril Islands (Russian Federation), which is not included in Red List assessment (Maran et al. 2016). A pers.comm of 2014 available in the assessment tells that population is not established. Kisleyko et al. (2021) found 36 occurrences of *M. lutreola* on Kuril Islands from 2014 to 2021. As, in comparison, *M. lutreola* has high numbers in the native range, even adding those few individuals present on Kuril Islands the assessment likely would not change. We do not estimate a change in IUCN Red List Category.

Bettongia penicillata

Introduced for conservation purposes, but it is unclear from Red List assessments if the species is included (Woinarski & Burbidge 2016a). Low reintroduction success rate, but no useful assessment information on the status of the three populations on the South Eastern islands (Australia) indicated in DAMA (Biancolini et al. 2021). Probably those populations are declining as well (as the native ones on the mainland). We do not estimate a change in IUCN Red List Category.

Desmana moschata

There is no information available (Rutovskaya et al. 2023). We do not estimate a change in IUCN Red List Category.

Manis culionensis

Contrasting evidence for presence of the species on Balabac Island (Philippines; Schoppe et al. 2019). Introduced and present on Apuli Island (Philippines), but no information on population trend is available (Schoppe et al. 2019; Biancolini et al. 2021). In any case, the surface of Apuli Island is likely too small to sustain an adequate number of individuals. We do not estimate a change in IUCN Red List Category.

Eulemur mongoz

Given that the population on the Comoros Islands is probably larger (Razafindramanana et al. 2020) and less at risk than the one in Madagascar, including the alien population would lower the classification to at least EN if not

VU. One would need to know the population trend on the Comoros Islands. We do not estimate a change in IUCN Red List Category.

Macaca nigra

The alien population on Bacan Island (2800 km^2; Indonesia) is not included in the IUCN RL assessment (Lee et al. 2020). It's not a reintroduction/translocation for conservation purposes (Biancolini et al. 2021), and the population likely undergoes fewer human pressures (e.g., hunting) compared to the native range, and it has high numbers (Hilser et al. 2013). There were 100,000 individuals in the late 1990s. Considering the number of introduced individuals, the IUCN categorization of the species would certainly diminish. Adding also Bacan Island's area to *M. nigra* Extent Of Occurrence (EOO), it would pass the threshold of 100km^2 (required to be categorized as CR under criterion B1). With information on the population trend in the native range, the categorization could shift even more. We estimate a change in IUCN Red List Category to EN.

Saguinus oedipus

The introduced population in Colombia is still present, but it is not considered in the IUCN RL assessment (Rodríguez et al. 2021). Probably nothing would change as the locations are very small and there is no information on the numbers of individuals. We do not estimate a change in IUCN Red List Category.

Dasyprocta mexicana

Assessed as CR in 2008 (Vázquez et al. 2008), reported as being invasive in Western Cuba (Borroto-Páez & Mancina 2017). If the species is classified as invasive, it must have enough individuals to produce negative impacts, and the population must still be growing or at least be stable. Thus, the classification could shift to EN, VU, or even NT. We estimate a change in IUCN Red List Category to EN.

ENDANGERED

Axis porcinus

The introduced populations (several, scattered across Australia, Andamane and Nicobare Islands, possibly Sri Lanka; Biancolini et al. 2021) are not included in the assessment (Timmins et al. 2015a), but as they are declining, it is likely that the

inclusion wouldn't change the assessment. We do not estimate a change in IUCN Red List Category.

Bos javanicus

The IUCN RL assessment indicates 4000-8000 wild native reproductive individuals, but Garik Gunak Barlu National Park (Australia) population (one of the several introduced populations of the species) alone has 6000 total individuals (Gardner et al. 2016). The Australian population is thriving and genetically it's composed by wild individuals (Gardner et al. 2016), and it's highly likely that it's not experiencing the same pressures as of the native populations. Therefore, if the Australian population would be considered in the assessment, the species would likely have a lower threat category. We estimate a change in IUCN Red List Category to VU.

Tragulus nigricans

Only 21 individuals have been reported to be present on Calauit Island (Philippines; Widmann 2015). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Dasyurus hallucatus

Introduced for conservation purposes (Biancolini et al. 2021) but not included in Red List assessment (Oakwood et al. 2016). Introduced on two Australian islands so small that it is likely irrelevant. We do not estimate a change in IUCN Red List Category.

Sarcophilus harrisii

Introduced for conservation purposes (Biancolini et al. 2021), but the assessment is very old (2008; Hawkins et al. 2008) and it seems to not include the introduced populations. It was introduced on Maria Island (Australia), but the island is too small, and the introduced population is likely in semi-captivity. We do not estimate a change in IUCN Red List Category.

Dendrolagus matschiei

Population estimates of 2500 mature individuals, EOO 14000 km^2 (Ziembicki & Porolak 2016). Adding the introduced populations of Umboi Island (930 km^2;

Papua New Guinea) and the Western part of New Britain Island (more than 1000 km²; Papua New Guinea) wouldn't allow to pass the 20000km² threshold required to shift from EN to VU. The number of mature individuals would be higher than 2500 (which could cause a shift to VU). But precise population trends are difficult to obtain for this species. We do not estimate a change in IUCN Red List Category.

Oryctolagus cuniculus

There are so many introduced populations scattered globally (Biancolini et al. 2021) that of course including them would shift the categorization to LC. Several of those populations are invasive and causing environmental and socio-economic negative impacts (Villafuerte & Delibes-Mateos 2019). Some introduced populations that are not invasive could be safeguarded as "safety populations". We estimate a change in IUCN Red List Category to LC.

Macaca fascicularis

Even after removing the pre-historical introductions (several across Indonesia), the areas where the introduced populations are present are small and scattered (Biancolini et al. 2021, Hansen et al. 2022). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Macaca nemestrina

Some of the introduced populations in DAMA (e.g., Singapore; Biancolini et al. 2021) are not established/viable (Ruppert et al. 2022). Very small areas scattered across the globe (from Indonesia to Cuba) remain (Biancolini et al. 2021). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Macaca sylvanus

The alien population in Gibraltar is very small (300 individuals) so it is likely irrelevant (Wallis et al. 2020). But the alien population is stable and could be valuable in the future. We do not estimate a change in IUCN Red List Category.

Elephas maximus

The species is considered native (genetic evidence; Williams et al. 2020) in the alien range indicated in DAMA (Borneo Island; Malesia, Indonesia, Brunei; Biancolini

et al. 2021), therefore the available information does not allow a complete re-assessment. We do not estimate a change in IUCN Red List Category.

VULNERABLE

Ammotragus lervia

As it is assessed with criterion C1 (Cassinello et al. 2022), considering also the alien populations (especially the Spanish one and North American one) probably could shift the category to NT or even LC, as the mature individuals would be more than 10,000 and likely not decreasing (as some of those are invasive populations that could be stable or increasing). We estimate a change in IUCN Red List Category to NT.

Babyrousa babirussa

Prehistoric introduction on Buru Island (Indonesia) already included in the IUCN RL assessment (Macdonald et al. 2008). We do not estimate a change in IUCN Red List Category.

Cephalophus adersi

Introduced only on two very small islands in Madagascar (5 individuals introduced in one of them; IUCN SSC Antelope Specialist Group 2017a, Biancolini et al. 2021). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Gazella subgutturosa

Introduced for conservation purposes (Biancolini et al. 2021), it seems the alien population is already included in the assessment (IUCN SSC Antelope Specialist Group 2017b). Wide native distribution, introduced on two very small islands (in the Middle East) too small to make a difference. Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Hippopotamus amphibius

Too few individuals in the introduced range (Colombia; Lewison & Pluháček 2017, Biancolini et al. 2021). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Hydropotes inermis

The introduced population (United Kingdom; Biancolini et al. 2021) occupies an extended area, and the population numbers are relatively good (Harris & Duckworth 2015). It could potentially be a good addition, and especially it likely doesn't have the same pressures (poaching and habitat destruction) that the species has in the native range. We estimate a change in IUCN Red List Category to NT.

Nanger soemmerringii

The introduced population on Dahlak Kebir and Norah Islands (Eritrea) is the bigger one (IUCN SSC Antelope Specialist Group 2016). Without considering it, the species would be EN or CR. From the IUCN RL assessment it is not clear if the introduction has conservation purposes (in that case, it could be included in the assessment; IUCN SSC Antelope Specialist Group 2016). We do not estimate a change in IUCN Red List Category.

Rangifer tarandus

Wide native distribution with many individuals (Gunn 2016), introduced populations (small islands scattered across the globe; Biancolini et al. 2021) too small to make a difference. Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Rusa marianna

There is no information available (MacKinnon et al. 2015). We do not estimate a change in IUCN Red List Category.

Rusa timorensis

Assessed as VU because there are less than 10,000 wild native mature individuals (Hedges et al. 2015). The introduced populations in several areas of the world have high numbers (120,000 in New Caledonia, 60,000 in Mauritius, etc; Hedges et al. 2015). Several populations are invasive and are causing negative impacts (Hedges

et al. 2015). Some introduced populations that are not invasive could be safeguarded as "safety populations". We estimate a change in IUCN Red List Category to LC.

Rusa unicolor

Introduced populations in several areas of the world (Biancolini et al. 2021). Several populations are invasive and are causing negative impacts (Timmins et al. 2015b). Some introduced populations that are not invasive could be safeguarded as "safety populations". We estimate a change in IUCN Red List Category to LC.

Tragelaphus derbianus

Without knowing the population trend in the introduced population (Cuba), it is not possible to estimate if and of how much the IUCN RL assessment would change (IUCN SSC Antelope Specialist Group 2017c). We do not estimate a change in IUCN Red List Category.

Petrogale penicillata

Introduced only on two very small islands (Hawaii and New Zealand; Woinarski & Burbidge 2016b, Biancolini et al. 2021). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Thylogale browni

The introduced population is very close geographically to the native population (Leary et al. 2016a). Probably if the species is declining due to hunting on the mainland (Papua New Guinea), it will also be declining in the introduced population. However, nothing is known about EOO/AOO and population numbers, so we cannot assume that the rate of population decline is different between the native and alien populations. We do not estimate a change in IUCN Red List Category.

Thylogale brunii

Introduced only on one very small island (Kai Kecil Island; Indonesia; Leary et al. 2016b). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Phascolarctos cinereus

The species has been introduced to various Australian islands and mainland Australia, and some populations are invasive and thus likely to have stable or positive population trends (Woinarski & Burbidge 2020). But it is not clear from the assessment whether these populations are included or not. Moreover, in the "In-place species management" section of the IUCN RL assessment, it is marked "Successfully reintroduced or introduced benignly: Yes" (Woinarzi & Burbridge 2020). We do not estimate a change in IUCN Red List Category.

Lepus corsicanus

In the main part of the introduced range (Corse Island; France) the species appears to be increasing, but detailed information on population trends or threats is missing (Randi & Riga 2019). We do not estimate a change in IUCN Red List Category.

Eulemur albifrons

Introduced to Nosy Mangabe (Madagascar) for conservation purposes according to DAMA (Biancolini et al. 2021) and Red List assessment (Borgerson et al. 2020), but in the Red List map it is shown as native. It seems anyways that the alien population is included in the assessment (Borgerson et al. 2020). However, the island is likely too small to make a difference. We do not estimate a change in IUCN Red List Category.

Eulemur fulvus

Possibly the introduced one (Mayotte Island, France) is a hybrid population (Irwin & King 2020). We do not estimate a change in IUCN Red List Category.

Macaca arctoides

DAMA refers to an invasive population in Cuba in 2017 (Biancolini et al. 2021). In the IUCN RL assessment (dated 2020), the species is results to be introduced to Hong Kong (Chetry et al. 2020). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Macaca leonina

There are populations of *M. leonina* and *M. nemestrina* found on either side of the distribution limits in the Isthmus of Kra (Asia), but many of these populations are the result of release by humans (Boonratana et al. 2022). Likely irrelevant. We do not estimate a change in IUCN Red List Category.

Trachypithecus auratus

The introduced population on Lombok Island (Indonesia) is considered of uncertain origin in the IUCN RL assessment (Nijman 2021), but it is present in the geographic range part. The island is very small, and the introduction is likely irrelevant. We do not estimate a change in IUCN Red List Category.

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