The EICAT assessment of the environmental impacts of alien mammal species in Italy

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Abstract:
Biological invasions by alien species have increased worldwide as a consequence of globalisation and the growing connectivity among regions. In Italy, alien mammalian species account for more than 10% of the country's mammal fauna, highlighting their ecological relevance in the Mediterranean region. To assess the environmental impact of these species, we conducted a comprehensive review of the scientific literature documenting their effects on native biodiversity in Italy. All impact records were systematically assessed using the EICAT framework, allowing a standardised classification of both impact mechanism and magnitude. Competition, Grazing/herbivory/browsing, and Predation emerged as the most frequently reported impact mechanisms, with most records assigned to the lower impact categories (Minimal Concern and Minor). Nevertheless, some alien mammals, notably Procyon lotor and Sciurus carolinensis, were reported to exert severe impacts on native taxa at the population level, posing significant challenges for biodiversity conservation and invasive species management. Despite the limited availability of impact data for several species, our study provides the first comprehensive synthesis of the documented environmental impacts of alien mammals in Italy. Integrating national evidence with information from European and global assessments can improve risk assessment and help identify potential impacts before they are documented in Italy. For poorly studied or localised species, adopting a precautionary approach may prevent delays in management actions and reduce future impacts on native biodiversity.

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Abstract

Biological invasions by alien species have increased worldwide as a consequence of globalisation and the growing connectivity among regions. In Italy, alien mammalian species account for more than 10% of the country's mammal fauna, highlighting their ecological relevance in the Mediterranean region. To assess the environmental impact of these species, we conducted a comprehensive review of the scientific literature documenting their effects on native biodiversity in Italy. All impact records were systematically assessed using the EICAT framework, allowing a standardised classification of both impact mechanism and magnitude. Competition, Grazing/herbivory/browsing, and Predation emerged as the most frequently reported impact mechanisms, with most records assigned to the lower impact categories (Minimal Concern and Minor). Nevertheless, some alien mammals, notably *Procyon lotor* and *Sciurus carolinensis*, were reported to exert severe impacts on native taxa at the population level, posing significant challenges for biodiversity conservation and invasive species management. Despite the limited availability of impact data for several species, our study provides the first comprehensive synthesis of the documented environmental impacts of alien mammals in Italy. Integrating national evidence with information from European and global assessments can improve risk assessment and help identify potential impacts before they are documented in Italy. For poorly studied or localised species, adopting a precautionary approach may prevent delays in management actions and reduce future impacts on native biodiversity.

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Introduction

Human activities, particularly global trade and international mobility, have profoundly altered biogeographical barriers, facilitating the introduction of alien species into non-native regions at an unprecedented rate (Seebens et al., 2017; Pyšek et al., 2020). Alien species – defined as species intentionally or unintentionally introduced by humans into areas where they did not evolve and to which they could not have dispersed naturally (Essl et al., 2018) – have been introduced beyond their native ranges since ancient times (Seebens et al., 2021). According to the IPBES report (2023), over 37,000 alien species are currently established worldwide, with establishment rates remaining high globally.

Among them, mammals are widely recognised as one of the most impactful groups, due to their substantial effects on biodiversity, ecosystem functioning, and human well-being (Vilà et al., 2010; Genovesi et al., 2012; Capizzi et al., 2018). In Europe, several alien mammal species are currently expanding their geographic ranges, a process that is further facilitated by human-mediated translocations (Genovesi et al., 2012; Polaina et al., 2020). Fortunately, only a small proportion of introduced species become established and subsequently invasive. Once introduced, alien mammals typically exhibit high ecological plasticity, generalist feeding behaviour, and high reproductive potential. These traits facilitate their successful establishment and spread across a wide range of habitats (Capellini et al., 2015; Tedeschi et al., 2022), often resulting in significant ecological impacts on native communities and ecosystem functioning (Haubrock et al., 2025).

To systematically assess and compare these impacts, the Environmental Impact Classification for Alien Taxa (EICAT), officially adopted by the IUCN (IUCN, 2020), provides a standardised framework for assessing the environmental impacts of alien species across taxa and geographic regions.

EICAT categorises impacts according to their magnitude, mechanism, and confidence level, based on evidence from the scientific literature, and evaluates whether effects occur at the level of individuals, populations, or species (Hawkins et al., 2015; Kumschick et al., 2020). The EICAT framework has been successfully applied to assess the environmental impacts of several taxonomic groups of alien species, including birds (Evans et al., 2016), amphibians (Kumschick et al., 2017), and plants (Quaglini et al., 2025), and is increasingly used to support evidence-based management and conservation decisions (Kumschick et al., 2024).

Assessing the impact of alien species can provide valuable information for biodiversity conservation and management, particularly in high biodiversity regions, where alien species may exert severe ecological impacts (Li et al., 2016). In this context, Italy is recognised as a biodiversity hotspot (Rondinini et al., 2014), hosting approximately 700 vertebrate species (Rondinini et al., 2022). At the same time, Italy harbours a considerable number of alien taxa (Gherardi et al., 2008; Nocita et al., 2017; Razzetti et al., 2025), increasing the potential for negative interactions with native biodiversity. The most recent atlas of Italian mammals (Loy et al., 2025) includes 20 alien species and one cryptogenic species of uncertain origin (i.e., the crested porcupine, *Hystrix cristata*) among 121 terrestrial and 19 marine mammal species recorded in the country. Consequently, alien mammals account for approximately 15% of the total Italian mammal fauna and about 17% of terrestrial mammal species.

Given the scale and potential impacts of biological invasions in Europe, including countries such as Italy, the European Union adopted a dedicated regulation for the prevention and management of the introduction and spread of invasive alien species (EU Regulation 1143/2014). This regulation establishes a set of restrictions (e.g. release into the environment and placing on the market) and obligations (e.g. monitoring, eradication, control) for species included in the List of Invasive Alien Species of Union Concern (the

Union list). The list is regularly updated and currently includes 114 species, of which 16 are mammals. Nine of these mammal species are already present in Italy.

Despite the number and ecological relevance of alien mammals in Italy, information on their impact on biodiversity remains limited. Available data are fragmented across numerous publications, many of which focus on a single species (e.g., Bertolino et al., 2014; Cerri et al., 2017; Mori and Mazza, 2019) or a small subset of species (e.g., Mori et al., 2019). In this context, our study aimed to provide a comprehensive assessment of the environmental impacts of alien mammals in Italy using the EICAT protocol, reporting both the ecological mechanisms involved and the corresponding impact magnitude. We expected the available literature to be biased toward a limited number of alien species and anticipated that the ecological impacts would reflect both research efforts (e.g., the availability of dietary studies) and the ecological characteristics of the species considered.

Materials and Methods

Data collection

We compiled a list of mammal species introduced to Italy and currently established in the country, based on the most recent annotated checklist (Loy et al., 2019) and the Atlas of Mammals in Italy (Loy et al., 2025). A subsequent literature review led us to include two additional species: the Wapiti (*Cervus canadensis*; Mattioli et al., 2001; Brook et al., 2018), whose historical presence in Italy resulted in introgression with native Red deer (*C. elaphus*), although the persistence of these genetic traces remains to be confirmed, and the muskrat (*Ondatra zibethicus*), whose current occurrence in Italy remains uncertain. Data on the environmental impacts of the assessed species in Italy were collected through an extensive systematic literature review (for details, see Supp. Mat. 1). For each species, impacts reported in each data source (i.e.,

scientific articles, book chapters, and technical reports) were extracted and assigned to one of the 12 impact mechanisms defined by the EICAT classification (IUCN, 2020): Competition, Predation, Hybridisation, Transmission of disease to native species, Parasitism, Poisoning/Toxicity, Bio-fouling or other physical disturbance, Grazing/Herbivory/Browsing, Chemical impact on ecosystems, Physical impact on ecosystems, Structural impact on ecosystems, Indirect impacts through interaction with other species. Each impact was assigned to one of five magnitude categories (Tab. 1): Minimal concern (MC), Minor (MN), Moderate (MO), Major (MR), or Massive (MV). In addition, a confidence level ("low", "medium", or "high") was assigned to reflect the degree of certainty associated with the impact classification (IUCN 2020).
In the EICAT framework, population size is measured exclusively in terms of the number of mature individuals (IUCN 2020). In this study, for ground-nesting birds on islands, we classified rat predation on eggs and chicks as either a reduction of the reproductive performance of mature individuals or, when adequately documented, a decline of the population inferred by the decrease in breeding success. In fact, such predation is ecologically significant because it can severely reduce reproductive success and, over time, affect the number of breeding pairs and population dynamics (e.g., Capizzi et al., 2016).
To better assess the potential ecological impacts of the target species, we complemented the review process with information on species-specific impact mechanisms and their corresponding magnitude retrieved from the IPBES database (Bacher et al., 2024), considering two spatial scales. First, we examined impacts reported in Europe (excluding Italy), and subsequently those reported from regions outside Europe.
When no relevant information was available in the IPBES database, we provided illustrative examples from other scientific studies that had been assessed using the EICAT framework (Supp. Mat. 2).

Results

We compiled a list of 23 alien mammal species reported in Italy, belonging to 5 orders and 13 families (Tab. 2). Most species belong to the order Rodentia (10 species; 43.5%), followed by Cetartiodactyla (5; 21.7%) and Carnivora (4; 17.4%) (Tab. 2). Eleven species are currently widespread in Italy. Eight species can still be regarded as localised, as their populations remain limited in distribution and show limited expansion. Four species are considered not established, having been recorded only from a few individuals, with the current status of *O. zibethicus* and *C. canadensis* remaining uncertain. One widespread species (*H. cristata*) has an uncertain origin in Italy. However, recent studies have questioned its native status, suggesting that the species was introduced during historical times (Trucchi and Sbordoni, 2009; Trucchi et al., 2016).

A total of 501 data sources were retrieved through the systematic review of scientific literature. Following screening based on the presence of a clear description of environmental impacts, 62 articles (12.4%) and two technical reports (0.4%) were retained for further analysis. From these sources, 76 individual impact records were extracted, corresponding to an average of 1.2±0.7 impact records per data source (Supp. Mat. 3).

Recorded impacts were assigned to 8 out of 12 EICAT impact categories: Competition (N=18, 23.7%), Predation (N=15, 19.7%), Hybridisation (N=2, 2.6%), Transmission of disease (N=8, 10.5%), Grazing/herbivory/browsing (N=29, 38.2%), Physical disturbance (N=2, 2.6%), Chemical impact on ecosystem (N=1, 1.3%), Indirect impacts through interactions with other species (N=1, 1.3%); (Fig. 1). The frequency of impacts differed significantly among impact mechanisms ($\chi^2 = 78.105$, df = 7, $p < 0.001$).

Considering the magnitude of the impacts, most records were classified as Minor (MN; N=36, 47.4%), followed by Minimal Concern (MC; N=26, 34.2%), and Moderate (MO; N=12, 15.8%). Only two impacts (2.6%) were classified as

Major (MR) (Fig. 2), while no impacts were assigned to the Massive (MV) category. The distribution of impact magnitudes differed significantly among categories (χ^2= 35.579, df = 3, $p < 0.001$).

Impacts retrieved through the review of the Italian literature were recorded for 15 mammal species (65.2% of the assessed species) belonging to 4 orders and 9 families, primarily Rodentia (N=8 species; 53.3%) and Cetartiodactyla (N=4; 26.6%) (Tab. 3). The mean number of impact records per species among those with documented impacts was 5.1±4.2, with *Sciurus carolinensis* (14 records; 18.4%), *H. cristata* (13; 17.1%), *Dama dama* (11; 14.5%), and *Rattus rattus* (6; 7.9%) being the most represented. For the remaining species, impacts were recorded less frequently, and no impacts were identified for 8 species (34.8%), which were consequently classified as Data Deficient (DD).

At the species level, *H. cristata*, *S. carolinensis*, and *Sylvilagus floridanus* exhibited the greatest diversity of impact mechanisms, with impacts recorded in three distinct EICAT categories each (Tab. 3). The highest impact magnitude (MR) was recorded for two species (Fig. 3): *Procyon lotor* through Predation and *S. carolinensis* through Competition. Moderate (MO) was the highest impact category recorded for *Callosciurus erythraeus* (Competition), *C. canadensis* (Transmission of disease), *D. dama* (Competition), *Myocastor coypus* (Grazing/Herbivory/Browsing), *R. rattus* (Predation), and *S. floridanus* (Indirect impacts through interactions with other species).

The IPBES database (Bacher et al., 2024) contained 282 impact records associated with the mammal species introduced in Italy and considered in this study (n. of species = 23; Tab. 3). Of these, 71 (25.2%) were reported from Europe outside Italy. Among them, 22 involved ecological mechanisms not reported in Italy or were assigned a higher impact magnitude than that documented at the national scale. The remaining 211 impacts (74.8%) were reported from regions outside Europe (Tab. 3). Among these, 27 involved ecological mechanisms not recorded in Italy or exhibited higher impact magnitude than those reported for the country.

Discussion

We compiled information on 23 alien mammal species introduced to Italy, including species that are currently established, species recently recorded whose establishment status remains uncertain, and species introduced in the past whose current presence in the country is unclear. Overall, these taxa account for 18.7% of Italy's terrestrial mammalian fauna (121 species from Loy et al., 2019 and the two additional species *C. canadensis* and *O. zibethicus*). This value is comparable to the proportion of alien mammals reported for Europe (28.5%) when considering only terrestrial species, including cryptogenic taxa (Genovesi et al., 2012). The presence of these non-native mammals results from a combination of intentional releases, human-mediated transport and accidental escapes from captivity. The history of mammal introductions in Italy reflects broader European patterns, whereby species have been translocated both within and across biogeographical regions over the past centuries (Tedeschi et al., 2022). *H. cristata* is currently considered a cryptogenic species because unequivocal evidence of its introduction to Italy is lacking. However, recent studies have questioned its native status, supporting the hypothesis of a historical human-mediated introduction. In this regard, the earliest Holocene fossil remains currently available have been dated to approximately 560–720 CE (Masseti et al., 2010; Loy et al., 2019). This relatively recent chronological evidence is consistent with a possible introduction during the early medieval period.

Four of the assessed species (*C. canadensis, Genetta genetta*, *Nyctereutes procyonoides* and *O. zibethicus*) are considered not established in Italy, as there is no evidence of recent reproduction and only sporadic records are available. Individuals of *N. procyonoides* have been recorded in north-eastern

Italy, dispersing from Austria and Slovenia, where the species is already established (Lapini, 2006; Loy et al., 2025). *G. genetta* is currently considered not established in Italy, as only a few records were documented in the past (Gaubert et al., 2008). However, recent observations from the westernmost part of Liguria (north-western Italy, province of Imperia), likely reflecting an eastward range expansion from neighbouring France, suggest that this carnivore may become established in Italy in the near future (Mazza and Mori, 2023). *O. zibethicus* entered Italy through natural range expansion from Slovenia (Lapini and Scaravelli, 1994). However, the species has not been recorded in the country for several years, and its current presence remains uncertain. Another case of uncertainty regarding the status of established species is represented by *C. canadensis.* The species was introduced during the nineteenth century into the former royal hunting reserve of La Mandria, a large estate historically used by the House of Savoy for hunting and leisure and currently protected as a regional park (Parco naturale regionale La Mandria, Piedmont Region). In this area, hybridisation with *C. elaphus* and the transmission of the trematode *Fascioloides magna* have been documented (Mattioli et al., 2001; Králová-Hromadová et al., 2011). However, it remains uncertain whether genetic traces of this historical hybridisation persist in the local red deer population. Consequently, it is unclear whether the documented impacts should be regarded as ongoing or merely historical. Nevertheless, we included this species to provide a comprehensive overview of alien mammal introductions in Italy and because any persisting introgression would itself constitute a continuing impact on native red deer populations. All remaining species are currently present in Italy with one or more established populations (Loy et al. 2025).

Despite the availability of information on the ecology, introduction and establishment of alien mammals in Italy (Genovesi et al., 2012; Loy et al., 2019, 2025), their environmental impacts remain poorly investigated. This is reflected in the relatively low number of data sources identified through our systematic review, suggesting that the impacts these species have received limited research attention in the country. Notably, of the 23 species considered here, 8 (34.8%) have not been investigated for their potential environmental impacts in Italy. This pattern is largely explained by the fact that these species have been recorded only from a few individuals and subsequently disappeared (*N. procyonoides*, *O. zibethicus*), remain highly localised (*Ammotragus lervia*, *P. lotor*, *E. sibiricus*), or are recent invaders in Italy (*G. genetta*). For *Crocidura pachyura* and *Lepus capensis*, the lack of impact studies likely reflects both the relatively recent clarification of their taxonomic status and their long-term presence in Italy since ancient introductions (Riga et al., 2001; Contoli et al., 2014; Loy et al., 2019), which has led many authors and practitioners to regard them as effectively native components of the Italian fauna. On the other hand, for several species that have been established in Italy for a longer period, consultation of the IPBES database (Bacher et al., 2024) highlighted numerous impacts reported elsewhere in Europe but not yet documented in Italy (e.g., *A. lervia*, *C. erythraeus*, *D. dama*, *Oryctolagus cuniculus*, and *Ovis aries*). However, it is not possible to disentangle impacts that are genuinely absent in Italy from those that may already be occurring but have not yet been investigated or reported, particularly considering potentially insufficient research effort or the still limited presence of some species within the country. The IPBES database lists an additional 282 impact records worldwide for mammal species occurring in Italy. Of these, 49 impacts involved ecological mechanisms not reported in Italy or were assigned a higher impact magnitude than those documented at the national scale. This finding highlights important knowledge gaps and suggests that the ecological impacts of alien mammals in Italy may be underestimated due to uneven research effort and limited data availability. Furthermore, the IPBES database is not exhaustive. For instance, in the database, we did not retrieve studies on *Neogale vison*, a species widely recognised for its substantial predatory impact on native fauna. For example, Niemczynowicz et al. (2017) documented substantial impacts of this species on ground-nesting birds, showing that mink control increased the breeding success of three wader species, from 10–20% to 70–80%. Significant impacts have also been reported for the Southern water vole *Arvicola sapidus* (García-Díaz et al., 2013) and for populations of the Eurasian water vole *Arvicola amphibius* (Woodroffe et al., 1990), highlighting the species' capacity to cause severe declines in small semi-aquatic mammals. The presence of several *N. vison* populations in Italy (Loy et al., 2025) suggests that similar impacts could potentially occur on populations of the Italian water vole, *Arvicola italicus*, an endemic species (Castiglia et al., 2016). In this context, a study by Mori and Mazza (2019) demonstrated that water voles represent a key prey item for *N. vison* also in Italy, highlighting the plausibility of negative effects on native vole populations.

Regarding the established species, the limited number of their impact assessments may reflect limited monitoring efforts, a low perceived risk associated with some species, or their relatively recent establishment. On the other hand, demonstrating impacts at higher biological scales (e.g., population level) generally requires long-term datasets or studies specifically designed to quantify such effects. In contrast, many available studies focus on diet composition or analyses of spatial overlap, approaches that are often insufficient to detect ecologically significant impacts on native species and populations. However, without targeted studies, it remains difficult to evaluate the ecological effects of alien species and, consequently, to develop evidence-based management strategies aimed at preventing future impacts. Similar knowledge gaps have been reported elsewhere in Europe, where information on the ecological impacts of alien mammals remains fragmented and is often restricted to a few well-studied species (e.g. *S. carolinensis*, Wauters et al., 2023; *N. vison*, Vada et al., 2023). Such uneven research effort may reflect differences in national management priorities, funding availability, and public perception of species impacts. At the continental scale, comprehensive assessments based on standardised frameworks such as EICAT remain relatively scarce, as they are generally conducted as part of broader analyses of alien species impacts (e.g. Volery et al., 2021). Overall, these limitations highlight the need for coordinated research efforts, harmonised monitoring programmes, and data-sharing initiatives to improve the evaluation of alien mammal impacts across Europe.

The predominance of Competition, Grazing/herbivory/browsing, and Predation impacts reflect well-documented ecological interactions between alien mammals and native taxa (Tedeschi et al., 2022). The high number of studies reporting competition interactions highlights the ecological relevance of this process within the Italian context. The two other most frequently reported impact mechanisms, grazing and predation, reflect the prevalence of dietary studies among the data sources included in the assessments. According to the EICAT guidelines (IUCN 2020), low-magnitude impacts (MC and MN) can often be inferred from these studies. At the same time, the high frequency of these mechanisms highlights the capacity of alien mammals to modify local food webs, altering resource use patterns and interspecific interactions (e.g., Amori and Battisti, 2008). For instance, predominantly herbivorous species such as *M. coypus* and *H. cristata* have been reported to consume a wide variety of plant species (Prigioni et al., 2005; Mori et al., 2017), while *P. lotor* exerts notable pressure on native aquatic fauna (Tricarico et al., 2021).

The remaining impact mechanisms were reported less frequently, likely because demonstrating these types of impacts often requires more complex study designs. This pattern is particularly evident for disease-related impacts. Although alien species are well documented as hosts or vectors of pathogens affecting native taxa (Crowl et al., 2008; Chinchio et al., 2020; Najberek et al., 2022; Roy et al., 2023), direct evidence of pathogen transmission and associated impacts on native populations remains difficult to obtain. During data collection, we identified several studies reporting parasites in alien mammal species in Italy (Supp. Mat. 4). However, these studies could not be classified under the EICAT "Transmission of Disease" mechanism, because they lacked direct evidence of transmission to native taxa. Nevertheless, they highlight the potential role of alien mammals as reservoirs of pathogens that may affect both wild animals and humans (e.g., *P. lotor* as a carrier of *Baylisascaris procyonis*; Lombardo et al., 2022).

The highest impact magnitudes were recorded for *P. lotor* and *S. carolinensis*, both included in the Union list. These species are known to cause severe ecological impacts, including local extinctions of native taxa. Documented examples include the White-clawed crayfish (*Austropotamobius pallipes* complex), negatively affected by *P. lotor* (Tricarico et al., 2021), and the Eurasian red squirrel (*Sciurus vulgaris*) locally displaced by *S. carolinensis* through competitive exclusion and disease-mediated interactions (Bertolino et al., 2014; Wauters et al., 2023). Moderate impacts were recorded for competitive interactions between *C. erythraeus* and *S. vulgaris* (Mazzamuto *et al*., 2017), and *D. dama* and Roe deer (*Capreolus capreolus*), particularly in Central Italy (Ferretti et al., 2011). The assessments have also highlighted substantial impacts of *M. coypus* on aquatic vegetation (Bertolino et al., 2005), as well as moderate impacts associated with *S. floridanus* through indirect interactions with native species (Cerri et al., 2017) and chemical effects on ecosystems (Gheza et al., 2018)

The EICAT framework defines predation impacts in relation to reductions in the performance of mature individuals and effects at the population level (IUCN, 2020). However, the link between breeding success and population decline is often difficult to quantify directly. Several sources included in our assessments (e.g., Rannisi et al., 2008) documented severe impacts of *R. rattus* on the eggs and chicks of the Scopoli's shearwater (*Calonectris diomedea*). Like many pelagic birds, this species exhibits a K-selected life history and produces only a single egg per breeding season, making recruitment failure particularly detrimental to population persistence. Although rat predation does not directly remove mature individuals, chronic breeding failure can profoundly affect population dynamics (Ruffino et al., 2009). This is supported by field studies showing that breeding success was virtually null on islands where rats preyed on all nests, whereas following rat eradication it increased markedly and was accompanied by substantial increases in the number of breeding pairs (Baccetti et al., 2009; Ruffino et al., 2009; Capizzi et al., 2019; Gotti et al., 2020). These findings demonstrate that rat predation can severely affect Scopoli's Shearwater populations and highlight the importance of considering impacts on eggs and chicks when assessing the ecological effects of invasive rats on Mediterranean islands.

This review of the impacts of alien mammals in Italy highlights the substantial effects exerted by several invasive species while revealing important knowledge gaps for others. The scarcity or complete absence of impact studies for some taxa limits our ability to assess their ecological roles, quantify their impacts, and prioritise management actions. This issue is particularly relevant for species that are expanding their range and may threaten endemic species (e.g., *N. vison* in Sardinia; Dettori et al., 2016). Consequently, targeted research is needed to improve our understanding of the impacts of understudied species and to support evidence-based management. More generally, the absence of documented impacts should not be interpreted as evidence of negligible effects, as it may simply reflect limited research effort. Integrating information from European and global sources, such as the IPBES database and other relevant literature, can help identify potential impacts not yet documented in Italy and improve risk assessment. For species with localised distributions, adopting a precautionary approach may help prevent delays in management actions, reducing the risk that species become widespread before their impacts are recognised and become more difficult to mitigate.

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EICAT magnitude	Category definitions
Minimal Concern (MC)	Alien taxon causes negligible levels of impact, but no reduction of performance (e.g., growth, reproduction, etc.) of individuals in the native biota.
Minor (MN)	Alien taxon causes reductions in the performance of individuals in native biota but no decline in population sizes.
Moderate (MO)	Alien taxon causes population decline of at least one native taxon, but not a local extinction of the native taxon.
Major (MR)	Alien taxon causes the sub-population extinction (or presumed) of at least one native taxon, but this process is naturally reversible if the alien taxon is no longer present.
Massive (MV)	Alien taxon causes local extinction (or presumed) of at least one native taxon, but this process is no longer reversible, even if the alien taxon is no longer present.

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Order	Family	Species	Status	Introduction	Distribution
Carnivora	Canidae	*Nyctereutes procyonoides**	Not established	Recent	Mainland
	Mustelidae	*Neogale vison**	Widespread	Recent	Mainland and islands
	Procyonidae	*Procyon lotor**	Localised	Recent	Mainland
	Viverridae	*Genetta genetta*	Not established	Recent	Mainland
Cetartiodactyla	Bovidae	*Ammotragus lervia*	Localised	Recent	Mainland
		Ovis aries	Widespread	Ancient	Mainland and islands
	Cervidae	*Cervus canadensis*	Not established	Recent	Mainland
		*Cervus nippon**	Localised	Recent	Mainland
		Dama dama	Widespread	Ancient	Mainland and islands
Eulipotyphla	Soricidae	*Crocidura pachyura*	Localised	Ancient	Islands
Lagomorpha	Leporidae	*Oryctolagus cuniculus*	Widespread	Ancient	Mainland and islands
		Sylvilagus floridanus	Widespread	Recent	Mainland
		Lepus capensis	Localised	Ancient	Islands
Rodentia	Cricetidae	*Ondatra zibethicus**	Not established/Extinct	Recent	Mainland

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	Hystricidae	*Hystrix cristata*	Widespread	Unknown	Mainland and islands
	Echimyidae	*Myocastor coypus**	Widespread	Recent	Mainland and islands
	Muridae	*Mus musculus*	Widespread	Ancient	Mainland and islands
		Rattus norvegicus	Widespread	Recent	Mainland and islands
		Rattus rattus	Widespread	Ancient	Mainland and islands
	Sciuridae	*Callosciurus erythraeus**	Localised	Recent	Mainland
		*Callosciurus finlaysonii**	Widespread	Recent	Mainland
		*Eutamias sibiricus **	Localised	Recent	Mainland
		*Sciurus carolinensis**	Widespread	Recent	Mainland

Table 3

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Species	Competition	Predation	Hybridisation	Disease	Physical disturbance	Grazing	Chemical impact	CPS on ecosystem	Indirect impact	Europe	World
A. lervia	-	-	-	-	-	MO, MN	-	-	-	Grazing (1 MN, 1 MO)	Grazing (1 MN)
C. erythraeus	MN, MO	MN	-	MC	-	MO	-	-	-	Competition (1 MC, 1 MO)	Competition (1 MN); Predation (1 MN); Grazing (4 MO)
C. pachyura	-	-	-	-	-	-	-	-	-	-	-
C. finlaysonii	-	MN	-	-	-	MC, MN	-	-	-	-	-
C. canadensis	-	-	MN	MN, MO	-	-	-	-	-	-	-
C. nippon	MO	-	MN, MR	MN	MO	MO, MN	-	MO	-	Hybridisation (6 MC, 4 MN, 4 MO, 5 MR); Transmission of disease (1 MC, 1 MN); Physical disturbance (1 MN, 1 MO); Grazing (3 MN, 5 MO), CPS (2 MO)	Competition (1 MN, 1 MO); Grazing (1 MN)
D. dama	MC, MC, MC, MC, MO, MO, MO, MO	-	-	-	MN	MC, MC, MC, MO, MO		MO	-	Grazing (2 MN, 4 MO), CPS (4 MO)	Physical disturbance (1 MN); Grazing (7 MN, 1 MO)
E. sibiricus	-	MN	-	-	-	-	-	-	-	Predation (1 MN)	-
H. cristata	-	MN	-	-	MN, MN	MC, MC, MC, MN,	-	-	-	-	-

						MN, MN, MN, MN, MN, MN						
G. genetta	-	MN	-	-	-	MC	-	-	-	-	-	
L. capensis									MN	-	Indirect (1MN)	
M. coypus	-	MO	-	-	-	MN, MN, MN, MO	-	-	-	Predation (1 MO); Grazing (1 MO)	Grazing (3 MC, 4 MN, 1 MO)	
M. domesticus	MR	MN, MN, MR	-	MO	-	MC, MC, MO	-	-	-	Transmission of disease (1 MR)	Competition (1 MO, 2 MR); Predation (5 MC, 5 MN, 7 MN, 4 MR); Grazing (2 MN, 1 MO)	
N. vison	-	MN, MN	-	-	-	MC	-	-	-	-		
N. procyonoides	-	MN	-	-	-	MC	-	-	-			
O. zibethicus	-	MO	-	-	-	MR, MN	-	MC	-	Predation (2 MO); Grazing (2 MN, 2 MO, 1 MR); CPS (1 MC)	Grazing (2 MN)	
O. cuniculus	MR	-	-	-	-	MR	-	MO	MR	-	Competition (1 MN, 4 MO, 1 MR); Grazing (1 MN, 8 MO, 2 MR); CPS (7 MN, 1 MO); Indirect (1 MN, 7 MO, 1 MR)	
O. aries	-	-	-	-	-	MC, MC, MO	-	MO	-	-	Grazing (2 MN, 4 MO); CPS (1 MC, 3 MO)	

P. lotor	MN	MN, MN, MR	-	MN, MN	-	MN	-	-	-	Predation (2 MN); Transmission of disease (1 MN); Grazing (2 MN)	Competition (2 MN); Predation (1 MO); Transmission of disease (1 MN)
R. norvegicus	MR	MN, MN, MR	-	-	-	MC, MO	-	MN	-	Competition (1 MR)	Predation (1 MC, 1 MN, 14 MO, 4 MR); Grazing (1 MN, 4 MO); CPS (1 MN)
R. rattus	MR	MN, MN, MO*, MO*, MR	-	-	-	MC, MC, MR	-	MO	-	Predation (1 MN)	Competition (21 MR); Predation (6 MN, 12 MO, 30 MR); Grazing (1 MC, 4 MN, 2 MO, 2 MR); CPS (1 MN, 1 MO)
S. carolinensis	MC, MC, MC, MN, MN, MN, MO, MR	-	-	MC, MN, MN, MN, MR	-	MC, MN	-	-	-	Competition (1 MC, 1 MN); Transmission of disease (1 MN, 2 MR)	
S. floridanus	MN	-	-	MC	-	-	MO	-	MO	-	Competition (1 MN)

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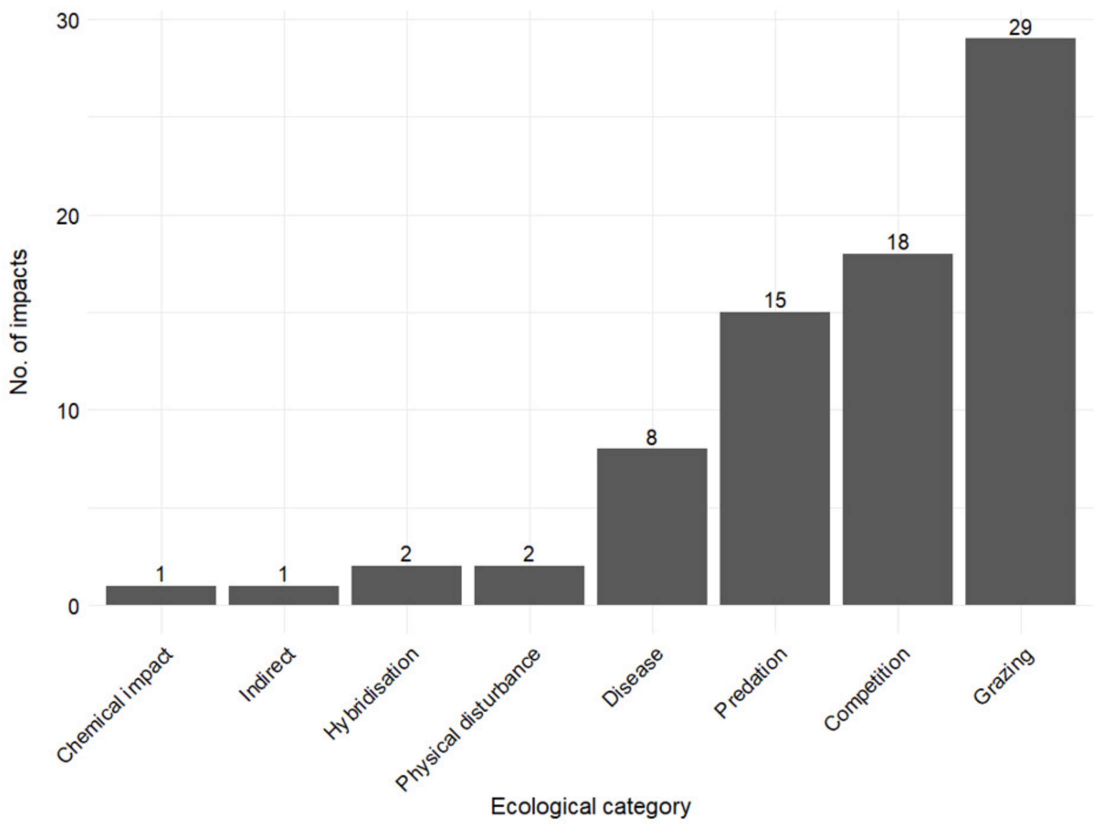

Figure 1 – Categorisation of environmental impacts of alien mammals by mechanism types. Categories follow the EICAT framework.

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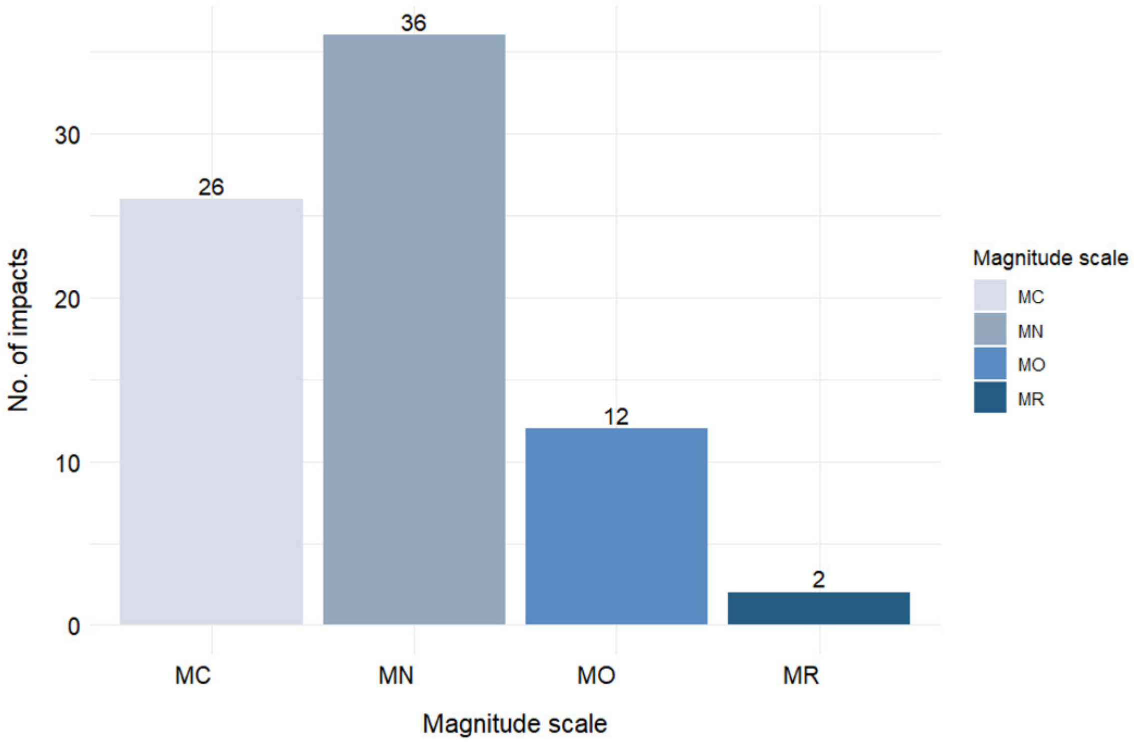

Figure 2 – Categorisation of the environmental impacts of alien mammals according to their severity. Categories follow the EICAT framework: MC, Minimal Concern; MN, Minor; MO, Moderate; MR, Major.

Figure 3 – Number of impacts of each alien mammal across different EICAT categories: MC, Minimal Concern; MN, Minor; MO, Moderate; MR, Major.

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Manuscript body

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Tables

Table 1 - Download source file (14.91 kB)
Table 1 – Definitions of the EICAT magnitude category of impact (from IUCN 2020).

Table 2 - Download source file (18.12 kB)
Table 2 – List of alien mammal species recorded in Italy with their respective orders, families, and status. (*) species included in the Union list (EU Reg. 1143/2014). Localised: species present with one or few, localized populations; Widespread: species present with multiple populations or one large population. Not established: only isolated reproductive events are known, or multiple records are reported in the same area, even without documenting reproductive events. Extinct: a species previously present that is no longer observed. The columns "Introduction" and "Distribution" report, respectively, information on the introduction period (Recent or Ancient, i.e. after or before 1500 AD, following the Italian legislation, Decreto Ministero Ambiente, 19 January 2015) and whether the species occurs in mainland Italy, islands (including Sardinia and Sicily), or both.

Table 3 - Download source file (20.81 kB)
Table 3 – List of impact mechanisms and their magnitude for each species. *Impacts on eggs and chicks are not considered under the EICAT framework. All impacts recorded in Italy are shown in black. For each species and ecological mechanism, impacts reported in the IPBES database (Bacher et al., 2024) are summarised in the last two columns (Europe, excluding Italy, and World, excluding Europe). For each cell, only the highest IPBES impact score was retained (blue for Europe; red for World), and only when it exceeded the corresponding Italian score. The category “Chemical, physical, or structural impacts on ecosystems” (CPS) was grouped into a single impact category, as these impact types are not distinguished in the IPBES database.

Figures

Figure 1 - Download source file (54.4 kB)
Figure 1 – Categorisation of environmental impacts of alien mammals by mechanism types. Categories follow the EICAT framework.

Figure 2 - Download source file (46.26 kB)
Figure 2 – Categorisation of the environmental impacts of alien mammals according to their severity. Categories follow the EICAT framework: MC, Minimal Concern; MN, Minor; MO, Moderate; MR, Major.

Figure 3 - Download source file (133.34 kB)
Figure 3 – Number of impacts of each alien mammal across different EICAT categories: MC, Minimal Concern; MN, Minor; MO, Moderate; MR, Major.

Supplementary Online Material

File 1 - Download source file (18.58 kB)
Supplementary methodology of the literature review process

File 2 - Download source file (16.44 kB)
Examples of other scientific studies assessed using the EICAT framework

File 3 - Download source file (122.85 kB)
EICAT assessments of the environmental impacts of alien mammal species in Italy

File 4 - Download source file (19.38 kB)
Database of the studies reporting diseases and parasites in alien mammal species in Italy, identified during the review of the scientific literature.