

Short Note

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Widespread population of invasive ferrets *Mustela furo* (Carnivora: Mustelidae) on the island of Madeira, Macaronesia

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Abstract: Invasive mammalian predators are arguably the most damaging group of alien animals for global biodiversity and their impacts are particularly damaging in endemic-rich insular ecosystems. Ferrets (*Mustela furo*) are well-known for their potential to establish self-sustaining feral populations. Yet, knowledge about their distribution and trophic interactions is scarce. Here, we provide ample evidence of a well-established and widespread population of ferrets on the subtropical island of Madeira (Portugal). Ferrets are using natural and human-dominated habitats, where they are preying on both native (e.g., Cory's shearwaters (*Calonectris borealis*) and the endemic and IUCN Endangered Zino's petrel (*Pterodroma madeira*)) and non-native vertebrates.

Keywords: *Calonectris borealis*; invasive predators; island conservation; Mustelidae; *Pterodroma madeira*

Invasive species pose a major threat to global biodiversity, particularly in vulnerable island ecosystems where native

species often exhibit a loss of defensive traits and behaviours needed to deal with novel predators (Carthey and Banks 2014; McCreless et al. 2016). Islands hold a disproportionate share of the global terrestrial biodiversity (Kier et al. 2009) and invasive species – in particular invasive mammals – can impact insular biodiversity through predation, competition, disturbance, disease transmission, and facilitation of other introduced species (Doherty et al. 2016; Nogales et al. 1996).

Ferrets (*Mustela furo* Linnaeus, 1758) are domesticated animals derived from the western European polecat (*Mustela putorius*), a mustelid native to western Eurasia and North Africa, and nowadays widespread in the western Palaearctic, ranging from the Atlantic coast of Iberia in the west to the Ural Mountains in Russia in the east (Skumatov et al. 2016). Historically, ferrets were used for hunting rabbits and rodents and nowadays are increasingly popular as pets worldwide (Ferrant et al. 2008; Köbrunner et al. 2020). Escaped individuals have established multiple self-sustaining populations outside their native range, where they are an important threat to native wildlife, in particular to island ground-nesting birds (Bodey et al. 2011; Spatz et al. 2017). Ferrets are less wary and exhibit reduced levels of aggression when compared to their wild ancestor (Kitchener and Birks 2008; Poole 1972), making them vulnerable to predation and competition in areas where other predators and competitors exist. As a result, feral ferrets are typically found on islands where other native mammalian predators are scarce or absent (Kitchener and Birks 2008). Nonetheless, they often co-occur with other non-native mammalian predators such as free-ranging and feral domestic cats and rodents, with whom they interact, often with synergistic impacts on native prey (e.g., Garvey et al. 2021).

On Macaronesia, a biogeographic region that encompasses the archipelagos of Madeira, Selvagens, Azores, the Canary Islands and Cabo Verde, feral ferrets occur on La Palma in the Canary Islands (Medina and Martín 2010) and on Flores, Faial, Pico, São Jorge, Terceira, São Miguel and Santa Maria in the Azores Islands (Lamelas-López et al.

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2020; Lamelas-López and Salgado 2021). In Azores, ferrets have been reported to have a significant impact on native biodiversity, particularly through predation on seabirds (Lamelas-López et al. 2021; Neves et al. 2011). On Madeira Island, feral ferrets are likely to have been present since the 16th century, when they were employed for rabbit hunting, which could have led to the establishment of feral populations through escaped individuals (Medina and Martín 2010; Sarmiento 1936). However, information regarding the species' establishment and distribution on Madeira as well as its impacts on native biodiversity and interaction with other non-native mammals such as rodents and free-ranging cats is lacking.

In this study, we provide evidence of a widespread and established population of ferrets in Madeira and provide the first insights into the trophic interactions of the species on the island. We compiled a total of 52 ferret sightings recorded between 2001 and 2023. Although most records correspond to opportunistic observations of either live or dead individuals (Supplementary Table S1), we also include photographic evidence from a 582 trapping-nights camera trap study first conducted in 2021 (detailed in Soto et al. 2023), and then replicated in 2023. Additionally, we provide a

noteworthy record of a female ferret with her two offspring, which serves as compelling evidence of successful reproduction in the wild.

Our findings indicate that ferrets are present and breeding throughout Madeira, being found across a variety of habitats, ranging from natural old-growth forest (laurissilva) to rural areas. Most records were from sites located within the Madeira Natural Park, the island's largest terrestrial protected area, while only four records were in rural or peri-urban sites (Figures 1 and 2). This suggests that ferrets in Madeira may exhibit a preference for natural habitats, where they seemingly rely on hunting native and non-native fauna to meet their dietary needs. Furthermore, 19 ferret records were from the Ecological Park of Funchal, a peri-urban protected area next to the island's capital, where a recent study estimated the existence of 1.4 free-ranging cats per km² (Soto et al. 2023). Although this does not indicate that both species interact, it provides evidence of co-occurrence, suggesting possible cumulative impacts on native prey.

Ferrets are generalist and opportunistic predators, and they can switch their diet according to the availability of prey (Smith et al. 1995). Studies from other islands indicate

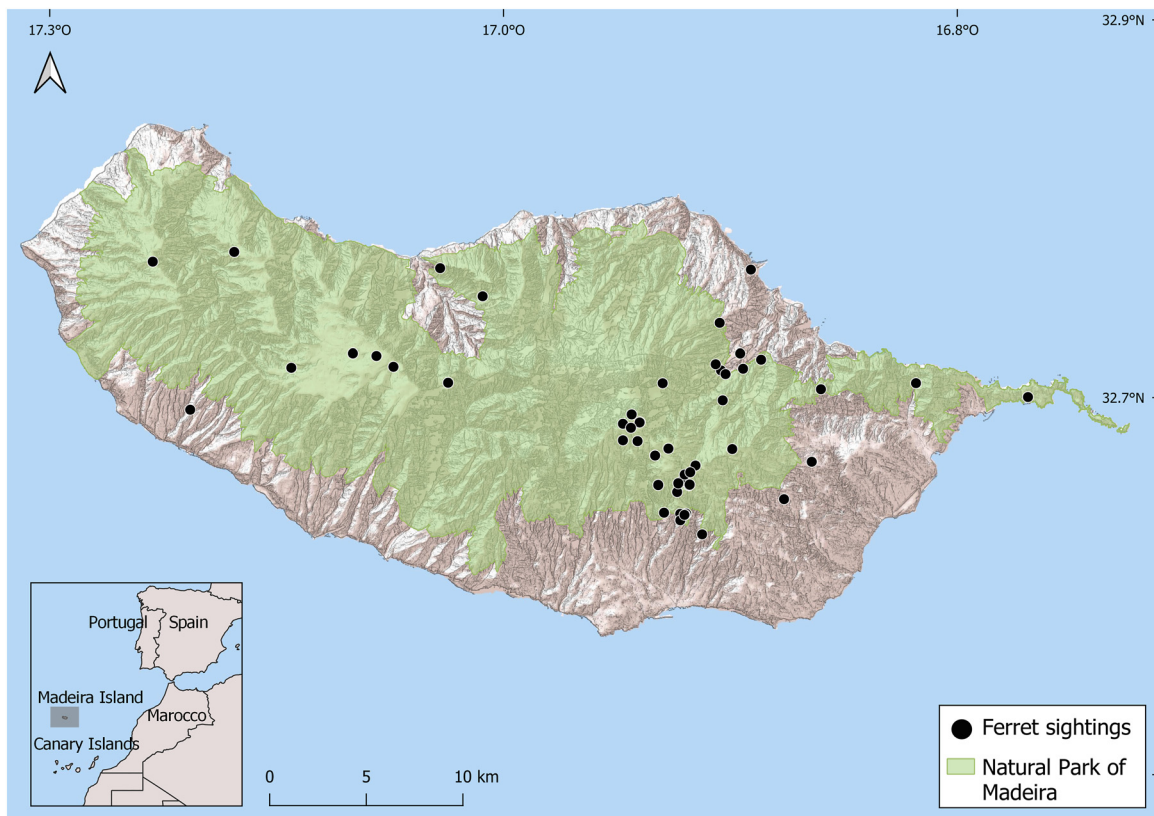


Figure 1: Distribution of the observations of *Mustela furo* in Madeira island, Portugal. Coordinates and year of observation are provided in Supplementary Table S1.



Figure 2: Examples of *Mustela furo* observations in Madeira island. Ferret predation on (A) IUCN endangered Zino's petrel (*Pterodroma madeira*), (B) juvenile of Cory's shearwater (*Calonectris diomedea*) and (C) rodent (*Rattus* spp.). Photos (D) and (E) were captured during camera-trap surveys conducted in 2021 and 2023 in the Ecological Park of Funchal, respectively. Photo (F) depicts a road-killed individual.

that ferrets feed primarily on lagomorphs (Bodey et al. 2011; Clapperton and Byrom 2005), but also prey on other native taxa such as lizards and passerines, as well as non-native mammals such as rodents (Dowding and Murphy 2001; Smith et al. 1995). Based on camera trap data, we detected

two predation events by ferrets on seabirds: specifically, on an adult Zino's Petrel (*Pterodroma madeira*) and on a chick of Cory's Shearwater (*Calonectris diomedea*) (Figure 2A and B), listed respectively as Endangered and Least Concern by the IUCN. Furthermore, we also provide photographic evidence

of ferret predation on non-native rodents (*Rattus* spp.; Figure 2C). Due to their opportunistic nature, ferrets pose a high risk of hyper-predation events that can have an impact on species of conservation concern (Bodey et al. 2011). Accordingly, our findings have important implications for the conservation and management of Madeira's native vertebrates, in particular species with long lifecycles and low reproductive rates such as the narrow-ranged and IUCN Endangered Zino's Petrel.

Ground-nesting seabirds are particularly vulnerable to the impacts of invasive mammalian predators on oceanic islands (Bodey et al. 2011; Dias et al. 2019). Although still poorly understood, the impacts of ferrets on seabird populations are increasingly on the radar of conservation practitioners. On Ireland's Rathlin Island for instance, ferrets have caused a drastic reduction in the local population of Atlantic puffin (*Fratercula arctica*) and gulls (*Larus* spp.), as well as the local extirpation of Manx shearwater (*Puffinus puffinus*) (Bodey et al. 2011). In addition to *Calonectris borealis* and *Pterodroma madeira*, Madeira Island is home to multiple other ground-nesting species of seabirds such as Macaronesian Manx shearwaters (*Puffinus puffinus canariensis*) and Madeiran storm petrels (*Hydrobates castro*) (Meirinho et al. 2014; Rodríguez et al. 2020), which are also likely to be affected by ferrets and other non-native mammalian predators. Additionally, ferrets can prey on multiple other species that play crucial roles on Madeira's ecosystem dynamics such as the endemic Madeira laurel pigeon (*Columba trocaz*), a key seed-dispersal (Oliveira et al. 2002) or the endemic Madeira-wall lizard (*Teira dugesii*), an important arthropod predator and pollinator (Esposito et al. 2021) and a key prey for a wide array of native predators (e.g., the Macaronesian Kestrel (*Falco tinnunculus canariensis*)) (Jesus et al. 2005; Rocha et al. 2010).

Overall, our study provides important information regarding the distribution and ecological interactions of a poorly known invasive carnivore on an endemic-rich oceanic island. Our observations, compiled over the last two decades, indicate that ferrets might constitute an important threat to Madeira's native vertebrates and highlights the need for continued monitoring and control of non-native vertebrates. Given the rising popularity of ferrets as pets, we underscore the importance of increasing public awareness for responsible pet ownership through targeted education campaigns, and we urge authorities to consider banning this species as a pet in oceanic islands, where their impact in native biodiversity is likely to be particularly severe.

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Research ethics: No ethical approval was needed as there was no direct handling of the animals.

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Data availability: Relevant data is presented in the Supplementary Material.

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