



Vulnerability of ground-nesting waterbirds to predation by invasive American mink in the Cape Horn Biosphere Reserve, Chile

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ABSTRACT

Biological invasions constitute one of the most important threats to biodiversity. This is especially true for “naïve” birds that have evolved in the absence of terrestrial predators in island ecosystems. The American mink (*Mustela vison*) has recently established a feral population on Navarino Island (55°S), southern Chile, where it represents a new guild of terrestrial mammal predators. We investigated the impact of mink on ground-nesting coastal waterbirds with the aim of deriving a vulnerability profile for birds as a function of different breeding strategies, habitat, and nest characteristics. We compared rates of nest survival and mink predation on 102 nests of solitary nesting species (*Chloephaga picta*, *Tachyeres pteneres*), on 361 nests of colonial birds (*Larus dominicanus*, *Larus scoresbii*, *Sterna hirundinacea*), and on 558 artificial nests. We calculated relative mink and bird densities at all nest sites. Nests of colonial species showed the highest nest survival probabilities (67–84%) and no predation by mink. Nest survival rates for solitary nesting species were lower (5–20%) and mink predation rates higher (10–44%). Discriminant analyses revealed that mink preyed upon artificial nests mainly at shores with rocky outcroppings where mink were abundant. High nest concealment increased the probability for predation by mink. Conservation planning should consider that invasive mink might severely affect the reproduction success of bird species with the following characteristics: solitary nesting, nesting habitat at rocky outcrop shores, and concealed nests. We recommend that work starts immediately to control the mink population with a priority in the nesting habitats of vulnerable endemic waterbirds.

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1. Introduction

The earth's biota is greatly altered by invasive plant and animal species producing concern and discussion about their ecological consequences (Elton, 1958; Vitousek et al., 1997; Gobster, 2005; Vellend et al., 2007). Biodiversity on islands is particularly vulnerable to biotic exchange (Courchamp et al., 2003; Sax and Gaines, 2008). The survival of introduced species on islands and the significance of their ecological impacts are less a matter of low insular biodiversity (Levine and D'Antonio, 1999); rather it depends on the nature of those species that are present or those groups of species that are missing from the islands (Goodman, 1975; Simberloff,

1995). This is especially true for alien carnivore invasions on islands where terrestrial mammalian predators were absent before. Their impact on insular bird populations can cause extensive population reductions and even local extinctions (King, 1985; Atkinson, 1996; Macdonald and Thom, 2001).

Bird populations are regulated by natural limiting factors like predation, food supply, nest sites, parasites, pathogens, competition, and human-induced factors like hunting, pesticides or pollutants (Newton, 1998). The effects of predation depend on the extend to which it is additive to compensation by other losses. In some ground-nesting waterbirds, however, predation can not only reduce egg and chick stages (Opermanis et al., 2001; Kauhala, 2004; Nordström and Korpimäki, 2004), but actually also their breeding numbers (Côté and Sutherland, 1997; Newton, 1998). Hence, bird species are assumed to develop their own strategies to minimize predation (Martin, 1993). It is widely accepted that prey naïvety plays a significant role in the confrontation with the threat of an introduced predator, because native fauna often lack those strategies to minimize predation as behavioral or evolutionary

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adaptations (Berger et al., 2001; Short et al., 2002; Nordström et al., 2004). Critical factors among those adaptations are (i) social factors like coloniality (Inman and Krebs, 1987; Siegel-Causey and Kharitonov, 1990), (ii) area-specific factors like habitat (Willson et al., 2001; Whittingham and Evans, 2004) or nest density (Ackerman et al., 2004), and (iii) site-specific factors like nest height (Martin, 1995) or nest concealment (Butler and Rotella, 1998; Rangen et al., 2000). Those factors have been investigated separately or in combination, with artificial and/or natural nests, often with contradictory results (Major and Kendal, 1996). Finally, nest predation processes cannot fully be understood without knowledge of the predator community, i.e., abundance and searching behavior of predators (Angelstam, 1986; Miller and Knight, 1993).

The American mink (*Mustela vison*) is a carnivorous species from North America that has recently established its southernmost reproducing population in the world on Navarino Island, Cape Horn Biosphere Reserve (southern Chile, 54–56°S). It was first registered on the island in 2001 (Jaksic et al., 2002; Rozzi and Sherriffs, 2003), but arrived earlier in Tierra del Fuego on the other side of the Beagle Channel in the 1940s and 1950s (Lizarralde and Escobar, 2000). Therefore, it is most probable that some individuals crossed the Beagle Channel after escaping from fur farms in Tierra del Fuego (Rozzi and Sherriffs, 2003). On Navarino Island, mink represent a new guild (Root, 1967) because the island lacks native terrestrial mammalian predators. In this pristine ecoregion the most diverse and abundant group of vertebrates are birds (Rozzi et al., 2006). Many of them are ground-nesting, including two songbird species (*Turdus falcklandii*, *Zonotrichia capensis*) that use ground nests in the Cape Horn region (S. McGehee, unpublished data), while in other parts of Chile the same species nest in trees. Therefore, scientists and public agencies have expressed strong concerns about the impact of mink on the island's avifauna, especially ground-nesting birds (Rozzi and Sherriffs, 2003; Anderson et al., 2006; Soto and Cabello, 2007).

American mink are semi-aquatic mustelids inhabiting marine coasts, flowing waters, and banks with a generalist diet including prey from both aquatic and terrestrial sources (Dunstone, 1993). Birds are most exposed to the risks of opportunistic predation by mink during their reproductive period due to the birds' limited mobility (Arnold and Fritzell, 1987; Bartoszewicz and Zalewski,

2003) in combination with the higher energy requirement of the breeding mink (Dunstone, 1993). In Europe, introduced mink have successfully established feral populations (reviews in Macdonald and Harrington, 2003; Bonesi and Palazon, 2007), which prey significantly upon ground-nesting wetland birds (Ferrerias and Macdonald, 1999) and seabirds (Collis, 2004; Nordström and Korpimäki, 2004). Also some cases of surplus-killing of chicks and adults within a colony have been reported (e.g., Craik, 1997). In South America, wild mink populations in the southern part of Chile and Argentina also include birds in their diets (Medina, 1997; Previtali et al., 1998; Fasola et al., 2008; Schüttler et al., 2008; Ibarra et al., 2009). However, studies on the impact of mink on waterbirds in the southern hemisphere are scarce.

The main purpose of our study was to understand the impact of the American mink as a recently introduced terrestrial predator on the nest survival of naïve ground-nesting waterbirds on Navarino Island. We aim to draw an overall vulnerability profile of bird species to predation by mink as a function of their breeding strategy (colonial vs. solitary nesting), as well as area-specific (habitat), and site-specific (nest concealment) factors. Based on this profile, we discuss high priority species of ground-nesting waterbirds for conservation and implications for the management of mink populations in the southernmost tip of the Americas.

2. Methods

2.1. Study area

The study was carried out on Navarino Island (2528 km²), Chile, located at the extreme southern tip of South America (Fig. 1). The island forms part of the Cape Horn Biosphere Reserve (Rozzi et al., 2006) and belongs to the Magellanic Sub-Antarctic forest ecoregion, recently identified as one of the 24 most pristine wilderness areas of the world Forest Biome (Mittermeier et al., 2003). The main habitats include (i) evergreen rainforests dominated by *Nothofagus betuloides* and *Drumys winteri*, (ii) Magellanic deciduous forests of *Nothofagus pumilio*, (iii) peatlands, moorlands, and bogs (*Sphagnum* spp.), (iv) high-Andean communities dominated by

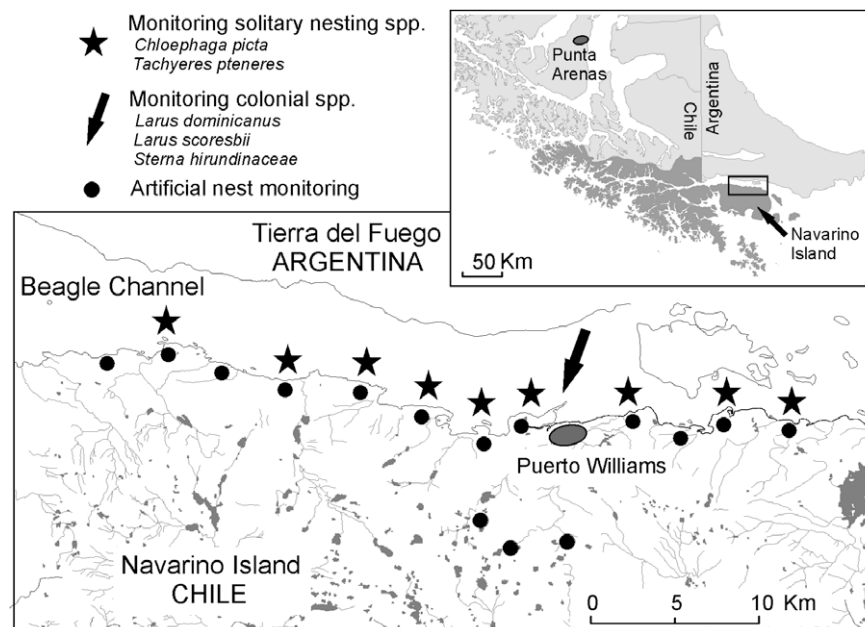


Fig. 1. Map of the nest monitoring study sites. Navarino Island is located within the Cape Horn Biosphere Reserve (54°–56°S, shaded in dark grey, top right) in southern South America.

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