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Exotic Vertebrates of Cape Horn, Chile

Exotic Vertebrate Fauna in the Remote and Pristine Sub-Antarctic Cape Horn Archipelago, Chile

Christopher B. Anderson[1,2 *], Ricardo Rozzi[2,3,4], Juan C. Torres-Mura[2,5], Steven M. McGehee[2], Margaret F. Sherriffs[2,6], Elke Schüttler[2,7,8] and Amy D. Rosemond[1]

[1] Institute of Ecology, University of Georgia, Athens GA 30602 USA

[2] Parque Etnobotánico Omora, Puerto Williams, Magallanes, Chile

[3] Universidad de Magallanes, Casilla 113-D, Punta Arenas, Magallanes, Chile

[4] Department of Philosophy and Religion Studies, University of North Texas, P.O. Box 310980, Denton TX 76203 USA.

[5] Museo Nacional de Historia Natural, Sección de Zoología, Quinta Normal, Santiago de Chile.

[6] Center for Population Biology, Section of Evolution and Ecology, University of California, One Shields Avenue, Davis, CA 95616 USA

[7] UFZ-Centre for Environmental Research UFZ, Permoserstrasse 15, 04318 Leipzig, Germany

[8] Technical University Munique-Weihenstephan, Department of Ecology, Am Hochanger 6, 85350 Freising, Germany

* Author for correspondence (email: canderson@alumni.unc.edu; phone: 1-706-542-4366, fax: 1-706-542-4819)

Abstract

Pristine wilderness is a scarce global resource, but exotic species are so common that they constitute a principal component of worldwide ecological change. The relationship between these two topics, invasion and remoteness, was the impetus behind five years of fieldwork aimed at identifying the assemblage and range of exotic vertebrates in Cape Horn, Chile, identified as one of the world's most pristine wilderness areas. While the archipelago has extremely low human population density and vast tracts of undisturbed land, we discovered that several terrestrial vertebrate groups were dominated by exotic species. Native birds were diverse (approx. 154 spp), and only 1.3% (or two spp.) were introduced. In contrast, exotic terrestrial mammals (twelve spp.) and freshwater fish (three spp.) outnumbered their native counterparts, constituting 55% and 75% of the assemblages. Using GIS, we found that not all areas were impacted equally, largely due to intensity of human occupation. Human settled islands (Navarino and Tierra del Fuego) hosted the greatest number of exotics, but humans alone did not explain observed patterns. Remote islands also had introduced species. North American beavers (*Castor canadensis*), American minks (*Mustela vison*) and feral domestic dogs and cats were particularly widespread, and their range in isolated parts of the study area raised important ecological and management questions. In conclusion, the Cape Horn Archipelago retained areas free of exotic vertebrates, particularly parts of the Cape Horn and Alberto D'Agostini National Parks, but at many sites introduced species were overwhelming native biota and altering these previously remote natural ecosystems.

Key Words: Cape Horn, Chile; exotic species; invasive; global change; Sub-Antarctic Forests; Tierra del Fuego; wilderness

Abbreviations: TDF = Tierra del Fuego

Introduction

The impact and distribution of exotic species is today a major area of scientific interest and conservation concern (Courchamp et al. 2003). Together with habitat fragmentation and global warming, species introductions constitute a principal cause of current global ecological change (Vitousek et al. 1996). As a country, Chile hosts proportionally few exotic vertebrates. Introduced species represent only 3.9% of the Chilean vertebrate assemblage (Jaksic 1998). However, within the Patagonian ecoregion of southern South America, exotics constitute a higher proportion of vertebrate fauna. For example, in the Argentine portion of Tierra del Fuego 67% of mammal species were found to be exotic (Lizarralde and Escobar 2000), and a study of freshwater fish in the Chilean portion of Tierra del Fuego Island described two exotics and only one native species (Vila et al. 1999).

The political unit of Cape Horn County is the world's southernmost forested ecosystem and encompasses all of the islands south of the Beagle Channel, in addition to the Chilean portion of Tierra del Fuego Island located south of the highest peaks in the Darwin Mountain Range (Figure 1). The area belongs biogeographically to the Magellanic Biome (Pisano 1981), and more specifically to the Magellanic Sub-Antarctic Forest Ecoregion (Rozzi 2002). It recently has been classified as one of the world's most pristine remaining wilderness areas due to its extensive size, the intact nature of its native vegetation and its low human population density (Mittermeier et al. 2002). Mittermeier et al. (2002) also point out that the Magellanic Sub-Antarctic Forests have a very high percentage of protected area (75% in Cape Horn County and 51% for the whole region), compared to the world's other remaining wilderness areas, and consequently merit special recognition.

Based on these criteria, this region is apparently remote from direct human influence, but in fact the Yahgans first settled the ecosystems of southern Chile 7,500 years ago (Ocampo and Rivas 2000). European explorations began in the 1500s, and colonization commenced in earnest in the late 1800s, provoking the first major landscape changes and introductions of exotic vertebrate fauna, principally associated with livestock grazing (Martinic 1973). The first record of a deliberate introduction of vertebrates to the islands south of the Beagle Channel was in 1867, when goats were brought to Lewaia Bay on Navarino Island by Anglican missionaries (Martinic 1973). During the 20th Century the number of introductions increased and expanded from domestic animals, including invasive species that expanded throughout the archipelago and others that did not become established at all. The realization that non-native biota can reach even the most remote areas left on the planet poses a conservation challenge for southern Chile, particularly given that a large portion is also classified by the Chilean environmental commission (*CONAMA*) as a priority area for national biodiversity conservation (Rozzi and Massardo 2002).

Despite the area's importance, detailed and precise information about exotic species in this area is currently lacking. Effective management of the extant national parks (Cape Horn and Alberto D'Agostini) and the proposed UNESCO Cape Horn Biosphere Reserve requires up-to-date knowledge of the assemblage and distribution of exotics, as well as their associated impacts. In order to achieve this goal, this paper 1) synthesizes existing information of native and non-native vertebrate fauna in the Cape Horn Archipelago, 2) uses five years of monitoring and survey information to describe in greater detail the exotic vertebrate assemblage and distribution patterns and 3) analyzes three taxa identified as particularly harmful or widespread: the North American beaver (*Castor canadensis*), the American mink (*Mustela vison*) and feral domestic predators (dogs and cats). These species further are used to highlight the implications of invasion, demonstrating the effect of ecological barriers, the potential rapidity of establishment and the possibility for changing positive ecosystem feedbacks loops to negative. While providing relevant information for local managers, our information also serves to better comprehend the global context of species invasion dynamics.

Materials and Methods

Study Area

Cape Horn County is located within the administrative district known as the Chilean Antarctic Province, which in turn is itself part of the Magallanes and Chilean Antarctic Region (Figure 1). The study area consists of an archipelago with hundreds of islands that cover approximately 15,488 km^2. The political boundaries also correspond largely to biogeographic barriers created by the icecap found towards the north in the Darwin Mountain Range on Tierra del Fuego Island and the sea barriers on all other sides. The area is part of the Magellanic Sub-Antarctic Forest Biome (for a detailed site description see Rozzi et al. 2004a).

Data Collection and Analysis

The data presented here were collected by the authors over five years of fieldwork associated with the Omora Ethnobotanical Park's long-term ecological research efforts in the sub-Antarctic ecoregion. A total of forty sites on nineteen islands were surveyed over the course of five years (Appendix 1). Sampling included systematic and opportunistic mistnetting, point-count transects and checklists for birds, which were conducted in alpine, shrub, pasture and forested habitats between January 2000 and January 2005. Avian sampling has been carried out systematically six days per month on Navarino Island since 2000. In addition during January and April 2002; April 2003; January and May 2004; January and May 2005 bird surveys were conducted during boating expeditions throughout the archipelago. Data concerning fish presence and absence were based on at least one day of rod-and-reel fishing per surveyed water body on Navarino, Hoste and Tierra del Fuego Islands, as well as opportunistic observational evidence and interviews with fishermen.

Sherman traps for small mammals were deployed on Navarino Island in quarter hectare grids in shrub, rush wetlands, cushion bog, pasture and evergreen, deciduous and mixed forest habitats. In addition, traps were placed around human settlements. Traps were baited with oats and checked twice daily. In January and May 2004 and January and May 2005 expeditions were conducted by boat through the archipelago in order to access remote and difficult portions of the county, and qualitative Sherman trap sampling for small rodents was conducted from one to two nights per site on Hoste, Herschel and Horn Islands.

Live traps (20 x 20 x 70 cm) were used in April and May 2005 at Pia Sound, Olla Cove and Yendegaia Bay (Tierra del Fuego Island) and on Navarino Island to sample for mink. A total effort of 420 trap nights was carried out on Navarino Island and twenty-five trap nights for TDF. Visual surveys were conducted at each site for a distance of 0.5 to 2 km of stream or coastline and divided into 200 m sections that were classified as positive or negative detection of mink evidence. Detection surveys were made of the places where tracks were likely to be found, such as sandy or muddy ground, and scats were searched for on exposed marking places, such as rocks and fallen trees for territorial scent marking (Dunstone 1993).

At each stop during expeditions, visual transects and surveys were also used to detect evidence (spoor, rooting, disturbance and tracks) of larger exotic species, such as beavers, muskrats and feral domestic animals, throughout the archipelago during stays of one to three days. Locations where observational transects were conducted during expeditions included: London Island; Romanche Bay (Gordon Island); Ventisquero Sound, Pía Sound, Olla Cove and Yendegaia Bay (TDF); Islotes Holger; Parque Omora, Inútil Bay, Wulaia Bay and Douglas Bay (Navarino); Jemmy Button Island; Orange Bay and Ponsonby Sound (Hoste Island); Mascart Island; Kendall Cove (Wollaston Island); Puerto Dillon (Grevy Island); Victoria and Washington Channels (Bayly Island); Puerto Maxwell and Saint Martin Cove (Hermite Island); Martial Cove (Herschel Island); and Cape Horn Island (for details see Appendix 1).

All survey and observational information was geo-referenced in order to utilize GIS to produce distribution maps. Maps were then used to identify areas free of exotics and also recognize the species that were particularly wide-spread and independent of human-association. In addition, collected field data were supplemented with a bibliographic review and questionnaires of local residents, sailors, fishermen and scientists. Non-native species under domestic or animal husbandry practices, such as sheep or chickens, were not considered in the analysis because they are kept exclusively in enclosures. On the other hand, pigs, cows, dogs, cats and horses were examined because many also have become feral or are free ranging.

Results

Human Inhabited Islands – Navarino and Tierra del Fuego

We identified a total of seventeen exotic vertebrate species, including mammals, birds and freshwater fish, inhabiting Cape Horn County, Chile (Table 1). No native or introduced amphibians or reptiles were discovered in the study area. The twelve recorded exotic mammal species represented a majority (55%) of the total mammalian assemblage (22 total spp.) (Table 2). Rodents and carnivores contributed the most introduced species with four non-native species each.

Two typically associated human rodents, *Rattus norvegicus* and *Mus musculus*, were found only in Puerto Williams on Navarino Island. Likewise, the only wild exotic birds detected in the whole stud area were the rock dove (*Columba livia*) and the house sparrow (*Passer domesticus*), which were confined to Puerto Williams. The rock pigeon (*C. livia*) was introduced deliberately by residents of Puerto Williams during the past decade, while *P. domesticus* probably crossed from the Argentine portion of Tierra del Fuego (TDF). These two exotic avifauna made up only 1.3% of the approximately 154 native bird species that inhabit terrestrial and coastal areas of the archipelago (Couve and Vidal 2000). The introduced grey fox (*Pseudalopex griseus*), which is native to the continental mainland of South America, was only found in the study area at Yendegaia Bay on TDF.

Among freshwater fishes, we identified three exotic species, which represented 75% of the archipelago's total assemblage. Only one native species (*Galaxias maculatus*) was confirmed within the county, while three more were described for the adjacent area of Argentina by Cussac et al. (2004). The exotic freshwater fish fauna in the study area were all Northern Hemisphere trout (Salmoniformes), including brown (*Salmo trutta*), rainbow (*Oncorhynchus mykiss*) and reliable fishermen accounts of brook (*Salvelinus fontinalis*) (Table 3). No exotic fish were found in the western portion of the county on Hoste or Tierra del Fuego

Islands. The only water bodies found to have trout were on Navarino Island and included: 1) Windhond watershed (brown and rainbow), 2) Robalo River below the dam (rainbow), 3) Navarino Lake (brook), 4) Mejillones River (rainbow), 5) Faraónes River (rainbow), 6) Lum River (rainbow), 7) Pilushejan River (rainbow) and 8) Douglas River (brown). In addition, several bog lakes along the north coast of the island, which are unconnected to adjacent water courses, contained brown and rainbow trout.

Feral Animals

While feral domestic animals were most abundant on Navarino and Tierra del Fuego, they were not strictly confined to those human-inhabited islands. We discovered, for example, scat and rooting disturbance from *Sus scrofa* at Romanche Bay on uninhabited Gordon Island in the western portion of the county and on Hoste Island. Pet dogs and cats likewise are being kept at isolated military outposts and ranches throughout the archipelago, such as Hoste, Horn, Lennox, Picton and Wollaston Islands. A similar native terrestrial predator (the Fuegian red fox, *Pseudalopex culpaeus*) only inhabited Hoste and Tierra del Fuego Islands.

On Navarino Island, dogs were found in all types of habitats, ranging from sea-level to above tree line. Cats, likewise, were observed even in remote forests. On several occasions they were seen preying upon songbirds in the Omora Ethnobotanical Park, Puerto Inútil and the small Holger Islands off the northwest coast of Navarino Island. *Sus scrofa*, the feral hog, was detected mostly around the northern and western coastlines of Navarino Island, especially in coastal, shrub and mixed forest habitats. Human-inhabited Navarino and Tierra del Fuego Islands were also the only locations where the European rabbit (*Oryctolagus cuniculus*) was seen.

At Yendegaia Bay, they were commonly found along river and coastal shorelines. Rabbits were once common on Navarino Island, as well, but they were virtually eliminated with the viral control program conducted in the 1950s. In 2004, however, we observed rabbits on several occasions on the northwestern tip of the island, and they may be a new introduction from an adjacent ranch.

Mink, Beaver and Muskrat

Based on surveys and mapping, we determined that three of the most widespread or potentially harmful exotic vertebrate species found in the archipelago were the North American beaver (*Castor canadensis*), the American mink (*Mustela vison*) and the muskrat (*Ondatra zibethica*). All three were brought from North America by the Argentine government in the 1940s and 1950s as part of an effort to introduce economically valuable furbearers. Once survey information was geo-referenced and mapped, it was also realized that these species had some the widest distributions of any exotic species in the archipelago and were the least associated with human settlements.

We first confirmed the presence of mink in Cape Horn County in 2001 on Navarino Island (Rozzi and Sherriffs 2003). During transects conducted in the austral summer of 2004 and 2005, we sighted mink or their tracks along the major watercourses of Navarino Island (Figure 2). Surveys and trapping also found them in the town of Puerto Williams and Omora Ethnobotanical Park, and one was observed on Hoste Island. On Navarino Island their densities ranged from 0.79 to 1.32 individuals per kilometer along coastal shoreline habitat, which river riparian habitat had a lesser density of 0.26/km. Minks are known also for the Argentine portion of Tierra del Fuego (Massoia and Chebez 1993, Lizarralde and Escobar 2000), but were not detected during our trapping and surveys in the Chilean portion of the island at Pia Sound, Olla Cove and Yendegaia Bay. Residents of the national police outpost at Yendegaia Bay reported never having seen them.

Beaver were detected easily given their dam building and foraging activities. They were found in every watershed on Navarino, Picton, Nueva and Lennox Islands. On Tierra del Fuego and Hoste Islands, their distribution is limited towards the western and southern portions of the study area (Figure 3). Overall, their distribution extended in the east from Nueva Island to the western tip of Hoste Island (see eastern and western extremes in Figure 3). Parts of the western portion of the Beagle Channel and the extreme, marginal islands along the Pacific Ocean have yet to be invaded. The distribution currently reaches its southern terminus at Orange Bay on Hoste Island, and the Wollaston Island group, which makes up part of Cape Horn National Park, has not yet been colonized.

Burrowing activity by muskrats (*O. zibethica*) and skeletal remains were evident in peat lands (*Sphagnum* spp.) and cushion bogs on Navarino and Hoste Islands. However, muskrats, like beavers, were not found to inhabit the western portion of the survey area, such as the southwestern portion of TDF, or the far southern Cape Horn National Park.

Finally, an important bibliographic review concerning exotic species in Chile reported that reindeer (*Rangifer tarandus*) were brought to Navarino Island in 1972 (Jaksic 1998), but we confirmed that this record was erroneous. A plan did exist to introduce reindeer, but the Chilean navy suspended the project. The individuals remained on the continent, eventually dying there (N. Soto – Wildlife Division Chief, Regional Agriculture and Livestock Service, pers. com.)

Discussion

Lessons and Implications of Invasion

LESSON 1: BARRIERS TO INVASION – Beavers have been able to colonize much of the county and at very high densities (Skewes et al. 1999). The lack of native predators, combined with their relatively high reproductive rates (up to eight offspring per year; Long 2003), allowed beaver populations to grow explosively after initial introduction in the 1940s. In addition, the habitat of the sub-Antarctic forests is very similar to the beaver's native range, and their ability to swim up to 5 miles across water bodies (Long 2003) has facilitated their expansion throughout the archipelago.

In terms of their impacts, "naïve" vegetation in southern Chile lacks a common evolutionary history with the beaver and, therefore, appears be more vulnerable to herbivory and flooding. While in North America some plants, such as the trembling aspen (*Populus tremuloides*), produce defensive chemicals in response to beaver foraging that in turn deters future impacts and allows regeneration (Basey et al. 1988), sub-Antarctic forests are totally suppressed and do not regenerate for at least a couple of decades, if at all (Lencinas et al. 2001). In addition, we have found that the herbaceous community assemblage associated with beaver meadows actually increases the number of exotic plants present in the riparian assemblage, which presents a case of one exotic species facilitating others (C.B. Anderson unpublished data).

The ability of this species to disperse across the Fuegian Archipelago is well documented (Skewes et al. 1999). Therefore, it is informative to note where we did ***not*** find them six decades after the initial introduction. Figure 3 showed the sites where we have confirmed the beaver's presence and absence in Cape Horn County.

To the west and southwest they have not been successful at colonizing, while farther north in Tierra del Fuego they have been able to travel far greater distances and even arrive to the Brunswick Peninsula on the continental mainland (Skewes et al. 1999). In addition, beaver have not been found in Cape Horn National Park (the Wollaston island group), even though they were present on adjacent Hoste Island and as far east as Nueva Island.

These characteristics of the beaver's geographic distribution indicated that the colonization of certain parts of Cape Horn County is not due to a lack of dispersal ability, but rather intrinsic local conditions that do not permit establishment of viable populations. The uncolonized portion of the county typically receives greater precipitation and has steeper topography. The vegetation community is Magellanic rainforest, typical of the western channels, where the floral assemblage is dominated by *Nothofagus betuloides* and *Drimys winteri* (Rozzi et al. 2004a). Often these forests are also stunted by the strong, constant winds that buffet the seaward side of the county. Physical parameters, such as rainfall and geomorphology, and biological characteristics, such as vegetation assemblage, could act together to create an ecological barrier that would explain why this habitat has not proven suitable for beaver establishment.

LESSON 2: PASSING UNDETECTED – The case of the mink is somewhat different than that which was previously described for beaver, but demonstrates another lesson of species invasions. Mink began to be introduced to Tierra del Fuego in the 1940s (Lizarralde and Escobar 2000), but even as recently as the early 1990s, Massoia and Chebez (1993) still classified it as a "species of hypothetical or doubtful presence" on Tierra del Fuego Island. Since then, it has not only been confirmed on Tierra del

Fuego, but today it is also frequently sighted on adjacent islands in the archipelago (Rozzi and Sherriffs 2003).

Like the beaver, mink have a relatively high fecundity rate (Long 2003). As carnivores introduced onto islands that often lack native predators (only Tierra del Fuego and Hoste Islands have native populations of the fox *Pseudalopex culpaeus* and native otter populations were brought to near extinction due to over-hunting), minks are flourishing in the abundant shoreline and freshwater ecosystems. While *M. vison* is known to utilize aquatic habitats to forage, its dispersal across large, marine water bodies, such as the Beagle Channel (average width approximately 4 km), was an unexpected discovery. We would have predicted that while it may have become an invasive species on Tierra del Fuego, where it was directly introduced, its limited dispersal ability to other islands would have restricted its overall distribution.

The fact that it has been able to establish itself without early detection by scientists and managers and to colonize several islands adjacent to its Tierra del Fuego source population in only a few years, therefore, is quite striking and alarming. This exotic carnivore raises particularly acute conservation concerns. In the Aysén Region of Chile detrimental impacts on bird diversity and abundance have been recorded after the arrival of mink, and consequently it is considered a harmful species (*SAG* 2001). The islands of the Cape Horn area host an abundant and diverse marine, coastal and terrestrial avifauna that evolved without significant terrestrial predators. Many songbird species, such as the austral thrush (*Turdus falcklandii*) and rufous-collared sparrow (*Zonotrichia capensis*), as a result use ground nests in the austral archipelago (S. McGehee unpublished data), while in other parts of Chile the same species nest in trees. Therefore, the impacts of mink on birdlife in Cape Horn County could be even more dramatic, than those experienced in other parts of Chile. Also, mink presence has been shown to affect the distribution of the rare native river otters (*Lontra provocax*) in Argentine lakes (Aued et al. 2003), and Delibes et al. (2004) found that an introduced mink's ecological niche can extend to the intertidal zone, where it would directly compete with sea otters and establish a new top predator throughout the archipelago.

LESSON 3: CONVERTING POSITIVE FEEDBACK LOOPS TO NEGATIVE – In the past, domestic pets have been allowed to be kept by residents stationed in Cape Horn National Park. The fact that we found dogs and cats at many isolated outposts throughout the archipelago is significant. These introduced predators, for example, caused the extermination of Cape Horn Island's colony of Magellanic penguins (*Spheniscus magellanicus*). However more significantly, this impact may not be limited to one population, but rather could extend to an entire community and ecosystem via an intricate feedback system.

The presence of a penguin nesting colony means the accumulation of penguin feces, which in turn elevates levels of nitrogen in the soil. The tundra soils of Cape Horn are naturally nutrient poor, and it is only in these enriched, penguin-modified areas that the grass species *Poa flabellata* are able to exist (Pisano 1982). *P. flabellata* itself further changes soil characteristics and structure, such as organic content and depth, which in turn permits the establishment of Graminae tundra formations (Pisano 1982). The interrelation of these ecosystem components becomes even more complex when we consider that penguin nesting success is also a product of habitat quality, which includes vegetation cover and the height and density of grasses that protect eggs from predation, temperature extremes and wind (Gandini et al. 1997).

This natural positive feedback loop between penguin presence, Graminae vegetation patches and nesting success for the penguin itself in the Cape Horn Archipelago may become a negative feedback that prohibits the recolonization of the island if steps are not taken to remedy this exotic species impact in Cape Horn National Park. The introduction of an exotic species to Cape Horn Island has the potential to alter an entire biotic assemblage and ecosystem, which is consequently a major economic opportunity vis-à-vis ecotourism, and demands prompt action. These results together demonstrate the diverse reasons to better understand and more effectively manage the exotic species in Cape Horn County, Chile.

Conclusions

While Jaksic (1998) found that overall Chile hosts few exotic vertebrates (3.9% of the total), this general trend was not the case in the Cape Horn area, where we discovered seventeen introduced vertebrate species. As a total number, this non-native richness could appear rather minor, when compared to more heavily impacted parts of Chile and the rest of the world. However, when the comparison is made in relation to the quantity of native species richness, the proportional domination of exotic mammals and freshwater fish was striking, 55% and 75% respectively.

Most introduced species were found on human inhabited islands. Those that were associated with human perturbed areas also generally did not appear to greatly affect native populations and ecosystems away from human settlements. On the other hand, several important species did not have distributions closely tied to humans (e.g. beaver, muskrats and mink). Significantly, though, we did find a portion of Cape Horn County that was still unimpacted by exotics. The unimpacted areas largely corresponded to the Cape Horn and Alberto D'Agostini National Parks, but our further finding that some species' ranges, such as the North American beaver, the mink and feral domestic predators, are increasing into the parks serves to underline the globalized threat of exotic species, even in remote areas, when management and control programs are lacking (Rozzi et al. 2004b and Anderson et al. 2005).

These results present us with lessons on how species become invasive and what their new role becomes within non-native ecosystems. Future work should expand on the information presented here to test the underlying ecological mechanisms for the distributions we have discovered. Finally, we hope that our findings serve to re-enforce the case that management and protection of this area is greatly needed. Care should be taken to prevent future introductions, and controlling the dispersal of those already present must be a priority for local and regional authorities.

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Table 1: Summary of introduced vertebrate fauna recorded for Cape Horn County, Chile with their mode of arrival and source of information. 1. Omora database 2. Canclini 1999, 3. Rozzi and Sherriffs 2003, 4. Sielfeld and Venegas 1980, 5. Sielfeld 1977. *indicates reliable fisherman report.

Introduced Vertebrate Species of Cape Horn County, Chile			
Order	***Scientific name***	**Common name**	**Source(s)**
		MAMMALS	
Artiodactyla	*Sus scrofa*	Feral pig	1
	Bos tarus	Feral cow	1
Carnivora	*Canis lupus familiaris*	Feral dog	1, 2
	Felis domesticus	Feral cat	1
	Mustela vison	American mink	1, 3
	Pseudalopex griseus	Patagonian grey fox	1
Lagomorpha	*Oryctolagus cuniculus*	European rabbit	1
Perissodactyla	*Equus caballus*	Feral horse	1
Rodentia	*Castor canadensis*	North American beaver	1, 4, 5
	Ondatra zibethica	Muskrat	1, 5
	Mus musculus	House mouse	1
	Rattus norvegicus	Norway rat	1
		FRESHWATER FISH	
Salmoniformes	*Salmo trutta*	Brown trout	1
	Oncorhynchus mykiss	Rainbow trout	1
	Salvelinus fontinalis	Brook trout	1*
		BIRDS	
Paseriformes	*Passer domesticus*	House sparrow	1
Columbiformes	*Columba livia*	Rock pigeon	1

Table 2: Native and exotic mammals of Cape Horn County, Chile. TDF indicates Tierra del Fuego and the other names refer to islands in the archipelago. 1. Omora database, 2. Allen 1905, 3. Cabrera 1961, 4. Milne Edwards 1881, 5. Olrog 1950, 6. Patterson et al. 1984, 7. Peña and Barría 1972, 8. Reise and Venegas 1987, 9. Sielfeld 1977, 10. Sielfeld 1984, 11. Thomas 1916.

Mammals Order	**Native Species**		**Site**	**Exotic Species**		**Site**
	Scientific name	**Common name**		***Scientific name***	**Common name**	
Artiodactyla	*Lama guanicoe*	Guanaco	TDF & Navarino[1]	*Sus scrofa*	Feral pig	Navarino, Hoste & Gordon[1]
				Bos tarus	Feral cow	TDF & Navarino
Carnivora	*Lontra provocax*	Large river otter	TDF, Grevy, Picton, Lennox, Wollaston, Hermite[5], Grevy & Gordon[10]	*Canis lupus familiaris*	Feral dog	TDF, Navarino, Hoste & Horn[1]
	Lontra felina	Sea otter	TDF, Hoste, Grevy, Picton, Wollaston[1], Bayly, Hermite, Herschel[5], Grevy & Gordon[10]	*Felis domesticus*	Feral cat	Navarino & Horn[1]
	Pseudalopex culpaeus lycoides	Fuegian red fox	TDF & Hoste[5]	*Mustela vison*	American mink	Navarino, Hoste & Argentine TDF[1]
				Pseudalopex griseus	Grey fox	Yendegaia, TDF[1]
Lagomorpha				*Oryctolagus cuniculus*	European rabbit	Yendegaia, TDF & Navarino[1]
Perissodactyla				*Equus caballus*	Feral horse	TDF & Navarino[1]
Chiroptera	*Histiotus montanus*	Eared bat	TDF, Navarino[5,7] & Wollston[5]			
	Myotis chiloensis	Chiloé bat	TDF, Navarino[5,7] & Grevy[5]			
Rodentia	*Abrothrix xanthorhinus*	Yellow-nosed mouse	TDF, Navarino1 & Hoste[3,9]	*Castor canadensis*	North American beaver	TDF, Navarino, Hoste, Picton, Nueva & Lennox[1]
	Akodon hershkovitzi	Cape Horn mouse	Herschel, Hermite & Horn[1, 6]	*Ondatra zibethica*	Muskrat	TDF, Navarino, Hoste, Picton, Nueva & Lennox[1]
	Euneomys chinchilloides	Fuegian chinchilla mouse	TDF, Wollaston, Hermite & Hoste[1]	*Mus musculus*	House mouse	Puerto Williams, Navarino[1]
	Oligoryzomys longicaudatus	Long-tailed mouse	TDF[8], Wollaston[1], Hermite[3,11] & Hoste[4]	*Rattus norvegicus*	Norway rat	Puerto Williams, Navarino[1]
TOTAL	**10**			**12**		

Table 3: Native and exotic freshwater fish fauna found in Cape Horn County Chile. *G. maculatus* is the only native fish confirmed for the study area: 1 = Omora database, 2 = Jenyns (1842), 3 = Vila et al. (1999), *indicates species only cited for areas adjacent to Cape Horn County, Chile in the Argentine portion of Tierra del Fuego (Cussac et al. 2004). When not otherwise noted, sites are located on Navarino Island.

Freshwater Fish	**Native Species**		**Site(s)**	**Exotic Species**		**Site(s)**
Order	***Scientific name***	**Common name**		***Scientific name***	**Common name**	
Osmeriformes	*Galaxias maculatus*	Common galaxia	Navarino I.[1], Hardy Peninsula (Hoste I.)[2] & TDF[3]			
	*Galaxias platei**		Roca, Escondido, Fagnano, Yehuín & Margarita Lakes(Argentine TDF)			
	*Aplochiton taeniatus**		Argentine coast of Beagle Channel on TDF			
	*Aplochiton zebra**		Area near Fagnano Lake (Argentine TDF)			
Salmoniformes				*Salmo trutta*	Brown trout	Pilushejan, Mejillones, Windhond and Douglas Rivers[1]
				Oncorhynchus mykiss	Rainbow trout	Lum, Guanaco, Mejillones, and Róbalo Rivers[1]
				Salvelinus fontinalis	Brook trout	Navarino Lake
TOTAL	**1 (3*)**			**3**		

Appendix 1. Sampling for exotic vertebrates was conducted at forty sites on nineteen islands. Here we give the site name, island, coordinates, sampling regime and date surveyed for each study site.

Location	Island	Latitude & Longitude	Type of Sample	Date
Mount Horacio	**London**	54º40'28"S; 71º56'43"W	Transect	Jan and April 2004
Basket Cove	**Basket**	54º41'49"S, 71º35'51"W	Transect	April 2004
Courney Sound	**TDF**	54º37'12"S, 71º20'33"W	Transect	April 2004
Ventisquero Sound	**TDF**	54º46'54"S, 70º19'10"W	Transect	Jan 2004
Pía Sound	**TDF**	54º47'16"S; 69º37'23"W	Transect and mink trapping	Jan 2004 and May 2005
Italy Glacier	**TDF**	54º55'36"S, 69º14'02"W	Transect	April 2004
Olla Cove	**TDF**	54º56'29"S; 69º09'22"W	Transect and mink trapping	Jan 2004 and May 2005
Yendegaia Bay	**TDF**	54°50'S, 68°48'W	Transect, rodent and mink trapping	May 2005
Romanche Bay	**Gordon**	54º57'13"S; 69º29'37"W	Transect	Jan 2004 and May 2005
Group of islets off NE coast of Navarino	**Holger**		Transect	Jan 2004
Piedra Cove	**Picton**		Transect	Oct 2003
	Nueva		Helicopter flyover	May 2003
	Lennox		Helicopter flyover	May 2003
Navarino Lake	**Navarino**		Fishing	2004
Windhond River & Lake	**Navarino**		Transect, rodent trapping, fishing and mistnetting	Mar and Nov 2003
Omora Park, lower elevation areas	**Navarino**	54°57'S; 67º39'W	Transect, rodent and mink trapping, fishing and mistnetting	2000-2005
Omora Park, Bandera Mountain	**Navarino**		Transects, rodent trapping and mistnetting	2000-2005
Omora Park, Róbalo Lake	**Navarino**		Transect, rodent and mink trapping and mistnetting	2000-2005
Guerrico Bay and Hill	**Navarino**	54°54'43"S; 67°51'09"W 54º55'S; 67º54'W	Transect, rodent and mink trapping and mistnetting	2000-2005
Mejillones Bay and River	**Navarino**	54°57'S; 67º39'W	Transect, rodent and mink trapping, fishing and mistnetting	2000-2005
Lum River	**Navarino**		Fishing	2004
Pilushejan River	**Navarino**		Fishing	Mar 2002
Wulaia Bay	**Navarino**	55º03'S; 68º09'W	Transect, rodent trapping and mistnetting	2002 and Jan 2004
Puerto Inútil	**Navarino**	54º58'32"S; 68º12'49"W	Transect, rodent trapping and mistnetting	Jan 2000 and Jan 2004

Douglas Bay	**Navarino**	55º10’28”S; 68º06’18”W	Transect, rodent trapping, fishing and mistnetting	Jan 2000 and Jan and May 2004
14th of July Bay	**Jemmy Button**	55º01’25”S; 68º13’45”W	Transect, rodent trapping and mistnetting	Jan 2004
Isla Grande Bay	**Hoste**		Transect	May 2004
Punta San Bernardo	**Hoste**	55º30’05”S, 68º04’15”W	Transect	May 2004
Misiones Cove	**Hoste**	55º31’18”S, 68º05’49”W	Transect	May 2004
Orange Bay	**Hoste**	55º31’18”S; 68º05’49”W	Transect, rodent trapping and mistnetting	Jan 2004
In Ponsonby Sound	**Mascart**		Transect	May 2004
In Ponsonby Sound	**Quemada**		Transect	May 2004
Kendall Cove	**Wollaston**	55º45’59”S; 67º25’04”W	Transect	Jan 2004
Lientur Cove	**Wollaston**		Transect	May 2004
Washington Channel	**Bayly**	55º40’39”S; 67º35’18”W	Transect	Jan 2004
Victoria Channel	**Bayly**		Transect	Jan 2004
Dillon Port	**Grevy**		Transect	Jan 2004
Martial Cove	**Herschel**	55º49’23”S; 67º18’01”W	Transect and rodent trapping	Jan 2004
Saint Martin Cove	**Hermite**		Transect and rodent trapping	Jan 2004
Maxwell Port	**Hermite**		Transect and rodent trapping	Jan 2004
SE Peninsula	**Cape Horn**	55º57’46”S; 66º13’29”W	Transect and rodent trapping	Jan and May 2004

Legend of the Figures

Figure 1: Map of southern South America with inset of the area that includes the Southern Patagonian and Sub-Antarctic Ecoregions. South of the dashed line lies the biogeographic and administrative territory of Cape Horn County, Chile.

Figure 2: Distribution of American mink (*M. vison*) in Cape Horn County, Chile. The shaded portion shows the county's area. Black dots indicate confirmed mink presence.

Figure 3: Distribution of beaver (*C. canadensis*) in Cape Horn County, Chile. The shaded portion shows the county's area. Black dots indicate confirmed beaver presence; white squares with black dots indicate their confirmed absence.

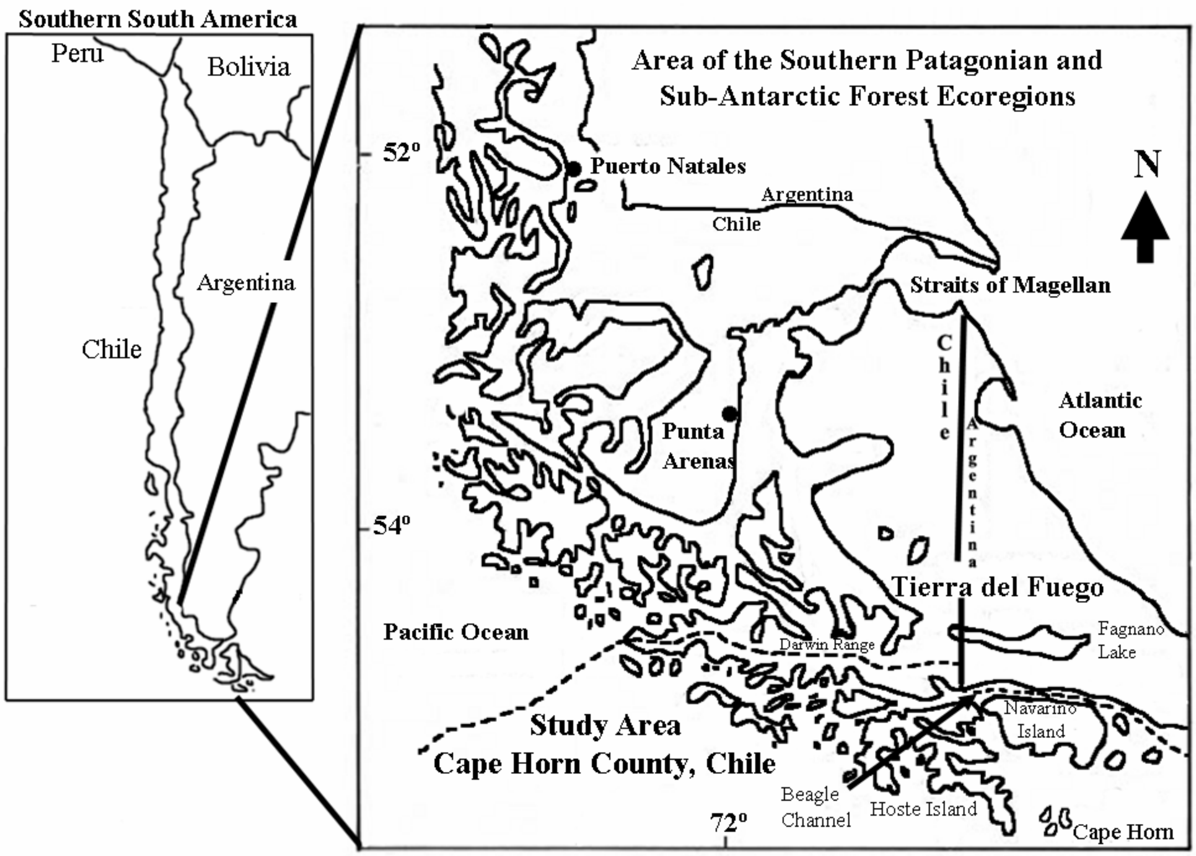
Southern South America
Peru
Bolivia
Argentina
Chile
Area of the Southern Patagonian and Sub-Antarctic Forest Ecoregions
52°
Puerto Natales
Argentina
Chile
N
Straits of Magellan
Chile
Argentina
Atlantic Ocean
Punta Arenas
54°
Tierra del Fuego
Pacific Ocean
Darwin Range
Fagnano Lake
Navarino Island
Study Area
Cape Horn County, Chile
Beagle Channel
Hoste Island
72°
Cape Horn

Fig. 1

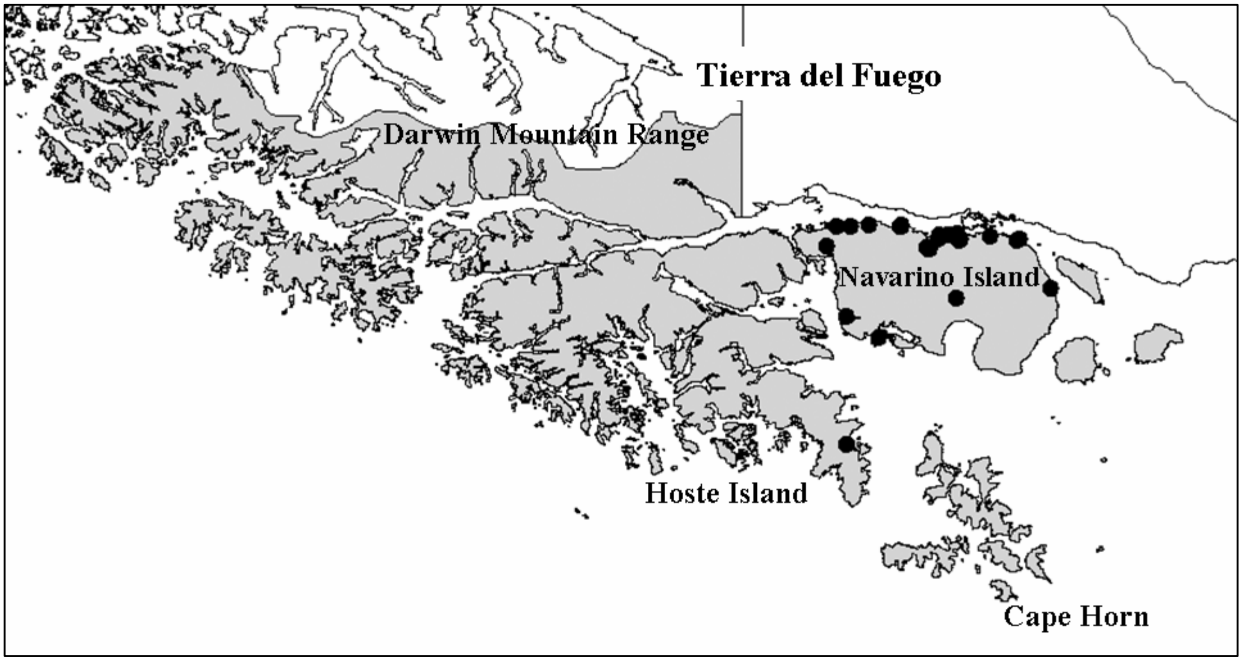
Tierra del Fuego
Darwin Mountain Range
Navarino Island
Hoste Island
Cape Horn

Fig. 2

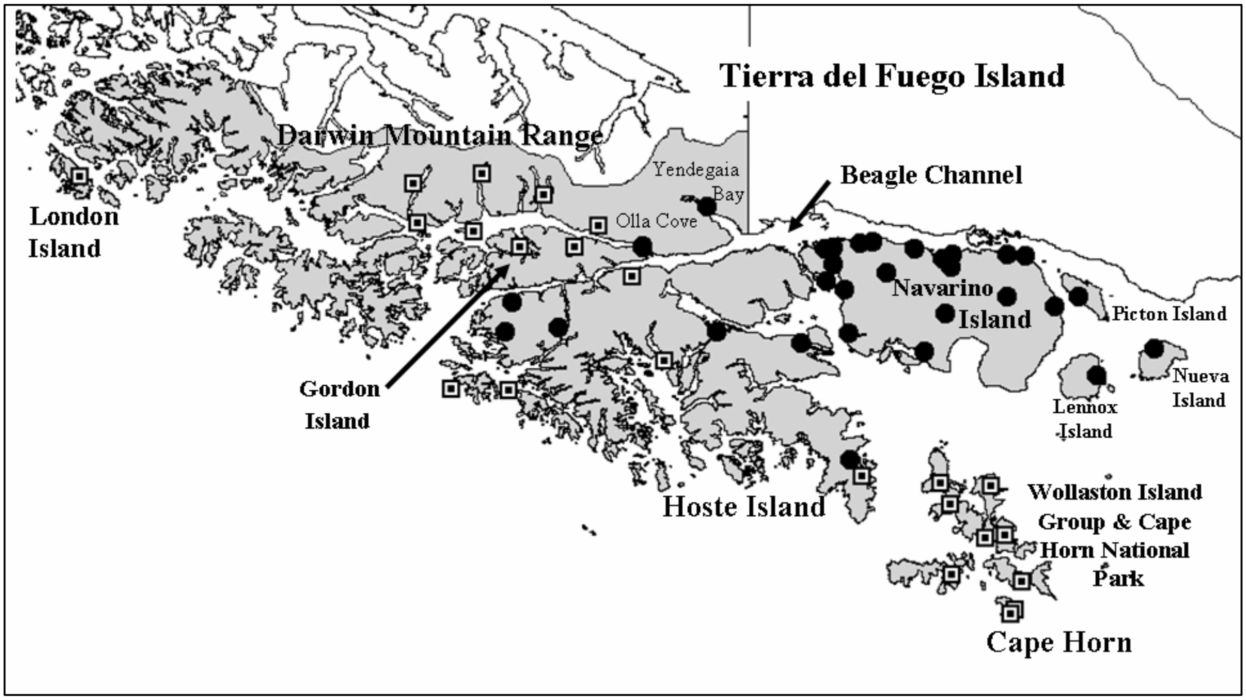
Tierra del Fuego Island
Darwin Mountain Range
Yendegaia Bay
Olla Cove
Beagle Channel
London Island
Navarino Island
Picton Island
Gordon Island
Lennox Island
Nueva Island
Hoste Island
Wollaston Island Group & Cape Horn National Park
Cape Horn

Fig. 3