

History of exotic terrestrial mammals in Antarctic regions

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Received September 2010; First published online 4 August 2011

ABSTRACT. A concise account of exotic terrestrial mammals known to have been introduced in Antarctica and the 19 peri-Antarctic islands is provided. This includes the entire region currently relevant to the Scientific Committee on Antarctic Research. Of the 24 introduced species 10 are extant at one or more locations in 2011. Some species have had a widespread distribution and others are represented by one, or a few, individuals. The majority arrived as deliberate introductions but that of some was adventitious. Details of their dates of introduction, current status, and indications of environmental effects, are tabulated. Current eradication programmes are noted.

Introduction

There have been various summary accounts of mammals introduced to Antarctic regions (for example Holdgate and Wace 1961; Bonner 1984; Clark and Dingwall 1985; Leader-Williams 1985; Hänel and others 2005; Frenot and others 2005; Convey and others 2006; Convey and Lebouvier 2009). This account collates information from these works, the author's *Chronology of Antarctic exploration* . . . (Headland 2009a), and a variety of other sources. The locations involved are: Ile Amsterdam, Auckland Islands, Balleny Islands, Bouvetøya, Campbell Island, Iles Crozet, Gough Island, Heard Island, Iles Kerguelen, Macquarie Island, Peter I øy, Prince Edward Islands, Ile Saint-Paul, Scott Island, Shag Rocks, South Georgia, South Orkney Islands, South Sandwich Islands, South Shetland Islands, and continental Antarctica. Five of the islands and Antarctica are under the ægis of the Antarctic Treaty and all locations have been in the region covered by the Scientific Committee on Antarctic Research (this no longer includes Auckland Islands and Campbell Island). With the exception of palaeontological evidence there is no record of any indigenous terrestrial mammal in these regions.

From about 1990 several attempts to eliminate various species have been implemented which, in general, have been successful although they are often very expensive. Similar projects are under way, or being considered, for species on other islands. Thus a significant reduction in numbers of exotic mammals is to be expected during the next decade. These programmes have the common object of restoring the original environment of very isolated regions. Several introductions have become extinct naturally for reasons that are not always clear. Other exotic fauna include birds (budgerigars, canaries, chickens, ducks, domestic geese, upland geese, guinea fowl, parrots, pigeons, rails, and many naturally occurring vagrants), reptiles (pet terrapins), fish (salmonids in Iles Kerguelen, Iles Crozet, Prince Edward Islands, and South Georgia, and ornamentals in several stations), and invertebrata (mainly annelids, parasitic and free-living helminths, arthropods also parasitic and free living,

and molluscs); neither these, nor exotic plants (which sometimes accompanied animals, for instance as fodder) are described.

A few mammalian introductions were very transient (for example opossums on the Auckland Islands, domestic rabbits in Ross Sea regions, hedgehogs at Cape Hallett, and other pets). Such bizarre occurrences are recorded as they emphasise the danger of accidentally introducing alien biota demonstrating the precariousness of the isolation of Antarctic regions. They also indicate the potential for inadvertent introduction of biota that might be vectors for viral or other pathogens. Occasionally a seemingly minor introduction could have had potentially catastrophic consequences if, for instance, an individual were female and pregnant. For example the single rat seen and killed on Heard Island in 1947, although its potential for breeding was not recorded. It is impossible to be certain what proportion of mammals travelling aboard ships actually landed, and some might have landed after death such as 'Toby', Charcot's pet pig.

The evaluation of introduced mammals may be described in several categories, although such criteria are difficult to apply uniformly and may be contentious. Breeding and non-breeding species is a basic division. Domestic or captive and free or feral are less well defined and might be equivocal owing to escapees, occasional renegade lapses from one category to the other (especially with cats), and deliberate liberty allowed to pastoral species and pets. Environmental effects may be regarded as minor when either the introduction has few consequences (such as an unsuccessful domestic species or anything which survived briefly) or because it was introduced to a limited region where it remained confined, for instance on one island in an archipelago (thus pigs on Ile aux Cochons of Iles Crozet were devastating to that island but did not affect the rest of the archipelago, mice on one of the Prince Edward Islands but absent from the other, and reindeer on South Georgia which affect local vegetation but their range is currently restricted by glaciers). Major effects include biological devastation (for example early reduction of bird populations by dogs on Macquarie Island, cats and rats on several islands) and severe

erosion (for example rabbits burrowing and destroying vegetation on Macquarie Island have exacerbated land slips).

Beneficial effects are mainly historical, notably survival by shipwrecked mariners consuming animals introduced for this humanitarian purpose, and as a source of fresh meat for whaling and research stations (reindeer on South Georgia, pigs and sheep at many whaling stations, small numbers of other domestic mammals once kept at scientific stations). Adverse environmental effects may be subject to concepts of local or widespread distribution of an animal. Thus the two reindeer populations of South Georgia have become more controversial as glaciers have receded and their range extended. In several instances exotic mammals have provided opportunities for biogeographical experiments and population dynamics research. Many species are notable for surviving long periods in substantial isolation such that acclimatisation, and eventual evolutionary adaptation, to a polar environment may have become apparent. Some isolated gene pools have been of veterinary or other scientific interest. Changes in environmental effects of a species may become apparent if a predator is removed; thus mice on Marion Island were not a major problem until the cats were eradicated. Comparable records of introductions, extinctions, and eliminations exist for many other insular and isolated parts of the Earth but, because of their generally extreme isolation and climates, Antarctic regions exhibit an epitome of the consequences of introduction of mammals.

As well as succumbing to programmes to eliminate exotic species, there are several instances in which they have become extinct naturally; for example cats on Campbell Island, rabbits on South Georgia, and dogs on Iles Kerguelen and Macquarie Island. Currently the general amelioration of climates in Antarctic regions might be expected to increase the chances of survival and to permit wider distribution of exotic mammals and other alien biota. The current decrease of glaciation in South Georgia, which has removed some natural barriers to the spread of reindeer, will permit range extension of the discrete populations of rats. In the latter instance this will adversely affect the proposed campaign to eliminate them. Conversely, however, the probability of rats reaching some of the more remote offlying islands will be reduced as opportunities for travelling over winter sea ice decrease. Laws and other regulations, theoretically, greatly reduce the likelihood of more introductions. Practically the occurrence of domestic animals (mainly cats and dogs) aboard yachts and other vessels continue to be reported, often through the International Association of Antarctica Tour Operators. It is evident that rodents (rats, mice, and rabbits) cause the most adverse environmental effects in Antarctic regions, and that cats are the next most hazardous introduction. Mice are the most persistent of the exotic mammals.

The islands and their exotic mammals are described sequentially concluding with observation on Antarctica

and these data are presented in Table 1. The 24 species of mammals recorded are: rodents: *Rattus rattus* (black rat, lesser species), *Rattus norvegicus* (brown rat, greater species) which are not certainly distinguished in some historical records, *Mus musculus* (with common and house mouse sub-species), *Cricetus cricetus* (hamster); lagomorphs: *Oryctolagus cuniculus* (rabbit), *Lepus timidus* (hare); canines: *Canis familiaris* (domestic and sledge dogs), *Alopex lagopus* (Arctic or fur fox) and *Cerdocyon thous* (crab-eating fox); felines: *Felis catus* (domestic cat); mustelids: *Mustela lutreola* (European mink); equines: *Equus caballus* (horse and pony) and *Equus asinus* (donkey) with mules, their hybrid (listed with donkey in the table); suiformes: *Sus scrofa* (swine); ruminants: *Rangifer tarandus* (reindeer), *Bos taurus* (cattle), *Capra hircus* (goat), *Ovis aries* (sheep), *Ovis orientalis [ammon]* (mouflon), and 'deer' unspecified; insectivores: *Erinaceus europaeus* (hedgehog); primates: vervet monkey (*Chlorocebus pygerythrus*) and possibly at least one other monkey; chiroptera: one unidentified bat; and marsupials: *Trichosurus vulpecula* (brushtailed opossum). It has not been possible to be certain of the identification of all species and varieties, especially where domestic mammals and some old records are involved. Linnaean taxonomy remains subject to persistent revision and the table has vernacular names. Also described are proposals to introduce mammals, mainly fur-bearing species, which have been made on several occasions. There are also reports of suspected animals, from evidence such as paw prints, which were not corroborated (such as otters on South Georgia suggested by Michael Hodges in 1906; Headland 1984b).

For completeness, Table 1 includes data on some aspects of *Homo sapiens*, which has had breeding populations on five peri-Antarctic islands and on Antarctica (although the latter, and one of the former, were introduced for political reasons). Attempts to establish a pastoral industry, mainly with sheep but occasionally with cattle, goats, and pigs, have been made on several islands. Dogs and horses were sometimes introduced to try to assist pastoralists who usually kept cats to control rodents. The industry persisted for many years on Ile Amsterdam, Ile Saint-Paul, Iles Kerguelen, Campbell Island and Auckland Islands. Similar attempts on South Georgia and Macquarie Island failed to survive a winter. Several expeditions, notably those observing the 1874 and 1882 transits of Venus, introduced animals as food for their duration on the islands, after which a few persisted.

Sources of information

Details of introductions and observation of the effects of introduced mammals appear in a disparate, and wide variety, of sources. Many records, especially earlier ones, are anecdotal, although there are a few systematic reports. Detailed accounts of several islands have provided useful summaries (Chown and Froneman 2008; Cumpston

Table 1. Exotic terrestrial mammals in Antarctic regions, 2011.

Mammal Location	Man	Black rat	Brown rat	Mouse	Cat	Dog	Horse/Pony	Donkey	Swine	Cattle	Sheep	Goat	Rabbit	Rein-deer	Other species	Σ Total/extant
Prince Edward Is	1799*			1817 =	1818*	1818*		1955*	1804*		1948*	1950*				7 / 1
Crozet, Iles	~			□ ~ +	● ~ +	○ ~		○	○ ~ +		○ ~ +	○ ~				8 / 4
Kerguelen, Iles	1772*	1800s		1800s	1887 =	1840*			1820s		1963*	1840 =	1874 =			14 / 7
Heard I.	~	■ ~ +		□ ~ +	□ ~ +	○ ~			○ ~ +		○	○	□ +			3 / 0
Amsterdam, Ile	1772*	1850s		1825 =	1873 =	1852 =	1950s*	1948*	1852*	1852*	1799*	1873*	1874*	1956*	1956* ○ Mink	14 / 7
Saint-Paul, Ile	~ +	■ ~ +		□ +	■ ~ +	● ~ +	○	○ mule	○ ~ +	○ ~ +	□ ~ +	○ ~ +	■ +	□ +	1957* □ + Mouflon	3 / 0
Macquarie I.	1855*	1850s				1855*					1952*					3 / 0
Auckland Is	~	○				○ ~ +					○					9 / 4
Campbell I.	1696*	1780s	1931*	1903 =	1800s	1833 =			1799*	1870*	1873 =	1826*				9 / 4
South Shetland Is	~	● ~ +	□ +	□ +	■ +	○ +			○ ~ +	■ ~ +	○ ~ +	○ +				12 / 1
South Orkney Is	1696*	1780s	1874 =	1829 =	1843*	1800s			1802 =	1843*	1853 =	1828*	1853 =		1853 = ○ Deer	12 / 1
South Georgia	~ +	● ~ +	● ~ +	□ +	○ +	○ +			○ ~ +	○ ~ +	○ +	○ ~ +	○ +		1857 = ○ ~ Hare	11 / 3
Gough I.	1810*	1810s		1820s	1820 =	1810*	1917*	1878*	1878*	1953*	1911*	1878*	1880*			11 / 3
Antarctica	~	■ ~ +		□ +	○ ~ +	○ ~ +	○ ~	○	○ ~	○ ~ +	○ ~ +	○ ~	■ +			11 / 3
Antarctica	1806*	1841 =		1840 =	1840 =	1843 =	1851*		1807*	1851*	1840*	1865 =	1840*		1890* ○ Opossum	11 / 3
Antarctica	~ +	○ ~ +		□ +	□ ~ +	○ ~ +	○ ~		□ ~ +	○ ~ +	○ ~ +	○ ~ +	○ ~ +			10 / 0
Antarctica	1810*		1810s	1810s	1896*	1811 =	1902*		1865*	1902*	1874*	1878*	1910s			10 / 0
Antarctica	~		● ~ +	○ ~ +	○ ~ +	○ ~ +	○ ~		○ ~ +	○ ~ +	● ~ +	○ ~ +	○			6 / 0
Antarctica	1819*	1927*			1820*	1820*			1912*	1912*	1912*					6 / 0
Antarctica	~ +	○ ~ +			○ ~ +	○ ~ +			○ ~	○ ~	○ ~ +					3 / 0
Antarctica	1821*				1927*	1903*					1925*					3 / 0
Antarctica	~			○ ~	○ ~ +	○ ~ +					○					14 / 3
Antarctica	1775*		1780s	1912 =	1905*	1800*	1905*		1912*	1882*	1882*	1882*	1872*	1911*	1914* ○ Vervet	14 / 3
Antarctica	~ +		■ ~ +	□ ~ +	○ ~ +	○ ~ +	○ ~ +		○ ~ +	○ ~	○ ~	○	○ ~ +	□ ~ +	1920* ○ + Fur fox 1925* ○ Crab fox	14 / 3
Antarctica	1675*	1968*		1888 =	1919*	1919*					1956*	1957*				6 / 1
Antarctica	~	○ ~		□ +	○	○ ~					○ ~	○ ~				6 / 1
Antarctica	1821*	1911 =		1974 =	1901 =	1840*	1908*	1912*	1903*	1933*	1951 =	1904*	1911*		1960* ○ + Hamster	14 / 0
Antarctica	~ +	○ ~ +		○ ~ +	○ ~ +	○ ~ +	○ ~	○ mule	○ ~	○ ~ +	○ ~	○	○		1963* ○ Hedgehog 1984* ○ Bat	14 / 0
Σ Total/ Extant		10 / 3	4 / 2	11 / 9	13 / 4	14 / 0	6 / 0	4 / 0	11 / 1	9 / 1	14 / 1	11 / 0	8 / 3	2 / 2	11 / 1	24 / 10

* earliest record of introduction, = earliest report of presence, dates expressed 1xx0s indicate the probable decade of introduction

■ extant with major environmental effects, □ extant, minor effects, ● extinct, major effects, ○ extinct, minor effects, ~ multiple introductions + breeding population.

Σ the total number of introduced mammals and those in 2011 (excluding man).

Man is the only introduced mammal reported from Bouvetøya (earliest landing 1822), Balleny Is (1839), Scott I. (1902), Peter I øy (1929), Shag Rocks (1956), and South Sandwich Is (1811)

1968; Green and Woehler 2007; Headland 1984b; Kerr 1976; McLaren 1948; and several others). Conflicting data are occasionally apparent between different sources. In several instances photographs or other illustrations provide evidence of introduced mammals. The geographical and historical data are from Headland (2009a). The author would appreciate further details of the exotic mammals reported, especially information about any not included in this account.

The organisation of this compilation has been complicated owing to the diversity of sources and frequent records of several species in one reference. Arranging details strictly by species would, in general, lead to excessive repetition. Original quotations, especially those from anecdotal sources, allow some of the best understanding of the circumstances. It is intended that the table, although simplified, will facilitate the comprehension of the occurrence and history of exotic mammals throughout the Antarctic regions.

Prince Edward Islands

Two islands (Marion Island and Prince Edward Island) with offliers, 19 km apart, of volcanic origin (Marion Island erupted in 1980); in the Indian Ocean. Area: 335 km² (290 km² and 45 km² respectively), highest elevation: 1231 m (Mascarin Peak, Marion Island) which has a remnant ice-cap. Sighted 1663, first landing 1799 (by sealers). Permanent occupation (scientific station) from 1947, sealers had previously wintered. South African territory. The sealing period lasted from 1799 to 1913 during which 103 sealers' vessels visited the islands and seven were wrecked. Currently the only exotic mammals are mice on Marion Island.

Marion Island and Prince Edward Island although close, have a different history of introduced species; the latter, currently with no introduced mammals and no recorded history of any, is protected as a valuable asset for biogeographical research. Mice were present on Marion Island soon after the first landing, undoubtedly introduced by sealers. A United States sealing gang landed in 1817 by Samuel B. Edes of *Pickering* reported 'a plague of house mice' (Richards 1984). Several subsequent accounts note their presence (often their abundance). A recent investigation of their mitochondrial DNA indicated that the current population are of Scandinavian or other north European origin (Jansen van Vuuren and Chown 2007). No Scandinavian vessel is recorded as reaching the island before 1909 but on 16 October of that year, *Solglimt*, a Norwegian sealer from Oslo, was wrecked and her complement of 70 men stranded ashore (Headland 2009a: 248). The speculation that this was the origin of the Scandinavian component of the mice is very persuasive. A cat and dog were introduced in 1818 from the Boston (United States) sealer *General Gates* commanded by Abimeleck Riggs (Richards 1984). Sealers on Marion Island commented that these animals 'were highly prized as long as we had them'. Neither they,

nor other cats or dogs accompanying sealers or shipwreck survivors, became established. By the time a permanent settlement, the South African meteorological station, was founded in 1947, mice had attained plague proportions. Alan Crawford's (1982) first camp was named 'Mouse Inn' which became an allusion to an accident involving a mouse and pot of soup. The adverse environmental effects of mice have been considered minor because they are on only one of the islands but, with increasing evidence of their predation of albatross chicks on Marion Island, this may be reassessed (Jones and Ryan 2009).

To attempt to alleviate problems with mice, cats were reintroduced in 1949. This time they became feral and increased to several thousands and became major predators of the island birds. A comprehensive cat eradication programme, which lasted a decade, was successful by 1991 and has proved a major environmental benefit (Bester and Bloomer 2009). A reduction of such a major predator of mice has resulted in their adverse effects increasing in importance, and their eradication is now under consideration.

Pigs, from Cape Town, were reported as introduced in 1804 by a United States sealing voyage led by Samuel B. Edes aboard *Meyars*. They were present in 1817 and reported by Edes again (Richards 1991). Sheep, dogs, pigs, goats and donkeys were reported as 'present at one time or another since 1948' by the South African meteorological station (Heymann and others 1987: 90) and further details are available for some of these species. John Marsh (1948) reported the landing of five merino sheep in January 1948 from HMSAS *Natal*, and the prompt fate of one suffocated in a bog (it contributed to a braai); the skeleton of another was found in a bog about a year later. They were pregnant and the intention was for a breeding population to be established. The 4th relief expedition, in April 1950, had to construct a sheep pen and reconstruct the pigsty (Terry-Lloyd 1950; La Grange 1950). Previously they were kept in a corral below the station using a cave for shelter. It was reported that the sheep landed in October were docile (Ouvry 1950). They dispersed on the island and the last of them were probably seen in 1973 (Watkins and Cooper 1986). Three pigs were also landed in 1950, one of which, a very large farrowing sow, caused severe tussles for the Royal South African Navy and HMSAS *Transvaal*, 'her squeals were appalling and her convolutions Herculean' (Ouvry 1950). More sheep were introduced from 1952 to 1959 (Chown and Fronemann 2008; Watkins and Cooper 1986). A note in 1961 describes the goats as difficult to catch but they were 'a real delicacy' on 'braaivleis' evenings (La Grange 1961). A donkey was taken to Marion Island for work during the 1955–1956 summer to lay an aqueduct for a hydroelectric station but it was removed when the work was completed (Watkins and Cooper 1986). Reports of the establishment of reindeer in Iles Kerguelen and South Georgia prompted the question 'Why not reindeer for Marion Island?' but no action was taken (Weather Bureau 1956).

Iles Crozet

Two island groups (occidental: Ile aux Cochons with Ilots des Apôtres and Ile des Pingouins, oriental: Ile de la Possession and Ile de l'Est) with islets and rocks, about 100 km apart, of ancient volcanic origin; in the Indian Ocean. Area: 325 km², highest elevation: 1090 m (Pic Marion-Dufresne, Ile de l'Est). Sighted and first landing 1772, sealers arrived 1804. Permanent occupation (scientific station on Ile la Possession) from 1963; sealers had previously wintered. French territory. The sealing period lasted from 1804 to 1911 during which 153 sealers' vessels visited the islands and 13 were wrecked. Exotic mammals currently occur on Ile aux Cochons (area 66 km², cats, mice and rabbits), Ile de la Possession (150 km², black rats), and Ile de l'Est (130 km², rabbits). The small Ilots des Apôtres and Ile des Pingouins are free from introduced species (Chapuis and others 1994).

Black rats and mice were undoubtedly introduced by early sealers. They are abundant on one island and have been reported from others. Cats also presumably arrived with sealers and were present in 1887 (Derenne and Mougouin 1976). In March 1910 when *Wakefield* visited a castaway hut and depot on Ile aux Cochons 'An ordinary domestic cat was seen ...' (Douglas 1930: 97). Cats are now present on one island only. Sealers used dogs in 1840 to catch ducks (Ross 1847) as well as to keep giant petrels (*Macronectes giganteus*) and other avian scavengers from feeding from stacked blubber of elephant seals (Watson 1931).

There are several accounts of the introduction of pigs to the eponymous Ile aux Cochons, the earliest records them as abundant in 1821 (Goodridge 1832). Additional introductions were made in 1834 by a London sealer, Alexander Distant, aboard *Sarah Barry*. In 1840 the island was reported as 'so overrun with these animals that ... you can hardly land for them.' (Ross 1847: 53). In 1873, when HMS *Challenger* passed close, a comment (Swire 1938: 130) was made 'We were sorry not to have landed on Hog Island [Ile aux Cochons] as we looked forward to a tussle with the pigs there, which are described as "numerous and ferocious".' A pig was landed on Ile de la Possession in 1843 (Watson 1931) and pigs appeared in a sketch in 1865 by James Stubbington (1867) in his diary of the voyage of *Dependent* which was wrecked, but pigs failed to become established on this island.

A report of landing of some goats on Ile de la Possession 'some years ago' appears in Ross's account with the note that they were thriving but 'still maintained their domestic state, under the protection of the sealers' (Ross 1847: 54). In 1874 sealers reported that rabbits 'were not good to eat because of their food' (Moseley 1879: 183). They were recorded by Lindesay Brine (1877) of HMS *Wolverne*, in December 1876, on Ile de Cochons but pigs were not mentioned in his account. Jerome Kidder (1876: 38) noted 'Rabbits, swine, and goats have been introduced upon the Crozet and some of the Kerguelen Islands from time to time, and have always thriven well.' Currently rabbits survive on two islands (Arnaud 1983).

Sheep were introduced when a permanent station was established in 1963 on Ile de la Possession, but were removed several years later. There is no record of their breeding.

Iles Kerguelen

One major island (Grande Terre), several minor ones, about 300 islets and rocks, and outliers; partly volcanic (with thermal springs); in the Indian Ocean. Area: 7215 km², highest elevation: 1849 m (Grand Ross), about 10% glacierised. Sighted and first landing 1772, sealers arrived 1791. Permanent occupation (scientific station) from 1951; sealers, pastoralists, and scientific personnel had previously wintered. French territory. The sealing period lasted from 1781 to 1922 during which 284 sealers' vessels visited the islands, nine were wrecked, and children born in 1818, 1852, and 1859. A whaling and sealing station operated intermittently in summers between 1908–1914, 1920–1929, and 1951–1956; two shipwrecks are associated with the industry. Intermittent pastoral settlement began in 1908 and finished in 1931. Most introduced species are on Grande Terre and a few of the islands in Baie de Moubihan; several of the islets are unaffected by introduced species providing good, although not extensive, sites for comparative studies. Iles Kerguelen have the largest number of extant species of introduced mammals. Eradication of adverse species (rabbits, cats, and rats) will be a particularly difficult and expensive task owing to the complex topography. Micol and Jouventin (1995) and Chapuis and Frenot (1997) provide details and dates of extant mammals that are: cats, rabbits, sheep, mouflon, black rats, mice, and reindeer. Populations have been eliminated on some of the smaller islands in Golfe du Morbihan and the practicalities of dealing with others are being investigated, as in several other French islands.

Sealers worked on Iles Kerguelen for about 130 years wintering ashore and aboard their vessels on many occasions, and whaling stations operated in the early 1900s (Headland 2009a). Thus it is astonishing that rats, neither *R. rattus* nor *R. norvegicus*, are reported as long established introductions. This suggests they were 'taken for granted' and not considered worthy of mention in the sparse sealers' literature unless something exceptional occurred. Records indicate they were a problem aboard vessels; in 1852 Nathaniel Taylor wrote 'we "smoked ship", which process cleared out all the two-footed and four-footed animals' (Palmer 1929: 75). Sealers' and later whalers' habitations suffered from infestation (Duchêne 1989). Currently it appears that *R. rattus* alone is present and its introduction, or possible reintroduction, dates from as recently as the mid 1950s (Dorst and Milon 1964; Lesel and Derenne 1975). A hunt for them was part of the procedure during the organising of a botanical laboratory in 1953 (Migot 1955). Earlier biological investigations and descriptions, such as those during the transit of Venus expeditions of 1874 (Corbet 1875; Kidder 1876) made

no reference to rats although they met several gangs of sealers and their vessels. The presence of mice was regularly reported at this time and in winter they inhabit station buildings (Duchêne 1989). Mice are another sealers' introduction; in 1825 John Nunn (Clarke 1850: 175) reported 'I do not remember to have seen any land quadrupeds upon the Island of Desolation [Kerguelen], except some white mice with red eyes, which, I believe were brought here amongst some casks. We amused ourselves in catching several of these during a very cold day in a heavy snow storm ...' HMS *Challenger* reported mice in 1873; 'the common English house mouse' (Swire 1938: 140). Kidder (1876: 38) noted that the common mouse 'abounds everywhere'. Raymond Raillier du Baty (1948: 201) found them inconveniently abundant in 1908 when visiting the German hut at Baie de l'Observatoire where an Eskimo [husky] dog was also seen as well as 'the bones of other dogs, showing that at one time it had had companions'.

George Campbell (1877: 106), aboard HMS *Challenger*, wrote, in February 1873, 'of an island in Royal Sound where some cats, escaped from sealers, had bred, live in holes and are wild and untamable, even when brought on board as kittens'. This was probably Ile du Chat, next to Ile aux Cochons in Golfe du Morbihan. Cats are noted again in 1874 (Corbet 1875), undoubtedly another consequence of early sealers' landings but they did not persist. In 1914 the Norwegian whalers at Port-Jeanne d'Arc had Manx (tail-less) cats (Seyrolle 1998). A later cat introduction was made in 1956 to control rats; it became feral and spread throughout Peninsula Courbet, with severe consequences (Chapuis and others 1994).

Dogs also undoubtedly arrived with sealers. Nathaniel Taylor reported them in 1852 (Palmer 1929), Campbell (1877: 104) bought 'a charming great black curly-haired Newfoundland hound' from sealers in 1873, *Gazelle* brought one in 1874, and the United States transit of Venus expedition had dogs at Pointe Molloy in 1874 (Corbet 1875). The population was supplemented by dogs landed from *Tanglin*, as part of Eric von Drygalski's German expedition aboard *Gauss* that also landed sledge dogs during the return voyage (Drygalski 1904, 1935). Two others were aboard *La Curieuse* in 1912–1914 (Loranchet 1960). Other introductions occurred with the shepherds and whaling vessels during the early 1900s. Some of these dogs became feral such that the British, Australian, and New Zealand Antarctic Expedition reported 'They have reverted to the wolf state, and are destroying all life which formerly found the island a haven of rest' (Mawson 1932). Feral dogs were not reported when the French station opened permanently at Port-aux-Français in 1951, but there appear to be no records of their prior demise.

In 1840 a report of hoof prints provided circumstantial evidence of the presence of equines (Ross 1847). Mules were introduced when a station was established at Port-aux-Français in 1948. The last of these remained neg-

lected around the station until dealt with by the butcher in 1953 (Migot 1955). Xavier Reppe (1957) published illustrations and details of dogs, cattle, ponies, lambs, and pigs on a farm at Port-aux-Français, as well as reindeer on the island in 1956 (Holdgate and Wace 1961). Photographs published in 1956 show cattle, sheep, and Shetland ponies (*Chroniques d'Outre Mer* 1956). The small farm continued to supplement the diet of the meteorological and research station for many years, although now it is only for sheep and their removal is under consideration (TAAF 2010).

A shooting party from HMS *Challenger* reported four skeletons of pigs in 1873. In 1874 the British transit of Venus expedition 'landed on Hog Island, so named because of an enormous animal kept by sealers near their wooden hut' (Perry 1876: 10). Corbet (1875:57) also noted that bullocks, sheep and pigs '... seem to get on all right on shore.' In 1918 it was reported that 'A few pigs thrive at the whaling station' at Port-Jeanne d'Arc (Great Britain 1918: 13).

Taylor describes cattle, sheep, and pigs ashore with a sealing party from 1852 with a 'cow-boy' to attend the first (Palmer 1929). Cattle were landed in 1874 by the British transit of Venus expedition. The chief astronomer, Stephen Perry (1876: 13) wrote 'Captain Fairfax was on shore in the afternoon arranging a shed for the cattle that had survived the storms.' The last one was slaughtered for Christmas and 'contributed, perhaps unwillingly, his full share to the festivities' (Perry 1876: 30). Some were referred to as bullocks, transported as food and unable to reproduce. A pair of goats was released in January 1874 but it was commented 'I very much doubt if they will be the parents of a future race of Kerguelen goats' (Perry 1876: 37). Albert Seyrolle (1998: 58) reported a cow and calf present with the shepherds at Port-Couvreux, October 1913, and that 'le lait leur est précieux'.

Sheep were a very early introduction arriving in 1799 with Robert Rhodes aboard *Hillsborough*. His account notes: 'Of land animals we saw none there is, however, abundance of food for cattle; the sheep we landed ... throve wonderfully on the grass ... they all became very shy ... some ... were left ashore' (*Sydney Morning Herald*, 14 August 1852). James Ross (1847), in command of HMS *Erebus* and HMS *Terror*, landed sheep in 1840, but most were shot after they had fattened. When turned loose they were described as difficult to stalk. Two rams, carried aboard *Tanglin* were introduced by the German Antarctic expedition in 1901 (Drygalski 1904). It had been intended to introduce ewes also, but they were killed by sledge dogs during the voyage. There were several attempts to begin a pastoral industry on the island that had a practical beginning with sheep imports in 1912 and 1913. Over 1000 sheep were landed but, by 1920, after the farm had been abandoned during World War I, only two rams could be found (Arnaud and Beurois 1996). In 1927 another attempt was made at the settlement of Port-Couvreux when pigs, sheep, cattle, and goats were

introduced. Photographs also show that cats and dogs accompanied the settlers, the latter presumably for use with the sheep. The enterprise did not prosper and, as with others on peri-Antarctic islands, was abandoned during the economic depression of the early 1930s (Arnaud and Beurois 1996) and the stock apparently died out.

Rabbits have flourished and became a severe problem on the main island and several minor ones. They were introduced by the British transit of Venus expedition in 1874. A note indicates they were 'procured at Robben Island [Cape Colony], boxes containing from 8 to 18 were deposited in different localities' (Perry 1876: 37). These unfortunately flourished; Mawson (1932) observed in 1929 'they have become a plague which has upset the natural balance ...'. Today their profound adverse effects on vegetation are visible as there are extensive closely cropped, almost pure, *Acaena* swards in many parts of the archipelago.

One male and two female European mink (*Mustela lutreola*) were released in 1956 on Ile du Chat, one of the small islands in Golfe de Morbihan. They, fortunately, do not seem to have reproduced as no traces of their presence could be found in 1965 (Lesel and Derenne 1975). Reindeer, also introduced in 1956, were released in two places and became established, and are a welcome addition to the diet (Lesel and Derenne 1975). Mouflon, originally from Corsica and thence a Paris zoo, were introduced in 1957, and are breeding on Ile Haute (6.5 km²). The genetics of this population, descended from a single pair and increasing to 700 animals, exhibit unexpected diversity (Kaeuffer and others 2006). Their removal is also proposed. When a scientific station was to be established in Kerguelen in 1947 consideration was given to the introduction of several fur bearing animals: sable (*Martes zibeline*), ermine (*Mustela erminea*), and sea otter (*Enhydra lutris*); but no action was taken (Blanc 1947) apart from the later attempt with mink.

Heard Island

One main volcanic island (currently erupting), McDonald Islands (rapidly enlarging volcanically) lying 38 km W and Shag Island lying 11 km N; in the Southern Ocean. Area: 390 km², highest elevation: 2745 m (Mawson Peak), about 70% glacierised. Sighted 1853, first landing 1855 (by sealers). Uninhabited, sealers and scientific personnel have wintered. Australian territory. There is some controversy about the earliest sighting of these islands (possibly 1833 or 1848, definitely 1853; Downes 2002) but the date of the earliest recorded landing is 15 February 1855. It has been hypothesised that fur sealers worked at Heard Island previously but this is highly doubtful; there are neither written details, nor corroborative evidence from the island, nor any indication that fur seals have ever been abundant there. The sealing period lasted from 1855 to 1910 during which 67 sealers' vessels visited and nine were wrecked. Sealers may have been in constant occupation for 25 years after discovery

(Bertrand 1971). The McDonald Islands and a few other offlying islands are all small, and there are no records of any introduced biota on them. Presently no introduced mammals are extant anywhere on the group.

Rats presumably arrived with sealers during the latter 1850s but there are no contemporary accounts until later. John Easmond (1882–1883), second mate of the sealer *Trinity*, was shipwrecked on the island for 15 months from October 1880 and commented that 'When we first landed on the island there were only a couple of rats in the shanties. They were as tame as chickens, and by the time we left there were 200 of them.' There are no subsequent reports of rats from this period, thus it may be presumed they could not survive long without human habitations. *Trinity* also carried a pair of rabbits collected at Iles Kerguelen and intended for release on Heard Island. Neither they, nor the vessel's two cats, survived the wreck. After the sealers there were few visitors to the island and, although huts were sporadically occupied, there were no reports of rats. In the 1947–1948 summers the Australian National Antarctic Research Expedition (ANARE) established a station during which a rat was seen in unloaded cargo and promptly clubbed to death. Alan Gilchrist (1992) wrote an account of the event, but neither sex nor species of the rat was determined (Woehler 2006). All are recorded as *R. rattus* in the table.

Dogs were introduced by sealers; some became feral and, in some literature, were reported as ferocious. Edgar Aubert de la Rüe (1930) had a large wolfhound with him during a brief geological visit made to Heard Island with his wife in January 1929. ANARE introduced teams of sledge dogs in 1952 which were transferred to Mawson station when that opened in 1954. The maximum at one time was 72. They were from the Falkland Islands Dependencies Survey and came via the French expedition to Terre Adélie. The ANARE station was open continually until 1954, during which an introduction of sheep was made in 1952; they were all eaten during the subsequent winter (Munro 2006).

Ile Amsterdam

One small volcanic island, about 90 km N of Ile Saint-Paul; in the Indian Ocean. Area: 85 km². Highest elevation: 881 m (Mont de la Dives). Sighted 1522, first landing 1696, sealers arrived 1789. Permanent occupation (scientific station) from 1949; sealers and pastoralists had previously wintered. French territory. The sealing period lasted from 1789 to 1876 during which 47 sealers' vessels visited and nine were wrecked. An unsuccessful attempt to begin a pastoral industry was made in 1870. Currently cats, mice, brown rats, and cattle are present. The last are now eliminated from part of the island, and the administration is considering their complete removal (TAAF 2010).

Two dogs were introduced by the wreck of *Lady Munro* in 1833 (M'Cosh 1835) and others with the

attempt at a pastoral settlement made in 1843. In 1852 wild dogs were also recorded by Ravisi (1853), who also noted the presence of goats. The presence of brown rats (surlulots) from 1931 is listed by Chapuis and Frenot (1997). There appears to be no earlier reference to either species of rat, although sealers' and pastoral activities, especially during the 1800s, would have made their introduction inevitable. Mice were reported in 1903 by the German Antarctic expedition aboard *Gauss* (Drygalski 1904). Xavier Reppe (1957) also noted wild cats have been present prior to 1931 (Chapuis and others 1994) and were probably a sealers' introduction.

Goats were introduced in 1826 by Isaac Percival, a United States sealer from Boston, but they were not reported subsequently. Percival was earlier responsible for introducing pigs in 1799, which were reported on several subsequent occasions (M'Cosh 1835). Pigs were reported as present in May 1821 by a United States sealing voyage commanded by Capt. Townsend aboard *Panther* from Providence (Richards 1984) and in 1823 (Goodridge 1832). In 1843 a French expedition, from Bordeaux, commanded by Martin Dupeyrat, aboard *Olympe*, reported wild pigs and dogs (Ravisi 1853). By 1874 it was noted that the pigs had apparently disappeared (Vélain 1877) but cattle were present.

Aubert de la Rüe (1931) reported the introduction of cattle by 'navigateurs hollandaise au XIX^e siècle' and continues that more cattle, from Réunion, were introduced in 1870 in another unsuccessful attempt to establish a pastoral settlement. There is, however, no corroboration of any Netherlands voyage to either Ile Amsterdam or Ile Saint-Paul after 1754 (1870 is given for cattle in the table). Sheep and goats were found from the farming attempt that had been abandoned only a few years later (Reppe 1957; Richards 1984). In 1873 Commodore Goodenough (1878) found signs of goat, sheep, and cattle. Drygalski's expedition killed three cattle for fresh meat in 1903, but not without encounters with the survivors (Drygalski 1904).

Ile Saint-Paul

One small volcanic island (with fumaroles and thermal springs) and offlier, about 90 km S of Ile Amsterdam; in the Indian Ocean. Area: 7 km², highest elevation: 268 m (Crête de la Novara). Sighted 1618, first landing 1696, sealers arrived 1789. Uninhabited; sealers and fishermen have wintered and children born in 1819 and 1930. Fishing station and a later lobster cannery, operated sporadically between 1819 and 1931. An unsuccessful pastoral industry started in 1849. French territory. The sealing period lasted from 1789 to 1876 during which 60 sealers' vessels visited and four were wrecked. Presently only mice are extant.

Black rats were an early sealers' introduction, probably late in the 1700s. They survived until an eradication campaign, in 1997, was successful. Two subsequent attempts also exterminated the rabbits by 1999, but failed

to eradicate the mice (Micol and Jouventin 1998). Charles Vélain (1877) observed that both species of rat, 'le Rat d'Alexandrie et le Surlulot', were present in 1874. Drygalski's expedition noted rabbits and mice, with tracks of either sheep or goats, present in 1903 (Drygalski 1904).

Pigs were reported in 1802 by George Nichols, aboard *Active*, and sporadically thenceforth (1806, 1820, 1823, and 1829) with the occasional additional introductions (Richards 1984); they were first associated with sealing gangs staying ashore with Goodridge (1832: 98) noting 'the wild hogs were numerous'. Later the fishing industry also reported them (Scherzer 1861). Mice were first reported by Aleck Osborne, a sealer, in 1829 and subsequently on several occasions (Goodridge 1832; Drygalski 1904). Goodridge (1832: 100) wrote about the hogs kept in a cave by 'feeding them on the mice we were able to heap together and kill ...'.

Sheep and rabbits were first reported in 1853 by a British naval voyage (David 1984). The sheep did not persist but rabbits remained until 1999 (Perillo 2000). In 1849 about a dozen cattle and 300 goats were imported in an attempt to start a pastoral industry (Ravisi 1853). They failed to survive after the farm was abandoned.

Goats had been previously introduced by Isaac Percival of the Boston sealer *Rob Roy* in 1828 (Richards 1984) and described in 1823 (Goodridge 1832). Further introductions were made in 1843 by Louis Mieroslawski when he started a fishing enterprise; he also introduced cattle and cats. By 1853 there was 'une grande quantite de ces animaux à l'état sauvage' of the latter (Ravisi 1853: 74). Deer of an undefined species were reported present in 1853 by a Cape Town sealer Captain Sinclair aboard *Elbana* who noted that 'the island was plentifully stocked with deer, goats and rabbits' (Richards 1984). Some of these were also reported in the same year when Henry Denham aboard HMS *Herald* observed 'sheep, cats and mice ran wild, ... some cattle, chickens and rabbits at the settlement' (David 1984). Scherzer (1861: 298) recorded, in 1857 when visiting aboard *Novara*, that 'swine, goats, cats, rabbits ... live here in a wild state'. He continued 'a female hare ... from Cape Town, was also set free ... fortunate for the propagation ... there was already a male hare on the island'. An illustration from 1928 includes a pet cat (Floch 1982).

Macquarie Island

One main island; outliers Judge and Clerk Islands 11 km N, and Bishop and Clerk Islands 37 km S; mainly of ancient volcanic origin with basement rocks and marine sediments; in the Pacific Ocean. Area: 128 km², highest elevation: 433 m (Mount Hamilton). Sighted and first landing 1810 (by sealers). Permanent occupation (scientific station) from 1948; sealers and scientific personnel had previously wintered. Sealing and penguin oil station operated 1888–1919. Australian territory. The sealing period lasted from 1810 to 1919 during which 144 sealers' vessels visited and 12 vessels wrecked.

Currently only rabbits, mice, and black rats are extant and a programme to eliminate all rodents began in 2010. Cumpston (1968) provided a detailed history of the island.

Black rats presumably arrived early in the 1800s with sealers and became widely distributed. Cumpston (1968) gave examples of where they have been pestilential in 1908: residing in mattresses, devouring human food, eating specimens, and causing fires that destroyed huts. Rabbits were reported as absent early in 1879 but introduced later that year or in 1880. Cumpston (1968) listed their increase and spread throughout the island. Their increase continued and, after the last of long established cats was killed in June 2000, they became even more pestilential for a variety of reasons. As well as devastating extensive vegetated areas their burrowing has contributed to substantial landslips. Introduction of rabbit fleas and myxomycosis, poisoning with sodium fluoroacetate, and fumigation have reduced numbers at different times but this was only temporary (Selkirk and others 1990). Mice were also established early and existed in sealers' huts. Edward Wilson, during Robert Falcon Scott's first expedition in 1901, reported them eating an ornithological collection left in a hut (Cumpston 1968).

Dogs were another introduction by the earliest sealers from Port Jackson [Sydney] and they soon became feral (Cumpston 1968). Robert Falla (1937) recorded that 'the ravages committed on the younger seals by innumerable wild dogs bred from those unthinkingly left ... by the first gangs'. He also reported how bird nests were 'despoiled of their young' and adults 'surprised and devoured by these canine rovers'. They may be implicated in the decline of the wandering albatross population. Dogs were noted by Fabian von Bellingshausen visiting aboard *Vostok* in 1821. This expedition introduced another dog, and recorded cats on the island (Bellingshausen 1945). Several subsequent sealers' references describe dogs on Macquarie Island but it is probable that they had died out by 1877 (Falla 1937). Scott landed an Aberdeen terrier on the island in November 1901 (Scott 1905) but it was taken to in New Zealand before *Discovery* sailed for Antarctica. In May 1909 John Davis, aboard *Nimrod*, observed that the resident sealers were 'accompanied by two little dogs' (Davis 1909: 409). The sledge dogs of the Australasian Antarctic Expedition of 1911–1914, led by Douglas Mawson, were taken ashore to feed on fresh seal meat (Mawson 1915) and two remained with the shore party.

Mawson's expedition also landed 12 sheep in 1911 and 25 in 1913 and Mawson wrote they were 'to feed on the rank grass until our departure' (Selkirk and others 1990). When the Commonwealth Meteorological Expedition took over the station in late 1913 'about a dozen sheep were let loose to roam at liberty and forage for themselves' (Mawson 1921). The meteorological station was closed in December 1915 when sealers may have found any sheep remaining a welcome addition to their diet. Subsequently re-establishment of a pastoral industry

was considered but no action was taken (Selkirk and others 1990).

In 1878 Donald Sinclair of the sealer *Jessie Niccol* landed a pig, some goats, and five donkeys but the experiment with the last was not a success, the surviving donkey was removed in 1879 (Cumpston 1968). The other animals had been eaten during a difficult period after many stores had been lost. The same source (Cumpston 1968: 118) indicated the presence of goats in 1890 but reported they were destroyed because '... they disturbed the sea-elephants and interfered with our trade'. A horse was landed by sealers in 1917 but a second was drowned in the process. The survivor was used for hauling a cart at a seal and penguin oil factory, the cart remains may still be seen near the meteorological station. Another horse arrived in 1918 and both appear on photographs before sealing ceased when they were left on the island (Cumpston 1968). Alan Villiers (1924: 7) reported that two horses were present in 1923 'their long tails dragging in the sand, and their manes in their eyes ...'. The skull of one of them was found in 1959 (Csordas 1985). A more recent introduction of equines was made by ANARE in 1969. Three ponies, 'Brandy', 'Lime', and 'Soda', arrived aboard *Nella Dan* intended for local haulage but the boggy nature of the ground was such that this were not successful and they were removed after their first winter (Bowden 1997).

In 1965 a biologist, Mary Gillham (1967) reported that the meteorological station maintained, with dubious success, a small flock of sheep and some cattle. The former were introduced when the station was established in 1948. Although previously breeding, they later became effectively sterile owing to overgrowth of their stems by fleece (Csordas 1985). The toponym Lambing Gully suggests where pregnant ewes were sheltered and the base diaries include details of the sheep. The cattle were intended to produce milk but the cow, imported pregnant, was nearly dry until she calved but the calf did not survive, and Csordas reported the vicissitudes of breeding cattle (Csordas 1985). Gillham also reported that pigs were introduced at the time of her visit and that goats, re-introduced in 1948, were exterminated in the early 1950s 'before they created the widespread havoc brought about ... on so many other oceanic islands' (Gillham 1967: 126). Csordas (1985) reported the last goats were killed in 1957 and that four pigs were introduced in 1953. Some of the feral cats were domesticated and appear in photographs of station personnel up to the 1990s (in 1989 the station pet cat was named 'Rover').

The advantages from the elimination of cats were somewhat offset by a marked increase in rabbit populations. In winter 2010 a campaign to eradicate rabbits, rats, and mice, began using poison, pathogens, and hunting. Already there have been complications with bird mortality. In any event it is anticipated that it will take several years during which trained dogs will be resident to assist by detecting any surviving rodents. If successful this will have eliminated all introduced mammals.

Auckland Islands

One main island with several smaller ones and offshoots, of ancient volcanic origin; in the Pacific Ocean. Area: 626 km², highest elevation: 705 m (Mount Dick, Adams Island). Sighted 1806, first landing 1807 (by sealers). Uninhabited, coast watchers and scientific station operated from 1941 to 1945; sealers, Maori and Moriori, colonial settlers, and pastoralists had previously wintered. New Zealand territory. The sealing period lasted from 1807 to 1894 during which 82 sealers' vessels visited and 11 were wrecked. Currently pigs, cats, and mice are present but a campaign is being planned to eradicate the first two. McLaren (1948) wrote a history of the islands.

The main island and several outliers have had a comparatively long history of occupation. Adams Island, the second largest and most southerly in the archipelago, has remained without any exotic species. Human settlement on the main island has been greater than on most of the other islands. Sealers arrived in 1807 and built huts that were inhabited sporadically for several decades. Maori settlers, with Moriori slaves, arrived in 1843 and remained until 1856. A British colonial settlement was established in 1849 but abandoned in 1852 after proving unsuccessful. The last inhabitants left in 1856. During the colonial period 16 births were recorded, and there were others with the Maori and possibly Moriori. Later attempts at establishing a pastoral industry were made but all lasted only briefly. During World War II two coast watching stations operated. Subsequently any occupation has been during summers only. The position of the Auckland Islands on the eastbound sailing route from Australasia to Europe, and the inaccurate charting of their position, caused a disproportionate number of shipwrecks. Several wrecks introduced mammals directly; others were landed as provision for castaways, often provided by the Invercargill Wreck Fund, which simultaneously organised introductions to Campbell Island (Kerr 1976).

Rats are now absent from the islands but were recorded twice in the 19th century. When a party from Jules Dumont d'Urville's expedition, aboard *Astrolabe* and *Zélée*, camped ashore in a sealers' hut on Enderby Island in 1841 they reported that rats (listed as *R. rattus* in the table) were sufficiently numerous as to present a problem 'while at night rats gnawed at the hammocks in which they were sleeping' (Rosenman 1987: 528). The colonial settlement at Port Ross was also troubled by rats and there are reports of the vessels being fumigated to remedy them. It is unusual for rats to die out naturally but this appears to have happened on the Auckland Islands as no subsequent record is known. It is unlikely that they were confused with mice by seamen (compare the situation of mice thought to be rats in South Georgia). The contrast between persistence of rats on Campbell Island and their absence on the Auckland Islands is unexplained.

Mice were present before January 1840 when Silas Holmes of the United States Exploring Expedition (1838–1842) caught one (Wilkes 1845: I: 94). They were

seen at Port Ross by Governor Charles Enderby in 1850 who wrote 'the English mouse appears to thrive about the houses, and I hear that there are rats, but they have not yet crossed my path.' (Enderby 1850: 24). Mice were abundant on Enderby Island in 1993 but apparently succumbed to the rabbit poisoning programme as a by-catch (the author saw many intoxicated mice out in broad daylight on this occasion). Most now occur on Auckland Island but a population was also reported on Masked Island, Carnley Harbour.

Feral cats are extant and probably arrived as 'working cats' with the early sealers. An early record is from 1840 when 'a cat's nest was found with two kittens in it, still blind: they were of course destroyed, but the old cat escaped' (Ross 1847: 149). They appear occasionally in photographs of the pastoral settlers and, undoubtedly, multiple introductions have occurred. The coast watchers' stations adopted the occasional cat as a pet (Turbott 2002). Dogs were introduced by Maori and Moriori settlers (1843), the colonists (1849), and shepherds (1909). The survivors of the wreck of *Grafton*, in 1864, encountered wild dogs. They later found a young cat that helped clear their hut from mice (Musgrave 1866). The wreck of *Derry Castle* in March 1887 introduced dogs to Enderby Island, they were present early in 1888 (Dougall 1888) but there are no reports of their subsequent persistence (McLaren 1948). The most recent dog introductions, under very strict control, have been used to assist with programmes to eradicate rabbits, pigs, and cats as well as assist with locating endemic teal, snipe, and other birds.

Pigs were the earliest introduction, having been landed in October 1807 by the London sealer Abraham Bristow aboard *Sarah* (Jones 1970). By 1840 they 'had become very numerous' (Ross 1847: 150). There were subsequent introductions, notably in 1843 when Maori, with Moriori slaves, arrived from the Chatham Islands aboard the Sydney brig *Hannah* (Captain Ellis). Their effects have been severe and, although eradication has been proposed, some were extant in 1998 although reduced by a trapping programme. The Maori also introduced dogs, which persisted, with several subsequent introductions, for at least two decades.

Ross (1847), aboard HMS *Erebus* in 1840, landed more pigs, sheep and rabbits. In 1849 a British colonisation expedition introduced horses, sheep, cattle, pigs, and poultry from the Southern Whale Fishery Company of London. Charles Enderby (1850: 12) recorded 'The Company has sent eighty cattle and three hundred sheep, most of which are landed on Enderby Island, ...'. More of both species were brought by subsequent voyages as well as horses which were kept on Rose Island but 'for which no use could be found' (McLaren 1948: 56) and they were removed in 1852 (Carrick 1903). The unsuccessful colony was abandoned in 1852 (Fotheringham 1995) and some of the stock left on the island were subsequently killed by sealers and Maori (Malone 1854). More introductions were made on Enderby Island in May 1895

when nine cattle and twenty sheep were landed (Lukins 1896). The progeny of the cattle persisted, adapting to include seaweed in their diet, until the last was shot in 1983 completing an eradication campaign (Turbott 2002). The sheep apparently did not survive very long. McLaren (1948: 93) described a later attempt to farm on the Auckland Islands. After a false start it began in 1900 when 2000 sheep were landed at Carney Harbour. 'The sheep died off in a few years, the buildings decayed, or were blown down ...' and the enterprise failed. Sheep were kept on the small Ocean Island in 1942 by coast watchers, but all were eaten within the year (Eden 1955). Rabbits flourished on Enderby Island until a successful poisoning campaign in 1993 which also eradicated the mice.

Goats, pigs, and rabbits were released by William Norman of HMCS *Victoria* in 1865 and more goats arrived a few days later aboard *Southland*, Captain James Greig (McLaren 1948). Turbott (2002: 141) wrote 'they were carried almost as a matter of course on the government vessels servicing castaway depots (1877–1927)'. In 1891 sheep and goats provided sustenance for the survivors of the wreck of *Compadre* (Eden 1955). In 1903 they were numerous on Ocean Island (Chilton 1909). In 1987 an eradication programme began when 107 goats were shot by 1990. Two were caught alive in 1997 and later searches found none (Turbott 2002).

A note in *Otago Witness* of Dunedin records '... since the beginning of 1890 the Southland Society has distributed 236 'possums, some of which have been sent as far afield as the Auckland Islands ...' (*Otago Witness* (Dunedin) 29 January 1891). The animals were originally from Tasmania. A government vessel, *Hinemoa*, sailed from Bluff to the islands in 1890 (Headland 2009a) and may have been the one that carried them. This was done when acclimatisation societies were introducing many species to New Zealand. There is no subsequent record of the opossums on the islands, as distinct from on the main islands of New Zealand where they became pestilential.

An account of the year 1942–1943, during the coast-watchers' time, written by Charles Fleming (McEwan 2006) noted the following mammals: pigs, sheep, cattle, goats, cats and mice. The first three were sources of fresh meat and the last two regarded as pests. The Rare Breeds Conservation Society (2010) has transferred and maintained some rabbits, pigs, and cattle from the Auckland Islands in New Zealand, but was unsuccessful in preserving any of the goats.

Campbell Island

One main island with offshoots, of ancient volcanic origin; in the Pacific Ocean. Area: 113 km², highest elevation: 569 m (Mount Honey). Sighted and first landing 1810 (by sealers). Uninhabited, coast watchers and a scientific station operated from 1941 to 1995; whalers, sealers, and pastoralists had previously wintered. Minor whaling stations operated 1909–1914. New Zealand territory. The

sealing period lasted from 1810 to 1912 during which 49 sealers' vessels visited and one was wrecked. All exotic mammals have been eliminated from the island. Ian Kerr (1976) wrote a comprehensive history of the island.

Brown rats undoubtedly arrived with sealers and were common until 2001 when a difficult, but carefully planned, eradication campaign was successful. In 1926 the government steamer *Tutanekai* took a party of shepherds there after the station had been abandoned for nine months and the first difficulty proved to be regaining possession of the house and store shed from the island's rats. Cats, introduced by shepherds, were 'unequal to the task' – 'rats shot by the hundreds' (Eden 1955: 22). Charles Chilton (1909) indicated a possible presence of black rats [not included in the table]. Photographs confirm that the pastoralists kept cats in the 1920s (Fraser 2001). The extermination of all cats was a policy decision in 1983 (Lucas 1983: 54) with the injunction that 'Meteorological Station staff and permitted visitors to shoot any cats on sight'. However their demise apparently happened with minimal human intervention only a few years later. Mice were another early introduction and were widespread. These caused problems for the coast watchers' depots and surveying parties (Eden 1955) but subsequently became sparse and any survivors probably died during the rat eradication campaign.

Dogs, introduced by sealers, became so ferocious that, in 1811, a sealing master, Charles Feen of *Mary and Sally*, called them hyenas (McNab 1907). Others, used by shepherds, were present in 1912 (Kerr and Judd 1978) and subsequently. Several instances of shepherds, with their dogs, conveyed to and from the island by vessels of the Ross Sea whaling fleet during the late 1920s are described by Watt (1989). Dogs were kept at the meteorological station until this was banned in 1963 (Rare Breeds Conservation Society 2010) after which hydatid disease died out in the sheep. Subsequent introductions were for brief periods, mainly involved in sheep control and eradication.

A boar and two sows were landed in late 1865 from HMCS *Victoria* when a regular series of voyages to relieve castaways on the New Zealand sub-Antarctic islands and Macquarie Island began (Kerr 1976). A similar voyage by *Amhurst*, in 1878, added to provisions for castaways: goats, 'two billies and three nannies', and more pigs, two boars and three sows. Kerr (1976) reported such voyages landing cattle, sheep, and goats on several occasions to supplement provisions for castaways. In 1907 Edgar Waite (Chilton 1909: 599) observed that he was unaware 'if the goats placed on Campbell Island in 1890, or their progeny, are still in existence' and he considered that the swine 'appear to have died off'.

A few sheep were reported as landed from *Vire* in 1874 during the French transit of Venus expedition (Jacquemart 1882). The pastoral period began in 1895 when between 300 and 400 sheep were introduced. Several later landings of sheep, in large quantities, were made for the pastoral enterprise (Kerr 1976). Wool production

continued until 1931 during which numbers rose to several thousands. The sheep were left after the enterprise was abandoned as it was no longer economical (Lucas 1983). From 1941 their progeny provided meat for the coast watchers and meteorologists. In 1953 three stud rams were introduced to try to improve the stock (Rare Breeds Conservation Society 2010). The last sheep were eradicated by 1991.

Eight cattle and two horses were landed in 1902 (Kerr 1976) and descendants of the former remained after 1931 (Lucas 1983). Horses were used by the shepherds, but were not practical owing to the boggy terrain; the last record was of a horse corpse, found in a mire in 1927 (Eden 1955). Small numbers of additional cattle were brought when more sheep were occasionally imported, but they did not spread extensively (Sorensen 1951). The last of the cattle were shot in 1987. Several photographs and accounts show the shepherds also kept dogs and cats (Kerr 1976).

An edited account of the years 1919 to 1921, during the pastoral settlement, written by Alfred Austin (Dingwall and Gregory 2004) noted the following mammals present: some thousands of sheep, about two dozen dogs, a small herd of wild cattle, pigs, and a horse. The last of the pigs was killed in August 1921 as 'shortage of pig food very acute' (p 91) which indicates they were domestic rather than feral. Cats, mice, and rats were also mentioned in the text. The Rare Breeds Conservation Society (2010) has transferred and maintained some Campbell Island sheep in New Zealand. Jack Sorensen (1951: 58) records 'a single record that rabbits were once liberated on Campbell Island. Fortunately they failed to survive ...'. Chilton (1909) does not record rabbits as introduced fauna of Campbell Island thus it may be that they arrived during the most recent attempt at farming alternatively HMCS *Victoria*, which visited in 1865, had rabbits aboard and released some on the Auckland Islands, and might also have done so on Campbell Island (the table records 1910s as the more likely period).

South Shetland Islands

A 540 km chain of four main groups, including eleven major islands, many minor ones, with numerous islets and rocks; some volcanic (Deception Island last erupted in 1970); average about 120 km north of the Antarctic Peninsula; in the Southern Ocean. Area: 3687 km². Highest elevation: 2105 m (Mount Foster, Smith Island), about 80% glacierised. Sighted and first landing 1819, sealers arrived 1820. Permanent occupation (military and scientific stations) from 1944; sealers had wintered unintentionally in 1821 and 1872. The sealing period lasted from 1820 to 1908 during which 197 sealers' vessels visited and 12 were wrecked. Summer whaling station operated at Deception Island 1912–1931, and seven shipwrecks are associated with this industry. Part of British Antarctic Territory; also claimed by Argentina and Chile, but under the aegis of the Antarctic Treaty (1959). The

islands have been occupied by 14 winter stations from ten countries (Headland 2009b) and several others have deployed summer stations. Presently there are no exotic mammals extant on the group. Several children have been born at the Chilean station on King George Island.

Rats probably arrived with early sealers but there are no records of this. Black rats were reported from the whaling station on Deception Island where most were considered to be new arrivals each summer. Occasionally some were able to winter when they caused much destruction before they died out (Olstad 1930). Most vessels had cats which first arrived with sealers; the earliest record is in 1820, introduced with the wreck of *Cora* (Jones 1975). The stations often kept pet cats; recently only one elderly animal remained on King George Island (it is unlikely to be alive in 2011). Dogs were also occasionally aboard sealers' and whalers' vessels. The earliest landed with Edward Bransfield from *Williams* in January 1820; it was attacked by skuas and became covered in blood (Campbell 2000). Dogs were kept at the whaling station on Deception Island (Bennett 1931). Their greatest numbers were sledge dogs, from 1947 onwards, first introduced at the British base at Admiralty Bay for use during the survey of the ice cap of King George Island. Nearly all dogs were removed by 1994 under the exacting requirements of the Protocol on Environmental Protection to the Antarctic Treaty, although a sporadic bark has been heard subsequently at one of the stations. Some private yachts and expeditionary vessels carry a dog or a cat which has, in several instances, been seen ashore.

Whalers brought pigs, cattle, and sheep as food annually to Deception Island, mainly from the Falkland Islands, during the whaling period (1905 to 1931). A pigsty was built when the land whaling station for Aktieselskabet Hektor was established in 1912 (Dibbern 2010). Subsequently pigs from 1944, sheep from 1947, and cattle from 1955 were regularly taken to Argentine and Chilean stations, and occasionally to British ones, until the practice fell into abeyance after cold storage facilities improved. The Chilean station Presidente Aguirre Cerda on Deception Island had regular imports of sheep from Punta Arenas varying from 30 to 60; in 1957 they produced 15 lambs (Mazzei 1994). The sheep pen, which also held the occasional cow, was situated behind the station until destroyed by a volcanic eruption in 1969. There was also a corral at 'Arturo Prat' on Greenwich Island photographs of which also show a pig with the sheep. Arthur Bennett (1931: 136), the Falklands Islands Dependencies magistrate appointed for Deception Island, wrote that whalers kept pigs 'for the twofold purpose of eating up scraps of food and being themselves converted into food later on'.

South Orkney Islands

Four major islands, several minor ones, with offlying islets and rocks; Inaccessible Islands 30 km W; of

metamorphic origin; in the Southern Ocean. Area: 622 km², highest elevation: 1265 m (Mount Nivea, Coronation Island), about 85% glacierised. Sighted and first landing 1821 (by sealers). Permanent occupation (meteorological station) from 1903. An auxiliary whaling station, assisting floating factories, operated during summers at Signy Island from 1920 to 1926 and four shipwrecks are associated with the industry. Part of British Antarctic Territory; also claimed by Argentina but under the ægis of the Antarctic Treaty (1959). The sealing period lasted from 1821 to 1906 during which 10 sealers' voyages visited but with little success. Presently there are no exotic mammals extant on the group.

The meteorological station established on Laurie Island by the Scottish National Antarctic Expedition in 1903 had a resident dog, 'Russ', and *Scotia* was reported bringing eleven 'mongrel collies' from the Falkland Islands (Brown 1906). From 1904 the station has been maintained by Argentina and various dogs and cats have been kept for much of its existence. It is the longest continuously inhabited Antarctic region. In 1927 there is an account of several kittens arriving as a gift from South Georgia (Moneta 1958). The same source describes the arrival of four sheep which escaped shortly after landing and were not seen again. The exact year is unspecified but was several years before the event was recorded in 1929. The British Antarctic Survey station on Signy Island, opened in 1947, similarly used to keep domestic pets (cat and sledge dogs) until the 1963–1964 summer when a directive to stop the practice was issued. 'Ginger' was then deported to the Falkland Islands (Richard 1992). Although the islands were visited by sealers sporadically and whalers used various harbours during several summers, there are no introductions recorded from their activities. It thus appears that introductions have been confined to Signy Island and Laurie Island alone among the archipelago.

South Georgia

One main island, several small ones, many islets and rocks; outlying Clerke Rocks 65 km SE; mainly of sedimentary origin; in the Southern Ocean. Area: 3755 km², highest elevation: 2934 m (Mount Paget), about 55% glacierised. Probably sighted 1675, confirmed 1756, first landing 1775, sealers arrived 1786. Permanent occupation (whaling, scientific, and military stations) from 1904; sealers and scientific personnel had previously wintered. British territory, part of South Georgia and South Sandwich Islands; also claimed by Argentina. The first sealing period lasted from 1786 to 1913 during which 131 sealers' vessels visited and eight were wrecked. The island was the principal site for the land based Antarctic whaling and modern sealing from 1904 to 1965 during which six stations were built and several floating factories anchored, many hundreds of vessels visited, and summer populations occasionally exceeded 2000 men. Thirteen children were born on the island

from 1913 to 1980 (Headland 1998). Fifteen shipwrecks are associated with the industry and many vessels were scuttled off the island (Headland 1984a). In 2011 only rats, mice, and reindeer survived. A campaign to exterminate the rodents began in 2010 in which the reindeer might, unfortunately, be a by-catch.

The brown rat occurs on much of the main island but most small islands remain free from rats, notably Bird Island, the site of major ornithological research programmes, although a dead rat was found washed ashore there in 2005. A major study was completed in 1980 (Pye and Bonner 1980). Rats date from the sealing era, probably from the 1790s, and several separate introductions undoubtedly occurred. The toponym 'Ratten Havn', dating from 1878, is an indication of their presence (Boumphrey 1967). These continued during the whaling period and each whaling station retains a rat population in 2011. The author has observed differences between 'tussac rats' and 'station rats', the former being smaller, lighter coloured, more densely furred, and of more timid behaviour. Mice were mentioned by Robert Murphy (1947) in 1911–1912, but thought to be small rats. A similar statement was made when a population was discovered by geologists at what is now named Mouse Cove, a remote site on the southwestern side of the island. A wrecked shallow is evident there, which circumstantial, evidence of the method of their arrival. This population is reported as large furry mice with a thick layer of brown fat, probably the most environmentally stressed mice on Earth (Berry and others 1979). A report of mice at the abandoned whaling station of Grytviken was made in 1997, and their possible occurrence was noted at Gold Harbour in 2009. Selkirk and others (1990) included black rats in the introduced animals of South Georgia but is not clear about the source. However, considering the exceptional amount of shipping which had visited the island, especially during the whaling period, their occasional presence is highly likely. They are not included in the table.

Working cats travelled aboard sealers' vessels and were kept by whalers from the earliest years. *Daisy*, for instance had one aboard in 1912 (Mathews 2003). Most other vessels, until quite recently, also had a ships' cat. *Quest* in 1922, had one, 'Questie', and a pet dog 'Query' (Marr 1923). Cats inhabited all the whaling stations and the administrative post at King Edward Point; an estimate of around a hundred on the island at one time is probable. In 1970 the British Antarctic Survey organized a cull of cats and kittens at King Edward Point and Grytviken whaling station and achieved a bag of several dozen. This was also the time when the last survivors died out at the other abandoned whaling stations. The last cat, an elderly resident of King Edward Point, died in the 1980 winter. No cats are known to have bred outside human habitation although several ranged as much as 5 km away from houses in summer and paw prints in winter snow showed one sporadically ventured as far as 4 km. Most resorted to the whaling stations or scientific base for winter. The

danger of establishing feral populations was great and that the problems experienced on other islands were very narrowly missed on South Georgia. The occasional cat has been observed ashore, having arrived aboard a fishing vessel or private yacht; these animals are, however, highly domesticated.

Domestic and sledge dogs have regularly been ashore from the days of the early sealers. The earliest record appears to be a dog from the Nantucket vessel, *Ranger*, in 1800. James Weddell (1827: 58) visited in 1823 and reported about albatrosses having 'great power in their beaks, and, when on the nest, I have observed them defend themselves for half an hour against an active dog.' Murphy (1947) mentions the presence of a fox terrier bitch aboard *Daisy* in 1911–1912 and several photographs show dogs during the whaling period from 1904 to 1965 (Headland 1984b, Hart 2001). Eric Nordenhaag, the meteorologist from 1907 to at least 1912, kept a pet dog at King Edward Point (Mathews 2003). Wilhelm Filchner's (1922) expedition aboard *Deutschland* left sledge dogs ashore at its conclusion in 1912, but it was reported they became so wild that it was necessary that they be shot. Sir Ernest Shackleton's (1917) *Endurance* expedition used the time at South Georgia in 1914 to fatten sledge dogs on whale meat, and Shackleton was disappointed not to have any of Filchner's dogs available. Accounts exist of a variety of breeding curs from the whaling fleet accumulating at stations; these occasionally required a 'dog-shoot'. The last resident dog, a husky from Halley Bay, died at King Edward Point in 1974 but, as with cats, the occasional yacht has one aboard and a few have been seen venturing ashore. During the period 1904 to 1965 whalers were occasionally permitted to keep a domestic pet; although this was expected to be either a cat or dog (Lunde 2004), many appear in photographs (Hart 2009).

An unsuccessful attempt to breed the fur fox was made at Grytviken whaling station. The intention was to feed the foxes on the abundant whale meat and sell their winter pelts. Their accommodation, and consequent lack of breeding success, proved unfavourable. The earliest attempt began about 1920 and a small fox farm appears in photographs in 1922. It appears to have been discontinued until 1939 when another attempt to diversify activity at Grytviken was made. Fifty foxes were introduced but, although breeding occurred and pelts were exported, the project was unsuccessful and ended in 1947 (Hart 2001). In 1980 a few fox cages remained near the beach towards the whalers' cemetery.

The German contingent of the first International Polar Year Expedition (1882–1883) introduced dogs, 3 cattle, 17 sheep, and 9 goats when they established a station at Royal Bay. Although some of these ranged far none survived beyond the end of the expedition (Neumayer 1890–1891).

Pigs were introduced by sealers and whalers. *Daisy*, for instance, took four aboard in 1912 from Fernando de Noronha, three may have reached the island but they were unlikely to have landed (Mathews 2003). Most whaling

stations had several hundred present in heated piggeries that are shown on all maps of them (Basberg 2004). In summer they were sometimes allowed to roam freely. They flourished on a diet of whale products but few survived to form winter breeding stock. Introductions were an annual event for over half a century while whaling stations operated (Lunde 2004). It was reported that large sausages of bacon, pork fat, whale meat, and herbs were regarded as a delicacy by the whalers.

Horses and ponies have been introduced on at least four occasions: in 1905 by Ernest Swinhoe aboard *Consort* with three mares and a stallion (Allen 1920), by Wilhelm Filchner in 1911 (Filchner 1922) aboard *Deutschland* with Manchurian ponies, one horse at Ocean Harbour whaling station by Lauritz Larsen, and another appears on photographs at Husvik around 1912. The ponies produced several foals (Mathews 2003). The first introduction grazed on Hestesletten [horse meadow in Norwegian]. In the 1920s a horse provided transport at Grytviken (Hart 2009). Cattle, sheep (17 ewes with lambs reported in 1905; Allen 1920), and, to a lesser extent, goats were similarly kept at the whaling stations. Sheep, in particular, were left to graze in summer in fenced areas. One escapee survived several winters in the wild near Prince Olav Harbour where the toponym Sheep Point indicates where they were kept. The informal toponym 'Mutton Island', officially Grass Island, indicates also where they grazed in Stromness Bay, and almost eliminated the tussac cover (Allen 1920). Similarly King Edward Point, where the government station was situated, was called 'Sauodden' [Sheep Point] by the Norwegian whalers. Photographs also show cattle grazing (Headland 1984b). Sheep bones found on Hestesletten demonstrate some were feral. About 30 sheep from the Falkland Islands were released on Hestesletten in the 1955–1956 summer, of these 12 escaped slaughter at the end of summer. They wintered and when 11 were killed next summer, the remaining one escaped, they were reported to have been 'in a very healthy state and were particularly heavy, carrying much meat' (Pierce-Butler 1972). Rabbits were released on several occasions (1872, 1904, 1910; Allen 1920), all fortunately unsuccessful introductions although some bred for a few years; it was a very near miss for them becoming pestilential. The earliest example is believed to be when some were brought by a sealer in 1872, allegedly from Tristan da Cunha. Whalers made other introductions near Grytviken (Hope Point), Husvik (Kanin Bay) [kanin is rabbit in Norwegian], and Stromness (Grass Island) during the early decades of the 20th century.

Three introductions of reindeer were made in 1911, 1912 and 1925, of which two survive after all the 1912 animals were killed in an avalanche in 1918 (Bonner 1958; Leader-Williams 1988). The present population is at least 2500 in two separate introductions; both are currently spreading as glacial retreat gives them greater opportunities to reach new areas formerly separated by glaciers entering the sea. The introductions were made

by whalers for sport and food. On 28 September 1912 the Falkland Islands and Dependencies government (1912) enacted the 'Wild Animals and Birds (South Georgia) Ordinance' which provided legal protection for the introduced reindeer. This is the earliest, and perhaps only, legislation protecting any Antarctic introduced species (it also protected upland geese, *Chloephaga picta*). Over a century later it is probable that the elimination of the reindeer will be an unfortunate consequence of the rodent eradication campaign and there is currently a plan to reduce their numbers. Because of this a population of South Georgia animals has recently been established on the Falkland Islands to maintain their genetic strains.

At least one monkey has been on the island; a photograph taken in 1914 shows it wearing a collar and chain while clasping a flagpole. It was owned by the medical officer at Husvik whaling station and its appearance is of a vervet monkey (identified by primatologist Professor Colin Groves). This is an African species and was probably bought as a pet in Cape Town. It is possible other monkeys were introduced, especially as a more recent monkey jaw was found in Grytviken in 1980. Cages found in Grytviken and elsewhere appear to have been for parrots, but at least one held a monkey which was photographed within it, although insufficiently clearly for identification. A photograph, taken by Theodor Andersson in Grytviken between 1923 and 1932 (listed as 1925 in the table), shows a tethered pet fox, probably a crab-eating fox (*Cerdocyon thous*), sitting on a table in a cabin of a whaling station barracks (Lunde 2004). The identification is not entirely certain but this is a South American species reported as occasionally kept as a pet.

A variety of observations on the mammals kept at whaling stations include a translation of a note, dated 3 May 1912, from Søren Berntsen to his wife: 'You can believe we got some big bulls when *Orwell* arrived, but several of them died during transport. We got three dairy-cows with calves, but the calves take the milk themselves so we don't get any but we will not use the milk before we are certain that the animals are not sick since so many died underway. By now we have a whole herd in the cow-house. We had to shoot many of the bulls when they got ashore because they were so angry. They took people on their horns and threw them a long distance. Adolf [Gurijordet], you remember him who visited us once, he is from the countryside and he was attacked by a bull and hurt his leg so he had to stay inside for several days. We shot them down and lived well on fresh meat. I also have seven rabbits. I take care of them myself ... You can believe we have nice pigs as well. In total with small and large we have about 60 pigs so we can eat a lot of pig meat this winter, you can think.' When visiting the island aboard *Endurance* Sir Ernest Shackleton (1914) wrote 'Pigs are the principal domestic animals on the island, though there are sheep, goat, reindeer, two ponies, cattle, a bull, ducks, hens and a monkey'.

Several other examples of the many exotic mammals during the whaling period are given in reminiscences

compiled by Gibbie Fraser (2001). These are from men who lived ashore and aboard whalers' ships from the early 1940s to the end of the industry. A selection, indicating the page reference in Fraser, includes: '... the Manager and the Chemist went into the hills and shot some sheep and we had to go and carry them back to the butcher shop' (Peter Pole: 15); 'took down kye [cattle] from the Falkland Islands ... some left for winters before they killed them. They lived on the tussock grass' (Sonny Williamson: 21); '*Raven* was full of huge rats ... nearly the size of cats' (Geordie Mainland: 82); 'I took down 80 pigs ... the big ones hung up at around 200 pounds [90 kg]' (Alex Henry: 105); 'work in the piggery ... a fine job ... a bit smelly but it was warm' and 'they went to caa [drove] the sheep ... bit of a carry on ... as many men as sheep and only one dog ... slaughtered them all in one go' (Tom Robertson: 116); 'called along the Cape Verde islands ... sell you anything you could mention plus booze and monkeys' (Johnnie Polson: 122); '... took all the cats and kittens and banged their heads ... threw them over the side' (Attie Williamson: 156); 'on one trip south I looked after 60 pigs' (Karl Brown: 159); 'he slipped poison in among their feed when the pigman was not looking ... killed over 100 pigs' (Robert Wiseman: 197).

From 1917 the British Colonial Office considered acclimatisation of animals such as Alaska or Dall sheep (*Ovis dalli*), domestic goats, musquash or musk rat (*Ondatra zibethicus*), and 'smaller mammals' to South Georgia, fur-bearing species in particular. The final report deprecated this owing to the dangers of destruction of native fauna, particularly that 'it may be anticipated that it would prove highly destructive to the penguins' (Allen 1920: 20). This report also recorded that 'The brown rat has always been found to be an undesirable colonist, and the reduction of its numbers, or its complete extermination, if that were possible, would probably be an unmixed advantage.'

Gough Island

One island and several rocks, of ancient volcanic origin; in the Atlantic Ocean. Area: 65 km², highest elevation: 910 m (Edinburgh Peak). Probably sighted 1505, first landing 1675, sealers arrived 1804. Permanent occupation from 1955, South Africa has maintained the meteorological observatory after its first year, sealers had previously wintered. British territory, part of the Dependencies of Saint Helena. The sealing period lasted from 1804 to 1910 during which 34 sealers' vessels visited and one was wrecked. Mice are the only extant introduced mammal.

A summary of introduced mammals is included in the comprehensive report by Cooper and Ryan (1993) and more details are in Hänel and others (2005). Mice breed and are abundant, and have been so since at least 1888 when George Comer, a sealer, described them (Verrill 1895). In 1922 Frank Wild (1923: 271), aboard *Quest*, noted that in two huts at The Glen 'mice swarmed; they were very tame and showed little fear of us'. Their

local numbers sometimes increased to such an extent that the men of the meteorological observatory occasionally conducted ‘mouse hunts’, often achieving a bag of several hundred. Environmental effects must be regarded as significant, especially their recently detected predation of albatross and other chicks (Cuthbert and Hilton 2003). A feasibility study for eradication was recently prepared (Parkes 2008). The presence of rats has been investigated but no evidence of living rats has been found ashore, it is unusual to find both rats and mice on a small island as the larger eat the smaller, likewise it is rare for both to be present aboard one vessel. A dead rat was found in cargo aboard a supply ship in 1968 and another arrived in 1974, emphasising the problem of their potential arrival (Richardson 1984). Six sterilised female albino *R. norvegicus* were introduced in 1984 as a ‘Delilah trap’ to detect any suspected wild rats after a potential sighting, they were removed at the end of the programme during which no evidence of feral rats was found (Wace 1986).

Cats and dogs have been introduced on several occasions; the earliest record is 1919 for both. The last dog was removed in 1962. In 1919 the cat returned to the ship ‘gorged with mice’ (Hänel and others 2005: 142). Neither species has a record of breeding. In 1956 about 10 (also reported as 6) sheep were landed to provide food for the meteorological station (Holdgate and Wace 1961). Subsequently they bred and up to 30 sheep have been kept at The Glen (Cooper and Ryan 1993). Goats and a dog were landed in 1957, the former were intended to provide milk. Dogs, sheep, and goats were removed on administrative orders in 1963 (Wace and Holdgate 1976).

Antarctica

A continent (5th largest), partly volcanic (several active) with ice shelves, offlying and outlying islands. Area 13.83×10^6 km²; divided into sub-continent of Greater Antarctica (10.32×10^6 km²) and Lesser Antarctica (3.51×10^6 km²) separated by the Transantarctic Mountains. Highest elevation 4892 m (Mount Vinson). Glaciated 99.77% of surface area. Sighted and first landing 1820 (by sealers). Permanent occupation (scientific and military stations) from 1944; scientific personnel had previously wintered. Four shipwrecks are associated with the whaling industry, and several more expeditionary and commercial losses are recorded. Seven sovereign claims have been made over Antarctica, three of which overlap. The entire continent, and all other lands south of 60°S, is under the ægis of the Antarctic Treaty (1959). There have been 103 winter stations on the continent deployed by 24 countries (Headland 2009b) and many summer stations. Currently there are no exotic mammals extant on the continent. Several children have been born at the Argentine station Esperanza.

Rats made many arrivals because virtually every vessel carried them on early expeditions, and some still do. One representative example of the problem is given in the

account of the voyage of *Terra Nova* when their numbers became such that remedial action became desirable; ‘... Cheetham, our boatswain, who had crossed the Antarctic Circle fourteen times, showed himself as an adept at rat-catching and soon freed the ship from the pest. He used to throw the rats over the side, and the albatrosses and mollymawks would swoop down and devour the vermin in an incredibly short time’ (Huxley 1913: 390). Practical evidence of their residence ashore is seen in the historic hut at Cape Evans where members of Scott’s last expedition spent two winters (1911 and 1912). Among the artefacts remaining in the hut are several ‘break-back’ rat traps.

The problem of rats was partly controlled by cats kept aboard many vessels although most would not have landed. The account of one having kittens and their presentation to the Captain is given in the narrative of the *Erebus* and *Terror* expedition of 1839–1843 (Ross 1847). One cat, ‘Nansen’, wintered aboard *Belgica* in 1898 but died before summer returned; the vessel did not reach the continent and suffered from a surfeit of rats (Cook 1900). *Discovery* wintering in 1902 and 1903 had at least three cats aboard: ‘Blackall’ and ‘Poplar’, and ‘a small black cat’ (Savours 1966). Two cats were with the castaways of *Antarctic* on Paulet Island during the 1903 winter; but only one survived; its behaviour is often mentioned in the expedition narrative (Nordenskjöld and Andersson 1905). *Français* had cats, and prolific rats, aboard for the 1904 winter as well as dogs. A pet pig, ‘Toby’, was also aboard but died after winter and was buried next to an earlier grave of a dog. Toby had made two voyages to the Antarctic having been the ‘mascot’ aboard *Uruguay* the Argentine naval vessel that rescued Otto Nordenskjöld’s Swedish expedition in 1903 (Charcot 1906). Charcot’s next expedition, aboard *Pourquoi Pas?* (1908–1910), found both animal graves on Booth Island. It also carried dogs and cats, as well as rats (Charcot 1911). Roald Amundsen’s ship *Fram* had severe rat problems and took a cat aboard in Buenos Aires to help control them. It was shot on the Ross Ice Shelf in 1912 (Nilsen 1912). ‘Nigger’ was a black cat on the *Terra Nova* which appears ashore in Herbert Ponting’s film *90° South* but departed aboard the ship before winter. There were two cats aboard *Endurance* although neither, nor the expedition, was able to reach the continent (Shackleton 1917). One of them, ‘Mrs Chippy’, was the subject of a biography (Alexander 1997). Richard Byrd’s second expedition included two cats wintering at ‘Little America’ in 1932. ‘Lummo’ was the British Graham Land Expedition’s cat which spent two winters south, on the Argentine Islands in 1935 and Barry Island in 1936, but ‘Peter’ the expedition’s other cat, did not survive the first winter. Many more recent stations kept cats, some introduced as pets such as ‘Tiddles’ at Port Lockroy in 1952 (Richard 1992), ‘Kista’ and ‘Kosmo’ smuggled ashore at Halley Bay in 1961 (Noble 2009), and cases of ships’ cats being ‘detained’ ashore are parts of informal history of some British bases. Although the number has declined, in 1997 the author

observed only one, rather elderly animal, on the continent and it is probably now dead. More recently there are occasional reliable reports and sightings of cats at some stations and aboard vessels.

Dogs have been the most abundant introduced mammals, the majority used for sledge hauling and several hundred have inhabited the continent at one time. An early record is in 1840 when a dog, 'Sydney' acquired in Australia, is depicted on an 'ice island' having landed from Wilkes' United States Exploring Expedition aboard *Vincennes* (Viola and Margolis 1985). Sledge dogs have had discontinuous breeding populations at stations for over a century. Their range has extended around most of the continental coasts to the South Pole. The earliest introduction of sledge dogs was aboard *Southern Cross* in 1899 at Cape Adare where they were allowed to run free in the Adélie penguin colony (Borchgrevink 1901). A dog was landed on the Ross Ice Shelf from a whaling ship in 1923 (Villiers 1924). Virtually all early expeditions carried them and, after 1944, there was a continuous breeding population at several stations for half a century. A party of the Trans-globe Expedition wintered with a fox terrier in 1980 near the South African station in Dronning Maud Land (Fiennes 1983). The majority of the dogs were removed before the end of 1994 as stipulated by the Antarctic Treaty Environmental Protocol, but this stringent infliction was ignored in a few instances. No dogs have apparently been disclosed after 2005 although the occasional private yacht has carried one and these have been seen running free in Antarctica, as on the South Shetland Islands. At the conclusion of several expeditions, because of infirmity and other causes many dogs were shot or otherwise killed, and the frozen remains of some may still be seen.

Of all exotic animals dogs are the most likely to be able to survive without human assistance in Antarctica and 'live off the land'. A few instances of their release are recorded. Roald Amundsen's (1912) Norwegian expedition left escaped dogs before *Fram* departed from Antarctica in February 1912. At about the same time some of the dogs of the Japanese Antarctic expedition, led by Nobu Shirase (1913), had to be left ashore when the ship was forced to depart as ice accumulated. No details of the fate of any of these dogs are known although some of the former had broken into depots and resorted to cannibalism. On 22 March 1941, during a difficult evacuation of 'East Base', Marguerite Bay, some of the dogs of the United States Antarctic Service Expedition (1939–1941) were left in case the aircraft evacuation was not successful. They were tethered in the vicinity of an 8-hour time bomb so that if the aircraft was forced to return they could be rescued and used during a second winter (Spude and Spude 1993). Evidence that the bomb had not done its work successfully was found later. The other dogs had been shot and their remains apparent in 1946 (Fuchs 1982). In February 1958 difficult sea ice required evacuation and closure of 'Syowa' station of the Japanese International Geophysical Year expedition.

Fifteen tethered dogs were left. In February 1959 the station was reoccupied and two of the dogs were found alive (Matsumoto 1959). A private expedition, organized by Norman Vaughan (1995), aboard a DC-6 aircraft crashed in the vicinity of Patriot Hills on 25 November 1993. Aboard was a team of sledge dogs that survived and were released. Some escaped; although paw prints were seen about 45 km away their fate is unknown. There are several other accounts of dogs, or even of a team, becoming free. Many were never seen again but a few survived for months before returning to a base. Nine dogs from 14 in two teams from Horseshoe Island base were recovered after a tragedy in 1958. They had spent about a winter month in Marguerite Bay (Walton and Atkinson 1996).

Mice presumably had a similar history as rats although it is unusual for them to endure aboard a vessel when the latter are present. In 1974 a New Zealand mouse arrived at McMurdo station amongst air cargo, its fate being death by starvation (Caffin 1974). One base, in the Larsemann Hills, was reported as having a small population in 1990 but they died after its temporary closure. Four mice aboard *Discoverer III*, a United States artificial satellite, which was launched on 3 June 1959 but failed to go into orbit and was believed to have crashed in Antarctica, were presumed dead on arrival, and probably cremated on the way.

Equines have been introduced by several early expeditions: *Nimrod* in 1908 (ponies), *Terra Nova* in 1911 (ponies) and 1912 (mules), all on Ross Island, and *Deutschland* in 1912 (ponies) on the Filchner Ice Shelf, but none proved ideal for transport (Shackleton 1909; Huxley 1913; Filchner 1922). Equine remains may still be seen on Ross Island. Admiral Richard Byrd introduced a bull and two cows to provide milk during his second (1933–1935) expedition at Little America II. One cow calved during the winter and another died, thus three cattle were removed at the end of the expedition (Byrd 1935). Cattle are recorded at the Chilean 'General Gabriel Gonzalez Videla' station at Paradise Harbour in 1951 where sheep and pigs were also kept at various times, for the provision of fresh meat. Some stations also kept pigs that were fed leftover food, Port Lockroy was provided with a little pig for fattening in 1944, its slaughter was emotional for the base (Richard 1992). These animals occasionally appear in photographs. Two introductions of rabbits are known, both from the *Terra Nova* expedition (1910–1913). Tom Crean is reported as having a pet rabbit which gave birth on Christmas Day 1910. Scott wrote: 'She gave birth to 17, it is said, and Crean has already given away 22!' (Huxley 1913: 58). The 'Bipes' paper in the *South Polar Times* recounts the fate on another that stowed away in New Zealand in 1910 and was found dead in a hay bale at Ross Island (Taylor 1914). A photograph in the Scott Polar Research Institute collections indicates a goat, the mascot 'Billy', was aboard *Morning* during the relief expedition to Ross Island in 1903–1904 summer. It is, however, probable that he did not go ashore.

There are a few records of other introduced mammals in Antarctica. Hamsters were introduced for metabolic studies in 1960. There is a record of one of them giving birth to twins on 14 March 1961 at Amundsen-Scott station, South Pole (Stewart 1990). A persistent rumour around McMurdo station involves another smuggled in and kept as a pet for a winter in the late 1990s, but this is uncorroborated. Hedgehogs were present at Cape Hallett station during the 1962–1963 summer (Harrowfield 2007). An anecdote about a bat found in the hold of RRS *Bransfield* during the relief of Halley station on the Caird Coast, presumably during the single annual relief in the late 1980s, concluded that it was ‘a curious case but once found the species was returned to its origins in Uruguay’ (Richard 1992). Two alpacas (*Vicunga pacos*), purchased in Chile in 1947, for use as haulage animals by Finne Ronne’s expedition, were killed by the dogs during the southern voyage and did not reach land (Spude and Spude 1993). In 1910 *Terra Nova* had a guinea pig (*Cavia porcellus*) aboard from Lyttelton but this was ‘carelessly dropped overboard’ before reaching Antarctica (Taylor 1916: 53).

Bouvetøya, Balleny Islands, Scott Island, Peter I øy, Shag Rocks, and South Sandwich Islands

There are no records of introduced species on any of these rarely visited peri-Antarctic islands. Only the South Sandwich Islands have had a wintering population, from 1978 to 1981 (Canclini 2009). Bouvetøya is the only one with a record of shipwreck (Crawford 1982). Sealers’ visits were few or none for all the groups. Dates of their discovery and the earliest known landing are: Bouvetøya, discovered 1739, earliest landing 1822; Balleny Islands, discovered and earliest landing 1839; Scott Island discovered and earliest landing 1902; Peter I øy, discovered 1821, earliest landing 1929; Shag Rocks, discovered 1762, earliest landing 1956, and South Sandwich Islands, discovered 1775, earliest landing 1811. Wreckage reported on Macquarie Island and South Shetland Islands might indicate earlier calamitous landings.

Acknowledgements

Assistance in tracing records and much other advice came from many persons including: Dana Bergstrom, Arnoldus Blix, Robert Burton, Peter Clarkson, John Cooper, Elizabeth Downes, Max Downes Bruce Hull, Lorne Kriwoken, Ronald Lewis Smith, Peter McClelland, John Spletstoeser, Keith Springer, Bernard Stonehouse, and Benoît Tollu. Several of these, and some other colleagues, have provided various personal observations, which are incorporated in the record. The Scott Polar Research Institute archives and library provided many of the less accessible references. Lecturing engagements aboard ships chartered by Quark Expeditions gave me opportunities to make local observations on many peri-Antarctic islands and on Antarctica.

References

- Alexander, C. 1997. *Mrs Chippy’s last expedition*. London: Bloomsbury.
- Allen, H.T. 1920. *Report of the Interdepartmental Committee on Research and Development in the dependencies of the Falkland Islands*. London: HMSO.
- Amundsen, R.E.G. 1912. *Sydpolen : den Norske Sydpolsfærd med ‘Fram’ 1910–1912*. Kristiania: Jacob Dybwads Forlag
- Arnaud, P.M. (editor). 1983. *A la decouverte des Terres Australes et Antarctiques Françaises* Marseille: Museum d’Histoire Naturelle.
- Arnaud, P.M., and J. Beurois. 1996. *Les armateurs du rêve*. Marseille: Mme F. Jambois.
- Aubert de la Rüe, E. 1930. *Voyage d’exploration à île Heard*. Paris: Comité de l’Afrique Française.
- Aubert de la Rüe, E. 1931. Voyage aux Iles Amsterdam, Saint-Paul et Kerguelen. *La Géographie* 55(1–2): 20–33.
- Basberg, B.L. 2004. *The shore whaling stations at South Georgia*. Oslo: Novus Forlag.
- Baty, R. du. 1948. *Fifteen thousand miles in a ketch*. London: Thomas Nelson & Sons.
- Bellingshausen, F.G.B. von. 1945. *The voyage of Captain Bellingshausen to the Antarctic Seas 1819–21*. (Debenham, F. translator and editor). London: Hakluyt Society (second series 91).
- Bennett, A.G. 1931. *Whaling in the Antarctic*. London: Blackwood.
- Berntsen, S. 1912. *Letter to his wife*, 3 May 1912 (translation by Karl Jan Skontorp). Unpublished document in Norwegian (translated extract provided by R. Burton).
- Berry, R.J., W.N. Bonner, and J. Peters. 1979. Natural selection in house mice (*Mus musculus*) from South Georgia. *Journal of Zoology* 189: 385–398.
- Bertrand, K.J. 1971. *Americans in Antarctica 1775–1948*. New York: American Geographical Society.
- Bester, M.N., and J.P. Bloomer. 2009. *Successful eradication of feral cats from sub-Antarctic Marion Island, southern Indian Ocean*. In: Wolff, M., and M. Gardner (editors). Proceedings of the 2009 Galapagos Science Symposium. Puerto Ayora, Ecuador: Charles Darwin Foundation: 189–190.
- Blanc, F. 1947. *Possibilités de l’exploitation animale dans les Dépendances Australes de Madagascar*. Paris: R. Foulon.
- Bonner, W.N. 1958. The introduced reindeer of South Georgia. London: Falkland Islands Dependencies Survey (Scientific report 22).
- Bonner, W.N. 1984. *Introduced mammals*. In: Laws, R.M. (editor). 1984. *Antarctic ecology*. London: Academic Press: 237–278.
- Borchgrevink, C.E. 1901. *First on the Antarctic continent*. London: George Newnes.
- Boumpfrey, R.S. 1967. A visit to South Georgia by, H.W. Klutshak, 1877. *British Antarctic Survey Bulletin* 12: 85–92.
- Bowden, T. 1997. *The silence calling*. Sydney: Allen & Unwin.
- Brine, L. 1877. Report respecting the Crozet Islands, South Indian Ocean. In: Great Britain. 1877. Correspondence in regard to Her Majesty’s Ships visiting groups of uninhabited islands laying on the tracks of vessels between Great Britain and the Australasian colonies. Parliament. House of Commons. Sessional Papers. *Accounts and Papers* [C 1752], LII, 599. Ordered by the House of Commons, to be printed. London: HMSO.
- Brown, R.N.R., R.C. Mossman, and J.H. Pirie. 1906. *The voyage of the ‘Scotia’: being the record of a voyage of exploration in Antarctic seas*. Edinburgh and London: William Blackwood and Sons.

- Byrd, R.E. 1935. *Discovery: the story of the second Byrd Antarctic expedition*. New York: Putnam's.
- Caffin, J.M. 1974. Treaty breach. *Antarctic* 7(2): 44.
- Campbell, G. 1877. *Log-letters from 'The Challenger'*. London: McMillan.
- Campbell, R.J. 2000. *The discovery of the South Shetland Islands*. London: Hakluyt Society (third series 4).
- Canclini, A. 2009. *Islas Sandwich del Sur*. Ushuaia: Zagier & Urruty.
- Carrick, R. 1903. *Historical records of New Zealand*. Dunedin: The Otago Daily Times and Witness Newspapers Company Limited.
- Chapuis, J.L., P. Boussès, and G. Barnaud. 1994. Alien mammals, impact and management in the French subantarctic islands. *Biological Conservation* 67(2): 97–104.
- Chapuis, J.L., and Y. Frenot. 1997. Restauration d'îles Subantarctiques Françaises. *Association Amicale des Missions Australes et Polaires Françaises* 42: 28–32.
- Charcot, J.E.B. 1906. *Le 'Français' au pôle sud : journal de l'expédition Antarctique Française*. Paris: Ernest Flammarion.
- Charcot, J.E.B. 1911. *The voyage of the 'Why Not?' in the Antarctic*. London: Hodder and Stoughton.
- Chilton, C. (editor). 1909. *The subantarctic islands of New Zealand*. Wellington: Government Printer.
- Chown, S.L., and P.W. Froneman (editors). 2008. *The Prince Edward Islands: land-sea interactions in a changing ecosystem*. Stellenbosch: Sun Press.
- Chroniques d'Outre Mer*, 1956. Une réussite inattendue élevage et horticulture aux îles Kerguelen. *Chroniques d'Outre Mer* 30: 3–6.
- Clark, M.R. and P.R. Dingwall. 1985. *Conservation of islands in the Southern Ocean*. Gland: IUCN.
- Clarke, W.B. (editor). 1850. *Narrative of the wreck of the 'Favorite' on the island of Desolation*. London: William and Edward Painter.
- Convey, P., Y. Frenot, N. Gremmen, and D.M. Bergstrom. 2006. Biological invasions. In: Bergstrom, D.M., P. Convey, and A.H.L. Huiskes. 2006. *Trends in Antarctic terrestrial and limnic ecosystems*. Dordrecht: Springer: 193–220.
- Convey, P., and M. Lebouvier. 2009. Environmental change and human impacts on terrestrial ecosystems of the sub-Antarctic islands between their discovery and the mid-twentieth century. *Papers and Proceedings of the Royal Society of Tasmania* 143(1): 33–44.
- Cook, F.A. 1900. *Through the first Antarctic night*. London: William Heinemann.
- Cooper, J., and P.G. Ryan. 1993. *Management plan for the Gough Island wildlife reserve*. Rondebosch: University of Cape Town.
- Corbet, C. 1875. *Venus at the isle of Desolation*. Southampton: Alfred Randle.
- Crawford, A.B. 1982. *Tristan da Cunha and the roaring forties*. Cape Town: David Phillipon.
- Csordas, S.E. 1985. Domestic animals on Macquarie Island; an un-scientific paper on a semi-scientific subject. *Aurora* 18: 23–26.
- Cumpston, J.S. 1968. *Macquarie Island*. Canberra: Antarctic Division.
- Cuthbert, R., and G. Hilton. 2003. Introduced house mice *Mus musculus*: a significant predator of threatened and endemic birds on Gough Island, South Atlantic Ocean? *Biological Conservation* 117: 483–489.
- David, A.F. 1984. More light on the French settlement on St Paul Island. *The Great Circle* 6(2): 109.
- Davis, J.K. 1909. The 'Nimrod's' homeward voyage – in search of doubtful islands. In: Shackleton, E.H. 1909. *The heart of the Antarctic*. London: William Heinemann: 407–412.
- Derenne, P.R., and J.L. Mouglin. 1976. Données écologiques sur les mammifères introduits de l'îles aux Cochones, Archipel Crozet. *Mammalia* 40(1): 21–53.
- Dibbern, J.S. 2010. Fur seals, whales and tourists: a commercial history of Deception Island, Antarctica. *Polar Record* 46(238): 210–221.
- Dingwall, P., and G. Gregory. 2004. *A musterer's sojourn on Campbell Island: the diary of Alfred Austin 1919–1921*. Wellington: Department of Conservation.
- Dorst, J., and P. Milon. 1964. *Acclimatation et conservation de la nature dans les îles subantarctique Françaises*. In: Carrick, R., M.W. Holdgate, and J. Prévost. 1964. *Biologie Antarctique*. Paris: Hermann: 579–588.
- Dougall, W. 1888. *Far south*. Invercargill: Southland Times.
- Douglas, H.P. 1939. *The Antarctic pilot* (2nd edition). London: HMSO.
- Downes, M. 2002. *First visitors to Heard Island*. Hobart: Australian Antarctic Division.
- Drygalski, E. von. 1904. *Zum Kontinent de Eisigen Südens : Deutsche Südpolarexpedition*. Berlin: Georg Reimer.
- Drygalski, E. von. 1935. Hunde auf Kerguelen. *Sondeabdruck aus der Zeitschrift der Gesellschaft für Erdkunde zu Berlin* 1935: 1–2.
- Duchêne, J.C. 1989. *Kerguelen: recherches au bout du monde*. Tours: Territoire de Terres Australes et Antarctiques Françaises.
- Easmond, J. 1882–1883. Crusoes of the Antarctic: being an account of the voyage and shipwreck of their bark *Trinity* and hardships of her crew. *Forest and Stream* 19: 424–425, 443–444.
- Eden, A.W. 1955. *Islands of despair*. London: Andrew Melrose.
- Enderby, C. 1850. *The Auckland Islands*. London: Southern Whale Fishery Company.
- Falkland Islands and Dependencies Government. 1912. An Ordinance to provide for the preservation of certain wild animals and birds in South Georgia (no. 8 of 1912). *The Falkland Islands Gazette* 176: 197–198.
- Falla, R.A. 1937. *Birds*. Adelaide: B.A.N.Z.A.R. Expedition Committee (reports series B, vol. II).
- Fiennes, R. 1983. *To the ends of the Earth*. London: Hodder and Stoughton.
- Filchner, W. 1922. *Zum Sechsten Erdteil: Die Zweite Deutsche Südpolar-Expedition*. Berlin: Ullstein.
- Floch, D. 1982. *Les oubliés de l'île Saint-Paul*. Rennes: Ouest France.
- Fotheringham, B.I. 1995. *The Southern Whale Fishery Company at the Auckland Islands*. Unpublished M.Phil dissertation. Cambridge, Scott Polar Research Institute.
- Fraser, C. 1986. *Beyond the roaring forties: New Zealand's subantarctic islands*. Wellington: Government Printing Office.
- Fraser, G. [compiler]. 2001. *Shetland's whalers remember*. Fort William: G. Fraser.
- Frenot, Y., S.L. Chown, J. Whinam, P.M. Selkirk, P. Convey, M. Skotnicki, and D.M. Bergstrom. 2005. Biological invasions in the Antarctic: extent, impacts and implications. *Biological Review* 80: 45–72.
- Fuchs, V.E. 1987. *Of ice and men*. London: Anthony Nelson.
- Gilchrist, A. 1992. *Addendum to 'Biology Log', Heard Island '47-'48-'49*. Hobart: Australian National Antarctic Research Expeditions (unpublished document).
- Gillham, M.E. 1967. *Sub-Antarctic sanctuary: summertime of Macquarie Island*. London: Gollancz.
- Goodenough, J. G. 1878. *Memoirs of Commodore Goodenough, R.N., C.B., C.M.G., with extracts from his letters and journals*. London: C. Kegan Paul & Co.

- Goodridge, C. M. 1832. *Narrative of a voyage to the South Seas, and the shipwreck of the 'Princess of Wales' cutter, with an account of two years residence on an uninhabited island*. London: Hamilton & Adam.
- Great Britain. 1918. *Kerguelen*. London: Foreign Office (Handbooks prepared under the direction of the historical section of the Foreign Office 146).
- Green, K., and E. Woehler (editors). 2006. *Heard Island: southern ocean sentinel*. Chipping Norton: Surry Beatty and Sons.
- Hänel, C., S.L. Chown, and K.J. Gaston. 2005. *Gough Island: a natural history*. Stellenbosch: Sun Press.
- Harrowfield, D.L. 2007. *Call of the ice*. Auckland: David Bateman.
- Hart, I.B. 2001. *Pesca*. Salcomb: Aidan Ellis.
- Hart, I.B. 2009. *Antarctic magistrate*. Newton St Margarets: Pequena.
- Headland, R.K. 1984a. Wrecks, hulks and other vessel remains at South Georgia, Falkland Islands Dependencies. *British Antarctic Survey Bulletin* 65: 109–126.
- Headland, R.K. 1984b. *The island of South Georgia*. Cambridge: Cambridge University Press.
- Headland, R.K. 1998. Births on South Georgia and other Antarctic regions. *Falkland Islands Journal* 7(2): 10–14.
- Headland, R.K. 2009a. *A chronology of Antarctic exploration: a synopsis of events and activities from the earliest times until the International Polar Years, 2007–09*. London: Bernard Quaritch Ltd.
- Headland, R.K. 2009b. Antarctic winter scientific stations to the International Polar Year, 2007–2009. *Polar Record* 45(232): 9–24.
- Heymann, G., T. Erasmus, B.J. Huntley, A.C. Liebenberg, D. de F. Retief, P.R. Condy, and O.A. Van Der Westhuysen. 1987. Report to the Minister of Environment Affairs on an environmental impact assessment of a proposed emergency landing facility on Marion Island 1987. Pretoria: South African National Scientific Programmes (report 140).
- Holdgate, M.W., and N. Wace. 1961. The influence of man on the floras and faunas of southern islands. *Polar Record* 10(68): 475–493.
- Huxley, L. (editor). 1913. *Scott's last expedition*. London: Smith Elder & Co.
- Jacquemart, J. 1882. Ile Campbell. *Annales Hydrographiques* 37: 71–79.
- Jansen van Vuuren, B., and S.L. Chown. 2007. Genetic evidence confirms the origin of the house mouse on sub-Antarctic Marion Island. *Polar Biology* 30(3): 327–332.
- Jones, A.G.E. 1970. Captain Abraham Bristow and the Auckland Islands. *Notes and Queries* October: 369–371.
- Jones, A.G.E. 1975. Captain Robert Fildes in New South Shetland. *Notes and Queries* February: 70–75.
- Jones, M.G.W., and P.G. Ryan. 2009. Evidence of mouse attacks on albatross chicks on sub-Antarctic Marion Island. *Antarctic Science* 22(1): 39–42.
- Kaeuffer, R., D.W. Coltman, J.-L. Chapuis, D. Pontiet, and D. Réale. 2006. Unexpected heterozygosity in an island mouflon population founded by a single pair of individuals. *Proceedings of the Royal Society, Series B* (doi: 10.1098/rspb.2006.3743).
- Kerr, I.S. 1976. *Campbell Island; a history*. Wellington: A. H. & A. W. Reed.
- Kerr, I.S., and N. Judd. 1978. *Marlborough whalers at Campbell Island 1909–1916*. Wellington: Department of Lands and Survey.
- Kidder, J.H. 1876. Contributions to the natural history of Kerguelen Island made in connection with the United States transit-of-Venus Expedition 1874–75. *Bulletin of the United States National Museum* 2, 3.
- La Grange, J.J. 1950. Sojourn on Marion Island. Pretoria: Weather Bureau/Weerburo (*News Letter* 39): 4–6.
- La Grange, J.J. 1961. The island stations and Antarctica news. Pretoria: Weather Bureau/Weerburo (*News Letter* 151): 165–166.
- Leader-Williams, N. 1985. *The sub-Antarctic islands – introduced mammals*. In: Bonner, W.N., and D.W.H. Walton. 1985. *Key environments: Antarctica*. London: Pergamon: 318–328.
- Leader-Williams, N. 1988. *Reindeer in South Georgia*. Cambridge: Cambridge University Press.
- Lesel, R., and P. Derenne. 1975. Introducing animals to Iles Kerguelen. *Polar Record* 17(110): 485–494.
- Loranchet, J. 1960. Etude historique de la découverte des Terres Australes et Antarctiques Françaises. *TAAF* 13: 3–26.
- Lucas, P.H.C. 1983. *Management plan for the Campbell Island nature reserve*. Wellington: Department of Lands and Survey.
- Lukins, E. 1896. *Round southern isles*. Nelson: Bond Finney & Co.
- Lunde, S.T. 2004. *Grytviken*. Oslo: Institut Minos.
- M'Cosh, J. 1835. *Narrative of the wreck of the 'Lady Monro'*. Villafield: George Brookman.
- McEwan, M. (editor). 2006. *Charles Fleming's cape expedition diary: Auckland Islands, 1942–43*. Wellington: McEwan Associates.
- McLaren, F.B. 1948. *The eventful story of the Auckland Islands*. Wellington: A. H. & A. W. Reed.
- McNab, R. 1907. *Murihiku and the southern islands*. Invercargill: William Smith.
- Malone, R.E. 1854. *Three years' cruise in the Australasian colonies*. London: Richard Bentley.
- Marr, J.W.S. 1923. *Into the frozen south*. London: Cassell.
- Marsh, J.H. 1948. *No pathway here*. Cape Town: Howard B. Timmins.
- Mathews, E. 2003. *Ambassador to the penguins*. Boston: David R. Godine.
- Matsumoto, M. 1959. *Nan'kyoku-Yusōki [An account of Antarctic transport]*. Tokyo: Sogen-sha.
- Mawson, D. 1915. *The home of the blizzard*. London: William Heinemann.
- Mawson, D. 1921. Macquarie Island. *Proceedings of the Royal Geographical Society of Australasia (South Australian Branch)* 20: 70–85.
- Mawson, D. 1932. The B.A.N.Z. Antarctic Research Expedition. *Journal of the Royal Geographical Society* 30(2): 101–131.
- Mazzei, A. 1994. Telefax to Dr R. I. Lewis-Smith, 28 August 1994. Santiago, Instituto Chileno Antártico S10/998.
- Micol, T., and P. Jouventin. 1995. Restoration of Amsterdam Island, South Indian Ocean, following control of feral cattle. *Biological Conservation* 73: 199–206.
- Micol, T., and P. Jouventin. 1998. Le retour des oiseaux sur l'île Saint-Paul. *Pour la Science* 251: 21
- Migot, A. 1955. *The lonely south*. London: Travel Book Club.
- Moneta, J.M. 1958. *Cuatro años en las Orcadas del Sur* (10th edition). Buenos Aires: Peuser.
- Moseley, H.N. 1879. *Notes by a naturalist on the 'Challenger'*. London: Macmillan and Co.
- Munro, G.D. 2006. 'Waiting on the weather' – the ANARE years 1947–1955. In: Green, K., and E. Woehler (editors). *Heard Island: southern ocean sentinel*. Chipping Norton: Surry Beatty and Sons.
- Murphy, R.C. 1947. *Logbook for Grace*. London: Robert Hale.
- Musgrave, T. 1866. *Castaway on the Aucklands*. London: Lockwood and Co.

- Neumayer, G. (editor). 1891. *Die Deutschen Expeditionen und Ihre Ergebnisse*. Berlin: A. Asher and Co.
- Nilsen, T. 1912. Fram's reiser. In: Amundsen, R. 1912. *Sydpolen: den Norske Sydpolsfærd med 'Fram' 1910 – 1912*. Kristiania: Jacob Dybwads Forlag.
- Noble, P. 2009. *Dog days on ice*. Cheltenham: Reardon Publishing.
- Nordenskjöld, O., and J.G. Andersson. 1905. *Antarctica or two years amongst the ice of the South Pole*. London: Hurst and Blackett.
- Olstad, O. 1930. Rats and reindeer in the Antarctic. Oslo: Det Norske Vitenskabs-Akademi (scientific results of the Norwegian Antarctic expeditions 1927–28, 1928–1929, instituted and financed by Consul Lars Christensen) 4: 1–30.
- Ouvry, A.A.C. 1950. *Marion Island 5th relief voyage [HMSAS 'Transvaal']*. Pretoria: Director General of Naval Forces NF 3/2/5 (unpublished).
- Palmer, H. (editor). 1929. *Life on a whaler or Antarctic adventures in the isle of Desolation by Nathaniel W. Taylor*. New York: New London County Historical Society.
- Parkes, J. 2008. *A feasibility study for the eradication of house mice from Gough Island*. Sandy: Royal Society for the Protection of Birds.
- Perillo, T. (editor). 2000. *Rapport annuel sur l'état de l'environnement dans les TAAF*. Saint-Pierre: TAAF [Terres Australes et Antarctiques Françaises].
- Perry, S.J. 1876. *Notes of a voyage to Kerguelen Island to observe the transit of Venus, December 8, 1874*. London: Henry S. King & Co.
- Pierce-Butler, K.S. 1972. *Notes on domestic animals introduced to South Georgia*. Unpublished report, 21 July 1972. Cambridge: British Antarctic Survey (copy provided by R. I. Lewis Smith).
- Pye, T., and W.N. Bonner. 1980. Feral brown rats, *Rattus norvegicus*, in South Georgia, South Atlantic Ocean. *Journal of Zoology* 192: 237–255.
- Rare Breeds Conservation Society of New Zealand. 2010. *Campbell Island, Auckland Islands*. URL: www.rarebreeds.co.nz (accessed 28 April 2010).
- Ravisi, T. de. 1853. *Les îles Saint-Paul et Amsterdam*. Saint-Denis, Reunion: Ch. Jamin.
- Reppe, X. 1957. *Aurore sur l'Antarctique*. Paris: Nouvelles Editions Latines.
- Richard, K.J. 1992. Non-native (alien) species in Antarctica. *BAS Club Newsletter* 29: 30–42.
- Richards, R. 1984. The maritime fur trade; sealers and other residents on St Paul and Amsterdam Islands. *The Great Circle* 6(1): 24–44, 6(2): 93–109.
- Richards, R. [1991]. *The commercial exploitation of sea mammals at Iles Crozet and Prince Edward Islands before 1850*. Cambridge, Scott Polar Research Institute (Polar Monograph 1).
- Richardson, M.E. 1984. Aspects of the ornithology of the Tristan da Cunha Group and Gough Island, 1972–1974. *Cormorant* 12(2): 123–201.
- Rosenman, H. (translator and editor). 1987. *An account in two volumes of two voyages to the south seas by Captain (later Rear-Admiral) Jules S.-C. Dumont d'Urville of the French navy to Australia, New Zealand, Oceania 1826–1829 in the corvette 'Astrolabe' and to the straits of Magellan, Chile, Oceania, South East Asia, Australia, Antarctica, New Zealand and Torres Strait 1837–1840 in the corvettes 'Astrolabe' and 'Zélée'*. Melbourne: Melbourne University Press.
- Ross, J.C. 1847. *A voyage of discovery and research in the Southern and Antarctic regions during the years 1839–45*. London: John Murray.
- Savours, A. (editor). 1966. *Edward Wilson, diary of the 'Discovery' expedition*. London: Blandford.
- Scherzer, K. von. 1861. *Narrative of the circumnavigation of the globe by the Austrian frigate 'Novara' undertaken by order of the imperial government in the years 1857, 1858, & 1859*. London: Saunders Otley, and Co.
- Scott, R.F. 1905. *Voyage of the 'Discovery'*. London: Smith Elder.
- Selkirk, P.M., R.D. Seppelt, and D.R. Selkirk. 1990. *Subantarctic Macquarie Island: environment and biology*. Cambridge: Cambridge University Press.
- Seyrolle, A. 1998. *Journal de mer*. Orléans: Association Amicale des Missions Australes et Polaires Françaises.
- Shackleton, E.H. 1909. *The heart of the Antarctic*. London: William Heinemann.
- Shackleton, E.H. 1914. *Endurance diary, 7 December 1914*. Cambridge: Scott Polar Research Institute archives MS 1456/31 (Fisher papers).
- Shackleton, E. H. 1917. *South*. London: William Heinemann.
- Shirase, N. (leader). 1913. *Nankyoku-ki [A record of Antarctica]*. Tokyo: Nankyoku Tanken Koenkai.
- Sorensen, J. H. 1951. *Wildlife in the subantarctic*. Christchurch: Whitcombe & Tombs.
- Spude, C.H., and R.L. Spude. 1993. *East base; historic monument, Stonington Island/Antarctic Peninsula*. Denver: United States Department of the Interior, National Park Service.
- Stewart, J. 1990. *Antarctica: an encyclopedia*. Jefferson: McFarland & Company.
- Stubbington, J. 1867. *Diary of voyage aboard 'Dependent' (1865–67)*. Cambridge: Scott Polar Research Institute (*7):91(08) [1865–67] (unpublished document).
- Swire, H. 1938. *The voyage of 'Challenger', a personal narrative: a personal narrative of the historic circumnavigation of the globe in the years 1772–76 illustrated from paintings and drawings*. London: Golden Cockerel Press.
- TAAF [Terres Australes et Antarctiques Françaises], 2010. *Environnement – réserve naturelle*. Paris: URL: taaf.fr/spip/spip.php?article343 (accessed 12 October 2010)
- Taylor, T.G. 1914. *The bipes*. In: Cherry-Garrard, A. (editor). 1914. *The South Polar Times* Vol. III. London: Smith Elder & Co: 56–73.
- Taylor, T.G. 1916. *With Scott: the silver lining*. London: Smith Elder & Co.
- Terry-Lloyd, M.R. 1950. *Marion Island 4th relief voyage [HMSAS Natal]*, Pretoria: Director General of Naval Forces N.2/3/2.
- Turbott, G. 2002. *Year away*. Wellington: Department of Conservation.
- Vaughan, N.D. 1995. *My Life of adventure*. Mechanicsburg: Stackpole Books.
- Vélain, M.C. 1877. Observations générales sur la faune des deux îles. *Archives de Zoologie Expérimentale et Général* 6(1): 1–143.
- Verrill, G.E. 1895. Notes on birds and eggs of Gough Island, Kerguelen, and South Georgia. *Transactions of the Connecticut Academy* 9(2): 239–241.
- Villiers, A.J. 1924. *To the frozen south*. Hobart: Davies Brothers.
- Viola, H.J., and C. Margolis (editors). 1985. *Magnificent voyagers*. Washington: Smithsonian Institution.
- Wace, N.M., and M.W. Holdgate. 1976. *Man and nature in the Tristan da Cunha islands*. Morges: International Union for the Conservation of Nature and Natural Resources.
- Wace, N.M. 1986. Rat hunt on Gough Island. *Polar Record* 23(142): 95–97.
- Walton, E.W.K., and R. Atkinson. 1996. *Of dogs and men*. Malvern: Images Publishing.
- Watkins, B.P., and J. Cooper. 1986. Introduction, present status and control of alien species at the Prince Edward Islands,

- sub-Antarctic. *South African Journal of Antarctic Research* 16: 86–94.
- Watson, A.C. (editor). 1931. A voyage on the sealer *Emeline* and the journal from Washington Fosdick's manuscript preserved in the Museum of the Old Dartmouth Historical Society at New Bedford. *Zoölogia* 9(14): 475–549.
- Watt, J.P.C. 1990. *Stewart Island's Kaipiki shipyard and the Ross Sea whalers*. Hawke's Bay: J.P.C. Watt.
- Weather Bureau / Weerbuuro, South Africa. 1956. *Reindeer in the sub-Antarctic*. *News Letter* 87: 4.
- Weddell, J. 1827. *A voyage towards the South Pole performed in the years 1822–1824*. London: Longman, Hurst, Orme, Browne, and Green.
- Wild, F. 1923. *Shackleton's last voyage*. London: Cassell.
- Wilkes, C. 1845. *Narrative of the United States Exploring Expedition during the years 1838–1842*. Philadelphia: Lea and Blanchard.
- Woehler, E. 2006. Status and conservation of seabirds of Heard Island. In: Green, K., and E. Woehler (editors). 2006. *Heard Island: southern ocean sentinel*. Chipping Norton: Surry Beatty and Sons.

Note

History of exotic terrestrial mammals in Antarctic regions: a further note

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Received August 2011

Subsequent to this paper (Headland 2011) being submitted for publication, programmes to eradicate exotic mammals on Macquarie Island and South Georgia have made substantial progress.

With regard to the former, after delays owing to severe weather, baits for rodent eradication were laid throughout the island. Distribution of poison, release of pathogens, and hunting with dogs were also undertaken. Search and destroy operations for any surviving rabbit, rat, or mouse are to continue for several years. Early reports suggest that the programme has been very effective and most exotic mammals have been eliminated from Macquarie Island. Regeneration of the severely damaged grass areas may thus be anticipated (Tasmania Government 2011).

On South Georgia, a much larger and complex island, an experimental stage of eliminating rats from four separate areas has a preliminary report of success (South Georgia and the South Sandwich Islands Government 2011b). This also proved the techniques for use over the rest of the island. The island's government had come to the conclusion that the rodent

eradication will also require eradication of the reindeer and that will begin from the next austral summer (perhaps the stylised reindeer will then need to be expunged from the formal escutcheon of the territory) (South Georgia and the South Sandwich Islands Government 2011a). Thus, in a few more summers, the island may also be free from exotic mammals. Several years of monitoring, during which the possibility of rapidly deploying control measures is maintained, will be necessary to confirm success on these islands.

The Tasmanian and Commonwealth governments in Australia provided finance for the Macquarie Island operation, while the South Georgia Heritage Trust was responsible for South Georgia. The experience thus gained, combined with that from earlier programmes, might promote remediation of even more difficult islands. It is hoped that further progress will be made and that this will be reported in *Polar Record*.

References

- Headland, R.K. 2011. History of exotic terrestrial mammals in Antarctic regions. *Polar Record* 48(245): 123–144
- South Georgia and the South Sandwich Islands Government 2011a. Management of introduced reindeer on South Georgia'. Grytviken: South Georgia and the South Sandwich Islands Government (press release 19 February 2011).
- South Georgia and the South Sandwich Islands Government 2011b. News alert, 6 April 2011 URL: [http://www.sgisland.gs/index.php/\(h\)South_Georgia_News_and_Events](http://www.sgisland.gs/index.php/(h)South_Georgia_News_and_Events).
- Tasmania Government 2011. Parks and Wildlife Service, Macquarie Island Pest Eradication Service, 24 June 2011. URL: <http://www.parks.tas.gov.au>