



Aliens & islands



Following the New Zealand example of restoring offshore islands, Iles Aigrettes, a small islet off Mauritius's southeast coast, has had its alien species removed and native species re-introduced. It is now one of the last strongholds for several threatened birds, including the Mauritius Fody and Mauritius Olive White-eye. Aldabra giant tortoises have been introduced as ecological analogues for the extinct Mauritian giant tortoise. Image: Peter Ryan



Mauritius's Pink Pigeon declined to just 10 individuals in 1990 due to habitat loss, habitat degradation due to invasive plants, predation by introduced predators (macaques, rats, mongooses and cats), and diseases from introduced pigeons. It almost certainly would have gone extinct but for an intensive management programme, and remains dependent on continued captive breeding and release, supplemental feeding and predator control measures. Image: Peter Ryan

Peter Ryan discusses the impact of invasive alien species on remote islands.

Invasive species are one of the main threats to biodiversity, but their impact varies depending on the evolutionary history of the community being invaded. Among terrestrial ecosystems, those most susceptible to invasion are oceanic islands, which have not been connected to a continental landmass (in comparison to land-bridge islands, which have been linked to the mainland relatively recently). The few animals and plants that manage to reach oceanic islands evolve in the absence of groups that are less able to disperse large distances over water. As a result, island species are at a distinct disadvantage when new predators or competitors are introduced by human actions.

Birds on islands

Birds are a case in point. Of the 141 bird species that have gone extinct in the last 500 years, more than 90% lived on islands. Mauritius, home of the Dodo, has lost at least 20 bird species since humans arrived in the 17th century, with a further 11 disappearing from the neighbouring island of Réunion.

Hawaii lost 19 species – including an entire family of birds when the last of the four O'os went extinct in the 1980s. But this is less than half the total number of birds that have gone extinct in Hawaii since the islands were first colonised by humans. Many of Hawaii's more exotic birds, including several large, flightless geese, a short-legged ibis and a long-legged owl, disappeared shortly after the Polynesians arrived with their rats and pigs in the 13th century. And although hunting and habitat loss played a role in their demise, the primary cause of extinction for most island birds has been invasive species.

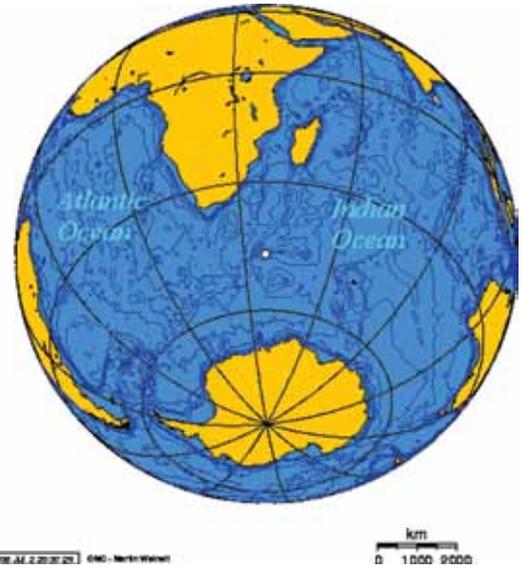
Predators that are new to the islands have caused the most damage to local species. Birds that evolved on mammal-free islands are easy prey for cats and rats. Seemingly unable to appreciate the danger posed by these strange new arrivals, adult birds remain on their nests to be eaten rather than abandoning their eggs and chicks. In one much celebrated (but apparently exaggerated) case, a lighthouse keeper's cat, Tibbles, is reputed to have wiped out an entire species. The tiny Stevens Island Wren, the world's smallest flightless bird,

Opposite page left: South Africa's Marion Island. Image: Wikimedia Commons

Opposite page right: South Africa's Prince Edward Island. Image: Wikimedia Commons



The Kau'i'o'o (Moho braccatus) – a member of the extinct genus of the o'os (Moho). Image: Wikimedia Commons



An orthographic projection centred on the Prince Edward Islands, showing their position in relation to South Africa. Image: Wikimedia Commons

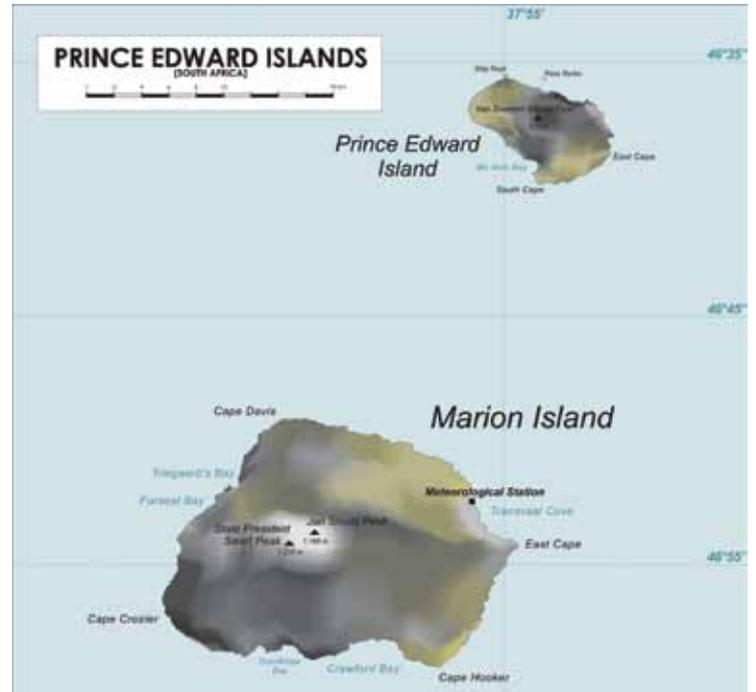
became extinct at the end of the 19th century, killed by cats introduced to this remote New Zealand island.

The Pacific island of Guam provides an even more sobering example of the susceptibility of island birds to introduced predators. Brown Tree snakes were accidentally introduced to the island by the US military just after the Second World War. Within 30 years, five of the island's eight birds were extinct, and the few surviving Guam Rails are all in captivity. But its not just predators that threaten island birds. Early explorers released rabbits and goats on islands to provide a source of food in the case of shipwreck. In many cases they had devastating impacts on the native vegetation, grazing once lush islands down to the ground, and literally destroying the habitat of the island's fauna. And introduced plants also can pose significant threats. For example, the Mexican Thorn *Prosopis juliflora* has transformed the once largely barren lowlands of Ascension Island, making them unsuitable for both nesting seabirds and turtles.

Our sub-Antarctic islands

South Africa has relatively few islands. The handful of guano islands scattered from Port Nolloth to Algoa Bay have suffered many introductions – including cats and rabbits. But the islands are tiny, and all have been linked to the mainland by sea level changes over the last 20 000 years. As a result they have not evolved unique island species. By comparison, South Africa's Prince Edward Islands, lying 2 000 km southeast of Cape Agulhas, are true oceanic islands. Formed by volcanic activity along the junction between the African and Antarctic tectonic plates, Marion (290 km²) and smaller Prince Edward Island (45 km²) are at least half a million years old. They lie in the heart of the Roaring Forties, and the cool, wet and windy sub-Antarctic climate limits plant growth to low grasses and forbs, providing little cover for landbirds. However, the islands are a crucial breeding and moulting site for hordes of seabirds and seals, including globally significant populations of iconic species like the wandering albatross (40% of the world population).

South Africa has an obligation to conserve these islands, and they are recognised as Special Nature Reserves, affording them the highest level of protection under South Africa's National Environmental Management: Protected Areas Act of 2003. However, this status has not spared them the impacts of invasive species – most of which have arrived since the islands were under South African control.



A map of the Prince Edward Islands. Image: Wikimedia Commons



The first mouse attacks on Grey-headed Albatross chicks were recorded on Marion Island in 2015, when almost 5% of chicks were attacked. The mice nibble away the back of the chicks' heads as they roost at night. Few chicks survive the gruesome wounds. Image: Peter Ryan



Swathes of pale yellow bent grass *Agrostis stolonifera* form monotypic stands on Marion Island, crowding out native plant species. Its dense root mass even prevents petrels from digging their burrows in some areas. Image: Peter Ryan



Although it is feasible to eradicate rodents from very small islands by spreading poison bait by hand, helicopters offer the only viable option on larger islands, such as Gough Island in the central South Atlantic Ocean. Each 120-kilogram bucket-load of poison bait is enough to treat about 15 hectares of this 6 500 hectare island. However, the island's rugged terrain poses an additional problem, and will require extra coverage to ensure all mouse territories are treated. Image: Peter Ryan

The Prince Edward Islands probably were first sighted by the Dutch in 1663, but alien introductions only began at the start of the 19th century, when American sealers were the first people to go ashore. Little is known about how and when the early aliens arrived. House mice were well established on Marion Island by 1818, and the cosmopolitan weed, annual meadow grass (*Poa annua*), probably reached both islands during this era. Not all the animals brought to the islands survived; fortunately the

pigs introduced deliberately for food died out, but the mice flourished, and shortly after South Africa annexed the islands in 1947, they made a nuisance of themselves at the newly established weather station on Marion Island.

Cats brought to control the mice soon turned feral, killing more birds than mice. By the 1970s some 2 000 cats were killing an estimated 450 000 seabirds each year, greatly reducing the populations of the island's burrow-nesting petrels and even driving a few species to local extinction. The loss of petrels from much of the island interior greatly reduced the import of marine nutrients, changing the island's vegetation composition and dynamics, with knock-on effects cascading through terrestrial ecosystems. These impacts are highlighted by the comparison between Marion and Prince Edward. The smaller island lacks introduced mammals, and still supports vast breeding populations of burrowing petrels. Tussock grassland and manured slope crest plant communities remain common, teeming with flightless moths and weevils, whereas these are all rare on Marion Island.

In a pioneering island restoration initiative led by Prof. Marthan Bester and colleagues from the University of Pretoria, sustained hunting, trapping and baiting saw the cats finally eradicated in 1991. At the time, we expected petrel numbers to recover quite quickly, and indeed their breeding success increased markedly – especially by the winter-breeding Great-winged and Grey Petrels that were hardest hit by the cats. However, we hadn't considered the possible impact of mice once they were the sole introduced mammal on the island.

First cats – then mice

House mice are even more ubiquitous than rats, having accompanied humans to islands all around the world. Like many successful tramp species they are generalists, eating a wide range of plant and animal food. At Marion Island they are largely responsible for the much lower densities of native

invertebrates compared with Prince Edward. However, they weren't thought to pose much of a threat to the island's birds. This changed in 2001, when Richard Cuthbert discovered that mice introduced to Gough Island – a British island in the central South Atlantic Ocean (and coincidentally home to another South African weather station) – were killing large numbers of Tristan Albatross chicks more than one hundred times larger than themselves! The mice are particularly devastating for winter breeding species, because other food resources are scarce at this season. Very few Tristan Albatross and Atlantic Petrel breeding attempts succeed, and even petrel species breeding in early summer like the Broad-billed Prion have suffered massive egg and chick mortality in recent years. As a result, plans are at an advanced stage to try to eradicate mice from Gough in the next few years.

Subsequent research on Gough Island by University of Cape Town PhD student Ross Wanless suggested that mice are particularly problematic for birds when they are the only introduced predator on an island. By removing cats from Marion, we have created just that scenario. In 2003 we recorded the first mouse attacks on Wandering Albatross chicks. Fortunately these attacks remain rare, but Marion mice have discovered a new trick – how to attack large fledglings of summer-breeding albatrosses. Mice attack large albatross chicks at night, usually gnawing into their backs and rumps, which in winter are protected only by a thick layer of down. The smaller, summer-breeding albatross chicks typically are well feathered by the time the mice start to become desperate for food, and their long, stiff contour feathers probably provide protection against mice. Certainly there have been few records of attacks on feathered chicks at Gough Island.

In 2009 several chicks at an isolated Sooty Albatross colony in the southwest corner of Marion Island were found with raw backs of their heads. Mice were the only likely culprits. Sleeping chicks tuck their bills under their back feathers to reduce heat loss, exposing the back of the head and neck. The head feathers are much shorter than those on the back, allowing access to the mice. There were no further records of attacks until 2015, when all three summer-breeding albatrosses came under attack. University of Cape Town students Ben Dilley and Stefan Schoombie confirmed that mice were guilty by photographing mice eating the chicks. More than 4% of the chicks of Grey-headed Albatross, Sooty and Light-mantled Albatross chicks were wounded, and few survive the attacks. Most worrying was the fact that incidents occurred all around the island.

The winter of 2015 also saw the first conclusive evidence of mouse attacks on petrel chicks at Marion, with Grey and Great-winged Petrel chicks both being killed. Ben Dilley recently concluded that the post-cat recovery of burrowing petrel numbers on Marion Island has been much slower than anticipated, especially for smaller species, with mice being the most likely culprits.

The good thing about islands is their isolation, which means that eradication is a viable option – provided adequate measures are put in place to prevent subsequent re-introductions. Ross Wanless, now head of BirdLife South Africa's Seabird Conservation Programme, recruited New Zealand expert John Parkes to assess the feasibility of eradicating House Mice from Marion Island. John concluded that there is a high probability of success provided experienced personnel run the operation.



*The Procumbent Pearlwort *Sagina procumbens* spreads like a rash of green spots over the red scoria on South Africa's near-pristine Prince Edward Island. Despite very strict controls on people visiting the island, *Sagina* managed to colonise Prince Edward from nearby Marion Island (probably from seeds carried on birds' feet or feathers), and is spreading even faster on Prince Edward than it did on Marion Island. Image: Peter Ryan*

Australia recently eradicated mice, rats and rabbits from sub-Antarctic Macquarie Island, and indications are that an ambitious, privately funded operation is succeeding in tackling rats and mice on South Georgia. However, French attempts to remove rodents from some of their sub-Antarctic islands failed to eradicate mice because of operational deficiencies – hence the need to use experienced operators.

The only way to eradicate mice from an island as large as Marion is to use GPS-guided helicopters to deploy poisoned bait from specially designed hoppers slung under the aircraft. Some poisoning of non-target species is inevitable, but this can be managed, and is a small price to pay compared with ongoing (and likely increasing) mouse impacts.

Forty years ago the decision was made to tackle the cats, and Marion remains the largest island from which cats have been eradicated. We now have the opportunity to carry out the largest mouse eradication yet undertaken to protect our globally important seabird populations.

Invasive invertebrates and plants

Birds might be the most visible group of organisms being affected by invasive species at the Prince Edward Islands, but they are not alone. Many of the islands' native invertebrates and plants also are at risk. House Mice pose the greatest threat to native invertebrates, including several species endemic to the islands, and their impact is increasing as climate change promotes higher mouse densities. However, at least 25 invertebrates have established themselves on Marion Island, radically changing the structure and functioning of terrestrial ecosystems. These include the first terrestrial isopods (the woodlouse *Porcellio scaber*), slugs and earthworms. We currently lack any way to eradicate or even to control these species. Worse still, their spread around the island has been accelerated by inadvertently transporting them with provisions flown to field huts.

Compared with only 15 native flowering plants, Marion has at least 18 introduced species, several of which are highly invasive and are now widespread on the island. The grass *Agrostis stolonifera* forms dense stands that displace native vegetation, reduce the abundance of native invertebrates, and

Seabirds find fine dining among jellyfish

Seabirds may have unknowing allies in their hunt for fish. Several years ago, a Japanese seabird specialist now studying the effects of climate change on life in Alaska's Bering Sea noticed that some birds seemed to target clusters of jellyfish. Last summer, he went back to Alaska and outfitted eight thick-billed guillemots (*Uria lomvia*), 45-cm-long black and white birds that nest on island cliffs, with the avian equivalent of a GoPro camera and a device that tracked their movements. Half of the resulting videos documented underwater excursions, which included 197 feeding events. In 85% of the birds' U-shaped dives, they encountered the jellyfish *Chrysaora melanaster*, a common species in that area, on their way back up. About one-fifth of the time, the birds altered their ascent to go after young fish hiding among the jellyfish, the seabird specialist and his colleagues report online in *Biology Letters*. The more fish hiding under the jellyfish, the more likely the birds were to attack, they note. In recent years, it seems that the number of jellyfish have been on the rise, fuelling concerns that their voracious appetites for microscopic sea creatures might have a negative impact on the food web and that their density might alter how fish behave – young fish seek refuge among the jellies' tentacles, for example – and consequently hamper the ability of predators to catch these fish. But this study shows the opposite can be true as well, with jellyfish creating more opportunities for seabirds. Next, the researchers plan to study guillemots in years when jellyfish numbers are down.

Source: *Science Magazine*

Hunter-gatherers ate porridge

Going on the palaeo diet? Don't put down your porridge just yet. Hunter-gatherers ate oats as far back as 32 000 years ago – way before farming took root.

This is the earliest known human consumption of oats, say Marta Mariotti Lippi at the University of Florence in Italy and her colleagues, who made the discovery after analysing starch grains on an ancient stone grinding tool from southern Italy.

The Palaeolithic people ground up the wild oats to form flour, which they may have boiled or baked into a simple flatbread, says Mariotti Lippi.

They also seem to have heated the grains before grinding them, perhaps to dry them out in the colder climate of the time. Mariotti Lippi notes that this would also have made the grain easier to grind and longer-lasting.

This multi-stage process would have been time consuming, but beneficial. The grain is nutritionally valuable, and turning it into flour would have been a good way to transport it, which was important for Palaeolithic nomads, she says.

To see the benefits of a plant-based diet, you only need to know that society has been largely fuelled by processed grains for the last 10 000 years, says archaeologist Matt Pope of University College London. 'There is a relationship there to be explored between diet, experimentation with processing plant food and cultural sophistication.'

This is another example of the advances made by Europe's Gravettian culture, which produced technology, artwork and elaborate burial systems during the Upper Palaeolithic era, says Erik Trinkaus at Washington University in St Louis, Missouri. 'These people were described 15 years ago as "Hunters of the Golden Age", and the details of that are still being filled out.'

Mariotti Lippi's team hopes to continue studying ancient grinding stones to find out more about the Palaeolithic plant diet. Grinding stones go back a long way, says Trinkaus, and people may well have been pounding and eating various wild grains even earlier than 32 000 years ago.

'We've had evidence of the processing of roots and cattails,' but here we've got a grain, and a grain that we're very familiar with,' says Pope. 'If we were to look more systematically for ground stone technology we would find this is a more widespread phenomenon.'

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Source: *New Scientist*

even exclude burrowing petrels from their former haunts.

Procumbent pearlwort *Sagina procumbens*, an innocuous-looking cushion plant, is even more damaging, invading virtually every habitat on the island. *Sagina* has also colonised Prince Edward Island, spreading across this near-pristine island even faster than it spread around Marion Island. Containers moved between South African research stations also saw *Sagina* introduced from Marion to Gough Island in the 1990s. Over the last 15 years the British government has spent millions in an attempt to eradicate it before it spreads to the island's interior. The result to date has been to merely contain it to a 400-metre length of coastal cliff adjacent to the weather station; the fight continues.

Prevention – better than eradication

Although eradication or control is possible for some species, clearly the best way to tackle alien species is to prevent their arrival in the first place. This realisation was slow to take hold, but strict quarantine measures were put in place at Marion and Gough by the late 1990s. All field clothing and equipment has to be thoroughly cleaned and inspected. Fresh produce is banned from going ashore, because fruit and vegetables carry a plethora of invertebrates, not to mention mould spores and other microscopic propagules. And the supply vessel, the *SA Agulhas II*, has to be fumigated and certified as rodent-free before she can sail to the islands. Despite these measures, new species continue to arrive; the woodlouse *Porcellio scaber* was first recorded in 2001 and a parasitic wasp *Aphidius matricariae* in 2002. The wasp is interesting because it parasitises an introduced aphid, *Rhopalosiphidum padi*.

Even stricter quarantine measures have been implemented for Prince Edward Island, which remains largely untouched thanks to the small number of visitors. Currently, scientists are only allowed to go to Prince Edward once every five years to conduct essential monitoring and research work. To the uninitiated these measures may seem needlessly draconian, but the long litany of seemingly innocuous alien species radically altering island ecosystems makes the measures essential if we want to conserve these precious crucibles of biodiversity. **Q**

Peter Ryan is the Director of the Percy FitzPatrick Institute of African Ornithology at the University of Cape Town (UCT). He was born in the UK but moved to Cape Town as a child, and was schooled in Fish Hoek before completing his BSc in Botany and Zoology and BSc Honours in Zoology at UCT. His passion for islands and their conservation was stimulated during his Masters study of the impacts of plastic ingestion on seabirds, which took him to Marion and Gough Islands. He spent a season in Antarctica before completing his PhD on the ecology and evolution of the finches of the Tristan da Cunha archipelago, based mainly on Inaccessible Island. After a year teaching at the University of California he returned to UCT to take up a lectureship in the Percy FitzPatrick Institute. Over the past few decades he and his students have worked on a wide range of bird and conservation-related research projects, focused mainly on seabirds and islands. He also has co-authored several popular books on birds, including field guides to southern African and sub-Saharan birds and Roberts 7, as well as books on the Prince Edward Islands and a field guide to the plants and animals of Tristan and Gough.

Further reading

Chown, SN, Froneman, W. (eds) 2008. *The Prince Edwards Archipelago: Land-sea interactions in a changing ecosystem*. Sun Media, Stellenbosch.