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Rat-wise robins quickly lose fear of rats when introduced to a rat-free island

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Differences between continental and island species in their ability to recognize mammalian predators are well documented, but how quickly acquired predator recognition behaviour declines or is lost when animals are translocated to sites without mammals has not been fully investigated. We compared predator recognition in a 'mainland' population of Stewart Island robins, *Petroica australis rakiura,* where rats have been present since the 1600s, and in a reintroduced island population where rats were recently eradicated and the resident robins have experienced a rat-free environment for about one generation. We found that the rat-free island population showed little fear or recognition of a model rat and were less agitated and more likely to approach and consume food in front of the model rat relative to robins on the mainland. The results of our study suggest that endemic species that acquire the ability to recognize mammalian predators lose this ability relatively quickly when translocated to islands where mammals are absent. These results raise questions about the costs of maintaining mammalian recognition behaviour in mammal-free environments, even when avian predators are present. They also raise concerns about whether island sanctuaries are appropriate sources for harvesting for reintroductions back to the rat-infested mainland.

Some species exhibit fully functional antipredator behaviour the first time a predator is encountered, but they can also improve their responses with experience (Griffin et al. 2000). Many species of fish, for example, show fear responses the first time they are exposed to alarm substances released from damaged skin of conspecifics, and they can learn to associate the alarm substance with specific predators (Chivers & Smith 1998). Although populations are expected to undergo rapid evolutionary change under increasing predation risk, the response of populations to relaxed predation is less predictable: that is, they might retain their ancestral antipredator behaviour, they might evolve greater behavioural plasticity in response to a changed environment, they might show a gradual reduction in response over time, or antipredator behaviour could be lost relatively quickly if its expression is experience dependent (O'Steen et al. 2002; Kelly & Magurran 2003). A reduction in response is predicted because vigilance and antipredator behaviour are costly, as they need to be traded off against other activities such as feeding or resting (Lima & Dill 1990). Therefore antipredator behaviour is expected to change or even be lost completely when prey become isolated from predators resulting in relaxed selection pressures (Coss 1999; Griffin et al. 2000; Blumstein 2002; O'Steen et al. 2002).

Loss of antipredator behaviour is common on oceanic islands where endemic species have evolved in the absence of terrestrial predators, which can result in population crashes when terrestrial predators do eventually colonize (Griffin et al. 2000; Blackburn et al. 2004). New Zealand has a long history of isolation and the extinction or threatened status of a high proportion of its endemic avifauna coincides with the introduction of mammalian predators by early Polynesians in about 1200 and later with European sealers/whalers after 1769 (Diamond & Veitch 1981; Worthy & Holdaway 2002). Although many endemic bird species on the mainland of New Zealand exhibit poor recognition behaviour of terrestrial mammals (Bunin & Jamieson 1996) and continue to decline in the presence of introduced predators such as rats, mustelids and feral cats, others show evidence of adaptive changes in predator recognition. For example, South Island robins, *Petroica australis,* have coexisted with introduced stoats, *Mustela erminea*, on the New Zealand mainland for over 100 years and responded strongly to a model stoat near their nest but not to a control (box), whereas robins inhabiting offshore islands and with no prior experience with stoats responded weakly to both the stoat model and the control (Maloney & McLean 1995). Nevertheless, naïve robins on islands learned to recognize and respond to the stoat model after just one training event, which involved viewing a simulated predator mobbing or hearing playbacks of robin alarm calls

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(Maloney & McLean 1995). Therefore New Zealand robins appear to possess the proper antipredator behaviours such as mobbing and alarm calling, but need to learn to recognize a mammalian predator as a specific threat.

The above studies, among others (Griffin et al. 2000; Massaro et al. 2008), indicate that some endemic island species can develop adaptive responses to introduced mammalian predators over relatively short evolutionary timescales. We investigated how quickly an endemic island species loses its adaptive response when the mammalian predator threat is removed. Reintroductions from mainland populations to offshore islands where introduced predators are absent are not only an important conservation management tool (Armstrong & Seddon 2008), but are ideal for testing the loss of predator recognition behaviour and its conservation implications. We studied predator recognition responses of a 'mainland' population of Stewart Island robins, *Petroica australis rakiura,* at Freshwater Valley, where Pacific rats, *Rattus exulans,* have been present since the 1600s and Norway, *Rattus norvegicus,* and ship rats, *Rattus rattus,* since the 1800s (Harper 2009). This mainland population was compared to a reintroduced robin population on Ulva Island, where Norway rats were eradicated in 1996, but two species of native avian predators, the flightless weka, *Gallirallus australis,* and a native owl, *Ninox novaeseelandia*, are common. The original robins on Ulva were sourced from Freshwater Valley and introduced in 2000 and 2001 (Jamieson 2011), but only two founders were still alive by the time we conducted our study. This study is the first to examine the potential loss of predator recognition behaviour in a population reintroduced to a 'rat-free' island.

METHODS

New Zealand robins of the genus *Petroica* (hereafter referred to as 'robins') are small (35 g), ground-feeding, insectivorous, forest passerines. They are socially and genetically monogamous, exhibit biparental care of offspring and remain resident on their breeding territory all year round (Higgins & Peter 2002; Taylor et al. 2008). Robins are naturally inquisitive towards humans and we took advantage of this trait for monitoring purposes by training birds to approach the sound of a researcher clapping hands to receive a food reward in the form of a mealworm (Tenebrio larva).

The study was carried out at two sites on Stewart Island: Freshwater Valley (46°50′S, 167°53′E), where Norway rats are common, and Ulva Island (46°56′S, 168°08′E) where Norway rats were eradicated by the Department of Conservation in 1996. Twenty-five robins sourced from Freshwater Valley were released on Ulva Island in 2000/2001, of which 12 survived and produced offspring (Jamieson 2011). Despite the relatively small number of founders, all introduced robins were sourced from areas where rats are known to be common (B. Beaven, personal communication), and therefore should not have been subject to a strong founder effect with respect to behavioural responses to rats. The population subsequently grew to 275 birds at the commencement of the current study in 2008.

Only territorial pairs with fledglings were targeted during our study so that all subjects were at a similar reproductive stage, and each was tested once against a pair of stimuli (rat versus box; see below). A small area of ground within a pair's territory was cleared of shrubs to allow a clear view for video recording. A branch was placed in the ground 1.5 m from the video camera to act as a perch for the birds and provide an unobstructed view of the food reward and the experimental model. Before the experiment was set up five mealworms were placed 60 cm from the perch so that the robins could expect to find food at this location on the ground. Once all five worms were eaten and at least one member of the pair was nearby, the experimental model covered with a cloth was set in place. The model stimulus was set 90 cm from the perch and 30 cm from where five more mealworms were placed on the ground. The stimulus was kept covered until the researcher returned to behind the video camera and then slowly removed the cover by pulling on an attached monofilament line. Robins were exposed to two model stimuli: a taxidermy mount of a Norway rat and a control in the form of a cardboard box similar in colour and size to the rat; the order in which the stimuli were presented was alternated between territorial pairs.

Once the model was exposed, data recording commenced when at least one of the adults landed on the perch or came within 1 m of the worms, and ended when all five of the mealworms were consumed or 5 min elapsed. We analysed two types of responses to the stimuli: the time it took for all five mealworms to be consumed (or collected) up to a maximum of 5 min and the intensity of behavioural responses towards the stimuli. Because we had no control over how many of the five mealworms either adult would consume (i.e. in some cases both male and female consumed the mealworms; fledglings never approached the mealworms), consumption time was analysed on a per territory basis. To quantify behavioural responses towards the two stimuli, however, we scored the behaviour of just one adult within the pair, whichever one was present during both stimulus trials (control and rat); in the majority of cases (22 of 25 territories) this was the male. There was one additional territory where both adults were present during both stimulus trials and for that case we used the male score. There were two further territories where behavioural data were excluded: in one case neither the male nor the female was present at both trials, and in another the male was aggressive towards the female and it was not clear whether the observed behavioural responses were directed towards the stimulus. Each behavioural response was subjectively ranked according to the level of agitation displayed by the bird (Table 1) and the ranked responses were summed within each stimulus trial to give a total intensity score. Because there were a large number of no responses, we grouped the summed intensity scores into three ordered categories (0 = 'no response', $N = 26$; 1 = 'mild response', scores 1–5, $N = 15$;

Table 1
Description of behavioural responses of robins towards stimuli and the corresponding rank scores

Behaviour	Description	Rank score
No response		0
Short alert posture	Bird stops, moves head side to side while facing stimulus for ≤5 s	1
Prolonged alert posture	Bird stops, moves head side to side while facing stimulus for >5 s	2
Side-hop	Bird on ground and hops sidewise away from stimulus	3
Peck and perch	Bird approaches worms slowly, pecks and flies off immediately to perch with or without a worm	3
Head-feather display	Forehead feathers raised exposing frontal white spot (Powlesland 1980)	4
Wing-flick	Rapid opening and closing of wings (Maloney & McLean 1995)	4
Short alarm call	1–2 alarm calls	5
Prolonged alarm call	Prolonged alarm calling accompanied by wing-flicks	6

Behaviours were ranked subjectively according to increased intensity of response (see Maloney & McLean 1995 for justification of a similar scoring scheme). If any one of the eight behavioural responses was observed more than once within a trial, it was scored only once. Short and prolonged alert postures or alarm calls were considered mutually exclusive if they both occurred, and only the prolonged response was recorded. Rank scores were summed across behavioural responses within a trial; the higher the intensity of response by a robin, the higher its summed score.