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SHORT COMMUNICATION

Survival of rock wrens (*Xenicus gilviventris*) using radio-tags, through an aerial 1080 pest control operation

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Abstract: We monitored 15 rock wrens *Xenicus gilviventris* wearing very high frequency radio-tags and/or colour bands following an aerial 1080 pest control operation in Kahurangi National Park. We found no evidence that rock wrens were susceptible to mortality from 1080, but we did note some welfare concerns for rock wrens from carrying radio-tags. Due to the high effort required to monitor rock wrens using radio-tags coupled with the low risk to rock wrens from pest control operations, we recommend using non-invasive transect counts to monitor rock wren populations annually at multiple sites.

Keywords: alpine bird, monitoring, mortality, poisoning, predator control, radio-tag

Introduction

Introduced exotic mammals are implicated in the decline and extinction of many native species in New Zealand (Holdaway 1999; Robertson et al. 2021). The scale of control operations for rats (*Rattus* spp.), house mouse (*Mus musculus*), mustelids (*Mustela* spp.), and brushtail possums (*Trichosurus vulpecula*) has been increasing steadily over the last 25 years. The main tool used to control these exotic mammals on mainland New Zealand is aerially-applied cereal baits laced with 1080 poison (Elliott & Kemp 2016; Nugent et al. 2019). Currently, predators are controlled in aerial operations over vast (> 300 000 ha) areas of indigenous forest and alpine grassland, with the total area controlled exceeding 1 000 000 ha in some years (Elliott & Kemp 2016; Department of Conservation 2022).

In general, the fledging rate of native birds can be increased by reducing predator numbers (Wright 2011). However, some native species are vulnerable to primary and/or secondary poisoning from 1080 operations (Veltman & Westbrooke 2011; Kemp et al. 2019). For these species, more detailed research is required to evaluate the population impact of the loss of some individuals against the benefits of reduced predator abundances (Powlesland et al. 1999; Powlesland et al. 2000; Kemp et al. 2018).

Rock wrens (*Xenicus gilviventris*; also known as, pīwauwau, mātuitui, and tuke) are small (14–20 g) endangered alpine passerines inhabiting Kā Tiritiri o te Moana / Southern Alps of Te Waipounamu / South Island, New Zealand. They are the only specialist alpine bird in New Zealand, being the only species that lives and breeds exclusively above the treeline. They are one of only two extant species of the New Zealand endemic Acanthisittidae wrens, of which there were once eight species in six genera, making them the (formerly) most diverse group of passerines in New Zealand (Mitchell et al. 2016). Rats have been largely responsible for the extinction of the rest of the New Zealand wrens (Holdaway 1999; Galbreath & Brown 2004; Bell et al. 2016).

There was a long-held belief that rock wrens, and alpine ecosystems, were relatively safe from introduced predators (Buller 1873; Guthrie-Smith 1936). However, more recent work has demonstrated that seasonal impacts from introduced predators can be significant (Stocker et al. 2006; Michelsen-Heath & Gaze 2007; O'Donnell et al. 2017; Weston et al. 2018; Rawlence 2019; Carpenter et al. 2023). The effects of human-induced climate change likely extend the duration of seasonal impacts, as temperature-limited ship rats (*Rattus rattus*) can inhabit alpine ecosystems for longer periods (Christie et al. 2017).

Increased awareness that predators need controlling in alpine ecosystems has led to an adaptive management approach to pest control in alpine areas, with a focus on outcomes for native species (Weston et al. 2018; Rawlence, 2019). Rawlence (2019) demonstrated that 1080 was effective in reducing predator numbers in the alpine areas of Kahurangi National Park and that rock wrens had significantly higher reproductive success in areas that received 1080 for pest control than in those that did not. This previous research instigated the current study, as some rock wrens disappeared after a 1080 operation in 2014, indicating the need to quantify potential primary or secondary poisoning risk to rock wrens from 1080.

The aim of this study was to better quantify the risk to rock wrens of aerial 1080 operations by using a more robust monitoring technique. In this study we attached very high frequency (VHF) radio-tags and colour bands to rock wrens and monitored them through an aerial 1080 operation in Kahurangi National Park in 2019.

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Study Site

This study was undertaken on the flanks of Mt Domett (41.06°S, 172.32°E) in Kahurangi National Park, where rock wrens are resident from the sub alpine scrub (1180 m a.s.l.) to the mountain tops (1645 m a.s.l.). The study site (240 ha) is comprised of granite geology which has been moulded by prehistoric glaciation and earthquakes and receives 4–6 m of annual rainfall. The study was undertaken between 12 November and 13 December 2019 during the laying and incubation phases of the rock wren breeding season (Heath 1989; Rawlence 2019).

Methods

Rock wrens were initially located using playback calls in suitable habitat. Rock wrens were then herded into a 2.6 × 6 m mist net (30 mm polyester, Avinet) by a team of five people. Captured rock wrens were fitted with a unique combination of three coloured split bands (Darvic, 2.8 mm internal diameter). Metal bands were not used due to potential thermal risk to birds when in torpor (McNab &Weston 2020). Rock wrens were then fitted with a small VHF radio-tag (Holohil BD-2NT) with an elastic leg loop harness (Rappole & Tipton 1991), with the modifications described in Streby et al. (2015) (Fig. 1). The total weight of the harness and radio-tag was 0.51 g, which is 3% of the mean female rock wren weight and 3.2% of the mean male rock wren weight ($n = 314$; Department of Conservation, unpubl. data), below the universally agreed 5% rule (Barron et al. 2010). To keep weight down, these radio-tags had an expected battery duration of only 20 days.

The study site was nested within the 'Oparara 2019' aerial 1080 operation; this covered 39 324 ha and delivered non-toxic, cinnamon lured cereal baits (6 g RS5) to the entire study site at 2 kg ha^{-1} as a prefeed on 3 November 2019, followed by toxic, cinnamon lured cereal baits laced with 0.15% 1080 poison (6 g RS5) at 2 kg ha^{-1} on 22 November 2019.

All rock wrens were radio-tracked (Lotek, Biotracker VHF) and sighted the day before the 1080 operation, and subsequently at daily intervals as the weather permitted. Dead birds were located and remains were sent to Manaaki Whenua – Landcare Research for 1080 residue testing with a minimum detectable level (MDL) of 0.001 μg g^{-1}. Recapture for radio-tag removal was attempted for all birds where practical.

Results

We attached radio-tags and colour bands to 14 rock wrens (seven male, seven female), of which 13 were still wearing their radio-tags on the day of the 1080 operation. We were also able to monitor one rock wren (male) from a previous study who was still colour banded, along with the bird that dropped its radio-tag (male), as they were the partners of radio-tagged rock wrens from this study. This gave us a total of 15 marked birds that we could monitor.

All radio-tagged and banded rock wrens were sighted alive each day for eight days after the 1080 operation. Between 1 December and 9 December 2019 there was a prolonged period of heavy rain, with a total of 282 mm recorded at a nearby rain station. This rainfall event prevented birds being re-sighted for nine days. From 10 December 2019 (18 days after the operation) we managed to relocate all radio-tagged and banded birds except for one bird, whose radio-tag had exceeded its battery life. Two of the radio-tagged rock wrens were found dead (both female). One was found dead on its nest, but no 1080 was detectable in the muscle tissue. A second bird was preyed upon, with insufficient remains to test for 1080. This bird was most likely preyed upon by a falcon (*Falco novaeseelandiae*), based on the presence of plucked feathers found with the radio-tag and the absence of any other remains (Fig. 2), which is consistent with falcon feeding behaviour (Fox 1977).

We had some welfare concerns for the rock wrens wearing radio-tags during this study, one of which we could mitigate. Two of the first four birds fitted with full length radio-tag aerials showed sign of entanglement from the aerial, after which we shortened the aerial from 135 mm to 85 mm. No further entanglements were detected, nor was there a noticeable decrease in signal strength. We also observed higher than expected nest abandonments in birds fitted with radio-tags. From the 15 birds which had either radio-tags or colour bands attached, we found seven nests with known outcomes. Of these nests, three continued as normal, two failed because one of the parent birds died, and two pairs abandoned the nest, with one of these pairs re-nesting only to also abandon their second attempt.

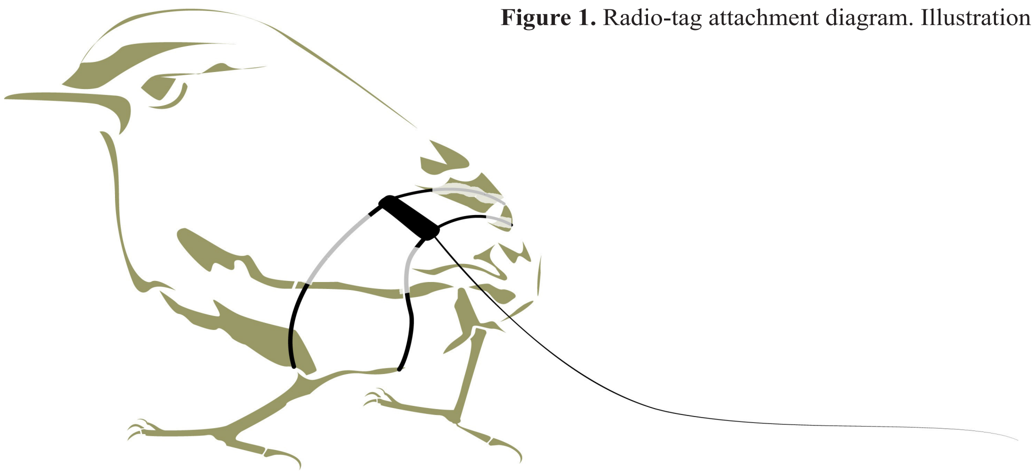

Figure 1. Radio-tag attachment diagram. Illustration by Anja McDonald.

Figure 2. Plucked feathers and radio-tag from the presumed falcon predated rock wren. Photo: author.

Discussion

The results of this study suggest that rock wrens are not susceptible to either primary or secondary poisoning in 1080 operations. All 15 rock wrens survived the operation. We would expect primary poisoning to have occurred within 8 days following the sowing of toxic baits, because 100 mm of rain (received after 9 days of monitoring) is the accepted level at which RS5 toxic baits are deemed non-toxic; this is due to the breakdown of the toxin upon contact with water (Bowen et al. 1995). Peak 1080 concentrations in invertebrates occur during the first 14 days following exposure; 1080 is still detectable in some invertebrates for a further 2 weeks, but at a low and diminishing level (Eason et al. 1993). Therefore, we would expect secondary poisoning to have occurred within 14 days following exposure.

After the 1080 risk period in this study had passed, we had one rock wren dead of unknown causes, one killed by a predator (probable New Zealand falcon), and another that we could not track due to radio-tag failure. Similar studies that retrieved dead passerines that later tested positive for 1080 recorded levels between 0.37–3.8 $\mu g\ g^{-1}$ (Powlesland et al. 1999; Powlesland et al. 2000). The single dead rock wren that we were able to assay did not test positive for 1080, which suggests 1080 did not enter the food chain of rock wrens during this study.

Veltman et al. (2014) suggested that 100 individuals need to be monitored, with no deaths attributed to 1080, for conservation managers to be confident of a < 3% mortality rate for any given species. The 15 radio-tagged and banded birds in this study are well short of the overall target, but in line with their suggestion of individual studies monitoring as few as 15 individuals, which can later be pooled to achieve the 100 individual target.

Based on the findings of this study, we suggest that the disappearance of 22 rock wrens following a 1080 operation in 2014 (Rawlence 2019) was more likely to have been caused by an unseasonable snowstorm than 1080 poisoning. Furthermore, Weston et al. (2018) also noted nest abandonments and missing banded rock wrens after snowstorms during the breeding season. However, we cannot entirely rule out an interactive effect where rock wrens become trapped by heavy snow falls immediately after a 1080 operation, and are thus more likely to eat baits or poisoned invertebrates.

Monitoring rock wrens through 1080 operations using radio-tags is risky due to the welfare concerns observed during this study. Monitoring using radio-tags is also expensive due to the fickle nature of weather-dependent 1080 operations, the short 20-day battery life of radio-tags suitable for rock wrens, and the remote locations of most rock wren populations. In the 104 nests monitored by Rawlence (2019), abandonments only occurred due to snowstorms or poor trail camera instalations at nests, never as a result of handling, which makes the abandonments observed in this study unusual, as no snow fell during the course of this study.

We believe that the welfare concerns observed during this study could be mitigated should the attachment of radio-tags be required in the future. We recommend having pre-made harnesses to reduce handling time, shortening aerials to

85 mm, and not attaching radio-tags during the nesting season, especially on gravid females. It would also be prudent to use rock wren populations without extensive cliffs in their home range to increase recapture chances for radio-tag removal.

Studies on small birds using radio-tags with a short battery life only provide a snapshot of how predator control operations impact a species, which is important if the risk of poisoning is high and carcass recovery is needed, but less important if poisoning risk is low, as observed in this study. The use of colour bands does provide a long-term method of monitoring, but is inadequate as a tool for monitoring mortality after 1080 operations, because carcasses are near impossible to find and missing birds can lead to inconclusive findings (Rawlence 2019).

Given the cost to rock wren populations from not effectively controlling predators (Michelsen-Heath and Gaze 2007; Weston et al. 2018; Rawlence 2019), we believe that repeating the methodology of this study multiple times to increase confidence that mortality is less than 3% should not be the highest research priority for this species. Instead, we suggest that monitoring rock wren population trends using simple transect counts (Monks et al. 2021) would be better for understanding the efficacy of 1080 as an alpine predator management tool over time. For the same investment as this study, conservation managers could monitor population trends at about ten sites, while retaining the ability to ascertain whether aerial 1080 operations delivered under certain environmental conditions result in declines in rock wren populations. Identification of factors that may result in declining rock wren populations would likely occur sooner using transect counts due to the increased sample size of sites, 1080 operations, weather, and their interaction. In summary, we recommend continuing an adaptive management approach to predator control, with population level rock wren monitoring at treatment and non-treatment sites.

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Additional information and declarations

Data and code availability: The data from this article is available from the authors.

Author contributions: TR designed the study. TR and KS led and undertook the field research. TR wrote the manuscript.

Ethics: This work was carried out under DOC AEC approval number AEC 331.

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