

Behaviour of stoats (*Mustela erminea*) raiding the nests of rock wrens (*Xenicus gilviventris*) in alpine New Zealand

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Abstract Understanding the behaviour of invasive predators is an important step in developing effective predator control techniques. Stoats (*Mustela erminea*), introduced to New Zealand in the 1880s, are major predators of indigenous birds in forest, wetland, and coastal habitats, and are an emerging threat to alpine biodiversity. Stoats have recently been found to prey upon rock wrens (*Xenicus gilviventris*), New Zealand's only truly alpine bird species. We monitored 32 rock wren nests using motion activated infrared (IR) cameras from 2 locations in the Southern Alps over 3 breeding seasons, 2012-2015. The behaviour of stoats that preyed upon 13 rock wren nests was quantified to describe how they behaved around rock wren nests, and to determine whether understanding these behaviours could lead to improved predator control to help to protect this vulnerable bird species. Stoats usually hunted alone. They could reach nests on cliffs and on the ground equally easily by climbing or jumping to them. Rock wren nests were attacked most frequently during the day (85% of nests) and at the chick stage in their life cycle, making this their most vulnerable stage. We suggest that this is because stoats are attracted to nests by the auditory cues of chicks calling out for food. Nests were rarely visited by stoats before or after the observed predation events. Stoats left little evidence of nest predation events beyond enlarging nest entrances. There was no indication that IR cameras or the actions of field workers affected predation behaviour, although some stoats clearly knew the cameras were there. There is an urgent need to deploy effective stoat control to recover rock wren populations. Control should focus on cliff habitats as well as on more accessible ground nests, and, if resources are limited, should primarily focus on the nestling stage. Future research could trial auditory lures to attract stoats to traps, and determine the vulnerability of rock wrens to predation outside the breeding season.

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Keywords predation; predator control; mustelids; infrared cameras

INTRODUCTION

Managing the impacts of invasive predatory species poses one of the greatest conservation challenges around the world, and especially in New Zealand (Innes *et al.* 2010). Numerous invasive predator species were introduced to New Zealand following the arrival of humans over the last ~800 years, including 3 mustelid species, 4 rodent species, feral cats (*Felis catus*), European hedgehog (*Erinaceus*

europaeus), brushtail possum (*Trichosurus vulpecula*), feral pig (*Sus scrofa*) and domestic dog (*Canis familiaris*) (King 2005). Their collective effects were catastrophic for the indigenous avifauna, resulting in numerous extinctions and a predominance of threatened species in the fauna (Miskelly *et al.* 2008).

The impacts of invasive predators have been extensively documented in forest, riverine, coastal and wetland habitats in New Zealand (Dowding & Murphy 2001; Sanders & Maloney 2002; Innes *et al.* 2010; O'Donnell *et al.* 2015). A recent review has also confirmed that predators, especially stoats

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(*Mustela erminea*), are also a threat to the survival of a large number of alpine species, particularly birds, reptiles, and invertebrates (O'Donnell *et al.* 2017).

The rock wren (*Xenicus gilviventris*) is a member of the ancient family of endemic New Zealand wrens (Acanthisittidae) and is New Zealand's only truly alpine bird species. This species can be separated into two distinct genetic lineages distributed across the South Island (Weston & Robertson 2015); the southern lineage is classified as Nationally Endangered and the northern lineage as Nationally Critical (Robertson *et al.* 2017), reflecting dramatic and ongoing declines in both (Michelsen-Heath & Gaze 2007).

Efforts to identify the causes of decline of vulnerable species, and appropriate management tools to reverse declines, are a high priority for conservation managers. Stoats have been identified as frequent predators on rock wren eggs, nestlings, and adults. In 4 studies in Fiordland, nest predation rates varied from 13–80%, with most losses attributed to stoats (Michelsen-Heath 1989; Willans & Weston 2005; Willans 2007; O'Donnell *et al.* 2017). Rock wrens are cavity-nesters, nesting in crevices on the ground among talus slopes and boulder fields or on cliffs. Clutches of 1–5 eggs are laid from mid-October through to mid-November, with replacement clutches laid as late as the end of December. Both sexes share incubation and feeding fledglings, but only the females incubate or brood chicks at night. They are vulnerable to predation on the nest for nearly 50 days (incubation averages 18–22 days, and chicks are brooded for 21–26 days), before dispersing 2–4 weeks after fledging (Michelsen-Heath 1989). The combination of their harsh habitat, weak flight and ground dwelling behaviours makes rock wrens potentially vulnerable to ground predators (O'Donnell *et al.* 2017).

Stoats are highly efficient predators, pre-adapted to cold climates and pulsed food resources (King & Powell 2011). Thus unlike rats (*Rattus* spp.), stoats are completely at home in alpine regions. They are active, predominantly solitary hunters that specialise in searching for small prey such as rodents and birds. Smith & Jamieson (2005) found the mean home range size for stoats in alpine grassland to be 57.27 ± 4.63 ha; furthermore, stoat populations in alpine areas were independent of those in other habitats such as beech forest further down on the same ranges. In a masting year for beech forests and/or alpine tussock grasses, heavy seed production is followed by an increase in numbers of rodents (Wilson & Lee 2010) and their predators, including stoats, stimulated by the abundance of available food (King 1983; Wilson & Lee 2010).

Although we know stoats are a threat to rock

wrens, little is known about their behaviour and their degree of threat. Collecting behavioural data on predators is important to focus management actions (Sutherland 1998). We investigated the behaviour of stoats at rock wren nests using infrared cameras over 3 nesting seasons, 2012–2015. We aimed to describe how stoats behaved around rock wren nests, and determine whether understanding these behaviours could lead to improved predator control to help to protect this vulnerable bird species. In particular, we (a) described how stoats behaved around rock wren nests, including how they approached the nests (direction of approach relative to entrance direction); (b) the pattern of timing of predation events; (c) how often stoats visited the nests before preying on them; (d) whether stoats visited again after preying on a nest; and (e) if there was any evidence that cameras or the presence of field workers affected stoat behaviour.

MATERIALS AND METHODS

Study areas

Nests of rock wrens were monitored during the austral spring-summer seasons (October–January) by Department of Conservation (DOC) staff at 2 sites not subject to predator control in alpine areas of Fiordland (Homer–Gertrude Valley) and South Westland (Haast Range) in the South Island of New Zealand (Fig. 1). The Homer–Gertrude Valley (44° 45' S, 168° 0' E), is a vertical sided U-shaped valley in the Darran Mountains. Rock wren nests were sited primarily in extensive boulder fields and talus slopes interspersed with subalpine scrub and patchy *Chionochoa* grasslands between 700 and 1100 m a.s.l. The Haast Range study area, between the Waitoto and Arawhata Rivers in South Westland, was centred on Lake Greaney (44° 5' S, 168° 47' E). The study area was dominated by *Chionochoa* grasslands interspersed with scrub-covered cliff systems and the occasional boulder patch and talus slope between 1000 and 1400 m a.s.l.

Locating nests

Nests in Homer–Gertrude Valley were monitored during 2012–13 and the Haast Range in 2013–14 and 2014–15. The territories of all adult rock wrens (pairs and lone birds) in each study area were mapped throughout each breeding season. A large proportion of adult wrens were already colour-banded, and new birds were marked through the season, so that we could follow known individuals with confidence. Once territories were identified, they were searched thoroughly as many times through the season as possible, at least once per week. Notes were kept of the behaviour and locations of all birds sighted (recorded with Garmin GPSmap 62s). Signs that nesting had

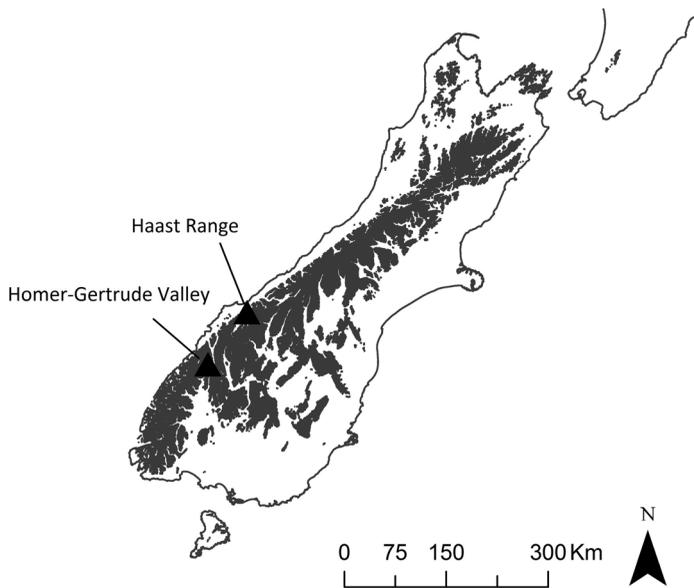


Fig. 1. Locations of the Haast Range and Homer-Gertrude Valley rock wren study areas in the Southern Alps, South Island, New Zealand. Shaded areas represent the extent of alpine habitats in New Zealand (after O'Donnell *et al.* 2017).

started included observations of individual birds carrying nest material, feathers, or insects, or flying repeatedly to specific locations, or one member of pair being suddenly absent.

Monitoring nests

A range of infrared (IR) motion triggered camera types was employed (primarily miniature KT&C model KPC-HD53 night vision cameras, but also Acorn Trail and Kinopta Blackeye cameras 2W 5V/12V s/n 1062) so that activity could be monitored at a subset of nests over whole 24 hour days. The KPC-HD53 cameras were linked to a Secumate mini RYK-9122 recorder (inside a pelican storm case), using AC 30 m cable and powered by a 12V deep cycle battery and a BP SX320d solar panel. Both were positioned *c.* 25 m from the nests, to ensure that visits by field workers to change batteries and SD cards did not disturb birds at their nest. Once a camera was set up, the nest was observed from a distance to ensure that the birds accepted the camera and returned to the nest. If birds did not return within 10 minutes, the camera was removed or shifted further away from the nest. The Secumate mini RYK-9122 recorder was set to motion detection recording, and the area surrounding the nest was set as the detection area. Detection area depended on how far the camera was from the nest, and varied from as small as *c.* 30 × 30 cm and as large as *c.* 5 × 5 m. The sensitivity threshold for activating the camera was generally set between 1-4%.

Miniature cameras (diameter *c.* 20 mm) were located *c.* 0.15 -5 m away from the entrance to the nest, in a position viewing the nest entrance, and allowing the best possible chance of identifying animals entering and exiting. Any nearby loose vegetation that would move in the wind, causing the camera to record, was removed. The camera setup, battery charge and SD cards were checked during each visit and replaced as required. All recordings were stored for analysis, plus background details relevant to each visitation. Records of the history of each nest, and field observations on the birds, were available to help interpret the video clips.

Analysis of behaviour

All video recordings were reviewed using a VLC media player and Windows media player. Multiple clips of stoat activity from one nest site were transferred to Windows Movie Maker and stitched together into one file. A visit was defined as the period of time starting when a stoat first appears in frame until it exits the frame again. Stoats are very active and fast-moving predators so it was common to observe a stoat making several short visits in quick succession. All series of visits spanning less than 12 hours were classed as a single bout of activity. Behaviours of stoats during visitations to the nesting sites were summarised by documenting a limited number of recognisable behaviours, and recording the timeline of events around each visit. We quantified the following: (1) date of stoat visits;

Table 1. Summary of stoat visits to 13 rock wren nests in the Homer-Gertrude Valley and Haast Range, 2012–2015.

Nest	Nest name	Date	Time of day	Location	Stoat entrance	In nest	Time start	Time end	Duration	No. stoats	No. visits
Homer-Gertrude											
1	Depot	11/12/12	Day	Boulders	Right	Eggs	15:14:29	15:18:36	0:04:07	1	2
2	Nuts	7/12/12	Evening	Boulders	Right	Chicks	19:01:43	19:01:56	0:00:13	1	1
		8/12/12	Night		Left	Adult	3:25:48	3:30:58	0:05:10	1	1
		9/12/12	Day		Left	Empty	8:34:42	8:34:55	0:00:13	1	1
3	Scree	15/12/12	Night	Boulders	Front	Chicks	23:10:17	23:45:09	0:34:52	4	3
4	Waratah 1	1/12/12	Day	Boulders	Left	Chicks	12:04:43	12:39:32	0:34:49	1	4
		2/12/12	Day		Front	empty	6:26:13	6:26:30	0:00:17	1	1
5	Waratah 2	18/12/12	Day	Boulders	Behind	Chicks	10:27:37	19:58:39	9:31:02	1	13
Haast											
6	Nest 1, Greaney	29/11/13	Day	Cliff	Left	Chicks	11:08:22	11:08:26	0:00:04	1	1
7	Nest 2, Hut	5/12/13	Day	Cliff	Above	Chicks	12:02:19	12:09:06	0:06:47	1	6
8	Nest 6, Thirsty	7/12/13	Evening	Cliff	Right	Chicks	21:17:32	21:22:53	0:05:21	1	4
		11/12/13	Day		Above	Empty	15:29:08	15:29:25	0:00:17	1	1
9	Nest 8, Thirsty	10/12/13	Day	Cliff	Below	Chicks	11:32:53	12:13:40	0:40:47	1	5
10	Nest 3, Greaney	15/11/14	Day	Cliff	Below	Chicks	13:28:01	15:31:11	2:03:10	1	9
11	Nest 6, Heveldt	2/12/14	Day	Boulders	Above	?	13:56:08	14:06:52	0:10:44	1	5
12	Nest 10, Greaney	2/01/15	Day	Cliff	Above	Eggs	14:24:18	14:26:03	0:01:45	1	1
13	Nest 4, Heveldt	4/12/14	Day	Cliff	Above	Chicks	11:17:40	11:22:48	0:05:08	1	3

(2) mode of approach (walked/ran or jumped); (3) nest phase (eggs or chicks); (4) number of stoat visits/nest; (5) intervals (minutes) between visits; (6) direction of approach relative to entrance direction; (7) number of visits following a predation event; and (8) any evidence that cameras affected stoat behaviour. Any other notable behaviours such as looking directly at the camera, or sniffing, rearing, and turning around inside the nest were also recorded.

RESULTS

We recorded and viewed more than 45,200 infrared digital video files from 32 rock wren nests, each

file ranging from 10 seconds to 1 hour in length, defined by the beginning and end of a separate triggering of the motion detector. Most files did not show any activity by stoats. Stoat activity, including predation on chicks and one adult rock wren, was recorded at 13 nests (summarised and saved as single .MP4 files, available for public viewing at: <https://drive.google.com/drive/folders/0Bw0Y82k6dImGbklRcFM5b2JOUmM?usp=sharing>; Table 1). Refer to Appendix 1 for detailed accounts of stoat behaviour recorded at each rock wren nest.

All predation events that were captured on camera involved stoats (Fig. 2). We documented 17 bouts of stoat activity, representing 61 visits at the 13 nests (Table 1). During those visits, stoats took



Fig. 2. Stoat raiding a rock wren nest for nestlings, with chick in jaws, Homer-Gertrude Valley, New Zealand, December 2012.

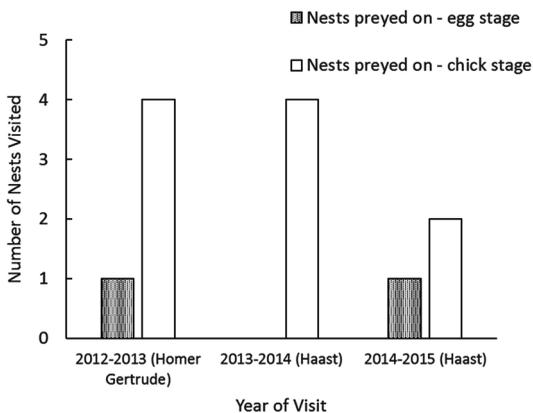


Fig. 3. Timing of stoat visits to rock wren nests in relation to nesting stage in the Haast Range and Homer-Gertrude Valley study areas, 2012–2015.



Fig. 4. A stoat jumps a metre-wide gap, Haast, New Zealand, December 2013.

at least 26 rock wren chicks and 2 clutches of eggs. At 3 nests, at least 1 adult rock wren was filmed, of which 1 was killed and 2 escaped alive. Three of the nests were visited by stoats over a period of more than 1 day. It was not possible to determine how many individual stoats visited nests, although 4 stoats were present at once at 1 nest and a second nest may have been visited by different stoats on 2 different days (as indicated by distinctive patchy white coat of the second stoat) in the Homer-Gertrude Valley (Table 1).

Stoat behaviour at nests

All but 1 of the visits filmed were made by stoats hunting alone. They moved rapidly during nest visits; often so fast that the movement-activated cameras did not wake up in time to film the whole sequence. Thus, some visits described here were too quick to be captured in full. Most stoat visits (85%) were recorded during the day or at just before sunset (before 2117 hrs; Table 1). Of the two nocturnal visits, 1 was recorded at *c.* 2300 hrs and 1 at 0325 hrs.

Stoat visits varied from rapid single nest checks lasting 4–17 seconds to a series of repeat visits extending over a prolonged period. The longest such series included 13 visits spread over 9.5 hours, and the second longest, 9 visits over 2 hours (*mean* = 49 min; Table 1). The exception involved 4 stoats acting together during a nest visit at night, diving in and out of the nest in turns, appearing as if more in play than as a serious predation attempt; after 30 minutes the nest was destroyed and no chicks or adult birds were seen subsequently.

Stoats visited nests at the chick stage more frequently than those at egg stage (Fig. 3), often as a series of repeat visits to remove each dead nestling. One adult wren was killed on the nest while incubating at night. Adult birds frequently returned to the nests during, or following, predation events. When this happened, they approached the nest more cautiously, and occasionally exhibited wing flicking aggressive displays, but were otherwise not overtly aggressive. Adult wrens frequently continued to visit the nest and bring food to it for some time after the chicks had been removed. At 1 nest that had contained chicks, a stoat was filmed inspecting the nest in the evening, but it emerged quickly, without carrying anything. A parent bird was present in the background. At 0330 hrs, the video shows a stoat approaching the nest entrance in darkness, very slowly and stealthily, clearly aware that an adult was on the nest, and then pouncing suddenly and emerging with the adult female. Shortly after dawn, the male wren brought food to the nest, returning several times. Once stoats had left the nests they left little sign of their presence. No remains of eggs or

Fig. 5. A stoat looks directly at the camera from inside a nest, Homer-Gertrude Valley, New Zealand, December 2012.



chicks were in the nests, but the nest entrances were enlarged, and in one case, the nest was destroyed.

Stoats frequently preyed upon cliff nests despite seemingly difficult access (7 of 13 nests), as much as those in boulder fields on the ground. Of the nests visited by stoats, 8 were walked to, 3 were jumped up or down to, and only 1 was climbed up to. The stoats were highly athletic. In 1 case, a stoat jumped a metre-wide gap to reach a nest in the rock crevice that contained chicks (Fig. 4); the stoat killed the chicks, then jumped back up repeatedly the way it had come, each time carrying a chick. At other nests the stoats jumped smaller distances between, across and around any obstacles in their way. Stoats appeared to enter and exit nests in the easiest way available to them, usually using the same entrance and exit strategy even if access was difficult. Thus, approach angles on the initial visits appeared random, either from the right ($n = 3$), left ($n = 4$), the front ($n = 2$), behind ($n = 1$) above ($n = 5$) or below ($n = 2$), often by climbing up or down vertical rock faces.

How often do stoats visit the nests before preying on them?

There was only 1 instance of a nest being visited before the predation event. Five of the nest cameras were distant from the nest, so that the whole surrounding cliff faces were visible, and stoats approaching but not entering nests would have been detected at least for these nests.

Do stoats visit again after preying on a nest?

Generally, when a stoat first found a nest with chicks, all the chicks were killed on the first visit. The stoat made a series of consecutive repeat visits only a few minutes apart to carry the dead chicks away individually. In most cases the stoat reappeared at least once and often several times within a short duration after the nest was empty, and checked inside it thoroughly. In 1 case, the stoat visited numerous times over 9.5 hours after preying

on the chicks and spent long periods in the nest itself (refer to Appendix 1, Nest 5).

Evidence that human activity affects stoat behaviour

There was no indication that the cameras affected stoat behaviour. Most stoats ignored the IR camera at the nest, focusing on entering the nest cavity. However, in 2 cases stoats looked directly at the camera or the IR light source briefly, then continued with their investigations of the nest (Fig. 5). We could not test whether activity of field workers visiting nests affected stoat behaviour. However, once a camera had been set up, observers never went closer than *c.* 25 m, and generally observed nests with binoculars from much farther away.

DISCUSSION

Impacts of stoats on rock wrens

Rock wrens, being obligate residents of the alpine zone of the South Island, New Zealand, are highly vulnerable to predation by stoats. The use of IR video monitoring is designed to provide useful information on the identity of key nest predators, rather than an unbiased measure of predation rates (Sanders & Maloney 2002). In this study, if cameras had not been used, we would not know the cause of the predation events, because stoats left virtually no specific sign of their visits. Stoat predation was detected at 40% of nests monitored using IR video cameras in this study. However, this is likely an underestimate of true predation rates, as we experienced many problems and system failures with video equipment. This resulted in incomplete nest monitoring sessions for a high proportion of nests (>30%), producing uncertainties about the fate of some nests. In addition, because camera monitoring commenced well into incubation of many nests, there is a possibility that additional nests were preyed on before they were discovered. Weasels (*Mustela nivalis*), ship rats (*Rattus rattus*) and mice (*Mus musculus*) have also been recorded

preying upon rock wren nests (O'Donnell *et al.* 2017), but their predation appears to be limited compared to that of stoats.

Both trapping and tracking tunnel studies indicate stoats are common in alpine areas (Smith & Jamieson 2005; O'Donnell *et al.* 2017; Smith & Weston 2017), which is not surprising given that they are cold-adapted animals (King & Powell 2007). Stoat populations in New Zealand irrupt periodically following mouse irruptions stimulated by heavy seeding of beech forests adjacent to alpine zones occupied by rock wrens (King 1983; O'Donnell & Phillipson 1996), so if stoats invade alpine zones during this time, then nest predation rates may increase markedly. Populations of mice and stoats can also irrupt after a good seed year for snow tussocks (Wilson & Lee 2010), although stoat irruptions originating solely from alpine sources have yet to be documented in New Zealand.

We do not know what number of stoats was responsible for the predation events recorded in this study. Home range sizes of stoats are relatively large, with an average size of 57 ha and range width of 1.4 km recorded for alpine stoats in the Borland area of Fiordland (Smith & Jamieson 2005). Thus, in our small c. 130 ha study area at Homer-Gertrude Valley, we may have been observing a single individual or family group. For example, in Homer-Gertrude Valley in 2012–13, at least 2 different patterned adults were observed at nest 4, and a party of 4 stoats, apparently very familiar with each other, visited nest 3. Young stoats emerge from their own dens at about the same time that most rock wrens are feeding chicks, and learn to hunt in family packs during the next few weeks before they become independent, so we assume that this was a group of young siblings (King & Powell 2007: 224–25). Therefore, if 1 or 2 stoats are having a disproportionate impact across rock wren habitats, then rock wrens may be at risk from stoat predation every season, regardless of masting cycles.

We conclude that stoats were not attracted to the rock wren nests by the presence of the miniature IR cameras. Most stoats paid no attention to the camera, and they approached the nests from apparently random directions, more likely related to ease of access. Rather, we suggest that stoats may be attracted to the nests by the auditory cues coming from the calls of hungry chicks left alone while the parents are foraging. All small mustelids have extremely sensitive ears, and hunt more by hearing than by sight; the ears of stoats are adapted to amplify sound (King & Powell 2007). Spurr & O'Connor (1999) reported that stoats were more strongly attracted to the recorded calls of bird chicks, compared with the calls of rodents and young stoats. Chicks do not call when a parent bird is with them, which may protect both chicks

and adult birds from discovery at night. That may explain why most of the visits filmed during our study were to undefended nests during the day.

Management implications

Control of stoats in rock wren habitats is likely crucial to recovering rock wren populations. Stoats are far more common than rats in alpine areas (O'Donnell *et al.* 2017). Our study shows that stoats are highly efficient nest predators; their tenacious behaviour and agile climbing ability mean that even cliff nests are just as vulnerable as those on the ground. Therefore, development of effective stoat control methods for alpine environments is needed urgently. Stoat control should at a minimum concentrate on the rock wren nesting season, starting in late September. If resources are limited, then control should focus on the most vulnerable phase, when young stoats are learning to hunt for themselves and while rock wren chicks are being fed on the nests (late November to early January). It is likely, based on the behaviours we observed, that stoat control will be required annually, not just in years following beech or tussock masting. Our results show that traps or toxins need to be deployed around nesting cliffs as well as in flatter, more accessible boulder fields.

Even common forest birds in New Zealand are declining slowly in areas without predator control (Elliott *et al.* 2010). Developing stoat control techniques appropriate for widespread use across alpine zones of the South Island (11% of New Zealand's land area; O'Donnell *et al.* 2017) will be challenging. Although trapping stoats can be effective at small scales (authors' unpubl. data), the use of toxins, such as aerially applied 1080, will be necessary to protect rock wrens at a landscape scale. The most recent such operation, in adjacent beech forests in winter 2015, achieved significant improvement in rock wren nesting success over the following summer (Elliott & Kemp 2016). Given that the most vulnerable nesting period is when chicks are noisy and being fed frequently, research on the use of auditory lures for stoat traps may also be productive. In addition, research should focus on determining what factors influence the survival of fledglings once they leave the nest, and of adults at other times of the year, to decide whether stoat predation is also a threat outside the breeding season.

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APPENDIX 1. Details of stoat behaviour recorded at each rock wren nest

Nest numbers correspond with those in Table 1. These descriptions should be read in conjunction with viewing the clips labelled by years and nest name at <https://drive.google.com/drive/folders/0Bw0Y82k6dImGbkIRcFM5b2jOUmM?usp=sharing>

Homer- Gertrude 2012-2013*Nest 1: Depot*

On 28 November, 4 December and 7 December, the parent birds were observed incubating. This camera is one of few that has audio. **11/12/2012 at 15:13:29:** Stoat appears from the right, looking and sniffing around; turns and heads towards camera, then down out of view. **At 15:13:52,** scuffling sounds can be heard. **15:18:36:** a stoat reappears, by a mode of entrance not seen, then it jumps up from the nest and disappears into bush behind it.

Nest 2: Nuts

Incubation first observed on 28 November, and again on 2, 4, 5 and 6 December. At the last check during the day on 7 December, young chicks were recorded in the nest. **07/12/2012 at 19:01:43:** In the evening a stoat appears from right; sniffs camera then turns to face nest, enters nest head first 19:01:49 until front half of its body is inside. There is what could be a parent bird in the left background. Stoat backs out at 19:01:53, turns around on itself and moves towards camera and exits off the left-hand side of frame at 19:01:56. **08/12/2012 at 03:25:48:** In darkness, stoat enters from left, stalks slowly towards nest, suddenly dives into nest at 03:26:13, reappears out of nest head first at 03:30:37, looks around licking lips, turns around on itself and re-enters nest to drag out an adult female wren. At 03:30:49 the stoat walks toward the camera with bird in mouth, drops it down on right hand side out of view, looks around, picks it up and carries on out of frame to the right at 03:30:58. At 05:50:12, an unbanded adult wren brought food to the nest, and again at 05:52:06. **9/12/2012 at 08:34:42:** Stoat appears from behind rock on left hand side of nest. Dives head first into nest leaving tail sticking out. Turns back on itself and moves head first towards camera 08:34:50, exits to right 08:34:55. The unbanded adult continues to visit the nest a couple of times but without food, and does not enter it.

Nest 3: Scree

Incubation observed on 26, 28 and 29 November, and young chicks on 30 November. Parents feeding chicks on 4, 6, 7, 11 and 14 December. **15/12/2012 at 23:10:17:** Late on 15th, four individual stoats attack this nest. Stoat one enters from right close to camera, moves forward towards nest, while a second stoat appears beside it on its left. Camera is obstructed for some time; when the view returns, one stoat moves off to the right while the other is inside the nest with its head sticking out. The nest cavity must be large enough to admit a whole stoat body, which is much larger than

that of a wren. Second stoat returns from behind camera, followed by a third and a fourth at 23:11:00. One tries to enter nest as another watches, and then works its way around to back of nest out of sight. All scramble over the top of each other and obstruct the view, when it returns there is still a member of group in the nest but viewer cannot tell which one, as the others continue to move in and out of frame. The one in the nest exits nest head first, and is replaced by another, which also enters head first and turns around inside to stick its head out, exits at 23:12:59. They seem to be competing for turns to enter the nest. 23:14:50: Stoat enters nest head first, turning around inside and exiting again to the right at 23:14:58. 23:15:11: Stoat enters from left behind camera and enters nest head first, turns around inside, pops head out and retreats back in again. Second stoat wanders across frame, then the one inside the nest exits to follow it going off top left of screen at 23:15:20. 23:15:30: Two stoats reappear in quick succession; one carries on straight past the nest, second pushes front half of body into nest a couple of times before a third appears at left and exits again. The one in the nest enters it fully and turns around inside. Another reappears and attempts to enter nest, is unsuccessful so stands on top of it at 23:16:48 whilst the other is still inside, before attempting to enter again. Camera is bumped slightly and we see a third stoat enter at left. The stoats outside the nest take off to the right out of frame before returning again, and two continue to squabble trying to get into nest. By 23:18:37 their dismantling of the nest appears to be more play than an attack on nest itself. 23:19:54 sees one stoat in the mess of the nesting material, which exits off screen at 23:20:06. A stoat returns a few seconds later and wanders through the mess, followed by a second. Stoat and nesting material out of view as others continue to cross in and out of frame. 23:22:09: Two appear to squabble amongst themselves. None in frame at 23:22:34. At 23:23:4, one returns, followed by second; nest is completely trashed by 23:24:43. Clip Ends 23:45:09.

Nest 4: Waratah 1

Parent birds observed feeding chicks on 28 and 30 November. **01/12/2012 at 12:04:43:** A stoat appears from left above the nest site, moves forward to a point just above the nest, swings back on itself with a swivel motion around the fulcrum of the forepaws like a gymnast, turning so its rear end faces away from nest in the direction opposite from that of its first approach, and enters into nest head first. 12:04:51: The front half of the stoat's body up to mid-section enters the nest, manages to wriggle enough to fit full body into nest including tail, but backs out slightly so just rear legs and tail are seen, then moves fully into nest at 12:04:55, turns around inside nest. 12:04:57: The head pops out from nest looking around, looks directly up at camera, then looks forward before retreating back into nest. 12:05:50: Dead chicks are pushed out of nest into view at nest entrance. 12:10:20: Stoat head pops out again at, looks around, looks up at camera (Fig. 5), sniffs in direction of camera, then looks forward again, looks back up at camera

and away again, front half of body exits nest, continues to look up in direction of camera, full body exits nest (Fig. 2). 12:10:33: Turns around on itself and exits above nest where it came in. 12:10:33: Three dead chicks can be seen at nest entrance. 12:17:38: Stoat enters centre of bottom frame, still above the nest, only head visible, looks around and sniffs above nest, picks up in its jaws one of the dead chicks that has been left at nest entrance, goes to exit head first on left but back-tracks, turns back on itself, and exits at centre of bottom frame 12:17:43. 12:18:20: Stoat head appears in same place as previously in centre of bottom frame, collects second chick in jaws, turn back on itself and exits in same fashion as before at 12:18:23. 12:18:49 Head reappears at centre of bottom frame, picks up third chick in jaws, turn back on itself and exits 12:18:50. 12:28:46: Stoat appears at left as usual, enters nest in the same way as before using swivel technique, full body minus tail entering nest, turns around inside nest and pops head out at 12:29:16 looking directly up at camera before looking forward; full body exits nest, turns around on itself and exits frame where it had entered on left 12:29:19. Camera corrupts at 12:36:39 until 12:36:48. 12:38:20: Stoat appears at centre of bottom frame, pushes front half of body and head inside the nest. Stoat rotates body round using swivel technique, full body enters nest [camera corrupts again at 12:38:58, returns 12:39:05]. 12:39:29: Stoat exists nest head first with a fourth chick in its jaws, turns around on itself and exits in centre of bottom frame 12:39:32. **02/12/2012 at 06:26:13:** Stoat appears from centre of bottom frame, dives head first into nest, pulls head out of nest at 06:26:22, looks and sniffs around, exits top left at 06:26:30. The images clearly show patches of white on the head, shoulders back and tail, which were present but much less noticeable the previous day.

Nest 5: Waratah 2

Parent birds observed incubating their second clutch on 18, 19, 22 December, and feeding chicks on 11, 13, 15 and 16 January. **18/1/2013 at 10:27:37:** An adult bird enters and then exits nest again. A stoat appears at 10:39:18, with its back towards the camera on all fours climbing head first up the rock, investigating a crevice just above where the adult bird was seen to exit. Jumps to another rock at 10:39:18, and pauses briefly with what appears to be a chick in its jaws. Makes exit over rocks towards upper right corner of view, last seen at 10:39:19. Reappears at 10:39:39, face towards camera looking down into nest. Swivels body around so its rear end is now beneath nest, and enters nest head first as far as front half of body at 10:39:41. Full body minus tail enters nest. 10:39:44 starts to back out of nest, fully backed out at 10:39:46 with a second chick in jaws, then jumps up onto rock above nest, and disappearing from sight into a crevice above it. Head sticks out at 10:39:52, moves to the right, under a rock and out of view. 10:39:55: Full head on view of stoat on rock above nest. Crawls down head first into nest using side rock for support, swivelling body so its rear end is below nest again as it enters half way 10:39:56. Reverses

out at 10:39:59 with third chick in jaws, and jumps back up and over rocks again towards top right hand corner as in first visit. Disappears out of view at 10:40:01. 10:40:36: Reappears in same location as before, head down towards nest and swivels body. Probably accessing the area through hole in rock just above nest, where it has been seen to exit previously. Front half of body enters nest, reverses out at 10:40:41 and jumps up above nest, pauses on rock for a second with back facing camera. Appears to be adjusting its hold, because when it turns side ways we can see a fourth chick in its jaws. Exits up and over rock, and disappears to right at 10:40:43. 10:41:28: Stoat jumps onto rock above nest site, pauses with back to camera then moves to side on view, fifth chick in jaws. Jumps up and over rock to left at 10:31:29, exits down into rocks out of view at 10:41:32. 10:42:14: Stoat reappears into view from beneath nest, pushes front half of body into nest head first, reverses out and climbs up above nest at 10:42:18 into the gap in rocks, tail sticking out, turns around, sticks head out looking around at 10:42:22, descends back down head first and disappears out of view below camera at 10:42:52. 10:43:39: Stoat reappears from beneath camera again, charges head first into nest, pushes in full body minus tail and hind legs. Reverses out at 10:43:45, jumps up above nest and exits behind rock on right 10:43:47. 10:54:27: Re-enters from bottom of screen, pokes head first into nest, only head enters, then jumps up above nest, tail visible briefly before going out of sight between rocks. 11:00:58: Stoat appears from above nest using swivel technique, enters nest with full body minus rear legs and tail, descends further into nest behind rock out of view 11:01:00, climbs down from nest out of view at 11:11:54, cannot tell if chick in jaws or not. 11:12:50: Stoat appears from beneath camera, does not enter nest but stands at entrance with back to camera looking around, partially standing up on hind legs, then enters nest head first, full body disappears into nest 11:12:53, exit not recorded. A bird appears briefly for a split second on screen at 12:00:48, just near nest entrance, descends beneath camera out of view, reappears nearly 50 minutes later with a grub sitting just in front of camera, hesitant to enter nest; clearly aware that something is wrong, flies to entrance of nest but does not enter, descends down rock again out of view. 13:04:13: Stoat exits nest head first and down rock. 13:05:02: Stoat re-enters from beneath camera, enters nest head first then jumps up above nest into a hole between rocks and out of sight at 13:05:07. Bird visible at a distance in top left background at 13:05:10. Bird returns beneath nest at 13:46:55, moves with great caution towards nest, looks in but does not enter, opens wings, then turns and flies off down the rock out of view. Bird returns again into view with grub in mouth in front of camera at 15:38:56 but flies off above camera out of view. 15:39:18: Bird appears in front of nest, distressed, flapping wings, flies off towards camera and out of view. Stoat's head pops out of nest, retreats. 15:39:24: Full stoat head now visible, looking around outside nest, climbs up above nest at 15:39:29, pauses then continues into hole in rock

out of view, scaring bird in back ground, reappears head first from same space at 15:39:36 and jumps down to rock in front of nest site, sniffs it, looks out towards the camera, then enters nest using swivel technique, disappears from view 15:39:43. Exits head first out of nest down rock at 15:53:58. 16:04:04: Stoat appears from bottom of rock beneath camera and enters nest head first, full body enters nest out of view, exits out and down, head first out of view at 18:37:33. 18:38:20: Stoat re-enters from beneath again, full body enters nest, exits down, and out head first at 19:58:39.

Haast 2013-2014

Nest 6: Nest 1 – 13/14 Lake Greaney

Parent birds observed incubating on 5, 8, 17 and 21 November, and feeding chicks on 22, 24 and 27 November. The male adult was present on 28th, but not apparently attending chicks. **29/11/2013 at 11:08:22:** Next day a stoat appears from grass behind the nest site. Climbs down through vegetation, puts head in nest and then moves on off camera to the left, all within a period of approximately 4 seconds, and not sighted again. Adult birds not seen in this clip, and nest appears abandoned, perhaps explaining lack of location-finding and interest by stoat.

Nest 7: Nest 2 – 13/14 Hut

This nest was in a crevice in a steep rock face, separated by a 1 m gap from an adjacent boulder face sheltering the camera. Incubation observed on 8 November, then chicks being fed on 2 December. **05/12/13 at 12:02:19:** Stoat appears on rock above camera, prospecting the leap required to reach the nest for 14 seconds. Jumps down and across gap to rock slab in front of nest site, enters the nest head first, pushes full body (including tail) inside. Sticks head and front half of body out of crevice into view and looks down from vantage point after 43 seconds. Returns back into nest and reappears with first chick in jaws, and jumps up across gap to where it came from with no hesitation after 7 seconds. 12:04:50: Stoats jumps down from above as previously and moves head first into nest. Returns with second chick in jaws and looks down briefly before jumping up and across the gap (Fig. 4), all within 6 seconds. 12:05:01: Stoat jumps down retrieves third chick from inside nest and jumps back up again within 3 seconds. 12:05:17: Stoat jumps down, retrieves fourth chick from inside nest and jumps back up again within 3 seconds. 12:06:23: Stoat jumps down and spends a few seconds in nest before reappearing head first and jumping back up without a chick. 12:09:04: Stoat jumps down and enters nest head first, quickly turns around inside nest and jumps back up within two seconds.

Nest 8: Nest 6 – 13/14 Thirsty

Camera placed approximately 15 cm from nest in tussock, but the birds were still returning. Incubation observed on 7 November, and two chicks being fed on 2 and 6 December. **07/12/13 at 21:17:32:** As dusk was falling (making the pictures very dark), a stoat enters view from right hand

side of frame, enters nest head first as far as shoulders, removes head from nest and sniffs camera before returning head into nest, repeats this process again before pushing full body (including tail) into nest. Turns around within nest and sticks head out of nest entrance with rear end still in nest, looks around and sniffs camera again, then retreats back into nest. Removes first chick from nest and places it in front of nest entrance, sniffs it. Stoat then re-enters nest head first, pushes full body inside, exits with second chick in jaws, drops it, returns into nest, comes out again and exits above nest site at 21:19:44. 21:20:14: Stoat reappears into view from right, collects first chick from nest entrance, carries it away out of view up and over nest. 21:21:26 reappears from above nest on left, from where it exited previously. Sniffs at second chick that had been left in front of entrance, picks it up in jaws and carries it off up above nest at 21:21:30. 21:22:45: Stoat appears head first from right. Sniffs camera, then pushes full body into nest, turns around and comes out head first. Sniffs camera, and leaves at 21:22:53 to right. **11/12/2013 at 15:29:08:** In full daylight, stoat can be seen approaching through grass from above nest. Stoat sniffs camera 15:29:11, and around entrance to nest for a few seconds. Enters nest head first 15:29:21, full body inside, turns around and comes out of nest head first 15:29:25: Sniffs camera again before leaving the way it came in.

Nest 9: Nest 8 – 13/14 Thirsty

This nest was not found until 19 November, and the contents of the nest could not be determined. The camera angle was not ideal so it usually did not trigger until the stoat was already inside the nest. By 2 December the parents were feeding chicks. **10/12/2013 at 11:32:53:** The first sighting of stoat shows it coming out of nest head first with first chick in jaws. Stoat looks around briefly before walking towards camera with well-grown chick at 11:32:55. Moves down below camera out of view 1:33:00. 11:36:23: Stoat first seen coming head first out of nest with second chick in jaws. Exits up above nest and goes out of view 11:36:27. Next sighting 11:37:31, stoat facing nest with head inside. Takes third chick from nest, and leaves with chick in jaws by same route at 11:37:32. 11:42:52: Stoat's tail is seen sticking out of nest, then moving further forward pushing whole body into nest. Stoat comes out head first with fourth chick in jaws at 11:42:54. Looks around for a few seconds and exits climbing up above nest. 11:44:44: Front half of stoat's body visible from head down, sticking out of nest. Looks down and then directly towards camera, looks down and then towards camera intently. Looks around again and exits climbing up and over nest 11:44:55. 12:13:36: Stoat exits head first slowly out of nest, looking in direction of camera. Continues looking towards camera, looks to opposite side briefly and exits above nest again.

Haast 2014-2015

Nest 10: Nest 3 – 14/15 Greaney

This nest was found at the chick stage on 4 November, half

way up a steep rock face. **15/11/2014 at 13:28:01:** A stoat appears at left, and climbs up the lower part of the rock face, jumps across a small gap to another section of rock, which is directly beneath nest, then climbs up the rock face into grass surrounding nest. Enters nest head first at 13:28:07 as far as front half of body, rummages around in nest until 13:28:22; body turns and looks over left shoulder then does full body turn. Exits nest same way it entered at 13:28:26, runs to bottom of rock, scales directly up it and out of view at 13:28:28. 13:31:29: Stoat enters from below by same route as before, enters nest head first as far as the front half of body, grabs first chick and removes it from nest by turning back on itself, exits nest and returns by same route at 13:31:40. 13:31:54: Reappears from left as before, jumps to base of rock face and works its way up to nest site as previously. Collects second chick from nest, and attempts a different exit route by climbing up above nest, but is unsuccessful so reverts to initial exit route at 13:32:18. 13:32:32: A stoat runs to base of rock from the left and then up to nest as before, collects third chick and exits as before at 13:32:49. 13:33:45: A stoat can be seen approaching from a distance across grass on left, reenters nest site from base of rock as before. Front half of body enters nest, movement visible inside nest, sticks head out and looks around, exits down rock and continues on down out of site beneath bottom frame at 13:34:58. 13:35:07: Re-enters from bottom frame, hangs around at base of rock sniffing. Then scales up side of rock and out of view 13:35:13. 15:04:33: As snow is falling gently, a stoat runs across side of rock face to base of rock and enters nest as before. Front half of body enters nest 15:04:40. Turns around in full circle and exits nest the way it entered, runs back up side of rock face at 15:05:45. 15:30:48, stoat head pops up on side of rock face. Spends two seconds looking up in direction of top of rock and sniffing around. Then turns around and descends down the rock face. Continues down out of frame at 15:30:55. 15:30:58: reappears from where it was last seen, climbs up by usual route across base of rock at 15:31:01. Climbs up to nest as before, and puts head and one foot inside at 15:31:06. Removes head and sniffs up above nest, standing on hind legs. Drops down onto all fours, turns and faces camera at 15:31:07. Turns around 180 degrees and climbs down from nest as

previously at 15:31:09. Scales back up side of rock face 15:31:11.

Nest 11: Nest 6 - 14/15 Heveldt

This footage deteriorated in quality prior to the stoat visit, and the image is fogged, so exact behaviour is difficult to identify. The nest was found on 14 November at the egg stage. **02/12/2014 at c. 13:56:08:** A stoat lands on the rock where the nest is situated and appears to have jumped across from right hand side. It moves about for a few seconds, then appears to move into nest and is no longer visible. Some blurry movement cannot be interpreted. 13:57:12: A white blur of a stoat's under face and belly is visible, facing in direction of camera, appears to be looking/sniffing around. Then a stoat jumps up the rock face on the right. 13:58:04: A stoat climbs up rock face to nest from below, exits to the right in the same way as before at 13:58:08. 13:58:17: Same behaviour again, glimpses of a white chest visible between 13:59:47 and 14:00:33; stoat makes same exit at 14:00:34. Returns at unknown time, exits again at 14:06:52.

Nest 12: Nest 10 - 14/15 Greaney

Nest found on 28 December at the egg stage, presumably a second clutch. **02/01/2015 at 14:24:18:** A stoat jumps down into view from rock on left hand side and enters nest head first as far as shoulders. Spends until 14:25:56 in this position, then turns head around facing towards camera. Looks directly up at camera, licks around mouth several times and jumps back up to the place where it entered at 14:26:03. This unusually long visit (nearly two minutes) would be consistent with a stoat eating the clutch of eggs inside the nest.

Nest 13: Nest 4 - 14/15 Heveldt

Nest found on 13 November, with birds incubating eggs. **04/12/14 at 11:17:40:** Nest with chicks. Stoat head appears in nest crevice. 11:17:56: Adult wren looks over cliff edge at nest. 11:17:58: Head of stoat at top of nest crevice. 11:18:09: Stoat exits nest, quickly running up cliff. 11:18:39 Adult wren appears, very agitated; suddenly flies off at 11:19:27. 11:19:30: Stoat climbs down into nest. 11:19:40: Stoat runs back up cliff. 11:22:48: Stoat seen climbing along cliff edge (outside nest).