Nest-boxes increase fledging success in the declining rifleman *Acanthisitta chloris*, New Zealand

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SUMMARY

The provision of nest-boxes was tested as a low cost method to increase fledging success in the rifleman *Acanthisitta chloris*, a declining endemic New Zealand species that is at risk from introduced mammalian predators. Nest success of riflemen in nest-boxes (80%) was five times higher than those in natural nest sites (16%). This difference was due to a reduction in the rate of predation in nest-boxes. However, aluminium nest guards did not further increase nest success in nest-boxes (82%). This outcome indicates that nest-boxes can provide a low cost and non-lethal method to protect rifleman nests from predators and increase fledging productivity.

BACKGROUND

The rifleman *Acanthisitta chloris* is one of two surviving species of New Zealand wrens (Acanthisittidae). This endemic family has fared poorly since human arrival in New Zealand due to the introduction of exotic mammalian predators and habitat loss (Diamond & Veitch 1981), with three species (*Dendroscansor decurvirostris*, *Pachyplichas jagmi* and *P. yaldwyni*) extinct shortly after Polynesian settlement, followed by another two species after European colonisation (*Traversia lyalli* and *Xenicus longipes*; Holdaway 1989). The rifleman is distributed across both the North and South islands (Robertson *et al.* 2007), but its range is fragmented and the status of the species was recently changed from least concern to at risk and declining (Miskelly *et al.* 2008). The reason for the recent decline of the rifleman is not known, but high rates of predation on nests by introduced mammalian predators is likely to be a factor (Innes *et al.* 2010).

As with other endangered New Zealand birds, translocations of riflemen to predator-free offshore islands has been used to ensure their conservation (Leech *et al.* 2007). However, reliance on island populations can increase the risk of extinction due to the vulnerability of small populations to disease, loss of genetic diversity and other stochastic processes (Frankham *et al.* 2002). Ensuring the rifleman maintains viable populations on the mainland is thus important to its long-term survival. Although control of introduced predators in selected mainland areas has proven beneficial in restoring populations of native birds (e.g. Moorhouse *et al.* 2003), the practice is expensive and feasible only over limited areas. Alternative management strategies are needed if the rifleman is to survive over more than a fragment of its original range.

The rifleman is a cavity-nesting species that builds a domed grass nest inside the hollows of living and dead trees, within dense clumps of dead foliage or even in disused animal burrows. They will also readily use nest-boxes. Nest-boxes have been shown to boost productivity in threatened bird species (e.g. Tatayah *et al.* 2007, Libois *et al.* 2012). However, in other species nest-boxes do not improve nest success, and can even be detrimental if predators develop a search image to target nest-boxes (Miller 2002). The provision of nest-boxes to riflemen has been used to study their breeding biology, mating system and cooperative behaviour (Sherley 1990, Preston *et al.* 2013), but little has been done to investigate their use as a management tool. In this study we compared nesting success of riflemen between natural nests and artificial nest-boxes to determine whether nest-boxes can increase productivity and reduce predation risk without the need for expensive predator control programmes.

ACTION

The nesting success of riflemen in natural cavities and nest-boxes was monitored during the austral summer (October-December) from 2002 to 2007. The study site, described by Gill (1980), was located at Kowhai Bush, a 240 ha block of native forest located approximately 10 km from the town of Kaikoura, New Zealand (42°37'S, 173°61'E). The study site comprised an area of forest of about 15 ha and was dominated by a manuka *Leptospermum scoparium* canopy. The understorey was dominated by introduced shrubs, but native vegetation is recovering after the cessation of grazing. A variety of introduced mammalian predators are present, including house mouse *Mus musculus*, two species of rats *Rattus* spp., three species of mustelids *Mustela* spp., common brushtail possum *Trichosurus vulpecula*, European hedgehog *Erinaceus europaeus* and feral cat *Felis catus*.

The number of nest-boxes in the study area was between 30 and 40 each year, and numbers increased as the study progressed, as new boxes were added while old ones were replaced. All nest boxes were made of plywood, with sides, floor and roof about 12 x 12 cm square. A 2.5 cm entrance hole was drilled in the front of each box about 1 cm from the top (Figure 1) but no perches were added. Small holes were drilled in the floor to allow drainage. Roofs could be removed to inspect nests and clean boxes. The cost per box averaged

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Figure 1. Male rifleman entering nest-box. The small size of the entrance hole excludes other species of hole-nesting birds and most introduced predatory mammals.

US$5.00 to $6.00, including construction labour but not the costs of installation or monitoring their use, which was done by the authors. Boxes were secured to manuka trees approximately 2 m above ground. The distance between adjacent boxes averaged about 50 m, with boxes laid in a grid pattern over the study area. About half of the boxes were also fitted with an aluminium collar, 50 cm in height, around the tree just under the nest box, to determine whether the exclusion of rodents further increased nest success. The outside of the nest-box was painted brown; the inside was not painted. Natural nests were located by following riflemen as they returned to the nest. A total of 12 natural nests were found over the course of the study and all were located within the same area as the nest-box grid. The number of natural nests was low as most birds on the study site used the nest-boxes we erected.

Nest success of both natural nests and nests in nest-boxes was estimated using the Mayfield method (Mayfield 1975) and compared using a Z-test (Hensler & Nichols 1981). Nests were visited every 3-5 days to monitor their progress throughout the incubation (20 days) and nestling (24 days) periods (Sherley 1985). To minimise disturbance, nests were usually checked from a distance by watching for parental activity. Riflemen generally do not flush when approached, and to prevent desertion we inspected nest contents only after adults left the nest naturally. Nest contents were inspected using a small torch and when necessary the roof was removed. The contents of nests in natural cavities were almost always impossible to see, and cavities were not altered to allow greater inspection. Thus we could not compare clutch size or number of fledglings and instead report nest success as the probability that at least one nestling fledged. Both natural and nest-box nests were inspected once parental activity had ceased. A nest was recorded as depredated if the nest contents were gone before nestlings could have fledged, the nest contained eggshells or partially consumed nestlings, or the nest was torn up. We could not confirm that a mammalian predator was responsible for each record of predation, however the disturbed nature of the nest linings, and chewed remains of eggs and nestlings left in the nest are typical of predation by rodents (Brown *et al*. 1998).

To determine whether other cavity-nesting birds in the study area might interfere with rifleman nests and thus be responsible for predation, we used video-cameras to monitor nest boxes during both the incubation and nestling stages. Cameras were set up 5-10 m from the nest-box and ran for periods of six hours (starting at dawn) during both the incubation and nestling periods. The number of other species visiting the nest boxes and their activities were recorded.

Most birds were not banded. It is possible that a nest-box used in successive years may have involved the same individuals; however the short life expectancy of this species (1.7 years for females and 2.2 years for males; Sherley 1985) relative to the length of our study should reduce the risk of pseudoreplication. No natural nest site was ever used twice.

CONSEQUENCES

The provision of nest-boxes significantly increased overall nesting success due to a reduction in the probability of predation (Table 1). Nest success of riflemen using nest-boxes without nest collars was approximately five times higher than that of birds in natural nest sites and this difference was significant ($Z = 2.18$, $p = 0.015$, $n = 54$ nests). However, there was no significant difference in nest success between nest-boxes with and without a protective collar around the nest tree ($Z = 0.23$, $p = 0.41$, $n = 69$ nests). The number of young fledged per nest could not be estimated for natural nests, but riflemen in nest boxes produced an average of 3.52 ± 0.16 (± SE, n = 23) fledglings per nesting attempt.

No predation events were directly observed with the video-monitoring of nests. However, common starlings *Sturnus*

Table 1. Predation risk and nest success of riflemen in natural nests compared to nest-boxes with and without aluminium collars. Daily probability of predation was estimated using the Mayfield (1975) method. Nest success was the chance of at least one chick fledging, calculated using the daily probability of predation and assuming a 44 day combined incubation and nestling period (Sherley 1985).

Type of nest	Number of nests	Number of nests depredated	Daily probability of predation (SE)	Nest success (%)
Natural nest	12	6	0.041 (0.016)	15.8
Nest-box without collar	42	6	0.0052 (0.0021)	79.9
Nest-box with collar	27	4	0.0046 (0.0023)	81.6

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vulgaris were observed to visit 1 of 15 nest-boxes filmed during the incubation period and 2 of 11 nest-boxes fimed during the nestling period (total hours of filming: 156 hours). A pair of house sparrows *Passer domesticus* and a single chaffinch *Fringilla coelebs* were also observed visiting one nest box each. All of the starlings attempted to enter the boxes but could only poke their head into the nest-box due to the small size of the entrance. None of the nests visited by starlings or other birds were later depredated and it appears unlikely that nest failure was due to interference by these introduced species of birds. Instead, all observed cases of nest loss in both natural nests and nest-boxes were consistent with predation by rodents**.**

DISCUSSION

The provision of nest-boxes greatly increased the number of rifleman nests that fledged young, due to decreased predation risk. This decrease appeared to be the result of the nest-box alone, as nest-boxes fastened to trees protected by aluminium sheathing had the same rate of nest success as nest-boxes on unprotected trees. The high success of nests in nest-boxes may be due to the small entrances, which excluded most predators while natural cavities and nest sites generally had much larger openings. Although we did not directly observe any predation events by mammals, a number of introduced birds were observed visiting nest-boxes occupied by riflemen, but in all cases they were unsucessful in entering boxes because of the small size of the entrance. The small entrances may also have deterred most mammalian predators and explain why metal tree guards did not reduce predation risk further.

The decrease in risk of predation we observed in nest-boxes might be expected to lead to a subsequent increase in population size or density of riflemen. Although we were unable to estimate population size as birds were not colour-banded, the number of nest-boxes occupied per year varied from 7 to 16 (mean = 12.5 ± 1.31 pairs), and there was no significant change over the 6 years of our study ($r = 0.22$, $p = 0.68$). A lack of increase in population size is not surprising as most young dispersed and our study site occupied only a small portion of the total forest area. Nonetheless, the use of nest-boxes could be a strategy to improve the conservation status of this species. If the number of young fledged per nest in nest-boxes (3.52) is multiplied by the probability of nest success (~80%; Table 1), then a pair of riflemen in a nest-box on average produce 2.8 young per nesting attempt. Assuming successful natural nests have a similar brood size to nest-box pairs, then on average they produce only 0.6 young per nesting attempt. Given that most riflemen live for only a couple of years, the lower rate of productivity in natural nests could explain the continuing decline of this species across its range. The use of nest-boxes may be a simple and cost-effective way to maintain rifleman populations where more expensive predator control measures are not feasible.

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