SHORT COMMUNICATION

Comparison of impact between carrot and cereal 1080 baits on tomtits (*Petroica macrocephala*)

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Abstract: This study investigates the hypothesis that tomtits are significantly less susceptible to 1080 poison operations when cereal rather than carrot bait applications are used, both at relatively low sowing rates. We made counts of territorial male tomtits along transects during standard 1080 possum control operations in 2001 to 2003. The transects had 3–5 kg ha^{-1} sowing rates of either carrot or cereal baits. The case-study evidence, all from operations that reduced possum populations to below five percent residual trap-catch, indicates that cereal bait operations with low sowing rates and large bait size have little, if any, immediate impact on tomtit populations. These results should be taken into account when planning aerial 1080 operations, especially given the contrasting evidence that carrot operations, even at low sowing rates, can have a negative impact on tomtits.

Keywords: aerial operations; carrot baits; cereal baits; compound 1080; mortality; sowing rates; tomtit; transect monitoring

Introduction

The background to this research is summarised in Westbrooke *et al.* (2003). Briefly, the tomtit (*Petroica macrocephala*), a small (10–13 g) forest- and scrub-dwelling passerine bird species, has proven particularly susceptible to aerial possum poison operations when the toxin 1080 has been used (Spurr and Powlesland, 1997; Powlesland *et al.*, 2000). From the results to date, it appears that low sowing rates (3 kg ha^{-1}) of large (12 g) cereal baits have little impact on tomtit populations compared to carrot bait operations (10–15 kg ha^{-1}, 6 g baits) (Powlesland *et al.*, 2000). However, recent carrot bait operations have been carried out at 3–5 kg ha^{-1} and so further research was required to determine whether this lower sowing rate also causes minimal tomtit mortality. Potentially, both the type of bait and the sowing rate may influence tomtit mortality. Thus, the current study aimed to augment the study of a cereal operation in Tongariro Forest in 2001, using the transect count methodology developed there (Westbrooke *et al.*, 2003).

Methods

We used the transect territory count methodology, tested at Tongariro Forest (Westbrooke *et al.*, 2003), to monitor the immediate impacts of 1080 poison operations at two sites treated with cereal baits and three sites treated with carrot baits at 3–5 kg ha^{-1}. These sowing rates are now commonly used as standard practice in possum poison operations.

1080 operations

Data were collected from central North Island sites involving a total of 4 operations from 2001 and 2003. Details of the operations are given in Table 1. The cereal operations were at Kapoors (NZMS 260 S19 272700, 623120) and Taurewa (NZMS 260 T19 273020, 623380) in Tongariro Forest in 2001, and Mt Pureora (NZMS 260 T17 273970, 629170) in 2003; and carrot operations at Mohaka Forest (NZMS 260 V19 284630, 623390), Kokomoka Forest (NZMS 260 V19 281210, 625040) and Waimanoa (NZMS 260 T17 274490, 629600) in 2003. The results from the two treatment areas within Tongariro Forest (Kapoors and Taurewa) were pooled because of possible lack of

Table 1. Operational and study characteristics for each site. The study in Tongariro forest took place in 2001. The remainder of the study took place in 2003.

Operation	Site	Bait application kg ha^{-1}		Drop	Pre counts	Post counts	Counts per	Residual possum
		Prefeed	Poison				phase	trap catch
Carrot baits								
Kokomoka Forest	Kokomoka Forest	3[1]	3[1]	26-May	17–23 May	10–15 Jun	3	0.2%
Mohaka Forest	Mohaka Forest	5[1]	5[1]	18-May	10–13 May	8–14 Jun	3	0.2%
Pureora	Waimanoa	3[1]	3[1]	23-Jul	11–14 July	5–7 Aug	3	0.0%
Cereal baits (12 g pellets)								
Pureora Forest	Mt Pureora	2[1]	2[1]	22-Jul	12–14 July	5–7 Aug	3	0.0%
Tongariro Forest	Kapoors & Taurewa	2[2]	3[2]	19-Sep	27 Aug–6 Sept	3–27 Oct	2	0.1% ± 0.3%
Non-treatment								
Tongariro Forest	Access 3	-	-	-	27 Aug–6 Sept	3–27 Oct	2	-

[1] 1080 concentration 0.08% w/w
[2] 1080 concentration 0.15% w/w

independence and labelled "Tongariro". The Mt Pureora and Waimanoa sites were in adjacent areas of Pureora Forest, with the alternative baits being used in separate areas within the same overall operation. In addition, we used data from the 2001 Tongariro Forest non-treatment site, Access 3 (NZMS 260 T19 273110, 623680). Sites were selected based on standard possum-poisoning operations during May–September, meeting the requirements of bait-type, sowing rate, and sufficient tomtits present. All the operations reported low possum catch rates after the treatment (Table 1). Because we chose standard operations, there was no scope for random allocation of treatments – and in that sense this is a case study, not a formal experiment.

Tomtit monitoring

We followed the methodology for counts of territorial male tomtits developed by Westbrooke *et al.* (2003), with a slight modification to the data analysis. This methodology involved counting the number of male tomtits identified within 40 m on either side of a series of transects within each operational area. Counts were carried out within a month before the poison operation. The after-operation counts were carried out soon after a two-week period had elapsed following the operation, allowing any immediate impact on tomtits to become evident. There were two counts before and two after each operation in 2001, increasing to three in 2003. There were 20 transects of 250 m length at each site, but some transects (three in Kokomoka Forest), originally counted were excluded from analysis because subsequent information showed that the transects were not in the aerial operation area. We re-analysed the 2001 Tongariro counts based on distance sampling (Westbrooke *et al.*, 2003) to create counts that parallel more closely those made for the later operations, but making no substantive change to the results for Tongariro. The earlier analysis integrated the information from distance sampling counts and banding from before the operation to create one estimate of tomtits for each transect. A similar estimate was made from the information collected after the operation. In the current analysis we simply averaged the counts on each transect before the operation, and after it.

This transect method of counting of territorial males relies on an assumption that this index provides a consistent estimate of the number of male tomtits present over the time frame compared. It does not require identification of all the tomtit males within 40 m of the transect, but does assume that a consistent proportion of them are represented in the counts. Thus changes due to greater conspicuous resulting from factors such as changes in bird behaviour, or changes in detectability at different distances, would undermine the value of the index.

Analyses

The difference for each transect between the average counts before each operation and the average counts after each operation is the key variable for analysis, with negative values indicating a decrease over this time period. The percentage change in tomtit counts were calculated by taking the change as a percentage of the average tomtit counts at each site before the

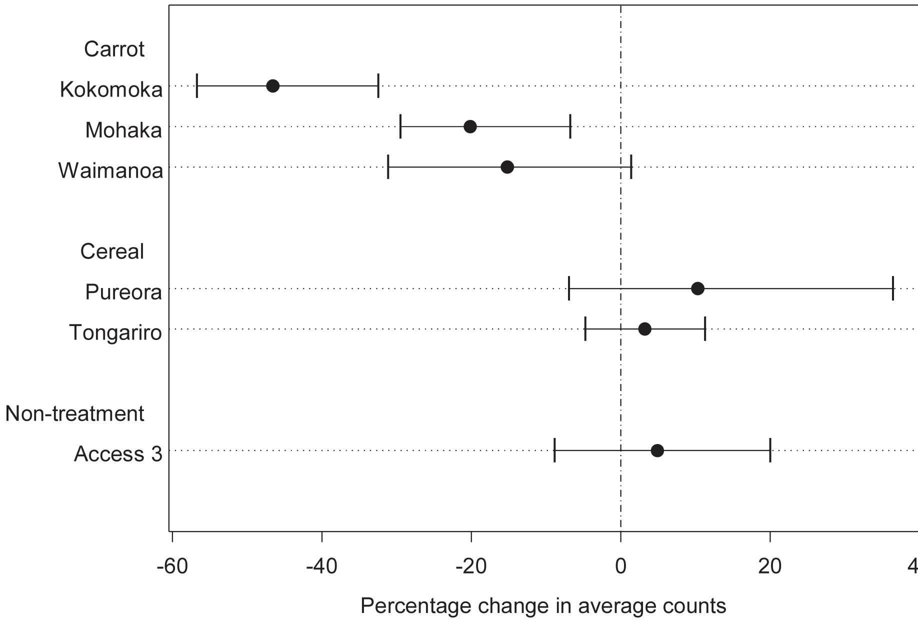

Figure 1. Changes in tomtit counts from before to after aerial 1080 operations, showing the contrast between carrot- and cereal-bait operations. Vertical bars show 90% bootstrap confidence intervals. The inclusion or exclusion of zero from the confidence interval is equivalent to a one-sided test of difference from zero at a 5% significance level, but overlapping of confidence intervals between sites is *not necessarily* equivalent to a non-significant difference.

operation. We used a mixed model ANOVA (i.e., hierarchical model) with treatment (carrot/cereal) as a fixed factor, and site as a random factor, to test the difference between treatments, while allowing for the clustered nature of the data within sites.

We also created estimates for the average percentage change at each site with individual confidence intervals to allow a visual comparison of the impact of sites within bait type. The confidence intervals were created using a bootstrap approach (Manly, 1997) to allow for any contribution to the variation in the estimate of average counts before the operation. We used 90% confidence intervals for consistency with the one-sided approach for assessing decreases after the operation, as the exclusion of zero from a 90% confidence interval is equivalent to a one-sided test of significance at the 5% level. We used a one-sided approach as we knew before looking at the data that we were primarily interested in decreases, or greater decreases, where carrot was used.

Results

There is a very clear difference between the carrot and cereal sites with the carrot-cereal treatment having P = 0.005 in the Wald test for fixed effects in the REML variance components analysis ($\chi^2_1 = 7.98$, $P = 0.005$).

Point estimates of change at carrot operations were all negative, indicating a decrease in male tomtit counts after the poison operation, while the estimates for cereal operations were all positive (Figure 1). The decrease in counts at Kokomoka is substantial (47%), and the 90% confidence interval is well below zero, showing a highly significant difference. The decreases at Mohaka and Waimanoa are 20% and 15% respectively, with confidence intervals that just exclude and just include zero respectively. In contrast, all of the cereal sites and the non-treatment site have point estimates above zero (Pureora at 10%, Tongariro at 3%, and 5% at the Access non-treatment site), and the confidence intervals all include zero (Figure 1).

Discussion

This study confirms earlier results from Pureora in 1998 (Powlesland *et al.*, 2000) and Tongariro Forest in 2001 (Westbrooke *et al.*, 2003) that best-practice cereal drops using large baits (12 g) with low sowing rates (3–5 kg ha^{-1}) have little, if any, short-term impact on male tomtit numbers. Further, it provides evidence that current standard carrot drops at low sowing rates (3–5 kg ha^{-1} 1080 carrot baits at 0.08% w/w) have negative impacts on male tomtit numbers, but with apparently lower impacts than carrots at 10–15 kg ha^{-1} had on banded tomtits at Pureora Forest in 1996 and 1997 (Powlesland *et al*., 2000).

In assessing the results, the limitations of the study methodology need to be borne in mind. The sites were chosen within standard planned operations, without any element of random allocation of treatment. The number of study sites was low, but typical of these studies. Except at Tongariro Forest, we did not run parallel non-treatment sites for comparison, choosing instead to allocate limited resources to study sites at more operations.

The limitations of index count methods also need to be kept in mind. While the count of territorial males adjacent to transects is a clear concept, the comparison of these before and after a poison operation has an implicit assumption that all other factors are equal. However, obviously time has elapsed and other factors could have changed, such as conspicuousness. A perturbation to a population, such as a significant impact of a poison operation on a territorial species, could lead to greater activity and song, and so mask a decline; or a reverse effect could lead to a greater decrease in an index than in the population.

This study deliberately focussed on short-term impacts, with all the post-operation counts taking place within six weeks of the operation. It demonstrates a clear difference between sites with cereal baits and those using carrot. There is no obvious alternative to the bait type to explain the patterns in the counts. For example, mortality rates due to other causes are an implausible explanation for the reduction in counts. However, it is important to ensure, as we did, that as many factors as possible remain the same during both sets of counts, such as use of the same observer at each site and avoidance of weather extremes.

Because this methodology relies on the assumption that other factors remain equal, it would be less suitable for investigating longer-term impacts of poison, where more intensive methods would be required. For example, mark-recapture methods have been applied to assess the mortality impact of brodifacoum poison operations on robins (*Petroica australis)* (Armstong and Ewen, 2001) and hihi (*Notiomystis cincta*) (Armstrong *et al*., 2001). If overall trends are of greater interest, then distance sampling (Buckland *et al*., 2001) could provide the necessary population estimates.

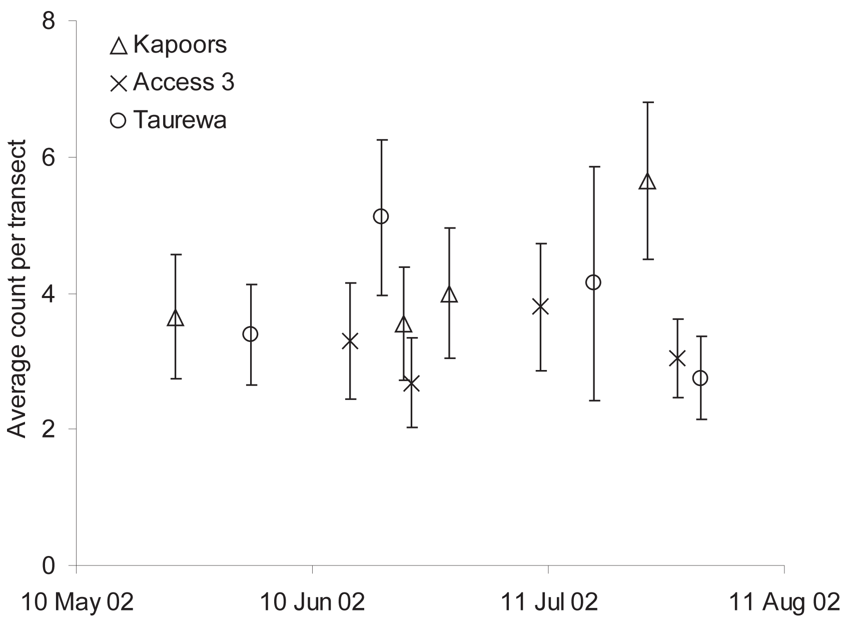

Figure 2. Average number of tomtits counted per transect during May–July 2002 at three sites in Tongariro Forest, with 95 percent confidence limits. Where counts were spread across two days (and in one case, three days), the midpoint of the days is used. Counts were taken on 18 or more transects in each set, except the third count at Taurewa on 17 July 2002, which only included seven transects.

However, both of these approaches would require substantially greater resources than the transect counts used in this study (Westbrooke *et al*., 2003).

The operations at Mohaka Forest and Kokomoka Forest took place in May, which was earlier in the season than the July to October window originally intended for this study. They otherwise met the criteria and reconnaissance indicated that tomtits were present and calling. Results from repeated transect counts in Tongariro Forest in late May to late July 2002 (Figure 2), a season after the 1080 operation there, show that average tomtit counts were reasonably consistent through this period (Westbrooke, unpublished data). Despite these limitations, we can have some confidence in the results presented here. The consistency of the male territorial count results with the banding results at Tongariro provides support for the methodology (Westbrooke *et al*., 2003).

The impacts of carrot baits on tomtits should not be extrapolated to other forest-bird species. Powlesland *et al*. (1999) showed that a 1997 carrot operation in Pureora Forest had no apparent impact on North Island robins (*Petroica australis longpipes*), but the same operation had a substantial impact on tomtits. Further, the impact of 1080 operations on bird populations can go beyond any immediate direct poisoning effect. Robin nesting success in Pureora Forest during the 1996/97 breeding season was much higher in the possum treatment block than in the non-treatment area, and enhanced recruitment, attributed to the impact of the treatment on predators, led to the population being above pre-treatment levels within a year (Powlesland *et al.*, 1999). Powlesland *et al.* (2000) reported enhanced tomtit nesting success in the 1997/98 season following 1080 possum control operations.

We see two possible directions for further research. Identification of the mechanisms underlying the difference in impacts of carrot and cereal baits on tomtits would be of great potential interest, especially as it could lead to enhancing existing mitigation methods. Direct research into the population dynamics of tomtits after 1080 operations, especially carrot ones, could provide managers with information on the medium-term effects of 1080 possum operations on tomtit populations, and investigate whether enhanced recruitment outweighs immediate mortality impacts.

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