The survival of *Peraxilla* mistletoes in the Tararua Range

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ABSTRACT

In the early years of the 20th century, red mistletoe (*Peraxilla tetrapetala*) and scarlet mistletoe (*P. colensoi*) were abundant in the Tararua Range. Possum (*Trichosurus vulpecula*) impacts are thought to be the cause of near extinction of mistletoe populations. However, since 1996 the Animal Health Board and Greater Wellington Regional Council began possum control operations in the Tararua Forest on a three-year cycle, and mistletoe sightings have increased. Although the population appears to be increasing, the condition of mistletoe plants in the population is not well understood. Here we present results from an intensive survey done in December 2004. A total of 56 plants were resurveyed using a foliar browse method, most were photographed, and host trees were tagged. We located five new plants.

Since 2000, 14 mistletoes have died (mortality 23% or around 5% per year). Probable causes of mortality vary from death of host trees due to disturbance or light competition, shading of mistletoes, and possum impacts. Existing bands on many host trees appear to be ineffective in preventing possums from reaching plants. There is now a core population of 47 plants (30 *Peraxilla tetrapetala,* 17 *P. colensoi*) which can be monitored in a systematic way. Plants are located in clusters around Holdsworth, Atiwhakatu and Blue Range. This is 76% of the total known population in the Tararua Range.

To protect the population, we recommend, in order of priority: (1) Banding all host trees, repairing existing bands, and managing surrounding vegetation to provide more light to shaded mistletoe plants; (2) Monitoring the population annually during flowering (this should enable new plants to be detected); (3) Restoring populations by planting mistletoe fruits on suitable host trees, and monitoring the germination success and growth of young plants; (4) Systematically ground search in different areas for new plants, particularly in the seven-year possum control areas. The Department of Conservation (DOC) has decided to repair existing bands on host trees, and will continue to closely monitor the plants for the time being.

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INTRODUCTION

In the early years of the 20th century, red mistletoe *Peraxilla tetrapetala* and scarlet mistletoe *P. colensoi* (Figs. 1 and 2) were abundant in the eastern side of the Tararua Range (Kirk 1894; Aston 1908; Zotov *et al.* 1938 all cited in Sawyer and Rebergen 2001). In the 1920s, Powell observed many plants on beech trees, and prolific flowering, in the Tauherenikau and Waiohine catchments (Ogle and Wilson 1985). However, mistletoe has been in decline since then, to such an extent that *P. colensoi* was thought to be extinct by the 1990s in Wellington (Sawyer and Rebergen 2001; but see Ogle and Wilson 1985). Nationally, the conservation status of both species is 'Gradual Decline' (de Lange *et al.* 2004). The Department of Conservation (DOC) has produced a recovery plan (Dopson 2001).

Figure 1 (above). *P. tetrapetala* in flower, Gentle Annie Track, Holdsworth. Photo: Steve Urlich.

Figure 2 (left). *Peraxilla colensoi* in flower, Pinnacle Ridge, Tararua Forest Park. Photo: Jenny Mason.

Possums (*Trichosurus vulpecula*) have been implicated as a cause of the decline in Wellington, and elsewhere in New Zealand (Ogle and Wilson 1985; Owen and Norton 1995). For example, Owen and Norton (1995) noted mistletoe leaves in possum stomachs. Sweetapple *et al.* (2004) found that in areas of south Westland where possums have been present for more than 10 years, *Peraxilla* spp. and *Alepis flavida* foliage was a significant component of possum diet.

Another cause of mistletoe decline is the loss of pollinating and dispersing birds, such as tui (*Prosthemadera novaeseelandiae*) and bellbird (*Anthornis melanura*) (Norton 1991; Ladley and Kelly 1995, 1996). Too few pollinators were found to visit mistletoe flowers to enable full fruit set at two South Island sites (Robertson *et al.* 1999). Hence, Norton (1997) advised caution in ascribing mistletoe decline to possums alone, as the extinction of *Trilepidea adamsii* was due to other factors (Norton 1991; 1997).

From the late 1990s to the early years of the 21st century, increasing numbers of plants have been found in eastern Tararua Forest Park, and two *P. colensoi* were found in the Otaki catchment on the western side. Sawyer and Rebergen (2001) suggested increased detection of plants may reflect mistletoe recovery following possum control. Supporting evidence for this comes from other studies where mistletoe condition improved following possum control (Sessions *et al.* 2001; Sweetapple *et al.* 2002). For example, there was a strong correlation between levels of foliar cover and possum density from studies in different catchments in south Westland (Bockett and Knightbridge 2004).

Possum control also reduces predation on pollinating and dispersing birds, meaning that it is difficult to separate out the factors leading to the increase in mistletoe detection in the Tararua range. Animal Health Board aerial 1080 operations with pre-feeding occurred in 1996, 1999, and 2002 in the Holdsworth area, so it is likely other predators of native birds, such as rats and stoats were also reduced in numbers. Therefore, possum control at three-year intervals has probably had a beneficial effect on mistletoes.

The other major factor in the putative recovery of red and scarlet mistletoe has been the increased awareness of the species amongst botanists during survey work (Sawyer and Rebergen 2001). Thousands of volunteer hours have been put in searching ridges and terraces off tracks over the past seven years to find mistletoes during flowering. Wellington Botanical Society member Chris Hopkins extensively searched the Holdsworth, Atiwhakatu and Mangaterere catchments over the last five years, and found 28 plants. Trevor Thompson has also found many plants, both in Holdsworth Lookout and Blue Range areas. So, increased detection may partly reflect the intensity of this commendable voluntary search effort.

In 2001, a mistletoe conservation management plan was produced for the Wellington Conservancy to protect the eight extant species found in the region. The goal was to: "ensure that all indigenous species of mistletoe continue to survive in the wild throughout their known range and that viable populations become or remain self-sustaining" (Sawyer and Rebergen 2001:p. 8). This paper addresses that need for populations of the two *Peraxilla* mistletoes in the Tararua Range. It partially meets two objectives of the Wellington Conservancy mistletoe management plan (Sawyer and Rebergen 2001: p. 8), which are to:

1. Survey historic mistletoe sites.
2. Develop and implement a monitoring programme to regularly inspect a representative sample of mistletoe populations to determine population trends and dynamics.

This paper reports on a survey of *Peraxilla* mistletoe condition carried out from 11 to 17 December 2004. We also evaluate the usefulness to managers of monitoring mistletoe in assessing the effectiveness of animal pest control.

METHODS

Sightings of individual species dating from 1995 were collated, cross-referenced and mapped. The greatest concentrations of plants detected from the ground were within the Blue Range and Holdsworth areas. The majority of these plants had been detected by two of the authors (CH and TT) since 1999, and many had been banded. Consequently, plants were easily relocated in December 2004.

Each plant was measured following the Department of Conservation's best practice guidelines for mistletoe monitoring (Knightbridge 2003). Briefly, two observers used the Foliar Browse Index (FBI) method to assess plant condition (Payton *et al.* 1999).

The FBI method measures a number of parameters such as the amount of foliar cover, visible browse, flowering and fruiting. Foliar cover and flowering levels were analysed by Mann-Whitney U-tests (Payton *et al.* 1999: pp 37–39). Plant volume was estimated for each plant. Pollination levels were assessed by counting the number of opened versus unopened flowers using the guide in Dopson (2001:p14). This was done by randomly placing two 1 m × 1 m quadrats at the base of the host tree 180° apart, and 100 samples were taken in total. All flower petals were examined to see whether they had been opened. If there were <100 samples in two quadrats, an alternative method was used to search the ground around the host tree for 5 minutes, or until 100 samples were obtained.

Host trees were identified, tagged, diameter measured, and location affixed with GPS. Photos were taken of each mistletoe plant, and viewing positions were recorded and marked where necessary. The intactness of the aluminium bands on host trees and surrounding trees was recorded.

RESULTS

Population dynamics

Fifty-six known mistletoe plants were relocated. Of these, fourteen had died since 2000 (11 *P. tetrapetala* and 3 *P. colensoi*). Mortality was split evenly between causes attributable to the death of the host tree, and where the likely cause of death was unable to be confidently determined. Five new plants were detected, of which 4 were *P. colensoi*.

Plants range in volume from 0.001 cm^3 to 5.6 cm^3 for *P. tetrapetala* and 0.03 to 14.7 cm^3 for *P. colensoi*, suggesting both populations were all-aged with recent recruitment (Fig.3). The cluster on the True Left of the Atiwhakatu Stream on Spot Height 535, for example, was dominated by small plants. Two *P. tetrapetala* plants were partially obscured and their volumes were unable to be assessed.

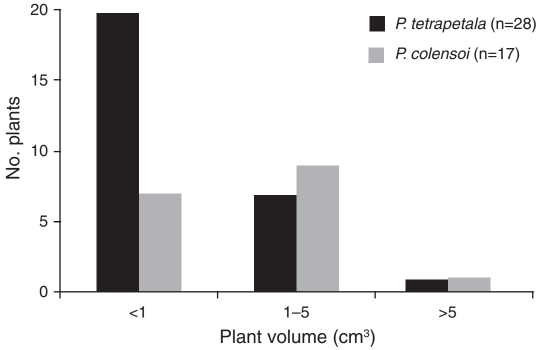

Figure 3. Estimated plant volumes for two mistletoe species, Tararua Range.

There was a weak relationship between the volume of individual mistletoe plants and the diameter of the host tree (R^2=0.08, n=45, P=0.05). As plant volume increased they tended to be found on larger trees, although small (<0.1 m^3) (and presumably young) mistletoe plants were found on all sizes of host trees (Fig. 4). The estimated volume of each plant did not account for past browsing, so that plants which previously had a healthy volume of leaves may have been severely knocked back.

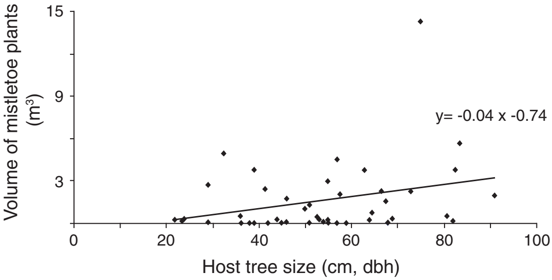

Figure 4. Plant volume-host tree diameter relationships for 45 mistletoe plants, Tararua Range.

Foliar cover and browse

Peraxilla tetrapetala foliage cover was greater on average than *P. colensoi* (Fig. 5), although statistically there was no difference (Mann-Whitney U-test statistic=274, P=0.18, n=43). Mean cover for *P. tetrapetala* was 51.2 $\pm$ 4.4 SEM and for *P. colensoi* 41.5 $\pm$ 5.0 SEM. Plants of each species tended to either be well foliated (grouped between 55–75%) or sparsely covered (15–35%) (Fig. 5). Four *P. tetrapetala* plants were partially obscured and their foliar cover was unable to be assessed. However, they may be able to be scored in future as canopy conditions change.

To test whether banding had made a difference to foliar cover levels, we compared plants which had been protected by host tree banding (Fig. 6a) or caging of plants (Fig. 6b), with those without adequate protection. Plants without adequate protection include those on host trees without bands, and those where bands were judged to be ineffective (Fig. 6c and 6d).

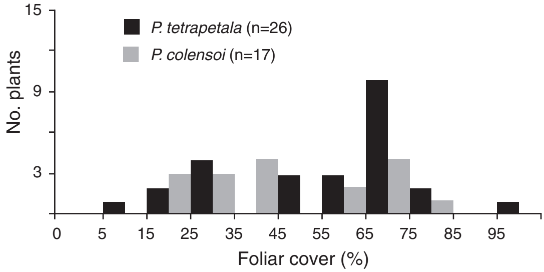

Figure 5. Mean foliar cover for two mistletoe species, Tararua Range.

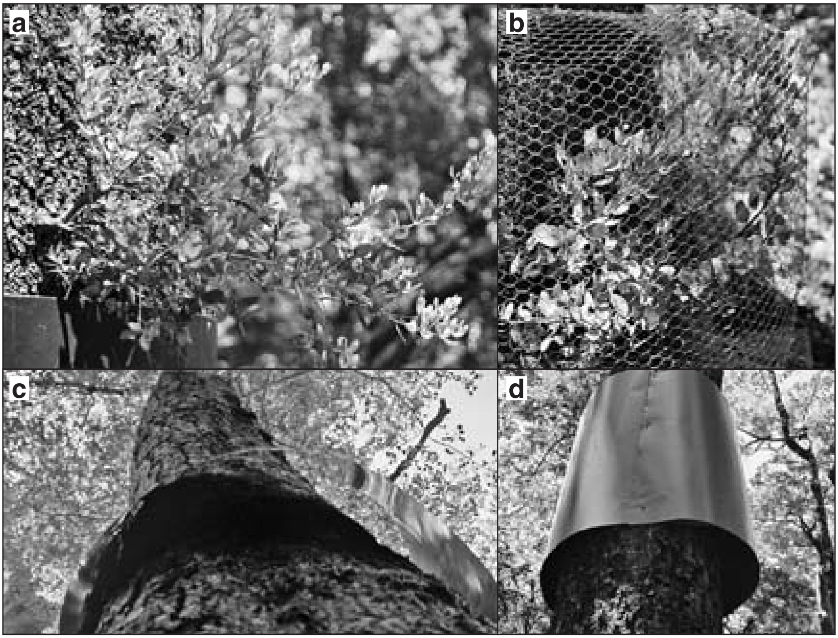

Figure 6. Effective banding (a) and caging (b) to protect mistletoes, and ineffective banding (c) and (d) potentially allowing possums to access mistletoes.

Foliar cover levels were generally greater where bands were providing an apparent effective barrier to possums although the statistical difference was weak (Mann-Whitney U test statistic=305, P=0.06, *n*=43) (Fig. 7). The mean cover for banded plants was 54 ± 4.6 SEM, and for not protected 41.5 ± 4.6 SEM.

Browse

Browse clearly attributable to possums was detected on three *P. colensoi* and one *P. tetrapetala*. Insect browse was more prevalent, with ten *P. tetrapetala* and sixteen *P. colensoi* plants being eaten.

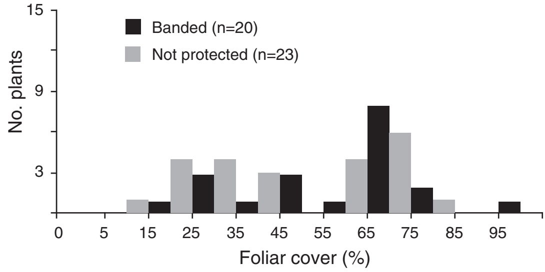

Figure 7. Mean foliar cover for banded and not protected mistletoes, Tararua Range.

Flowering and pollination

Flowering intensity varied for both species (Fig. 8); some individuals flowered prolifically, others had few or no visible flowers. There was no difference in flowering between species (Mann-Whitney U test statistic=231, P=0.78, *n*=45).

Evidence for pollination was strong. Over 95% of flowers collected from the ground had been top-opened indicative of pollination (Table 1). A tui was observed in one plant opening flowers. Only *P. tetrapetala* flowers were examined, as *P. colensoi* flowers were still not fully developed at the time of sampling. Should *P. colensoi* pollination be studied in future, then sampling should be done in early–mid January.

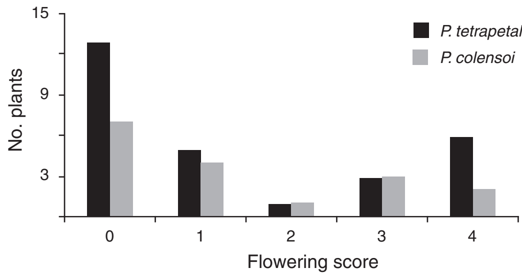

Figure 8. Flowering scores for two mistletoe species, Tararua Range. 0 = Nil flowers observed on an individual plant; 1 = 1–25% of flowers covering individual plants; 2 = 26–50%; 3 = 51–75%; 4 = >75%.

Table 1. Numbers of mistletoe flowers collected and pollination status of flowers (Types after Dopson 2001:p14).

Closed mature flower (Type 1) *not pollinated*	**Top-opened petals intact (Type II)** *pollinated*	**Bottom-opened but pistil intact (Type III)** *not pollinated*	**Top-opened petals not intact (Type IV)** *pollinated*	**Bottom-opened ovary absent (Type V)** *pollinated*	**Unopened insect-eaten (Type VI)** *not pollinated*
3	4	5	560	7	0

DISCUSSION

The level of annual mortality (c. 5%) of mistletoes is a concern to the Department of Conservation. In the Landsborough valley on the West Coast, annual *Peraxilla* mortality was just over 1% between 1994 and 2002 when possums were kept below 5% RTC (Bockett and Knightbridge 2004). However, in other Westland valleys with similar management of possum densities, average annual mortality averaged 8% over 10 years, and foliar cover declined from 47 to 16% (Bockett and Knightbridge 2004). With such conflicting outcomes from possum control, it is difficult to predict what might happen to the mistletoe population in the Tararua Range.

Therefore, it is important to protect the existing population clusters with adequate banding, and to monitor plants closely. Currently, foliar cover (Fig. 5), flowering (Fig. 8), and pollination (Table 1) of the surviving population is in reasonable condition. However, the annual mortality rate is probably too high, and also indicates that plants could suddenly go into decline. This would have serious consequences for effective pollination, seed dispersal, and recruitment of new plants, if plants become isolated from one another. Biodiversity loss would result if mistletoes became functionally extinct.

Therefore, where current banding is inadequate, or where host trees are not yet banded, priority should be given to eliminating possum browsing by ensuring all host trees are effectively banded. Mistletoe is a highly preferred food for possums (Owen and Norton 1995; Sweetapple *et al.* 2002; Bockett and Knightbridge 2004), and evidence from these studies suggests they will actively seek it out.

There is also the need to actively manage the surrounding vegetation of those mistletoes which are shaded. Providing a release for them by increasing light will help to maintain them in the forest ecosystem. This might reduce the risk of sudden and premature mortality, if plants are exposed to better growing conditions. Monitoring of host tree health and levels of canopy dieback should also be recorded. This should enable an early warning of whether host trees are experiencing crowding and competition for light, which could be alleviated by managing surrounding trees.

Annual monitoring is required to track the condition of existing plants, and to learn more about their dynamics over time. In conjunction with protecting and monitoring existing plants, a restoration project could be undertaken to boost the mistletoe population above its current precarious state. This is a relatively simple concept, which may be ideal for a community partnership. The observations of early botanists suggest the eastern Tararua Ranges were ablaze with the red flowering of mistletoes and northern rata. Restoring this vision has the potential to capture public imagination. This could be done by collecting seed, planting on potential host trees in, and amongst the existing clusters, recording these data, and monitoring establishment success.

The mistletoe population size structure shows that most plants are small plants, possibly reflecting that new recruitment is occurring, particularly on the True Left of the Atiwhakatu Stream. However, plants first identified in 1996 on the Holdsworth Lookout track by one of us (TT) had been knocked back by browsing, and had re-sprouted from sub-surface root stock Therefore, it is difficult to identify whether small plants have re-sprouted from pre-existing root stock, or have recently established from seed.

Increased ground survey is required to protect new recruits, re-sprouts, and older surviving plants which are yet to be located. This is another way of increasing the protected core population by finding plants before possums. For example, the Kiriwhakapapa/Blue Range area is a hotspot of *P. colensoi*, and intensive survey would be justified in this area.

Survey of the seven-year possum control areas would also yield valuable information on the success of aerial 1080 operations, and the identification of damage thresholds. At the outset of this study we anticipated being able to compare mistletoe condition between areas receiving different possum control regimes. However, the critical status of the existing populations of *P. colensoi* and *P. tetrapetala* means the focus is now on ensuring the survival of these species in the Tararua Range.

Resources are needed to meet these four objectives (protection, monitoring, restoration, survey). Most mistletoe plants are not visible from above the canopy, many *P. colensoi* for example, establish on trunks underneath the canopy. Therefore, systematic ground survey is more likely to detect plants than sustained aerial survey.

Therefore, to protect the population using existing resources, we recommend, in order of priority:

1. Banding all host trees, and repairing existing bands. Managing surrounding vegetation to provide more light to shaded mistletoe plants.
2. Monitoring the population annually during flowering; this should also enable some new plants to be detected.
3. Restoring populations by planting mistletoe fruits on suitable host trees at two locations: Holdsworth Lookout and Blue Range. Monitoring the germination success and growth of young plants should occur to improve techniques.
4. Systematic ground searching in different areas for new plants, particularly in the seven-year possum control areas.

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