Possum (*Trichosurus vulpecula*) control benefits native beech mistletoes (Loranthaceae)

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Abstract: The Australian brushtail possum (*Trichosurus vulpecula*) has been blamed for the decline of three native New Zealand beech mistletoe species (*Alepis flavida, Peraxilla tetrapetala* and *Peraxilla colensoi,* Loranthaceae), but there are few quantitative data on possum effects, and anecdotal evidence is often conflicting. We present results from two monitoring programmes that suggest possum control operations can improve mistletoe health. In the Eglinton Valley significantly more *Alepis flavida* plants outside a possum control area declined in condition than *Peraxilla* spp. inside the control area from 1995 to 1997. In 1997, the control area was extended to include *A. flavida* plants and their condition significantly improved by 1999. *Alepis flavida* at Eglinton was also compared to *A. flavida* at Mavora Lakes, where no control was undertaken. Significantly more of the Eglinton plants declined from 1995 to 1997, while the reverse was true from 1997 to 1999, after the Eglinton site was controlled. In the Hurunui River Valley significantly more mistletoes improved or remained in the same condition within the possum control area than outside the control area between 1997 and 2000. Overall, these results suggest that possum control is an effective tool for protecting native beech mistletoes, but more monitoring data are needed to understand how frequent and how intense control efforts must be to afford this protection.

Keywords: *Alepis flavida*; herbivory; Loranthaceae; mistletoe; *Peraxilla colensoi*; *Peraxilla tetrapetala*, possum; *Trichosurus vulpecula*.

Introduction

Peraxilla tetrapetala, P. colensoi and *Alepis flavida* are three of the five endemic loranthaceous mistletoe species still extant in New Zealand. These plants sequester water and nutrients through haustorial connections to their host plants but produce their own photosynthate. All three are relatively host-specific, primarily occurring on southern beech (*Nothofagus*) trees (Norton, 1997). They require avian pollinators and dispersers to reproduce (Ladley and Kelly, 1995a, b; Kelly *et al.*, 1996). The mistletoes are very slow-growing, taking two years from germination to produce a shoot of 15 mm length. They live for many decades and appear to have little negative effect on their host trees (Ladley and Kelly, 1996; Ladley *et al.*, 1997).

The Australian brushtail possum (*Trichosurus vulpecula*) has been blamed for the decline of numerous native plant species in New Zealand, including native loranthaceous mistletoes (Ogle and Wilson, 1985). However, few quantitative studies have measured the exact effects of possums on mistletoes. Wilson (1984) suggested that possums were contributing to the decline of mistletoes because from 1978 to 1982 *Peraxilla colensoi* and *P. tetrapetala* plants at Mt. Misery, Nelson Lakes National Park, were browsed by possums almost once per year on average and were over 50% defoliated in half these attacks. In contrast, Owen (1993) found that possums contributed little to overall leaf loss on *P. colensoi* in the upper Haast Valley (southern South Island). Sessions and Kelly (2001a) observed similar low levels of browse on *P. colensoi, P. tetrapetala* and *Alepis flavida* at three other South Island sites (Craigieburn, Lake Ohau and Waipori), but higher defoliation on *A. flavida* in the Eglinton Valley (Fiordland).

This variation in defoliation by possums is supported by anecdotal evidence which suggests that some correlation exists between the duration of possum habitation and the decline of mistletoe populations (Ogle and Wilson, 1985; Brockie, 1992; Ladley, 1994; Ogle, 1997). The effects of possums appear to vary among geographical regions. In areas invaded by possums only within the past decade (e.g., western Waitutu forest, southern Fiordland and South Westland) and on possum-free islands (e.g., D'Urville Island in the Marlborough Sounds, islands in Lake Waikareiti within Te Urewera National Park, Little Barrier Island, and Pigeon Island in Dusky Sound, Fiordland), beech mistletoes are still abundant (Ogle and Wilson, 1985; Ogle, 1997). However, some healthy mistletoe populations persist in areas long inhabited by possums [e.g., Craigieburn (Sessions and Kelly (2001a)], and other populations have declined in the absence of possums [e.g., Great Barrier Island (Ogle and Wilson, 1985; Ogle, 1997)].

Despite these complex distributional patterns, mistletoe plants generally increase in size when they are protected from possums. At sites throughout New Zealand, banding host trees with aluminium collars or enclosing mistletoes in cages usually has led to an increase in size or foliage cover of the protected plants (e.g., Courtney, 1997; Dopson, 1997; Jones, 1997; Barkla and Ogle, 1997; Simpson, 1997; Walls, 1997). Likewise, mistletoes appear to have benefited from intensive possum control operations (Ogle, 1997). For example, a few *Tupeia antarctica* and *Ileostylus micranthus* plants on Kapiti Island have re-sprouted since possums were eradicated from there in 1983-84 (Atkinson, 1992; Sawyer, 1997). Milne (1996) found that in Tongariro National Park over a three year period significantly more *Peraxilla tetrapetala* increased in size in an area with possum control than in a nearby area without control. P. Sweetapple (Landcare Research, Lincoln, N.Z., *unpubl.*) found that only 2.6% of *Tupeia antarctica* plants were browsed when possum densities were kept below 3% trap-catch rates, while 75.9% of plants were browsed when trap-catch rates reached 4.6%. However, the mean trap-catch rates were based on small sample sizes and had high variances so this difference should be interpreted with caution.

The precise impact of possums on mistletoes remains unclear. Several offices of the New Zealand Department of Conservation have recently initiated mistletoe monitoring programmes to test whether possum control benefits *Alepis flavida, Peraxilla tetrapetala* and *Peraxilla colensoi*. Here we report results from the longest running mistletoe monitoring programme, in the Eglinton Valley, Fiordland, and from the Mainland Island site in the Hurunui River Valley, north Canterbury. Results from both programmes indicate that control operations can improve mistletoe health.

Study areas and methods

Eglinton Valley monitoring programme

The Eglinton Valley, in Fiordland National Park, New Zealand, is a large, glaciated valley at 350-380 m elevation, with steep sides rising to 1800 m a.s.l. (44°58'S, 168°01'E). The valley floor and lower slopes are dominated by red beech (*Nothofagus fusca*) and silver beech (*N. menziesii*), with mountain beech (*N. solandri*) increasingly common at higher altitudes.

In 1994, a possum control operation was initiated over 6400 ha of this valley to reduce the local possum population by 80% and to maintain long-term control below 20% of the original population (Rance and Rance, 1996). At the same time, a mistletoe monitoring programme was initiated to determine the success of possum control operations in improving mistletoe condition (Rance and Rance, 1996). A total of 99 mistletoe plants (23 *Peraxilla colensoi*, 44 *Peraxilla tetrapetala* and 32 *Alepis flavida*) were marked at four sites in the Eglinton Valley: Knobs Flat, Deer Flat, Dore Pass track, and Totara Flat. Both *Peraxilla* species occurred at the first three of these sites, located within a possum control area. *Alepis flavida* was monitored only at Totara Flat, which was located outside the initial control area. Because of the complete defoliation and death of many *A. flavida* at this site, control was extended to this area in a one-off poison operation over approximately 1025 ha in November 1997.

As an extension of the Eglinton programme, a similar monitoring scheme was initiated in 1995 in the Mavora Lakes area, 28 km east of Totara Flat. A sample of 29 *Alepis flavida* plants was monitored for five years, with measurement each October from 1995 until 1999. Forest in this valley is predominantly mountain beech, with some red and silver beech. It is slightly higher (*c.* 620 m a.s.l.) and drier than the Eglinton Valley, with less forest cover. Possum control was conducted at the Mavora site in January 1999 and 40 possums were killed, yielding a trap-catch rate of 13.6% (Department of Conservation, Te Anau, N.Z., *unpubl. data*).

Twice each year, during late winter (August-September) and mid-summer (January-February), each mistletoe in the Eglinton programme was scored based on its overall appearance and the amount of total browse observed. Each plant was given a condition ranking score according to the following scale: 1 = 0% defoliated (undamaged); 2 = 1-10% defoliated (light damage, some browsing detectable); 3 = 11-25% (moderate damage, browsing easily detectable); 4 = 26-50% (heavy damage); 5 = 51-75% (very heavy damage); 6 = 76-99% (severe damage); 7 = 100% (appears dead, no leaves); and 8 = mistletoe disappeared. It was assumed that most visible damage could be attributed to possum browse. Mistletoes are not browsed by other mammals or birds, and insects, pathogens and weather damage usually contribute relatively little to leaf loss in most populations (Owen and Norton, 1995; but see Sessions and Kelly 2001a, b).

For analysis, plant conditions in November 1995, November 1997 and October 1999 were compared for each plant, and the plant was classified as having either declined or not declined in condition. Plant results were grouped according to initial condition, and the numbers of plants whose condition declined within each category were compared using *G*-tests. In addition, the change in plant condition from 1995 to 1997 was compared with the change from 1997 to 1999 using a *G*-test for each sample population. These time periods were compared because the *A. flavida* population was outside the possum control area until 1997, then within it once control operations were extended to cover the Totara Flat site. Changes in plant condition among the three Eglinton samples (*A. flavida, P. tetrapetala* and *P. colensoi*) and between the two *A. flavida* samples (Mavora and Eglinton) were also compared with *G*-tests for both periods, 1995 to 1997 and 1997 to 1999.

Hurunui Mainland Island

The south branch of the Hurunui River Valley is located in the southwest corner of Lake Sumner Forest Park in northern Canterbury (41°45'S, 172°04'E). This steep-sided, glaciated valley is approximately 18 km long. It rises from 700 m a.s.l. at its mouth to 940 m a.s.l. near its headwaters. The forest is composed primarily of mountain beech, with extensive areas of mixed red and silver beech forest on the terraces. In 1995, the south branch of the Hurunui was designated a Mainland Island by the Department of Conservation and possum control was initiated across a 10-km stretch in the mid-section of the valley, encompassing 4200 ha.

In 1996, 53 mistletoe host trees (8 containing *Alepis flavida* and 45 with *Peraxilla tetrapetala*) were permanently marked. In total, these host trees contained 275 individual mistletoe plants. Twenty-five hosts (6 with *A. flavida* and 19 with *P. tetrapetala*) were located within a possum control area (where there were less than 0.3 possums per ha, or 1.3 possums per 100 trap nights, after two years of poisoning), while the remaining 28 hosts (2 with *A. flavida* and 26 with *P. tetrapetala*) were located outside this treatment area. In March 1997, and at yearly intervals thereafter, all the mistletoes in each host tree were scored collectively on the same eight-point scale used in the Eglinton study. Paired *t*-tests were used to compare the mean scores in 1997, 1998, 1999 and 2000 for both the treatment and non-treatment samples. Sites were also classified as either declining in condition or not, and a *G*-test was used to compare changes in condition in the treatment and non-treatment areas from 1997 to 2000.

In addition, 74 mistletoe host trees were marked in 1998 and 1999 in the north branch of the Hurunui River Valley. These plants provided an additional non-treatment comparison. Forty mistletoe host trees (4 with *Alepis flavida* and 36 with *Peraxilla tetrapetala*) were marked in 1998, and 34 host trees (1 with *A. flavida* and 33 with *P. tetrapetala*) were added to this sample in 1999.

The standard trap-catch methodology of Warburton (1997) was used to provide an index of relative possum densities at the 'South Branch' sites from 1996 until 2000. Eight trap lines were established in the treatment area and two lines within the non-treatment area. Five additional lines were established in the 'North Branch' site in 1998. Trap-catch rates were compared between the treatment and non-treatment sites using *t*-tests.

Results

Eglinton

Overall, in the Eglinton Valley from 1995 to 1999, *Alepis flavida* plants were significantly more likely to decline in condition than *Peraxilla* spp. plants (Table 1; Fig. 1). Although the *Peraxilla* plants of both species continued to decline in condition from 1995 until 1997, their rate of decline was lower and their overall condition was better than that of *A. flavida*. The rate of *Peraxilla* decline also levelled off in 1998 and 1999. Plants which were more than 50% defoliated at the beginning of the study were more likely to decline, although this trend was significant only in *P. tetrapetala* (Table 1).

All species in the Eglinton Valley were less likely to decline in the latter part of the study, although the difference was not significant for *P. tetrapetala* (Table 2). Possum control appears to have improved *P. colensoi* health more than *P. tetrapetala*, as *P. colensoi* had a significant reduction in the number of worsening plants

Table 1. Percentage of mistletoe plants with worsening condition (i.e., a higher condition score), November 1995 to October 1999 in the Eglinton Valley. Sample sizes are in brackets.

% plants worse	*P. tetrapetala* (*n*)	*P. colensoi* (*n*)	*A. flavida* (*n*)	*G* (species)
Overall	61.36 (44)	60.87 (23)	84.38 (32)	5.84 (*P*=0.05)
Started < 50% defoliated	50.00 (32)	58.82 (17)	78.95 (19)	4.41 (*P*=0.11)
Started > 50% defoliated	91.67 (12)	66.67 (6)	92.31 (13)	2.27 (*P*=0.32)
G (initial condition)	7.46 (*P*=0.01)	0.12 (*P*=0.73)	1.13 (*P*=0.29)	

Table 2. Percentage of mistletoe plants with worsening condition from November 1995 (the baseline) to November 1997, and from November 1997 to October 1999 at Eglinton and Mavora. Sample sizes are in brackets. (* denotes χ^2 instead of G, because $ln(0)$ is undefined).

% plants worse	*P. tetrapetala* (*n*)	*P. colensoi* (*n*)	*A. flavida* Eglinton (*n*)	*A. flavida* Mavora (*n*)	*G* (Eglinton species)	*G* (*A. flavida*)
Baseline-1997	45.65 (46)	60.00 (25)	96.88 (32)	0.00 (29)	27.34 ($P < 0.001$)	57.12* ($P < 0.001$)
1997-1999	34.04 (47)	18.18 (22)	16.00 (25)	48.28 (29)	3.67 ($P = 0.16$)	6.59 ($P = 0.01$)
G (time period)	1.31 ($P = 0.25$)	8.91 ($P = 0.002$)	45.14 ($P < 0.001$)	18.45* ($P < 0.001$)		

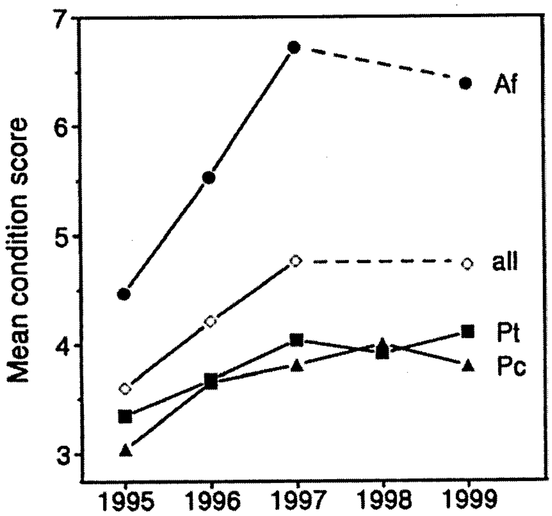

Figure 1. Mean damage condition scores for the three monitored beech mistletoe species, *Alepis flavida* (circles), *Peraxilla colensoi* (triangles), *P. tetrapetala* (squares), and all species combined (open diamonds) in the Eglinton Valley from 1995 to 1999. Condition scores were given according to the amount of damage on the plant, with 1=0% defoliated (undamaged); 2=1-10% defoliated; 3=11-25%; 4=26-50%; 5=51-75%; 6=76-99%; 7=100% defoliated; and 8=mistletoe disappeared. *A. flavida* was not scored in 1998.

between 1997 and 1999. The greatest improvement between the first and second intervals was for *A. flavida*, which had changed from untreated to possum-control status. As a result, *A. flavida* was far worse than *Peraxilla* spp. from 1995 to 1997 while it was outside the possum control area, but in 1997 to 1999 the three species did not differ significantly in the percentage of plants in declining condition. *A. flavida* did worse at Eglinton than at Mavora from 1995 to 1997, while the reverse was true from 1997 to 1999 (Table 2). The possum control conducted at Mavora in January 1999 did not result in any immediate improvement in plant condition, as the same number of

Table 3. Percentage of mistletoe plants with worsening condition from 1997 to 1998, from 1998 to 1999, and 1999 to 2000 in the treatment ($n = 25$ host trees) and non-treatment ($n = 28$) areas in the Hurunui River Valley. In 1998-1999 and 1999-2000, plants from the North Branch ($n = 40$ in 1998-1999 and $n = 74$ in 1999-2000) were also included in the non-treatment sample (in brackets) for comparison. (* denotes χ^2 instead of G because $ln(0)$ is undefined).

	Area with possum control	Area without control	*G*	*P*
1997-1998	12.00	58.33	12.31	0.0005
1998-1999	11.54	14.29 (25.00)	0.09 (2.23)	0.7635 (0.1350)
1999-2000	12.00	60.71 (48.04)	16.99* (20.24)*	< 0.0001 (<0.0001)

plants (nine) declined in condition between October 1998 and October 1999 as had declined in the previous year (October 1997 to October 1998).

Hurunui

At Hurunui between March 1997 and April 2000, significantly more mistletoes outside the possum control area declined in condition compared with mistletoes within the control area ($\chi^2 = 14.39$, $P < 0.001$). Plants within the treatment area did not change significantly in condition from 1997 to 2000 ($t = 0.95$, $P = 0.35$), with mistletoes on only 3 hosts (12%) declining in condition over the three years. The plants in the non-treatment area declined significantly, from 1.6 to 3.9 ($t = 5.00$, $P < 0.001$), and mistletoes on 17 hosts (60.7%) worsened during this period. Only eight *Alepis flavida* plants were marked, so that sub-sample could not be tested separately. The more abundant *Peraxilla tetrapetala* plants ($n = 45$) were able to be tested, and the results for this sub-sample matched those of the entire sample.

In 1997, 88% of the monitored plants in both the treatment and non-treatment areas had condition scores of 1 or 2, suggesting that the mistletoes were in a similarly

Table 4. Trap-catch results from the treatment (n=8) and non-treatment (n=2) trap-catch lines in the south branch of the Hurunui River Valley, as well as the non-treatment lines (n=5) in the north branch in 1999 and 2000 (in brackets). Trap-catch numbers are possums per 100 corrected trap-nights.

Year	Treatment mean trap-catch	Non-treatment mean trap-catch	*t*-statistic	*P*-value
1996	2.7	2.7	0.02	0.9859
1997	1.7	9.7	-3.92	0.0044
1998	1.4	7.4	-3.81	0.0052
1999	2.5	8.3	-2.70	0.0270
		(7.4)	(-3.90)	(0.0018)
2000	5.8	19.6	-3.03	0.0163
		(17.5)	(-3.50)	(0.0039)

good condition in both areas at this time. Within the treatment site, the proportion of plants with scores of 1 or 2 remained constant at 88% in 1998 and 1999, and only 12% of plants declined in condition each year (Table 3). In contrast, plant condition within the non-treatment area fluctuated much more widely. Only 58% of plants in the non-treatment area had scores of 1 or 2 in 1998; that proportion rose to 75% in 1999 and then dropped to just 39% in 2000. The percentage of plants declining in condition varied from 58% in 1997, down to 14% in 1998, then back up to 61% in 2000 (Table 3). These fluctuations within the non-treatment area meant that while there was a significant difference between the treatment and non-treatment sites in the number of plants declining in condition from 1997 to 1998 and from 1999 to 2000, this difference was not apparent from 1998 to 1999 (Table 3). These patterns were still present when additional plants from the non-treatment North Branch area were included in the analysis.

Possum densities were significantly higher in the non-treatment area than in the treatment area in every year after 1996 (Table 4), although this difference was based on only two trap lines within the non-treatment area. When an additional five non-treatment lines from the North Branch were included, the difference was more statistically significant. These two non-treatment sites were not grouped in order to calculate a single index of non-treatment possum density, but rather to indicate that possum numbers were lowered in the treatment area compared with nearby non-treatment areas. The year to year fluctuations in mistletoe condition within the non-treatment area did not correspond to changes in possum densities, as possum numbers did not drop in the non-treatment area in 1998 (Table 4). It is unclear why possums increased in the non-treatment area from 1996 to 2000, although it is possible that possums moved from the treatment area to the non-treatment area since no physical barriers separate the two South Branch sites.

Discussion

Both the Eglinton and Hurunui monitoring programmes indicate that possum control can benefit mistletoe plants. At Eglinton in 1995 to 1997, *Alepis flavida* plants outside the possum control area declined in health more than *Peraxilla* spp. plants within the control area. Once the control area was extended to include *A. flavida* through a one-off control operation, plants of this species significantly improved in condition.

Moreover, although interspecific differences between the Eglinton populations [e.g., differences in relative palatability or their susceptibility to browse; Sessions and Kelly, 2001a] may have confounded the effects of possum control, *A. flavida* plants in the Mavora area were significantly more healthy than the *A. flavida* at Eglinton until 1997 when control was extended to the latter population. From 1997 to 1999, the Mavora population declined while the Eglinton *A. flavida* population improved. This indicates that the recovery of *A. flavida* at Eglinton post-1997 was not due to some general improvement in climate which suited the species.

Possums may have been responsible for the decline of the Mavora *A. flavida* from 1997 to 1999, but no data on possum densities at the site prior to 1999 are available. Possum control conducted in January 1999 did not result in any apparent improvement in plant condition by October 1999. It is possible that plants had not yet had adequate time to recover, particularly since the control was achieved after the mistletoes would have produced new shoots for the year. By comparison, at Eglinton, where control was conducted in November prior to the mistletoe growth season, *A. flavida* plants improved dramatically within 9 months of possum control. The possum control yielded a corrected trap-catch rate of 13.6% (Department of Conservation, Invercargill, N.Z., *unpubl. data*), which is reasonably high compared with many other beech forest sites (Sessions, 1999). This indicates that possum numbers were relatively high in the area prior to control. Ongoing monitoring will determine whether the 1999 possum control benefits *A. flavida* at Mavora over the longer term.

Peraxilla tetrapetala plants at Eglinton were more likely to decline if they were already at least 50% defoliated. For this species at least, protection from browse did not benefit plants that were already unhealthy. This may be due to the heavily browsed plants becoming susceptible to other factors like fungal attack. Alternatively, some plants may have been in poor condition due to factors other than possum browse, such as pathogens or weather damage, which were not ameliorated by the control operations. Unprotected *A. flavida* continued to decline over time, regardless of prior defoliation. For *P. colensoi*, only four plants were at least 50% defoliated, which was too small a sample size to detect a difference between lightly and heavily defoliated plants.

The Hurunui results also suggest that mistletoe health is protected or improved when possums are controlled. Mistletoe health was similar in the treatment and non-treatment areas at the start of the monitoring period, and plants declined significantly only in the non-treatment area after three years. Overall, mistletoe health appeared to be consistently high after possum control, whereas without control, plant condition fluctuated greatly from year to year. All three untreated areas (the Eglinton *A. flavida* area, Mavora and Hurunui) showed a sudden worsening of condition at some time. In the Hurunui, these fluctuations do not appear to be related to changing possum numbers from year to year. This pattern may be caused by the heterogenous browsing habits of possums, where only some plants are eaten and plants may be rapidly defoliated in a short time period (Sessions and Kelly, 2001a), or it may be caused by changes in possum diet from year to year due to changes in the relative abundance of other food types. Mistletoe does not appear to be a highly preferred food for possums at some sites (Owen and Norton, 1995).

Although the survival of New Zealand's beech mistletoes is likely to depend on a number of factors, including pollinator abundance, host health, environmental conditions and herbivore abundance, our results suggest that possum control does benefit these threatened plants. Given the year to year changes that mistletoe populations can undergo, long-term data are needed to determine overall trends in the condition of plants. Data from ongoing monitoring should help us to understand exactly how low possum populations must be kept to ensure the protection of native beech mistletoes.

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References

Atkinson, I.A.E. 1992. *Effects of possums on the vegetation of Kapiti Island and changes following possum eradication.* Contract Report 92/52. Department of Scientific and Industrial Research, Wellington, N.Z.

Barkla, J.; Ogle, C. 1997. Status of loranthaceous mistletoes in the Wanganui Conservancy. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 47-49. Department of Conservation, Wellington, N.Z.

Brockie, R.E. 1992. *A living New Zealand forest.* Bateman, Auckland, N.Z.

Courtney, S. 1997. Status of loranthaceous mistletoes in the Nelson-Marlborough Conservancy. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 59-65. Department of Conservation, Wellington, N.Z.

Dopson, S. 1997. Some aspects of reproduction and possum control of five loranthaceous mistletoes in the central North Island and comparisons with South Island studies. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 115-124. Department of Conservation, Wellington, N.Z.

Jones, C. 1997. Mistletoe management, Tongariro-Taupo Conservancy. In: de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 183-186. Department of Conservation, Wellington, N.Z.

Kelly, D.; Ladley, J.J.; Robertson, A.W.; Edwards, J.; Smith, D.C. 1996. The birds and the bees. *Nature 384:* 615.

Ladley, J.J. 1994. *The reproductive ecology of the Loranthaceae mistletoes of New Zealand.* M.Sc. thesis, University of Canterbury, Christchurch, N.Z.

Ladley, J.J.; Kelly, D. 1995a. Explosive New Zealand mistletoe. *Nature 378:* 766.

Ladley, J.J.; Kelly, D. 1995b. Mistletoes: How these showy specialists and honeyeaters need each other. *Forest and Bird 278:* 16-21.

Ladley, J.J.; Kelly, D. 1996. Dispersal, germination and survival of New Zealand mistletoes (Loranthaceae): Dependence on birds. *New Zealand Journal of Ecology 20:* 69-79.

Ladley, J.J.; Kelly, D; Robertson, A.W. 1997. Explosive flowering, nectar production, breeding systems and pollinators of New Zealand mistletoes (Loranthaceae). *New Zealand Journal of Botany 35:* 345-360.

Milne, R.C. 1996. *Conservation management of Loranthaceae mistletoe in the Central North Island, New Zealand.* M.Sc. thesis, Victoria University, Wellington, N.Z.

Norton, D.A. 1997. Host specificity and spatial distribution patterns of mistletoes. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 105-109. Department of Conservation, Wellington, N.Z.

Ogle, C.C. 1997. Evidence for the impacts of possums on mistletoes. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 141-147. Department of Conservation, Wellington, N.Z.

Ogle, C.; Wilson, P. 1985. Where have all the mistletoes gone? *Forest and Bird 237:* 10-13.

Owen, H. 1993. *Mistletoe and the brushtail possum in silver beech forest, South Westland, New Zealand.* M.For.Sci. thesis, University of Canterbury, Christchurch, N.Z.

Owen, H.; Norton, D.A. 1995. The diet of introduced brushtail possums *Trichosurus vulpecula* in a low-diversity New Zealand *Nothofagus* forest and possible implications for conservation management. *Biological Conservation 71:* 339-345.

Rance, C.; Rance, B.D. 1996. *Monitoring of mistletoe in the Eglinton Valley, Fiordland.* Ecological Management Number 4, Department of Conservation, Invercargill, N.Z.

Sawyer, J. 1997. Status of loranthaceous mistletoes in the Wellington Conservancy. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 55-57. Department of Conservation, Wellington, N.Z.

Sessions, L.A. 1999. *Monitoring leaf loss and possum impact on New Zealand beech mistletoes.* M.Sc. thesis, University of Canterbury, Christchurch, N.Z.

Sessions, L.A.; Kelly, D. 2001a (in press). Heterogeneity in vertebrate and invertebrate herbivory and its consequences for New Zealand mistletoes. *Austral Ecology 26 (4).*

Sessions, L.A.; Kelly, D. 2001b. Methods for monitoring herbivory and growth of New Zealand Mistletoes (Loranthaceae). *New Zealand Journal of Ecology 25:* 19-26.

Simpson, N. 1997. Mistletoes in Otago. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 75-77. Department of Conservation, Wellington, N.Z.

Walls, G. 1997. Status of loranthaceous mistletoes in the Hawke's Bay Conservancy. *In:* de Lange, P.J.; Norton, D.A. (Editors), *New Zealand's loranthaceous mistletoes*, pp. 51-53. Department of Conservation, Wellington, N.Z.

Warburton, B. 1997. *Trap-catch for monitoring possum populations.* Department of Conservation, Christchurch, N.Z.

Wilson, P.R. 1984. The effects of possums on mistletoe on Mt Misery, Nelson Lakes National Park. *In:* Dingwall, P.R. (Editor), *Protection and parks: Essays on the preservation of natural values in protected areas*, pp. 53-60. Department of Lands and Survey, Wellington, N.Z.