

**Biological Control of Ragwort: Assessing the Impact
of Ragwort Flea Beetle (*Longitarsus jacobaeae*
(Coleoptera: Chrysomelidae))**

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Summary

Project and Client

The impact of ragwort flea beetle (*Longitarsus jacobaeae* (Coleoptera: Chrysomelidae)) on ragwort (*Senecio jacobaea* (Asteraceae)) infestations was investigated in a collaboration between Landcare Research, Wellington, Taranaki and Auckland Regional Councils, horizons.mw, Environment Bay of Plenty, and Environment Southland, from February 1999 to June 2001.

Objectives

- Measure relative abundance of ragwort flea beetle adults as an index of potential pressure on ragwort populations at sites throughout New Zealand.
- Measure changes in ragwort abundance and estimate the impact of ragwort flea beetles on ragwort populations at sites throughout New Zealand.
- Assess the effectiveness of ragwort flea beetle as a biological control for ragwort in New Zealand.

Methods

To assess the abundance of ragwort flea beetles and their impact on ragwort populations, 11 sites, comprising 20 or 24 randomly placed 0.5m² plots, were set up on ragwort infestations throughout New Zealand by regional council staff. Three of those sites were maintained from autumn 1999 to June 2001, the remainder for shorter periods, with one abandoned after being set up. At each site, insecticide treatments were applied periodically to half the plots, with water sprayed on the remaining (control) plots. The frequency of sampling of beetles and plants varied among sites. Data recorded by regional council staff were forwarded to Landcare Research for analysis and interpretation.

Results

- Adult beetles were found throughout the year at most sites, suggesting that the life history is less seasonal than previously thought.
- Maximum beetle numbers varied more than 50-fold among sites. Over time within sites, beetle numbers fluctuated from 0–200 per sample at the most variable site.
- Ragwort abundance varied from 0–13.8 plants m⁻² among sites, and this range was also the maximum recorded within a site.
- Orthene® (active ingredient acephate) did not adequately protect plots from beetle attack and it was replaced with Halmark⁷ (active ingredient esfenvalerate) after August 1999.
- Two sites showed statistically significant differences in ragwort abundance between insecticide-sprayed and water-sprayed plots. Beetle numbers at four sites were too low to expect a treatment effect, and at three sites the decline in ragwort populations in both treatments was consistent with an abundant beetle population and the failure of Orthene® to suppress beetle attack.
- Despite having a ragwort flea beetle population that grew to high levels, ragwort abundance remained similar in both treatments at the Southland site. However, grazing

management at this site promotes high ragwort populations and if beetle numbers remain high, effective control is expected.

Discussion

Despite problems with the insecticide treatment and low beetle populations at several sites, the results suggest that ragwort flea beetles effectively suppress ragwort infestations. However, we believe the relationship between the beetle and its host plant to be more complex than first thought. In particular, recruitment of ragwort seedlings into swards after the beetle has removed most ragwort plants may be very low, and adult beetles may cause substantial mortality of recently germinated seedlings.

Recommendations

- If ragwort flea beetle populations are high at a site, then we recommend some form of continued monitoring of beetle and ragwort numbers.
- If the assessment is to be continued at sites where ragwort is now scarce, then swards in all plots at those sites should be disturbed to allow recruitment of ragwort seedlings.
- Consistency in applying spray treatments is vital. If regional councils are unable to maintain these treatments, Landcare Research may be able to assist; otherwise, spray treatments should be discontinued.

1. Introduction

The impact of ragwort flea beetle (*Longitarsus jacobaeae* (Coleoptera: Chrysomelidae)) on ragwort (*Senecio jacobaea* (Asteraceae)) infestations was investigated in a collaboration between Landcare Research, Wellington, Taranaki and Auckland Regional Councils, horizons.mw, Environment Bay of Plenty, and Environment Southland, from February 1999 to June 2001.

2. Background

An Italian strain of the ragwort flea beetle was imported to New Zealand from Oregon, USA, in 1981 and released in the field in 1983 as a possible biological control agent for ragwort (Syrett 1989). The beetle is now common in all regions of New Zealand and anecdotal evidence suggests that it can effectively control ragwort infestations. However, the Biosecurity Act 1993 (BSA) requires local authorities to evaluate the effectiveness of their weed control strategies¹, and this requires a scientifically defensible method. Landcare Research developed such a method to help regional councils meet their requirements (McGregor 1998). After a training workshop in January 1999, regional council plant pest officers returned to their regions to implement the method.

3. Objectives

- Measure relative abundance of ragwort flea beetle adults as an index of potential pressure on ragwort populations at sites throughout New Zealand.
 - Measure changes in ragwort abundance and estimate the impact of ragwort flea beetles on ragwort populations at sites throughout New Zealand.
 - Assess the effectiveness of ragwort flea beetle as a biological control for ragwort in New Zealand.
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4. Methods

The methods used to set up and monitor the trial were detailed by McGregor (1998) (copy of original article appended to this report). Field work was carried out by Regional Council staff with assistance in some cases from Landcare Research staff.

During winter 1999, evidence from Landcare Research trials and from several regional councils began to suggest that the recommended insecticide, Orthene⁷ (active ingredient acephate) was not adequately suppressing ragwort flea beetle attack. The reasons for this are

¹ Section V (80) of the BSA states: “(7) A regional council shall not approve a regional pest management strategy unless satisfied that the benefits for the region of implementing the strategy outweigh the costs to the region.”

not fully understood, but may be a consequence of poor translocation of Orthene⁷ during cold weather. Therefore, in August 1999 we recommended that the trial sites be resprayed as soon as possible with Halmark⁷ (active ingredient esfenvalerate), at 0.25 mL/litre. Halmark⁷ was used from the beginning of the trial at the Turakina site (Manawatu–Wanganui region) and at the Orere Farms (Auckland region) site.

Table 1 Location and date of establishment of experimental sites

Region	Site name	Grid ref. (NZMS 260)	Date established
Auckland	Alcove Properties	Q10 146247	02-Mar-99
Auckland	Orere Farms	S11 670100	17-Mar-00
Bay of Plenty	Campny's	U15 052646	11-Mar-99
Bay of Plenty	Horomanga/Isley	V17 420046	18-Mar-99
Bay of Plenty	McCann	V15 392543	23-Feb-99
Bay of Plenty	Nettlingham	T14 650925	11-Mar-99
Bay of Plenty	Sisam's	W16 568350	17-Feb-99
Taranaki	Larkin property	Q20 267924	21-Apr-99
Manawatu–Wanganui	Turakina (Scott's Road)	R23/S23 980250	14-Apr-99
Wellington	Carterton	S26 210144	26-Mar-99
Southland	Ward Road	D46 168187	24-Feb-99

Ten trial sites were set up in autumn 1999: nine in the North Island and one in Southland. A further site (Orere Farms) was set up in the Auckland region in autumn 2000 (Table 1). At Orere Farms, there were 12 replicates of each of the two treatments; at all other sites there were 10 replicates. One site in the Bay of Plenty (Campny's) was not maintained after it was established. At two of the four remaining Bay of Plenty sites and at Carterton (Wellington Region), trials were abandoned early because no ragwort plants remained at the site²; Wellington Regional Council subsequently withdrew from the programme at the end of the first year. During the second year, the plots at the single Taranaki site were destroyed by a logging operation; consequently, no data were available from that site, nor from the EBOP sites after June 2000.

Where there was any suggestion that ragwort abundance may have differed significantly between insecticide-treated and water-sprayed plots, repeated measures analysis of variance (rm_ANOVA) was carried on transformed counts of total ragwort numbers in each plot. The transformation was $x' = \sqrt{x+1}$; residual plots showed that the residuals from the analysis were approximately normally distributed, with no indication that the variance of residuals was strongly correlated with predicted means.

² However, the presence of ragwort plants is not a prerequisite for the method to work: even if no plants are present, protection of plots with insecticide should allow ragwort to establish in those plots, provided suitable germination gaps are present in the pasture.

5. Results

5.1 Ragwort flea beetle abundance

Ragwort flea beetle abundance varied substantially within and among regions and years (Fig. 1). Numbers were highest for any region in any year, at Orere Farms, Auckland, in May 2000, with over 200 beetles vacuumed from a five-plant sample. However, this population subsequently declined, so that 1 year later, in May 2001, only about eight beetles were sampled per five plants; this was also the largest difference among years for any site. However, the flea beetle population at the other Auckland site, Alcove Farms was among the lowest from any region during 1999, and although it appeared to increase during 2000, it declined to its lowest level in January 2001. This great variation in beetle abundance within a region was confirmed in the Bay of Plenty, where populations at different sites during autumn and winter 1999 varied by an order of magnitude or more (Fig 1b).

The consistently smallest population was at the Taranaki site, where numbers peaked at 3.67 ± 0.76 (mean \pm standard error), although only 1 year's data were available for this site. Maximum beetle numbers were slightly lower at the Nettlingham (Bay of Plenty site) but this was only sampled four times, over 4 months.

Seasonal patterns of abundance were seldom clear, partly because the pattern of sampling was irregular at many sites. However, at some sites, notably McCann (BOP), Manawatu–Wanganui, and Alcove Properties (Auckland) the pattern of beetle abundance gave little or no indication of following the generally accepted life history as described by Syrett (1986; 1996); thus, with few exceptions, adult beetles were present throughout the year (Fig. 1). Conversely, the Southland site appeared strongly seasonal, although the site was not sampled in late winter and spring, and inspection of the site in late August 2001 showed that adult beetles were abundant (P. Ayson, Environment Southland, pers. comm.).

5.2 Ragwort abundance and treatment effects

The highest ragwort population recorded from any site in any year was from Sisam's, BOP, where insecticide-treated plots at setup had a mean of 6.9 ± 3.84 plants per 0.5 m^2 plot (mean \pm standard error of mean), equivalent to almost 14 plants per square metre. Generally, however, populations at other sites were much lower, with the lowest peak of abundance being at the Manawatu–Wanganui site (0.8 ± 0.25 plants per 0.5 m^2 (Fig. 2)).

The most spatially variable population was the Manawatu–Wanganui site, where the coefficient of variation for insecticide-sprayed plots was 241% on 12 September 2000 and 20 November 2000. Variation over time is difficult to assess as sites were sampled for different periods and with differing frequencies. The usual method of estimating temporal variation, namely, as the standard deviation of the logarithm of successive mean populations, is not possible for these data as some means were zero; in any case, this is strongly biased when spatial variance is large and sample size small, as for these data (Stewart-Oaten et al. 1995). The Sisam's (BOP) site had the greatest range (maximum minus minimum) of plant densities, but this was true only for the insecticide-treated plots (but this treatment was ineffective). Temporal variation was also large at Auckland's Alcove Properties site in water-sprayed

plots, but variation over time in insecticide-sprayed plots appeared much less at that site (Fig. 2a). Both treatments at the Southland site declined substantially during the 1999 winter, but recovered subsequently (Fig. 2b). The only other site that was sampled for 2 years or more was Manawatu–Wanganui; no ragwort was recorded from water-sprayed plots, and variability in the Halmark⁷-treated plots was low.

At the Horomanga/Isley (BOP), Wellington and Southland sites, ragwort populations declined markedly in both treatments following the initial setup. Only two sites had statistically significant differences in ragwort populations between insecticide-treated vs water-sprayed plots; these were Orere Farms (Auckland) ($p < 0.01$), and the Manawatu–Wanganui site ($p < 0.05$). At the Alcove Properties (Auckland) site, the ragwort population in the water-sprayed plots declined sharply from late November 1999, eventually disappearing completely by mid-August 2000; during that period, the ragwort population in the insecticide-treated plots remained approximately constant. However, in mid-November 2000, ragwort began to reappear in water-sprayed plots, and in February 2001 the ragwort population in those plots eventually reached the highest level recorded in either treatment at that site throughout the trial (Fig. 2a).

Ragwort populations at the Southland site remained similar in both treatments throughout the trial, despite substantial fluctuations over time (Fig. 2b). At no stage was there any indication of treatment effects for the Bay of Plenty, Wellington, and Taranaki sites, but Halmark® was either not used or had little time to cause an effect, and none of these sites were maintained for more than 13 months.

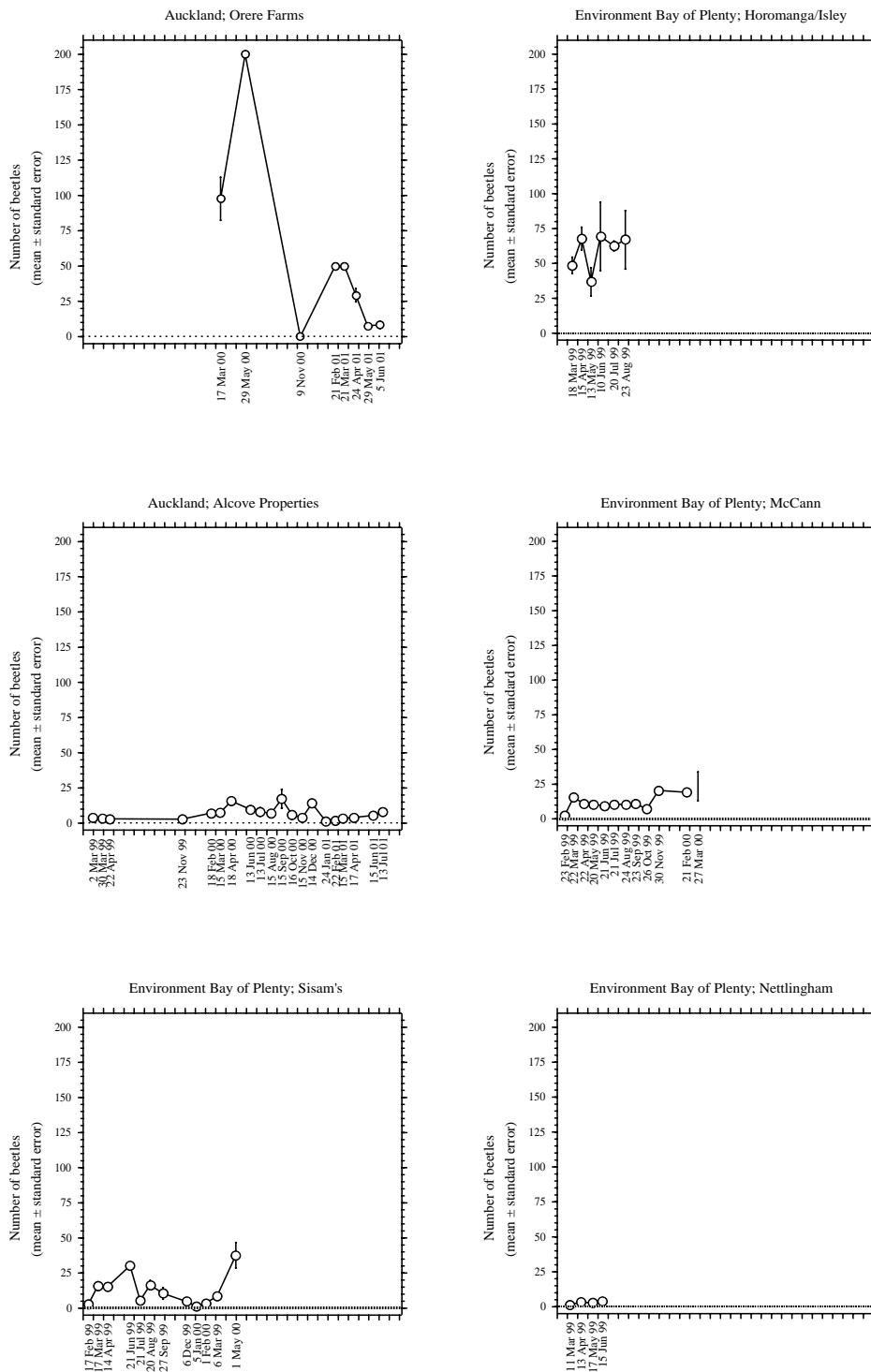


Fig. 1a Ragwort flea beetle abundance at the Auckland and Bay of Plenty sites. Data for McCann in March 2000 are range (data per 5-plant sample not recorded).

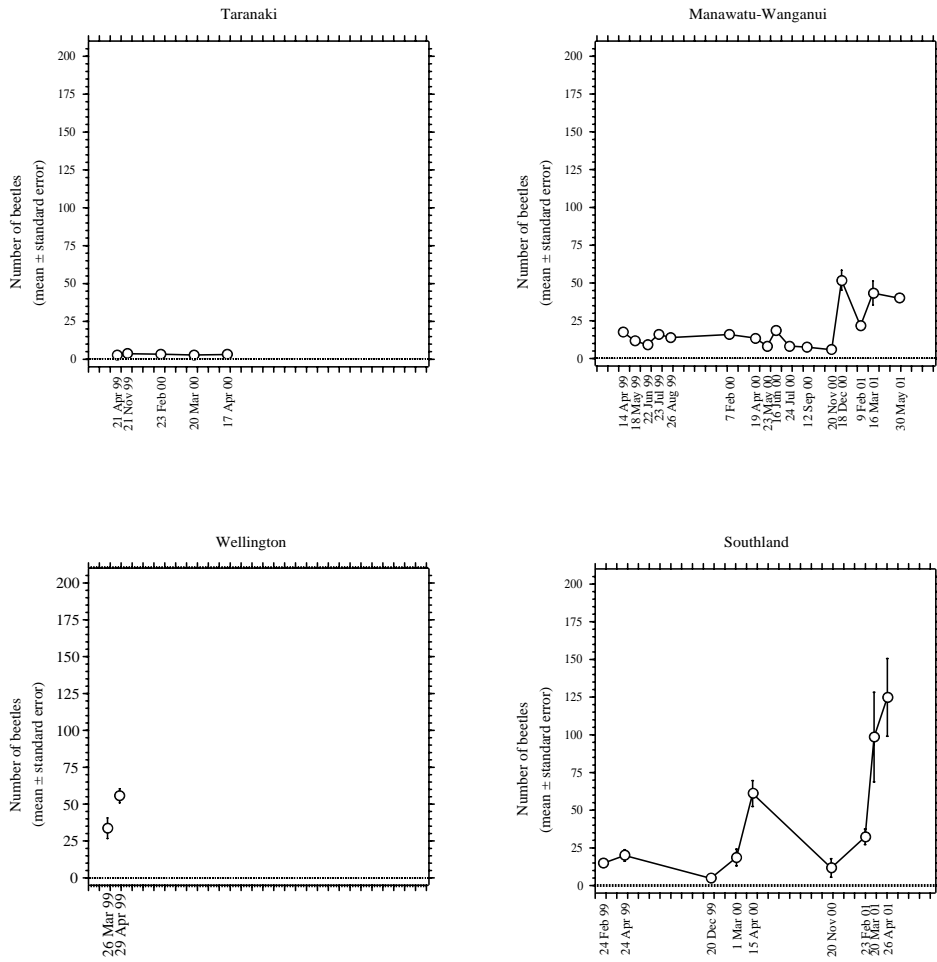


Fig. 1b Ragwort flea beetle abundance at the Taranaki, Manawatu–Wanganui, Wellington and Southland sites.

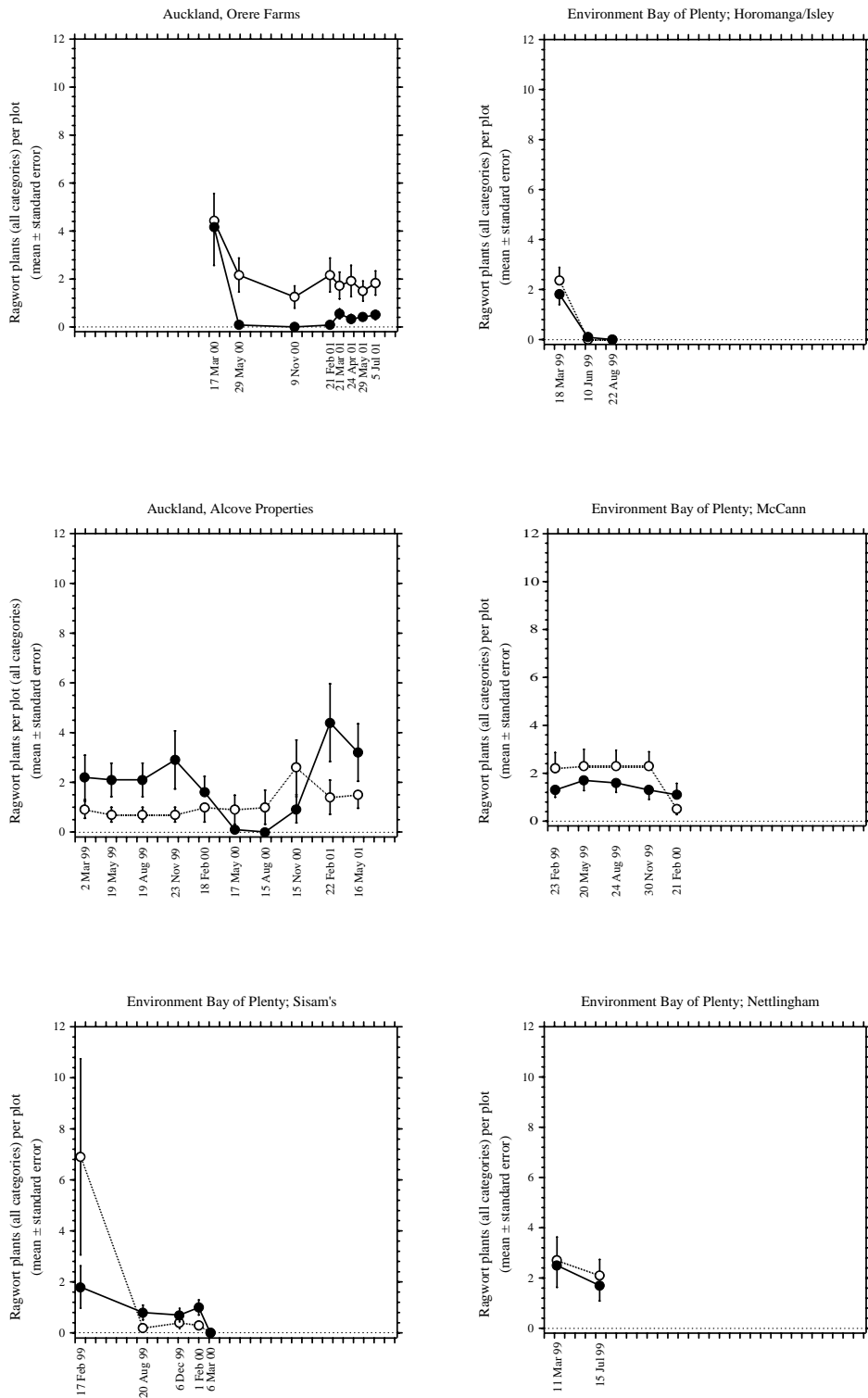


Fig. 2a Ragwort abundance at the Auckland and Bay of Plenty sites. Overlapping error bars not shown. Open symbols = insecticide; closed symbols = water.

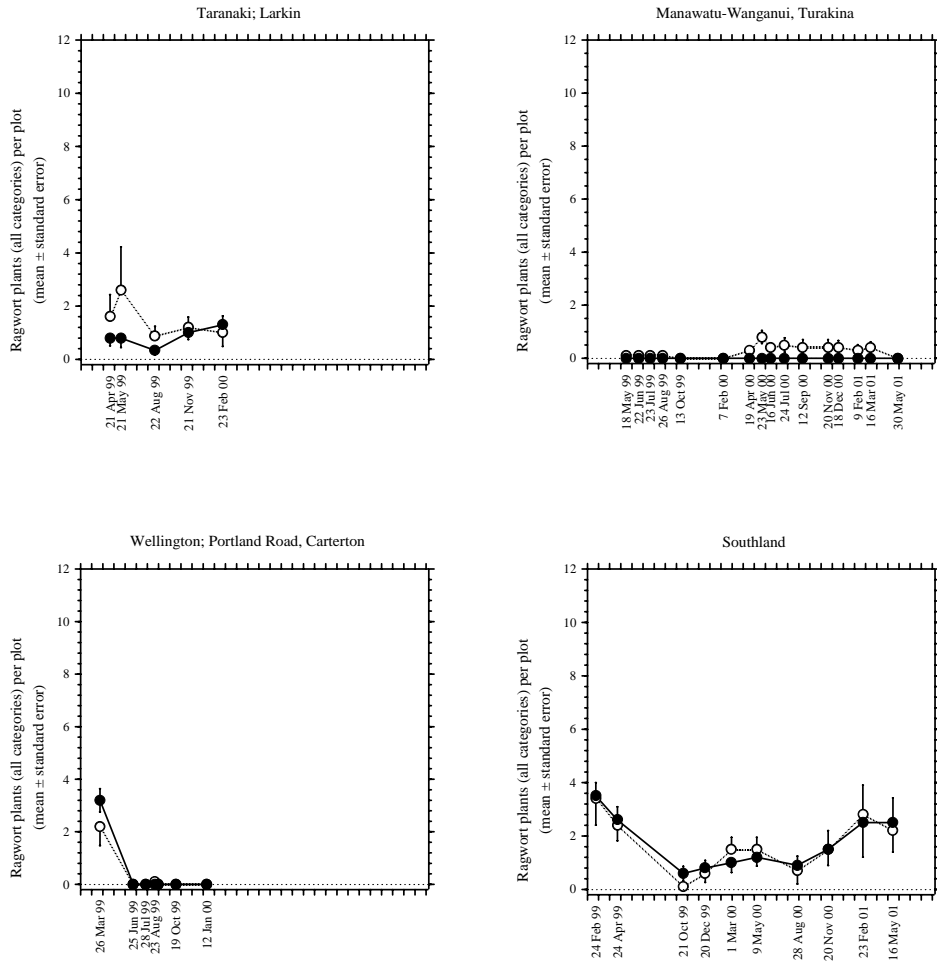


Fig. 2b Ragwort abundance at the Taranaki, Manawatu–Wanganui, Wellington and Southland sites. Overlapping error bars not shown. Open symbols = insecticide; closed symbols = water.

6. Discussion

Ragwort flea beetle abundance was measured per 5-plant sample rather than per unit area of land; therefore, it reflects the “pressure” on the ragwort population. For this report, this is the most relevant measure of beetle abundance. However, it does not necessarily indicate the true number of beetles present in an area: a large number of beetles per sample may be the result of a low number of ragwort plants in a given area. Thus, if beetles kill a large proportion of the ragwort population, then beetle abundance will appear to increase even if the true population is unchanged. This may account for some of the substantial variability in beetle abundance, but it is nevertheless clear that populations fluctuate greatly over time and that there can be huge differences between sites; for example, in autumn 2000, the two Auckland sites had beetle populations that differed by an order of magnitude, yet those sites had comparable ragwort populations.

The marked decline in ragwort populations at the Sisam’s (BOP), Horomanga/Isley (BOP) and Wellington sites soon after setup was probably caused by ragwort flea beetle, with the coincident decline in control and insecticide-sprayed plots presumably because Orthene® treatments did not protect plants from ragwort flea beetle attack. Throughout the study, the strongest evidence that ragwort flea beetle reduces ragwort infestations comes from the Orere Farms, Auckland site and the Manawatu–Wanganui site. At both these sites, Halmark® was used whenever plots were sprayed. Of the remaining sites, all but Southland had low beetle numbers, so that an impact on the ragwort population would not be expected; moreover, some plots at the Alcove properties (Auckland) site were infested with kikuyu grass, which would have out-competed ragwort plants and prevented recruitment of ragwort seedlings. A reanalysis of data from this site, with the kikuyu-infested plots excluded, confirmed the conclusion that the effect of beetles was not detectable. While this was largely because inter-plot variation in ragwort numbers was very high, particularly given that as many as 7 Halmark®-sprayed plots and 6 water-sprayed plots were excluded from the analysis, it is likely that the widely fluctuating beetle population and the patchy suppression of the ragwort population by kikuyu grass substantially reduced the beetle’s effectiveness as a biological control for ragwort at that site.

Although results from the Southland site indicate that 2 years of high beetle numbers had no apparent effect on the ragwort population, the prognosis is still promising. At that site, an initial decline in an abundant ragwort population in both treatments is consistent with ragwort flea beetle attack and the failure of the Orthene® treatment, while the subsequent recovery of the ragwort population in both treatments after the replacement of Orthene® with Halmark® is likely to be a consequence of the particular grazing management at that site. There, for the last two winters, the paddock has been grazed hard, with severe pugging that has damaged the pasture, creating an ideal environment for ragwort recruitment (P. Ayson, Environment Southland, pers. comm.).

Our strong impression is that the relationship between ragwort flea beetles and ragwort populations is considerably more complex than first thought. In particular, we speculate that after flea beetles have substantially reduced the ragwort population, the subsequent strengthening of the sward and perhaps consequent changes in grazing and other pasture

management make it difficult for ragwort to reestablish in the pasture. There is also some question about the effects of adult beetles on recently germinated ragwort seedlings; adult feeding is usually thought to be unimportant, but high beetle populations may indeed be a significant cause of mortality for those seedlings. Small plants may also be quickly killed by flea beetle larvae, and as these seedlings can be difficult to see in pasture, this may explain why ragwort populations have reportedly decreased dramatically in some areas after flea beetle populations have established – witness the apparent spectacular disappearance of ragwort from much of the South Auckland area (M. White, Auckland Regional Council, pers. comm.).

Some regions had difficulty maintaining experimental plots and spray treatments. If, in future, this method of assessing the impact of ragwort flea beetle is used, then it is critical that regular, effective spraying is carried out. Landcare Research could undertake this, so that the regional council's involvement would be largely limited to identifying suitable trial sites and liaising with the appropriate land owners/managers. This would be more expensive than using council staff, particularly where significant travel is required, but would give the best likelihood of an unequivocal result. Alternatively, a reliable contract worker could be trained to measure plots and apply treatments if council staff are otherwise committed.

7. Recommendations

- Where ragwort flea beetle populations are high (as indicated by regular vacuum sampling), some form of continued maintenance and data recording from the site should be considered, to relate beetle numbers to ragwort abundance. We recommend that those sites be monitored several times a year to record beetle numbers, using the standard vacuuming method, and ragwort populations, using either the existing, randomly positioned plots or some other random sampling method.
- If regional councils wish to continue with this assessment at sites where ragwort is now scarce, we recommend all plots be sprayed with a grass-specific herbicide (e.g., Galant®) to weaken the sward and thereby encourage ragwort recruitment into those plots. This spraying should be carried out in spring and/or late summer when beetle numbers would be expected to be low; this timing would also weaken the sward just before or during peak periods of expected ragwort germination.
- If spray treatments are continued, they must be applied regularly and effectively. If council staff are unavailable, then Landcare Research may be able to assist, either by maintaining the treatments or by training an appropriate person to do this. If regular spray treatments cannot be maintained, it is probably best to discontinue them, as treatments that do not adequately protect plots from flea beetle attack make interpretation of the results difficult.

8. Acknowledgements

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