Clover root weevil biocontrol distribution in the North Island – release tactics and outcomes

P.J. GERARD, D.J. WILSON and T.M. EDEN
AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton
pip.gerard@agresearch.co.nz

Abstract

Clover root weevil (CRW) has become one of New Zealand's most serious pasture pests. An Irish ecotype of *Microctonus aethiopoides* has been released and established as a biocontrol agent. Since early 2006, field samples have been taken to monitor its spread and establishment. The biocontrol agent has established well at sites where 1 000-2 500 parasitised CRW were initially released, except in the Far North, and is spreading at around 15 km/year. Industry field personnel assisted with distributing 2 000 mini-releases (10 parasitised CRW) to areas where CRW was causing damage. One hundred farmers were sent a postal survey and feedback from 59 respondents showed the mini-release approach was successful in terms of distribution of the parasitoid, technology transfer and funder recognition. Based on natural spread from many of the release sites, it is predicted that the parasitoid will be present on most North Island farms by the end of summer 2010/2011.

Keywords: *Microctonus aethiopoides,* biocontrol agent, white clover, *Trifolium repens*

Introduction

Clover root weevil (CRW) *Sitona lepidus* was first detected in New Zealand in 1996. With no specific natural enemies, extensive highly favourable pastures, and little competition from other insects that use clover root nodules as a resource, CRW quickly became one of New Zealand's worst white clover pests (Eerens *et al.* 2005). It spread rapidly throughout the North Island by 2005 and is now established and spreading in Nelson, Marlborough, Canterbury, Otago and Southland in the South Island (see Phillips *et al*. 2010, this volume). Large losses in pasture production became evident concurrently with the detection on CRW (Eerens *et al.* 1998) and with little known about the pest; the pastoral industry looked to AgResearch for solutions.

Initially, AgResearch entomologists considered the possibility that biocontrol agents previously introduced for other weevil pests could provide some useful suppression of CRW populations. A Moroccan strain of *Microctonus aethiopoides*, released in 1982, successfully suppresses lucerne weevil, *Sitona discoideus* (Goldson *et al.* 1993) and *Microctonus hyperodae*, released in 1991 (Goldson *et al.* 1999), is effective against Argentine stem weevil (ASW) (*Listronotus bonariensis*). However, laboratory testing showed that these parasitoids were unlikely to provide control of CRW (Barratt *et al.* 1997).

After consultation with pastoral industry representatives and overseas scientists with experience of CRW, a comprehensive research programme to combat CRW was initiated in 1997. One of the objectives of the programme was to find a suitable biocontrol agent that, when established, would provide farmers with an effective and environmentally safe control without greatly changing existing on-farm management systems. This was partially achieved with the discovery, introduction and release of an Irish strain of *M. aethiopoides* that is effective against CRW (Gerard *et al.* 2006). This parasitoid was released in early 2006 at four sites in the North Island; a high altitude sheep farm in inland Hawke's Bay, a lowland Waikato dairy farm and two sites in Manawatu. At each of the Waikato and Hawke's Bay sites, 5 000 parasitised CRW adults were released, and at each of the Manawatu sites, 2500 parasitised CRW adults were released. Establishment occurred at all sites and the populations successfully persisted through the winter (Gerard *et al.* 2007). The remaining part of the objective was to spread the parasitoid as widely and rapidly as possible to areas where CRW was causing damage (Gerard *et al.* 2008). This paper reviews the strategy and tactics adopted and the outcomes to date in the North Island.

Methods

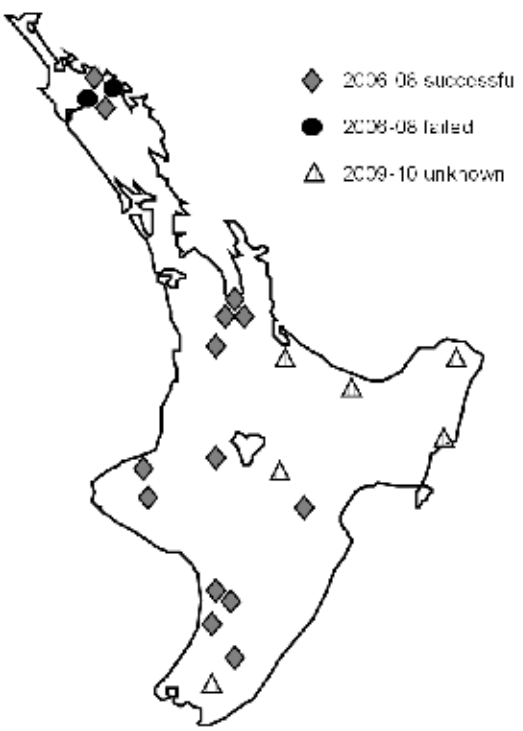
In addition to the four original releases of Irish *M. aethiopoides*, medium and mini-releases were made. Both used parasitoids mass reared in the laboratory. To obtain these, CRW adults were field collected and exposed to the parasitoid at a rate of two adults/100 weevils for up to 6 days. Parasitism levels of weevils achieved were typically 40-80% (P.J. Gerard *et al.* unpubl. data). The medium releases consisted of 1 000-2 500 "parasitised weevils" and the mini-releases batches of 10 "parasitised weevils". At 40% parasitism, the statistical likelihood that a mini-release would not contain a parasitoid is one in 165.

Medium releases (nursery sites)

Medium sized releases were used to establish nursery sites. These are locations where natural enemies are released to reproduce within an existing pest infestation and later collected for subsequent distribution to other areas (Van Driesche 1993), thereby reducing the need for and reliance on a large mass-rearing programme. Two regional councils (Taranaki and Northland) participated in this scheme in summer 2006/07 establishing sites at Stratford and Lepperton, and Okaihau and Pakaraka, respectively. In 2007/08, Landcorp Ltd established sites at Kerikeri, Te Kuiti and Moutoa, and in 2008, AgResearch established sites at Ruakura and Morrinsville (Gerard *et al*. 2008). The nursery sites were established at localities where topography and land use also favoured natural dispersal. Further medium-sized releases were made at nine other localities in summers 2007/2008 - 2009/2010, including Taupo Bay in Northland (Fig. 1).

CRW and parasitoid populations have been monitored monthly at the four original release sites using suction sampling methods described in Gerard *et al.* (2007) and overwintering parasitism levels assessed at the medium release sites when practicable. Parasitoid dispersal from release sites in Waikato, Hawke's Bay, Taranaki and Manawatu was assessed in winter 2008 and 2009 by following roads down likely dispersal routes (e.g. downwind) and suction sampling CRW populations in pastures with good (>20%) clover. In all cases GPS coordinates were recorded and the presence of *M. aethiopoides* larvae and levels of parasitism were determined by dissecting CRW under a microscope.

Figure 1 Locations of 2006-2008 successful and failed medium-sized Irish *M. aethiopoides* mass releases and subsequent 2009-2010 releases where establishment had yet to be ascertained by May 2010.



Mini-releases (farmer giveaways)

The mini-release strategy was designed to distribute the biocontrol agent to farmers most impacted by CRW as rapidly as possible. Releases of small numbers of Irish *M. aethiopoides* are feasible because the ecotype is parthenogenetic and a single female can therefore potentially found new populations. The mini-releases consisted of 10 CRW adults that had been exposed to parasitoids and subsequently housed in vented 70 ml specimen vials for distribution. Distribution was gratis and primarily through field days, DairyNZ and Meat & Wool NZ field and technical networks. Field staff from Ballance Agri-Nutrients and Ravensdown undertook distributions in the Gisborne region. All mini-release packages were prepared at AgResearch, Ruakura. Vials containing weevils were packed in polystyrene containers along with icepacks and couriered overnight to the distributors. The vials, along with instructions for release and an information sheet on the CRW problem and the parasitoid, were then delivered personally to farmers. Usually only one vial was provided per farm but multiple vials were given to runholders with extensive properties. Records were kept of the farms where the parasitised weevils were released so districts with low coverage could be targeted for later releases.

Farmer survey

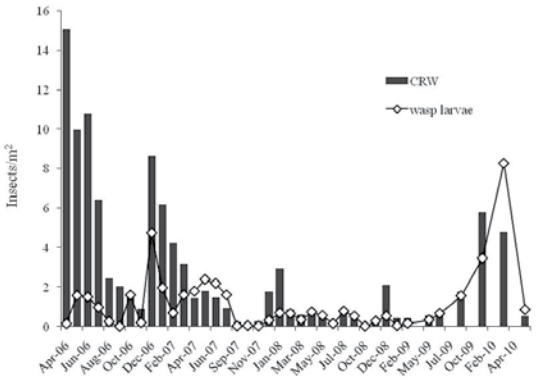
A postal survey of dairy farmers who received mini-releases was undertaken in spring 2009 to determine farmers' impressions of the mini-release strategy, their awareness of the CRW biocontrol programme, and to provide an indication of how successful the mini-release strategy was for getting the biocontrol agent released. Insufficient contact details were available to carry out a random survey of all recipients so those surveyed consisted of the first 100 farmers who had received samples through DairyNZ and for whom a full postal address could be readily obtained. The survey was constructed so that farmers could rate their response from 1-5 when answering the following questions:

1. Has clover root weevil been a problem on your property in the past?
2. Were the parasitised weevils alive when you received your sample vial?
3. Were you aware of the weevil biocontrol project

before you got the Irish *M. aethiopoides* sample?
4. How soon did you release the sample?
5. Were the instructions for release of the parasitised weevils clear?
6. Did the information pamphlets increase your knowledge of clover root weevil?
7. Were you aware that DairyNZ funded the research for clover root weevil biocontrol?

Results

Figure 2 Populations of CRW adults and Irish *M. aethiopoides* larvae at the Hawke's Bay experimental release site following release in 2006. Note: there are multiple larvae /CRW host.



Medium releases

Fig. 1 shows the 22 localities where medium releases were made from 2006 to 2010 and includes the original experimental release sites at Patoka, Hawke's Bay, Springdale Waikato, and Bulls and Feilding in Manawatu. This underestimates the number of release sites as at some of the 22 localities, releases were split between neighbouring farms (e.g. Te Araroa on the East Cape). Of the 15 releases of the biocontrol agent before 2009 only two appear unsuccessful, with no parasitism detected at two of the four sites in the Far North to date. However, 73-75% parasitism was found at the other two Far North sites in late May/early June 2010. The parasitoid has yet to be sampled at the 2009/2010 release sites.

While establishment and multiplication of Irish *M. aethiopoides* has generally been rapid, the widespread North Island drought in summer and early autumn 2008 severely checked clover growth. Consequently, CRW populations were affected and collection and redistribution of this biocontrol agent was limited to just two Taranaki re-releases in 2008. However, the parasitoid persisted well and high levels of parasitism (70-90%) were found in winter 2009 sites where monitored. The original Hawke's Bay release site in the inland hill country at Patoka was not affected by the 2008 drought and the CRW and parasitoid populations there are shown in Fig. 2. At this site CRW adult numbers declined over 3 successive years following the introduction of the biocontrol agent. In early 2010 the CRW population showed an increase in density following low parasitoid density in 2009, but the parasitoid responded immediately increasing to record levels. The result of CRW suppression was that pasture clover content from 2007 onward exceeded 25% of DM year round and was over 40% in spring 2009 (M.W. Slay pers. comm.).

The 2008 drought appeared to have only a minor impact on dispersal. Similar levels of parasitism to that at Patoka were found on farms up to 15 km from release sites in Hawke's Bay, Taranaki and Waikato in winter 2009 and around 30% parasitism was found in NW Waikato in May 2010, over 50 km from the closest release site. This experience and data from the Hawke's Bay and the Manawatu sites demonstrated that this biocontrol agent can disperse naturally at over 15 km/year from sites where it is well established (P.J. Gerard unpubl. data).

Mini-releases

Table 1 shows the distribution of mini-releases within Regional Council boundaries. In 2007, farmers received mini-release vials at field days at Dargaville, Port Waikato, and Hamilton. In 2008, 2009 and 2010 almost all mini-releases were carried out through pastoral industry networks, in particular DairyNZ Consulting Officers and fertiliser company field representatives.

As a consequence of the 2008 drought over much of the North Island, more than 30% of the mini-releases in 2008 went to Northland farmers, even though this region had over 150 mini-releases in 2007 and medium releases at several nursery sites. In 2009 and 2010 mini-release vials were distributed to districts identified as having poor coverage in previous years. Parasitised

Table 1 Regional distribution of mini-release vials of parasitised CRW in 2007-2010 based on North Island regional council boundaries.

Regions	2007	2008	2009	2010	Total
Northland	157	167	20		344
Auckland	35	46	90		171
Waikato	46	73	228		347
Bay of Plenty	1	17	145		163
Gisborne	1	0	471	25	497
Hawke's Bay	1	12	51	60	124
Taranaki	1	58	1		60
Manawatu-Wanganui	4	140	149		293
Wellington	1	29	44		74
Total	247	542	1199	85	2073

weevils have been found on mini-release sites in the western Waikato in May 2010, but it is not possible to determine if they resulted from the mini-release or natural dispersal from larger releases in the region.

Farmer survey

Fifty-nine of 100 questionnaires posted were returned completed. Feedback indicated that the mini-releases were well received, and showed 81% went to farmers who rated CRW from "sometimes to very often" causing a problem on their farms. The mini-releases were effective in terms of distributing the biocontrol agent to farms with 89% of insects arriving in excellent condition and 95% being released on the same day. Farmers with a CRW problem were much more likely to be aware of the CRW biocontrol programme ($P<0.01$) than those reporting no trouble, and these affected farmers in turn were much more likely to be aware that DairyNZ had helped fund the research ($P<0.05$). The farmers appeared receptive to the information provided, with 58% "learning a lot" and a further 31% "learning a bit". Full survey results were presented as a poster paper at 2010 New Zealand Plant Protection Conference (Gerard *et al.* 2010)

Discussion

The release and establishment of Irish *M. aethiopoides* against CRW can be compared to that of *M. hyperodae* introduced against ASW, the only other pasture pest biocontrol agent to be monitored after release. Over 480 000 parasitised ASW were released in the North Island between 1993 and 1998 with widespread distribution achieved through most regions by the end of 2002 (McNeill *et al.* 2002). The two *Microctonus* species are of similar size, have similar biology and development, and both disperse via flights of parasitised hosts. Some distribution by both, although to a lesser extent, is achieved by parasitoid adult flight, which may be assisted by wind. Unlike ASW (Pottinger 1966), CRW is a strong flyer and this has enabled this parasitoid to spread over 15 km/year compared to 2-11 km/year observed for *M. hyperodae* (Goldson *et al*. 1999; McNeill *et al.* 2002; Phillips *et al*. 2004). Several parasitoids can develop from a single host (Gerard *et al.* 2007) as opposed to one for *M. hyperodae,* and like *M. hyperodae*, Irish *M. aethiopoides* reproduces parthenogenetically. These factors produce a faster population increase than *M. hyperodae* and have probably contributed to this biocontrol agents apparent greater success. Therefore, while only round 40 000 parasitised CRW were released in the North Island, similar coverage and parasitism to *M. hyperodae* has been achieved. Given the rapid establishment, multiplication and dispersal of the Irish *M. aethiopoides* from the initial and medium release sites and the addition of over 2 000 mini-releases, further releases of the parasitoid in the North Island are not necessary. Similarly, while the parasitoid has been collected from regional council nursery sites and is known to have successfully re-established at new sites in Taranaki, the requirement for collection/re-distribution activity from nursery sites has also lessened. This includes in Northland where early results were disappointing (Gerard *et al.* 2008), but good parasitism levels have been achieved at two of the four sites in spite of the severe 2009/2010 summer drought in this region (NIWA 2010).

The mini-release project was a high profile shotgun approach delivering low numbers of parasitoids throughout the North Island within a narrow timeframe. The farmer support for dispersing the biocontrol agent in this way is evident by the results presented. While research is still in progress to determine the success of establishing the biocontrol agent in this manner, even if only a small percentage of releases established, it can be considered worthwhile. It involved significant interaction between industry and researchers, fostered farmer-science linkages and provided a means to transfer knowledge. It is rare that a scientist can place directly in a farmer's hand a tangible research-driven solution to a difficult problem.

Given the number of parasitoid releases, its rate of spread and favorable weather, the Irish *M. aethiopoides* should be widespread throughout North Island farmlands after summer 2010/11. However, there will be districts where establishment will be slow. For instance, after three successive drought years and associated detrimental effects on clover, neither CRW nor its biocontrol agent were present on lowland Hawke's Bay farms sampled in 2009. Also, in some districts and/or some years climatic factors may disrupt the availability of CRW (e.g. a very wet winter or summer drought) and the biocontrol agent may not reach sufficient levels by autumn to reduce CRW larval numbers to below damaging levels. Similarly, on a smaller scale, pasture management may have localised effects, for example, overgrazing in winter has been connected with a lack of available hosts for parasitoids emerging in September (Gerard *et al.* 2007). It is highly probable that pasture clover content is an important driver in determining the proportion and age composition of overwintering CRW adult populations surviving until this spring "bottleneck" in host availability. Therefore clover-friendly pasture management practices are likely to reinforce the stability and efficacy of the biocontrol system.

ACKNOWLEDGEMENTS

The authors thank the many DairyNZ consulting officers, Meat & Wool NZ regional managers and Ravensdown and Ballance Agri-Nutrients field staff, who took part in the mini-release scheme and assisted with the medium releases. We also thank Gabriela Burch (AgResearch) who co-ordinated the packaging and distribution of samples, the Waikato Bachelor of Science (Technology) summer students for assisting in the mass rearing of the parasitoid and all the participating farmers for access to their farms and survey responses. The CRW biocontrol programme has had long-term support from DairyNZ, Meat & Wool NZ, and FRST. The medium release sites were supported by the Northland and Taranaki Regional Councils and Landcorp Ltd and in 2008/2009 the mini-release project was supported by an AGMARDT Innovation Grant.

REFERENCES

Barratt, B.I.P.; Evans, A.A.; Ferguson, C.M. 1997. Potential for control of *Sitona lepidus* Gyllenhal by *Microctonus* spp. . *New Zealand Plant Protection 50*: 37-40.

Eerens, J.P.J.; Willoughby, B.E; Kettlewell, F.; Hardwick, S.; Bay, S. 1998: The clover root weevil in northern pastures: on-farm observations of its impact on white clover. *Proceedings of the New Zealand Grassland Association 60*: 287-290.

Eerens, J.P.J.; Hardwick, S.; Gerard, P.J.; Willoughby, B.E. 2005. Clover root weevil (*Sitona lepidus*) in New Zealand: the story so far. *Proceedings of the New Zealand Grassland Association 67*: 19-22.

Gerard, P.J.; Eden, T.M.; Hardwick, S.; Mercer, C.F.; Slay, M.W.; Wilson, D.J. 2007. Initial establishment of the Irish strain of *Microctonus aethiopoides* in New Zealand. *New Zealand Plant Protection 60*: 203-208.

Gerard, P.J.; Eden, T.M.; Wilson, D.J.; Burch, G. 2008. Distribution of the clover root weevil biocontrol agent in the North Island of New Zealand. *New Zealand Plant Protection 61*: 24-30.

Gerard, P.J.; McNeill, M.R.; Barratt, B.I.P.; Whiteman, S.A. 2006. Rationale for release of the Irish strain of *Microctonus aethiopoides* for biocontrol of clover root weevil. *New Zealand Plant Protection 59*: 285-289.

Gerard, P.J.; Wilson, D.J.; Eden, T.M. 2010. Farmer response to mini-release strategy for the clover root weevil biocontrol agent. Poster abstract, *New Zealand Plant Protection 63*: 238.

Goldson, S.L.; Proffitt, J.R.; Muscroft-Taylor, K.E. 1993. The economic value of acheiving biological control of *Sitona discoideus*. pp. 45-60. *In*: Plant Protection: Costs, Benefits and Trade Implications. Eds. Suckling, D.M.; Popay, A.J. New Zealand Plant Protection Society, Christchurch, NZ.

Goldson, S.L.; Proffitt, J.R.; McNeill, M.R.; Baird, D.B. 1999. Linear patterns of dispersal and build up of the introduced parasitoid *Microctonus hyperodae* (Hymenoptera: Braconidae) in Canterbury, New Zealand. *Bulletin of Entomological Research 89*: 347-353.

McNeill, M.R.; Addison, P.J.; Proffitt, J.R.; Phillips, C.B.; Goldson, S.L. 2002. *Microctonus hyperodae* : a summary of releases and distribution in New Zealand pasture. *New Zealand Plant Protection 55*: 272-279.

NIWA 2010. Summer 2009-2010 Climate Summary. http://www.niwa.co.nz/__data/assets/pdf_file/0003/102648/Climate_summary_summer0910_FINAL.pdf. (Accessed May 2010).

Phillips, C.B.; Iline, I.I.; Slay, M.W.A.; McNeill, M.R.; Cane, R.P. 2004. Distribution and biotypic composition of the Argentine stem weevil parasitoid in Hawke's Bay. *New Zealand Plant Protection 57*: 298-303.

Phillips, C.B.; McNeill, M.R.; Hardwick, S.; Ferguson, C.M.; Kean, J.M. 2010. South Island distributions of clover root weevil and its biocontrol agent. *Proceedings of the New Zealand Grassland Association 72*: 227-232.

Pottinger, R.P. 1966. Observations on the flight activity of stem weevil *Hyperodes bonariensis* Kuschel in Canterbury, New Zealand. *Proceedings of the 19th New Zealand Weed and Pest Conference*: 186-196.

Van Driesche R.G. 1993. Methods for the field colonization of new biological control agents. pp. 67-86. *In*: Steps in Classical Arthropod Biological Control. Eds. Van Driesche, R.G.; Bellows, T.S.J. Thomas Say Publications in Entomology, Lanham, MD, USA.