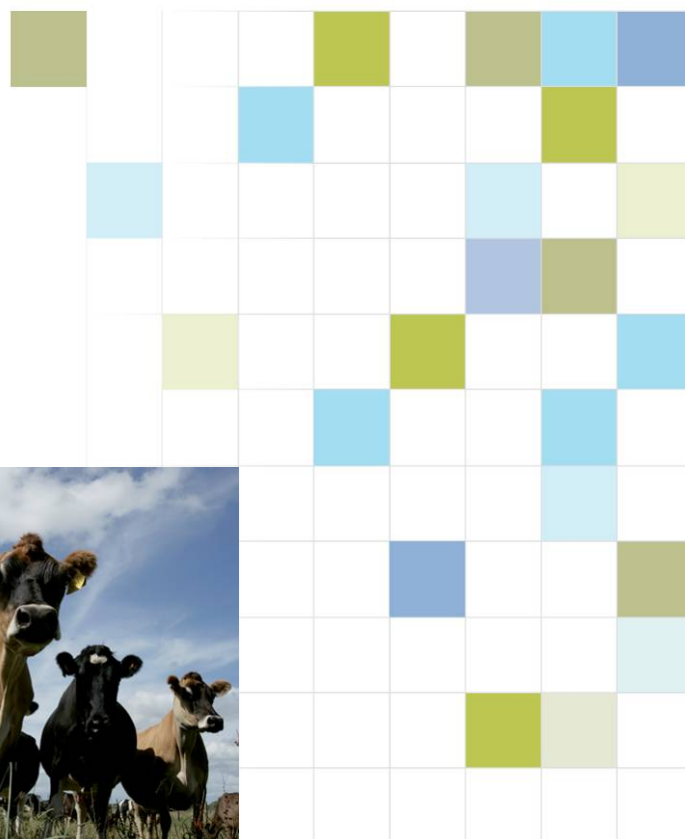


UPDATE ON THE ESTABLISHMENT AND DISTRIBUTION OF THE CLOVER ROOT WEEVIL BIOCONTROL AGENT IN THE NORTH ISLAND

May 2008



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SUMMARY

The Irish wasp *Microctonus aethiopoidea* was released in 2006 as a biocontrol agent for the clover root weevil *Sitona lepidus*, a serious pest of white clover in New Zealand. Following successful establishment, two strategies were implemented to accelerate the widespread establishment of the Irish wasp throughout the North Island.

One approach was the establishment of regional nursery sites that act as point sources for natural and assisted dispersal. With the assistance of Regional Councils and major landowners, these have been set up at sites favourable to the wasp, and local people have been provided the training and support to undertake collections and distribution of parasitized weevils. There have been two setbacks in this approach.

- The drought in early 2008 hit pastures, and therefore weevil populations hard. Only the Stratford site had sufficient weevils for collection which were released at two farms in south Taranaki.
- The wasp has failed to establish in the Far North for two years in succession. Investigations into causative factors have been initiated

The more high profile project was the giveaway promotion undertaken in 2007/08 where almost 800 samples of parasitized weevils were distributed for release directly to farmers through pastoral industry networks and events.

In spite of the setbacks, field results suggest that at localities where the host adults are present year round, the wasp will be able to reduce the abundance of damaging winter larvae. The Irish wasp has attributes known to be positively associated with successful control, namely:

- A much shorter generation time than the host;
- Almost continual availability of weevils
- Ability of more than one parasitoid to develop within a weevil.
- No critical mass associated with finding a mate.

With the clover root weevil adults having virtually no refuge, a high level of attack can be expected.

EXPERIMENTAL RELEASE SITES

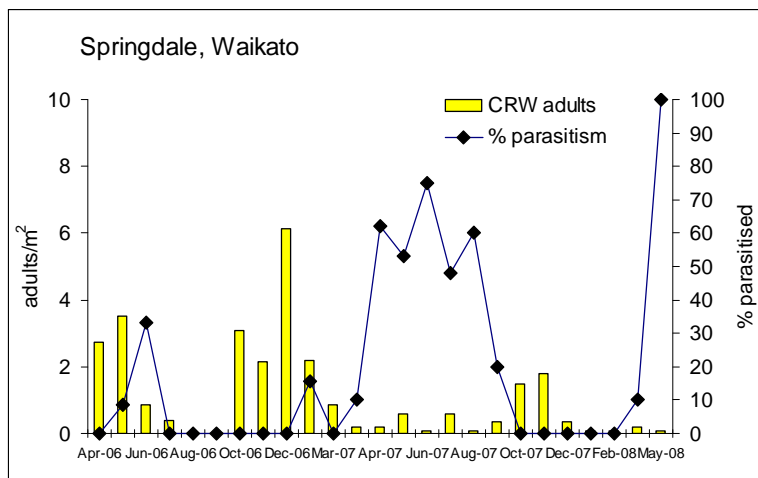
The clover root weevil (CRW) (*Sitona lepidus*) has become one of New Zealand's worst white clover pests (Eerens et al. 2005). A biological control programme was initiated in 1998 and following ERMA approval in November 2005, the Irish strain of *Microctonus aethiopoides* (Irish wasp) was released in early 2006 at experimental sites in the Waikato, Hawke's Bay and Manawatu (two sites). This parasitoid attacks adult weevils, rendering females sterile almost immediately and killing the host when the wasp larva emerges to pupate.

Fig. 1 shows the pattern of weevil adult abundance and parasitism levels at the four experimental release sites. The sites vary in management and climate from the intensively grazed Waikato lowland dairy pasture at the Springdale site in to the higher altitude sheep and beef pasture at Patoka, Hawke's Bay. By early winter 2006, establishment was confirmed with parasitism levels in the target host exceeding 10% at all sites. In spite of low weevil densities or an absence of weevils in mid-spring at all sites, the wasp persisted well peaking between 69-88% parasitism during the second winter in 2007. The North Island drought in early 2008 has significantly reduced weevil numbers at the Waikato and Manawatu sites but with the excellent searching efficacy of the Irish wasp, parasitism has reached comparable or higher levels in autumn 2008 as seen in autumn 2007.

Research will continue at these sites to determine the efficacy of the wasp in reducing damaging weevil populations. From the CRW and wasp data it will be possible to assess how the wasp contributes to CRW population regulation, as has been done for Argentine stem weevil (Barker & Addison 2006) and *Sitona discoideus* (Barlow and Goldson 1993). It is not possible to compare pre- and post-release data on pasture clover content as no historic data is available for three of the release sites. The Springdale site has been monitored since 1997, shortly after when the weevil first arrived in the district. The insect population went through the typical "boom and bust" invasion, then settled into a pattern where clover and weevil abundance generally oscillate in response to each other, with peak winter larval populations (those that cause the damage) ranging between 300-1000/m². But a recent change in pasture management has seen grazing practices change away from those favouring clover, with mean annual pasture clover content dropping from around 20% for the previous eight years to a 2007 average of only 10%. With clover levels less than 5% at the time of autumn adult emergence in March 2008, CRW larval recruitment was the lowest since monitoring commenced. As a consequence, it is now difficult to obtain a field measure of the benefits of biocontrol from this site.

Nevertheless, the results thus far suggest that at localities where the host CRW adults are present year round (eg the Patoka site in Hawke's Bay), sufficiently high levels of parasitism in the autumn-emerging CRW adults can be achieved to reduce the abundance of damaging winter larvae. The Irish wasp has three attributes in the field that are known to be positively associated with successful suppression of pests by a biocontrol agent: namely, a much shorter generation time than CRW; almost continual availability of CRW and importantly the ability of more than one parasitoid to develop within a weevil. In addition, the Irish wasp reproduces asexually (no males required) so has no critical mass associated with finding a mate. With the CRW adults having virtually no refuge, a high level of attack can be expected.

Fig 1: Clover root weevil adult populations and percent parasitism at four North Island release sites



Nursery sites

Nursery sites are locations where natural enemies are released to reproduce within an existing pest infestation and then are collected for subsequent distribution (Van Driesche 1993). They reduce the requirement for a large mass-rearing programme and associated costs for research staff time and facilities. Several organisations were keen to participate in this scheme and the AgResearch biocontrol team set up their own site at Ruakura (Table 1). Easily-accessible sites were sought that had good, relatively stable white clover content and weevil populations, conditions that facilitate the long term presence of Irish wasp populations. While the concept of nursery sites offers self-perpetuating sources of parasitized weevils for natural and assisted dispersal as long as required, they are relatively expensive to set up and local people are needed in most regions to undertake collections for monitoring and distributions.

The releases used for the nursery sites comprised of 1000-2500 CRW parasitized with Irish wasp from at least two breeding lines originating from different geographic localities in Ireland. To spread risk, the releases in the 2007/08 season were split between sites and months.

Success has been mixed to date (May 2008). Establishment was rapid at the Taranaki and Ruakura sites with parasitism levels ranging between 23 and 64% by early winter 2007 but the widespread North Island drought in summer and early autumn 2008 severely handicapped the planned distribution activities. Even though parasitism levels were good, the Ruakura and Lepperton CRW populations were too low (<8/m²) to carry out any collections and the widespread lack of white clover combined with very low densities of resident CRW on drought-affected farms meant that the probability of establishing the wasp was very poor. However, two collections were taken from the Stratford site and distributed to farms in localities that had received adequate moisture.

Table 1: North Island nursery site releases of CRW adults parasitized by Irish wasp: December 2006- January 2008

Operator	Location	Parasitized CRW released	Month of release	Establishment (% parasitism)
Taranaki Regional Council	Stratford	2500	Dec 2006	Feb 2007 (6%)
	Lepperton	2500	Dec 2006	Feb 2007 (6%)
Northland Regional Council	Okaihau	5000	Dec 2006	Not established
	Okaihau	700 ¹	Dec 2007	Not established
	Pakaraka	500 ¹	Dec 2007	Not established
Landcorp Ltd	Kerikeri	2000	Jan 2008	Not established
	Te Kuiti	1000 ¹	Jan 2008	May 2008 (3%)
	Foxton	1500	Jan 2008	July 2008 (17%)
AgResearch	Ruakura	3000	Jan 2007	April 2007 (5%)
	Morrinsville	1000	Feb 2007	April 2008 (24%)

¹ Size of initial release with ongoing releases in 2008

No parasitized weevils were recovered following the initial 2006 release in Northland in spite of seemingly good conditions for establishment. Further releases were made at the original and two additional sites in December 2007 and January 2008, but the Irish wasp does not appear to have established at these nursery sites (Table 1).

The Northland December 2006 release at the proposed Okaihau nursery site inland from Kerikeri appears to have been the first release of Irish *M. aethiopoides* that has failed to establish (Fig. 2). This was unexpected; especially as 5000 parasitized *S. lepidus* had been released. Establishment had been achieved that summer at the Taranaki and Ruakura nursery sites with smaller releases of 2500-3000 parasitized *S. lepidus*, and only 1000 parasitized weevils released on a farm near Morrinsville in February (Fig. 2) (Table 1). One possible explanation for the failure was that high temperatures reached in pastures on soils containing iron aggregates, such as at the Okaihau site, were possibly lethal to the parasitoid. Ferguson et al. (2008) showed that *M. aethiopoides* tends to pupate in the top 1 cm of soil/litter and this may make them vulnerable to extreme temperatures. However, maximum grass temperatures near Kerikeri were not unusually high (23- 32°C) during the time when most released parasitoids would have been pupating (1-7 January 2007) (B. Cooper, pers. comm.). Nevertheless, as a precaution the follow-up releases in Northland were split over several dates and a range of sites. Once again, no evidence of parasitism was found in weevils collected and dissected in May 2008 at any of the sites, even though *S. lepidus* was abundant and Northland had good rainfall during the summer. In contrast, the wasp has established at the Te Kuiti site in very dry conditions, albeit at low levels.

The apparent failure of the Irish wasp in Northland contrasts with the rapid establishment of *Microctonus hyperodae* in 1991 when released at Wellsford (Goldson et al. 1994) and further investigations into causative factors have been initiated. The Irish wasp persisted well at Waikato sites during the 2007/08 drought with autumn parasitism levels well above 90% (P. Gerard, unpublished data). With severe soil moisture deficits (>130 mm) and record high mean daily temperatures in January (eg 26.7°C at Ruakura, well above that of 24.7°C for Whangarei) (National Climate Base data), it seems unlikely that high temperatures alone are responsible for the apparent failure of the wasp to establish in the Far North sites.

Fig. 2: Farmers releasing parasitized weevils on the Okaihau (left) and Morrinsville (right) sites in summer 2006/07.



Distribution of wasps to individual farmers (giveaways)

The project whereby parasitized weevils were given out *gratis* to farmers was designed for multiple purposes.

1. Following widespread media publicity on the wasp releases, there was strong pressure from farmers keen to obtain the wasp with many having a high awareness of the damage caused by CRW through their own on-farm experiences and research extension. Therefore, the distribution of the giveaways was a rapid method to deliver the biocontrol agent to those farms most impacted by CRW.
2. The biocontrol programme had been funded by farmer levies through DairyNZ and Meat & Wool NZ, so there was a strong expectation of delivery by farmers.
3. It had an extension component with all giveaways accompanied with an information sheet on the weevil and wasp, as well as tips to maintain good clover levels in pasture.
4. It potentially served to accelerate the rapid widespread dispersal of the Irish wasp through all the North Island and thus hasten the benefits of biocontrol coming on line.

The giveaways consisted of 10 CRW adults that had been exposed to progeny of either a single Irish breeding line obtained from laboratory culture or from wasps reared from field-collected weevils from the successful experimental release sites (Gerard et al. 2007). The parasitized weevils were placed into 70 ml specimen vials in batches of 10 with a small segment of damp cotton wool and a clover leaf (Fig. 3). Distribution was primarily through field days and the DairyNZ and Meat & Wool NZ networks. Consulting officers and industry contacts were couriered overnight prearranged numbers of vials packed in 4.5 litre polystyrene containers with icepacks. The vials were distributed personally to farmers, along with instructions for release, and an information sheet on the CRW problem and the biocontrol agent. Usually only one vial was provided per farm. However, multiple vials were given to landholders who had:

1. Extensive areas of land,
2. A history of active support of the CRW management programme or
3. The consulting officer who misunderstood the guidelines.

Records have been kept of the farms where the parasitized weevils were to be released so districts with low coverage can be targeted for future releases.



Fig. 2: Giveaway vial with parasitized weevils and packaging showing supporting organisation logos. On reverse are instructions for release.

Table 2 shows the pattern of distribution of the giveaways according to Regional Council boundaries. In 2007, farmers received giveaway vials from researchers at field days at Dargaville (supported by Northland Regional Council), Limestone Downs (supported by C. Alma Baker Trust) and Gordonton near Hamilton (supported by NZ Clover Root Weevil Action Group). In 2008, almost all giveaways went out through the pastoral industry networks, in particular the DairyNZ consulting officers.

The wasp distribution project in 2008 was hampered by the widespread drought in the North Island. CRW adults for the mass rearing were collected from a Wairarapa clover seed crop as insufficient were available in Waikato. Local knowledge of consulting officers was crucial in identifying districts and farms with adequate clover to sustain CRW populations. As a consequence, over 30% of the giveaways in 2008 went to Northland farmers, even though this region had over 150 giveaways in 2007. However, although the nursery sites failed, it may be that with the diverse localities covered by this approach, it could facilitate the successful establishment of the wasp in the region .

Table 2: Regional distribution of giveaway vials of parasitized CRW in 2007/2008.

Regional Council	2007	2008
Northland	157	167
Auckland	35	46
Waikato	46	73
Bay of Plenty	1	17
Gisborne	1	0
Hawke's Bay	1	12
Taranaki	1	58
Manawatu	4	140
Wellington	1	29
Total	247	542

The distribution of the giveaways, as well as expediting the potential dispersal of the wasp, was an opportunity to reinforce the linkages between key primary industries and science. Rarely science can deliver a research-driven solution to a significant problem directly from the laboratory into the hands of multiple individual farmers. Interactions between industry extension personnel and researchers were critical to project success. Not only did the industry personnel have extensive farmer contacts, the local knowledge they possessed meant they were able to identify farms that were still suitable as release sites, at a time when drought was affecting many North Island districts. Furthermore, as the organisations responsible for investing farmer levies, DairyNZ and Meat & Wool NZ, were clearly acknowledged on packaging and accompanying information and publicity.

The *gratis* distribution of wasps to individual farmers contrasts markedly with the strategy used for the commercial distribution of the biocontrol agent for the Argentine stem weevil (ASW) when 10,000 parasitized weevils was selected as the minimum number for a release (McNeill et al. 2002). However, apart from the extension and promotional aspects intrinsic to this project, the Irish wasp does have attributes that should enable the establishment of new wasp populations from as few as 10 parasitized weevils, namely:

- Asexual reproduction – it does not need to find a mate and dispersal will not deplete gene pool.
- Rapid multiplication – the combination of good searching efficiency, ability to lay multiple eggs per host, and a 5-6 week life cycle in summer means it can multiply rapidly when hosts are most abundant.

The giveaway approach overcomes two of the major impediments associated with the previous commercially-based but very successful ASW biocontrol releases (McNeill et al. 2002).

- It ensures the releases are not restricted to the wealthier dairy-farming districts.
- It reduces the reliance on passive dispersal by parasitized weevils from a single release site. The proportion of CRW that fly in summer is dependent on climate and clover levels with few flying in cool, moist summers.

Apart from the drought, the main constraint with the project in getting good coverage is the paucity of sheep and beef farmer-orientated events, such as monitor farm days, over the optimal time to carry out releases in summer. One option being investigated to reach these farmers is using commercial networks (e.g. fertiliser companies) to assist in the giveaway distribution. With the long term meteorological forecasts predicting more favourable weather in summer 2008/09, further giveaways are planned with focus on poorly-covered regions (Table 1), and sheep/beef farmers. Sampling is currently underway to assess the proportion of 2007 giveaways that have led to successful establishment.

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