South Island distributions of clover root weevil and its biocontrol agent

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Abstract

Clover root weevil (*Sitona lepidus*) (CRW), a white clover pest from the Northern Hemisphere, was first found in the North Island in 1996. Its 2006 detection in the South Island coincided with the introduction from Europe of an insect parasitoid for biocontrol of CRW. Upon detecting CRW in the South Island, we surveyed for suitable locations to release the biocontrol agent. Our goals were to reduce clover damage and to minimise the number of releases required by allowing the parasitoid to spread with the pest. We released it in three large CRW infestations where it quickly became established. Although the parasitoid's natural spread rate appears similar to that of CRW, additional geographically isolated CRW infestations were detected which have probably arisen from accidental human assisted transportation, and the parasitoid will take several years to reach them. Three further releases of the biocontrol agent have been made, and more are planned.

Keywords: white clover, surveillance, dispersal, spread, biosecurity

Introduction

Clover root weevil (*Sitona lepidus*) (CRW), was first detected in New Zealand in Waikato in 1996 (Barratt *et al.* 1996) after it had already become widespread in Auckland, north Waikato and coastal Bay of Plenty (Barker *et al.* 1996). Thereafter, it advanced through the North Island at approximately 10-70 km/yr (Hardwick *et al.* 2004) and had reached the southern end of the North Island by 2005 (Gerard *et al.* 2009). It was first discovered in the South Island in January 2006 in Christchurch, with further detections in Richmond and Rai Valley in April 2006 (Phillips *et al.* 2007).

It was estimated that if left uncontrolled, CRW would cost New Zealand farmers $0.2-1 billion/yr once it became nationally distributed; these costs arise from the additional animal feed and nitrogen fertiliser needed to compensate for damage to white clover (Wear & Andrews 2005). Greater use of nitrogen fertiliser due to CRW is projected to increase New Zealand's greenhouse gas emissions by 0.74 Mt CO_2 equivalent during 2008-2012 (Wear 2006).

A biological control programme was initiated in 1998, and releases of an Irish strain of the parasitoid *Microctonus aethiopoides* commenced in January 2006 (Gerard *et al.* 2006). It has since become established at nearly all of its North Island release sites (Gerard *et al.* 2007). The Irish strain of *M. aethiopoides* was first released in the South Island at Richmond and Rai Valley between August 2006 and March 2007, where early indications suggested it was becoming established (Phillips *et al.* 2007).

This paper provides an update on the distribution of CRW and *M. aethiopoides* in the South Island following on from Phillips *et al.* (2007) until August 2010.

Methods

Assessment of the South Island distribution of CRW

Sampling was conducted in turf containing white clover in locations such as farm pastures, saleyards, showgrounds and amenity areas such as parks. Locations were chosen in response to varying priorities which included: (i) checking previously unsampled regions; (ii) maximising geographical coverage and minimising costs by capitalising on results from insect sampling being conducted in other research programmes; (iii) verifying informal reports of CRW's presence in new locations; (iv) delimiting newly detected CRW infestations; (v) identifying sites suitable for releases of the biocontrol agent; and (vi) monitoring the spread of CRW and the biocontrol agent. Sampling locations within 1 km of one another were treated as belonging to the same site and, for the purposes of this paper, were assigned the geographical coordinates of the first-collected sample.

Most sampling was conducted using motorised leaf blowers with mesh nets attached to their intake pipes to collect CRW adults (Phillips *et al.* 2000; Goldson *et al.* 2004), but visual searching, soil coring and sweeping were also used. Leaf blower sampling is cost efficient and can detect a low CRW population of 1 adult/m^2 with 95% confidence if a transect ≥100 m is sampled (C.B. Phillips *et al.* unpubl. data). We therefore only recorded CRW as being absent from a site if at least one leaf blower transect ≥100 m had been conducted, while all detections were recorded irrespective of sampling method. Some records of CRW at new sites arose from serendipitous observations by AgResearch staff, often during CRW flight periods.

South Island releases of *M. aethiopoides*

Following the initial Richmond and Rai Valley releases, *M. aethiopoides* was reared at Lincoln (McNeill *et al.* 2002; Goldson *et al.* 2005) and introduced to pastures as larvae within their adult weevil hosts at Upper Takaka on 9 April 2009, two sites at Rotherham on 7 May 2009 and 23 January 2010, respectively, and Rakaia Island on 21 May 2010.

Confirmation *M. aethiopoides* had established was sought by collecting CRW adults (the stage attacked by *M. aethiopoides*) and either dissecting them to search for evidence of parasitism or maintaining them in cages to allow any parasites present to develop and emerge. The number of CRW assessed per sample ranged from 18 to >200. Parasitism by the Irish strain of *M. aethiopoides* was distinguished from parasitism by the Moroccan strain (previously introduced to New Zealand for control of lucerne weevil, *S. discoideus*) on the basis that the former can produce several offspring per weevil, while the latter only produces one (Phillips *et al.* 2008).

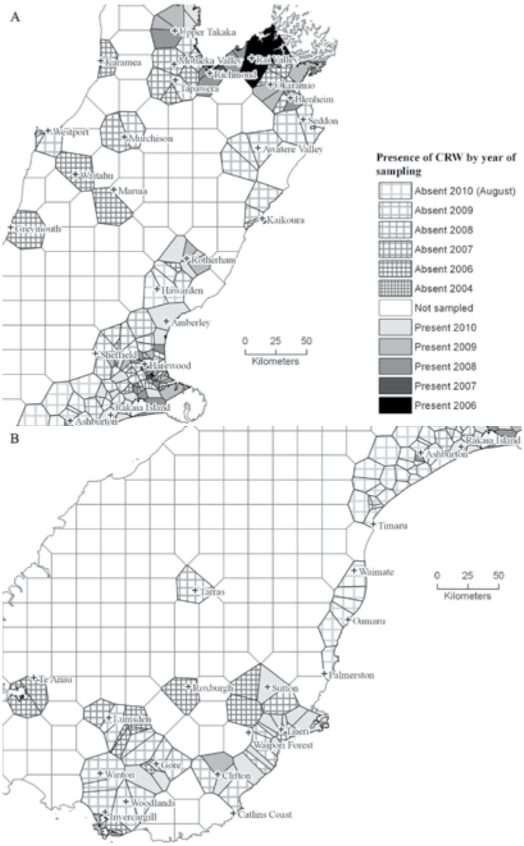
Mapping the South Island distribution of CRW

Details of each sample, including geographic coordinates of the sample site, were imported into the GIS software ArcGIS® Version 9.3 (Environmental Systems Research Institute, Redlands, California) for processing.

A 20 x 20 km grid of 'null' points was laid across a map of the South Island and those points within 20 km of a CRW sampling site were deleted. The South Island array of null points and sampling sites was used to generate Thiessen polygons (Thiessen 1911) where any location within a polygon is closer to its associated sampling site than to the sampling site of any other polygon. This approach enabled data from every sampling site to be shown on a map since, where sampling sites were within 20 km of one another, smaller polygons were generated for each site. It also meant that the areas of polygons generated by sampling sites which bordered unsampled regions were constrained to approximately 20 x 20 km, thus limiting unjustified spatial extrapolation of the sampling results. For repeatedly sampled sites, if CRW was absent then the most recent sampling date was used and, if it was present, then the earliest detection date was used. On the maps, polygons generated by sample sites were classified according to the year of sampling.

To facilitate description and discussion of the results, any site where CRW was detected that was located further than 20 km from the nearest previous site of detection was classified as a discrete and new infestation, while any infestation 20 km or less from the nearest previously known infestation was classified as contiguous with that infestation. This distance was used because it approximates the average annual rate of CRW spread observed in the North Island (Hardwick *et al.* 2004) and exceeds the estimated annual rate of natural dispersal observed in the South Island to date (see Results and Discussion).

Figure 1 Upper (A) and lower (B) South Island. Each shaded polygon contains a sampling site where CRW has either been detected or not detected (see legend).



Results

Fig. 1 shows the northern and southern South Island divided into sampling polygons, each containing a site where CRW has either been detected (98 polygons with a total area of approximately 910 000 ha), not detected (142 polygons; c. 3 230 000 ha) or not sampled (259 polygons; c. 11 million ha).

For the northern (Fig. 1a) and southern (Fig. 1b) regions of the South Island, CRW's presence is shown by the earliest year it was detected at that site, while its absence from samples is shown by the most recent year of sampling at that site.

Locations where CRW has been confirmed to be present

Phillips *et al.* (2007) summarised the results from 88 pasture samples taken from various South Island locations, the most recent being May 2007 from *M. aethiopoides* release sites in Richmond and Rai Valley. At that time, the only South Island detections of CRW were at Richmond, Rai Valley and Harewood (Fig. 1a).

Since the report of Phillips *et al.* (2007), a further 248 samples have been processed from a total of 190 South Island sites (147 sites sampled once, 33 sampled twice, eight sampled three times, one sampled five times, and one sampled six times). CRW was detected in 107 (43%) of the samples from 81 (43%) of the sites.

From June to December 2007, no new CRW infestations were found, although CRW was found in additional locations that were within 20 km of the previously known infestation at Harewood (Fig. 1a), so these populations were classified as contiguous. In 2008, new infestations were found in Ashburton (August), Blenheim (December) and Upper Takaka Valley (December; Fig. 1a). Sampling in 2008 also revealed that the CRW populations at Rai Valley and Harewood (Fig. 1a) had spread to additional locations within 20 km of the previously known infestations. In 2009, new infestations were found at Clinton (January; Fig. 1b), Rotherham (April; Fig. 1a) and Mosgiel (December; Fig. 1b), and further spread was noted within 20 km of the CRW infestations at Harewood, Blenheim and Upper Takaka (Fig. 1a). In 2010, new infestations were found at Gore (February) and Sutton (April; Fig. 1b), and spread within 20 km of the infestations at Upper Takaka, Rotherham, Harewood (Fig. 1a) and Mosgiel (Fig. 1b) was recorded.

Many of the 119 sites at which CRW was not found were from locations within 20 km of known infestations (e.g. near Christchurch; Fig 1a) and are not detailed here because those locations will likely soon become infested through natural spread of the weevil. However, more distant areas where CRW appeared to be absent are as follows. In 2006, samples free of CRW were obtained from near Karamea, Tapawera, Richmond (these were additional sites sampled following the 2006 discovery of a CRW infestation at Richmond), Okaramio, Westport, Waitahu, Maruia and Greymouth (Fig. 1a). In 2007, samples free of CRW were obtained from near Tapawera, Murchison and Kaikoura (Fig. 1a). In 2008, additional sites in the Motueka River valley and at Murchison (Fig. 1a) appeared free of CRW, as did sites on the Catlins coast, and at Tarras and Lumsden (Fig. 1b). In 2009, Kaikoura (Fig. 1a) still appeared free of CRW, and none were found at sites in Awatere Valley and Westport (Fig. 1a), Catlins coast and near Waipori Forest (Fig. 1b). In 2010, a site near Hawarden and numerous sites 20–55 km south and west of Ashburton appeared free of CRW, as did four sites within 32 km of Oamaru, three sites between Gore and Lumsden, three sites between Winton and Invercargill, and one near Woodlands (Fig. 1b).

South Island releases of *M. aethiopoides*

In April 2008, *M. aethiopoides* occurred in 50% of CRW adults (n = 30) collected from a 2006 Richmond release site and in 75% of CRW adults (n = 20) collected from a 2006/07 Rai Valley release site, thus confirming early indications that it had established there (Phillips *et al.* 2007; Fig. 1). CRW collected from the vicinity of Blenheim in April-May 2008 were also parasitised, presumably through natural dispersal of *M. aethiopoides* from Rai Valley, a straight line distance of c. 35 km (Fig. 1a). In April 2010, 5% of CRW adults (n = 111) collected from a Rotherham release site in North Canterbury were parasitised, thus confirming *M. aethiopoides*' establishment there. Its establishment at Upper Takaka Valley and Rakaia Island has not yet been confirmed.

Discussion

Since May 2007, new CRW infestations have been detected at Upper Takaka (a straight line distance of c. 45 km from the closest previously known infestation at Richmond), Blenheim (c. 34 km from the Rai Valley infestation), Rotherham (c. 94 km from the Harewood infestation), Ashburton (c. 82 km from Harewood), Sutton (c. 300 km from Harewood), Mosgiel–Clinton (c. 320 km from Harewood), and Gore (c. 405 km from Harewood). The Blenheim infestation is likely to have arisen from natural spread of the weevil, probably from Rai Valley. This is supported by the presence of *M. aethiopoides* near Blenheim, presumably also due to natural spread from its Rai Valley release sites. Similarly, the Sutton infestation may have arisen via natural spread from the Mosgiel–Clinton infestation, or vice versa, since their closest sites were only 33 km apart. However, our data are currently insufficient to demonstrate clearly that either of these pairs of proximal infestations is contiguous.

In contrast, the remaining infestations are more likely to be the result of inadvertent human assisted movements of the weevil. This is because the infestations are more widely separated from one another, and sampling between them has indicated the populations are probably discrete. Except for Blenheim, the remaining six new infestations have been found in rural locations, often quite remote from large urban areas, which suggest CRW is being accidentally moved to new locations in direct association with farming activities. In two cases, owners of properties that appeared to be central to new infestations indicated they had recently imported stock, equipment or feed from regions where

CRW was already widespread.

The most intensive and long-term South Island sampling for CRW has been in mid Canterbury around Harewood (125 samples over 4 years) where, assuming Harewood was the originally infested site, CRW has spread about 7-13 km/yr. In Marlborough, if Rai Valley is considered the source of the Blenheim infestation, then CRW has spread up to 19 km/yr. We assume that at small spatial scales (< 20 km) CRW flight is the dominant dispersal mode, while inadvertent human assisted dispersal is probably the major mode of spread over larger distances. Our estimated rate of natural dispersal for CRW in the South Island of 7-19 km/yr is at the low end of the 10-70 km/yr range observed in the North Island (Hardwick *et al.* 2004), although the latter may include a larger component of human assisted dispersal.

In addition to initial releases of *M. aethiopoides* at Richmond and Rai Valley (Phillips *et al.* 2007), new releases have been made at Upper Takaka, Rotherham and Rakaia Island, with establishment confirmed at Rotherham. Our preliminary observations suggest natural spread of *M. aethiopoides* to Blenheim, probably from Rai Valley, has kept pace with natural spread of CRW in that region, so it is possible there will also be little need for additional formal releases in new CRW populations that arise from natural spread of CRW from Richmond, Upper Takaka and Rotherham. The 17 km/yr spread of *M. aethiopoides* observed in Marlborough is similar to the 15 km/yr rate observed in the North Island (Gerard *et al.* 2010, this volume).

The early CRW detections at Richmond and Rai Valley (Phillips *et al.* 2007), and the more recent ones at Upper Takaka valley, Blenheim, Rotherham, Taieri Plains (including Sutton) and Gore have involved large, but localised, CRW populations. This contrasts with the situation in mid Canterbury where increasingly widespread detections have been characterised by small numbers of sparsely scattered weevils that are unlikely to support releases of *M. aethiopoides*. These scattered individuals have probably arisen through CRW flights that are quite frequent during summer in Marlborough, Canterbury and Otago (C.B. Phillips *et al.* unpubl. data). However, we are now observing increases in abundance of CRW at several mid Canterbury sites where it will be possible to make additional releases in 2010-11 if *M. aethiopoides* does not arrive quickly enough through natural spread from Rotherham and Rakaia Island. At Ashburton, the small CRW population detected in 2008 does not appear to be rapidly growing or spreading, and may be limited by low clover availability at that site. The biocontrol agent should spread to Ashburton from Rakaia Island, which is about 40 km away, in c. 3 years, but a formal release could be made earlier if pasture damage becomes evident. At Taieri Plains and Gore, there is a clear requirement for new releases of *M. aethiopoides* as it will not naturally disperse there from the nearest populations in Canterbury within the next decade. Releasing the parasitoid at both these locations is planned for late 2010 and early 2011.

There have been few reports of serious clover damage from CRW in Nelson and Marlborough, and those received have been from where *M. aethiopoides* is not yet present. The rapid establishment of *M. aethiopoides* in Marlborough and Nelson, therefore, appears to be achieving the goals of Phillips *et al.* (2007) of reducing CRW damage and minimising the need for additional releases of biocontrol agents in that region. Phillips *et al.* (2007) also speculated that the rate of CRW spread might be reduced by *M. aethiopoides*, but comparison of CRW spread rates between Rai Valley and Harewood provides no evidence for this. Elsewhere in the South Island, the only report of serious damage has been from Rotherham where *M. aethiopoides* is now becoming established. There is reason for optimism that natural spread of *M. aethiopoides* along with additional targeted formal releases will spare South Island farmers from the worst impacts of CRW.

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