# CLOVER ROOT WEEVIL IN THE SOUTH ISLAND: DETECTION, RESPONSE AND CURRENT DISTRIBUTION

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## ABSTRACT

*Sitona lepidus* had spread throughout the North Island of New Zealand by 2005, and was first detected in the South Island in January 2006 when one individual was found at Harewood, Christchurch. Intensive sampling during February 2006 recovered only two additional specimens. Several specimens were recovered from a separate Christchurch location in August 2006. Localised *S. lepidus* populations were discovered near Richmond, Nelson, in April 2006 and in Rai Valley in May 2006. A website established in May 2006 to provide information about *S. lepidus* was visited a mean of 135 times per month, but it was never used to report possible new South Island infestations. A biological control agent, *Microctonus aethiopoides*, was released at Richmond and Rai Valley between August 2006 and March 2007. By May 2007, it was parasitising from 4% to 14% of *S. lepidus* adults, which indicates it is likely to become permanently established.
**Keywords:** white clover, risk perception, surveillance, dispersal, spread, biosecurity.

## INTRODUCTION

Clover root weevil, *Sitona lepidus* Gyllenhal (Coleoptera: Curculionidae), was first detected in New Zealand in Waikato in 1996 (Barratt et al. 1996), and a delimitation survey conducted soon afterwards showed 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 per year (Hardwick et al. 2004) and was first noted at the southern end of the North Island in Wairarapa in 2005 (M.R. McNeill, unpubl. data).

It has been estimated that once *S. lepidus* becomes nationally distributed it will cost New Zealand farmers $0.2-1 billion per year due to the need for additional animal feed and nitrogen fertiliser to compensate for damage to white clover (Wear & Andrews 2005). Moreover, the greater use of nitrogen fertiliser due to *S. lepidus* is projected to increase New Zealand's greenhouse gas emissions by 0.74 million tonnes of carbon dioxide equivalent during 2008-2012 (Wear 2006). A biological control programme was initiated in 1998, and releases of a strain of *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) from Ireland that parasitises *S. lepidus* commenced in January 2006 (Gerard et al. 2007; Phillips et al. 2006). *Microctonus aethiopoides* has since established at all of its North Island release sites (Gerard et al. 2007).

This paper documents the initial South Island detections of *S. lepidus*, its known South Island distribution, and the responses made to date, including recent releases of *M. aethiopoides*. It also records reactions of farmers and members of the public to the presence of *S. lepidus* in the South Island that were obtained through semi-structured interviews with farmers, and via interactions with members of the public.

## METHODS

### Assessment of the South Island distribution of *Sitona lepidus*

Five sampling methods, of unknown relative efficacies, were used to make ad hoc assessments of the presence of *S. lepidus* in different South Island locations (see Fig. 1). Further details of sampling sites and dates are available at www.agresearch.co.nz/crw/.

- A prototype semiochemical trap, which is being developed to assist with surveillance at the national border, consisting of a cone trap baited with a blend of a *Sitona lineatus* (L.) pheromone (Blight et al. 1991), two derivatives of this pheromone and a plant based lure.
- A 1555 mm wide aluminium sweep-net dragged by a vehicle over pasture to collect adult weevils (McNeill et al. 2002).
- Blower-vacs with mesh nets attached to their intake pipes (Phillips et al. 2000).
- Visual searches for notches in white clover leaves that are characteristic of adult feeding damage by *Sitona* spp., including *S. lepidus* (Jackson 1920; Clements & Murray 1993).
- Visual searching of soil samples (~0.04 $m^2$ spade squares to a depth of 10 cm) for *S. lepidus* larvae and pupae (Jackson 1920; Gerard 2001).

### Web site development and usage statistics

An internet website (http://www.agresearch.co.nz/crw) was established in May 2006 to provide information on the identification, known South Island distribution, biology and management of *S. lepidus*, and this was promoted to South Island farmers through the media (e.g. Angus 2006) and at industry gatherings (e.g. 2007 South Island Agricultural Field Days). The website included a form allowing farmers to submit information on suspected infestations for scientific follow-up. All reports received from members of the public, either through the website or directly, were documented, responded to, and any specimens submitted were identified by the senior author.

### Farmer interviews

Semi-structured interviews were conducted with seven Nelson dairy farmers in October 2006 to learn of their reactions to the South Island discovery of *S. lepidus*. At the time of the interviews, *S. lepidus* was present on the properties of six of the interviewees, although only two interviewees had been directly informed of this. They were asked about pests that currently affect their pasture, and their pest management practices. They were then asked about *S. lepidus*, and the questions focussed on whether they thought it was present on their property, whether they had seen any evidence of it, and their response to its discovery in the South Island. A copy of the interview questions and outline can be obtained from www.agresearch.co.nz/crw/. Notes were taken at each interview, then summarised and assessed for common themes by the key interviewer.

### South Island parasitoid releases

The *S. lepidus* strain of *M. aethiopoides* was mass reared at Lincoln following the methods of McNeill et al. (2002) and Goldson et al. (2005). Parasitoids were released as 1st instar larvae within their adult hosts at Richmond and at two sites in Rai Valley. Partly to compensate for unexpectedly high mortality of parasitoid-exposed weevils in the laboratory, the releases were staggered over four dates between July 2006 and March 2007 (Table 1).

**TABLE 1: Number of parasitoid-exposed *Sitona lepidus* released at three Nelson sites by release date.**

| Release date | Richmond | Northern Rai Valley | Southern Rai Valley | Total number released |
|---|---|---|---|---|
| 26 Jul 2006 | 390 | 390 | | 780 |
| 21 Dec 2006 | 798 | | 798 | 1596 |
| 30 Jan 2007 | 405 | | 405 | 810 |
| 01 Mar 2007 | 1090 | | | 1090 |
| Total | 2683 | 390 | 1203 | 4276 |

## RESULTS

### Locations where *Sitona lepidus* has been confirmed to be present

The first *S. lepidus* specimen was recorded in the South Island on 25 January 2006 in a trial semiochemical trap at Christchurch International Airport Limited (CIAL) (Fig. 1). Three additional traps were installed in the vicinity of CIAL on 15 February 2006, then a further ten traps were installed and monitored every 2-4 weeks during summer 2006/07, but no more *S. lepidus* were captured. Preserved insects previously vacuumed from CIAL for another purpose by C. Pennell (AgResearch) during September and November in 2004, and during January, April, July and November in 2005, were examined for *S. lepidus* following the 25 January detection, but none were found. Roadside verges to the south and south-west of CIAL, and within a 7 km radius of it, were swept for approximately 2 hours on the evening of 15 February 2006, and one *S. lepidus* adult was recovered. Five areas of white clover situated within a 2 km radius of CIAL were vacuum sampled on 15 February 2006, including one approximately 130 m from the semiochemical trap where the initial detection of *S. lepidus* had been made. A white clover seed crop situated approximately 3 km south of CIAL and a dairy pasture approximately 2 km north-west of CIAL were also sampled. One *S. lepidus* adult was recovered from the dairy farm. This site was sampled again on 9 March 2007 and *S. lepidus* was recovered from two of the three paddocks sampled, where the combined density of adults and larvae (estimated by vacuuming of quadrats and visual searching of spade squares, respectively) was $<1.5/m^2$. Three *S. lepidus* adults were vacuumed from pasture at the Christchurch Showgrounds, 8 km south of CIAL, on 29 August 2006, and a further two were vacuumed at the same location on 8 March 2007 (Fig. 1).

In the first week of April 2006, weevils were vacuumed from clovers and grasses at six sites in north Canterbury, Buller and Nelson. An established *S. lepidus* population was found on 6 April at a dairy farm near Richmond in Nelson. A newspaper article on 18 April 2006 (Goodger 2006) reported that a local agriculturalist thought *S. lepidus* was also established at Dovedale and Rai Valley in Nelson. In response, vacuum sampling was conducted during 22-23 May 2006, which confirmed *S. lepidus* was present in the northern end of Rai Valley, but none were found at Dovedale. A vacuum sample taken on 11 August 2006 from pasture in the southern end of Rai Valley (10 km west of Havelock), where notching had recently been observed (by B. Stuart), confirmed that *S. lepidus* had also become established there (Fig. 1). A larva recovered from soil sampled on 10 October 2006 from pasture at Kaiuma, approximately 5 km north of Havelock, was confirmed by DNA sequencing to be *S. lepidus*.

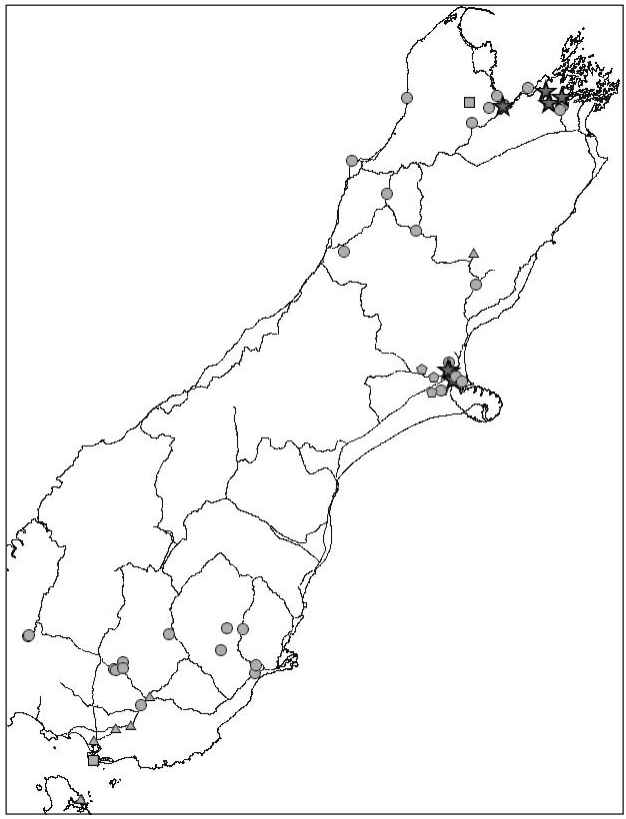

**FIGURE 1: South Island locations where *Sitona lepidus* either has been detected (stars), or has not been detected by vacuuming (circles), soil cores (squares), sweeping (pentagons) or visual searching for adult feeding damage (triangles) between 25 January 2006 and 9 March 2007.**

**Use of *S. lepidus* web site**

Between May 2006 and April 2007, the *S. lepidus* web site had been accessed an average (±SD) of 137 ± 65 times per month. The lowest visit rate of 38 occurred in May 2006, then the rate remained approximately constant at an average of 132 visits per month until April 2007, when an abrupt increase to a monthly maximum of 287 occurred. The most viewed pages, in order of declining frequency, described the identification (73 views per month), control (61 views per month) and distribution (42 views per month) of *S. lepidus*. Four downloadable pamphlets about *S. lepidus* were each viewed an average of 16 times per month, while media articles relating to *S. lepidus* were each viewed an average of four times per month. A web page intended to facilitate reporting of evidence of *S. lepidus* in additional South Island locations was only ever used once, but not by a South Island farmer as had been its intention.

**Assistance from members of the public**

Media interest in the arrival of *S. lepidus* in the South Island was high. During 2006, more than 40 television, newspaper and radio articles addressed the occurrence of *S. lepidus* in the South Island, some of which also publicised the web site noted above. From February 2006, when publicity about the discovery of *S. lepidus* in the South Island began, until April 2007, AgResearch was contacted by, and responded to, 24 concerned individuals, but no reports were consistent with the presence of *S. lepidus*. Specimens were obtained in six cases, and in five cases the insects involved were weevils, although none were *S. lepidus*, while the sixth case involved a fly. In addition, several students contacted AgResearch for information for school projects on *S. lepidus*, and were directed to the web site.

**Farmer interviews**

The interview results indicated that farmers did not consider *S. lepidus* to be an immediate concern. Interviewees reported that porina and grass grub sometimes caused problems depending on the season, and weeds were also of concern to some. They described established routines for managing these problems. None of the interviewees had seen *S. lepidus* on their property, although two had been informed it was present, and the others thought that it had been present for at least a season, maybe two. One interviewee had responded to reports of the discovery of *S. lepidus* by contacting a Waikato farmer to discuss its likely impact. The Waikato farmer had indicated there were ways of minimising its impact, so the interviewee had concluded that *S. lepidus* was not a high priority for action.

**Parasitoid releases**

*Sitona lepidus* adults vacuumed from the two Rai Valley release sites on 8 May 2007, and from the Richmond release site on 9 May 2007, were dissected to search for evidence of parasitism by *M. aethiopoides*. Immature parasites were found in 7% of *S. lepidus* from northern Rai Valley (n = 65 *S. lepidus* dissected), 10% from southern Rai Valley (n = 100) and 14% from Richmond (n = 100).

## DISCUSSION

Most of the *S. lepidus* distribution data reported here resulted from ad hoc efforts to capitalise on other research activities. There will almost certainly have been significant variation in *S. lepidus* detection probabilities between sampling methods and between sampling occasions, and there is little published information to assist in estimating confidence in the results. The sites where *S. lepidus* was not detected (Fig. 1) must therefore be regarded as locations where no evidence of *S. lepidus* was found, rather than as places where *S. lepidus* can be confidently regarded as having been absent. Nevertheless, intensive sampling at four sites within 30 km of Richmond, two within 15 km of Rai Valley, and seven within 25 km of Harewood failed to locate additional *S. lepidus* (Fig. 1), so the located populations appeared to be discrete and localised at the time of sampling. Moreover, comparisons with North Island observations suggest the South Island populations have yet to reach their peak densities. There is a clear need for studies to quantitatively compare the efficacy of different sampling methods for pasture pests to improve methods for detecting them, and for estimating their population sizes and geographical distributions.

The small number of *S. lepidus* recovered to date from the vicinity of CIAL suggests its initial detection in a prototype semiochemical trap was either extremely improbable, or the trap was remarkably effective, or both. The sporadic detections of just a few additional adult *S. lepidus* near Christchurch, along with the presence of an apparently very localised, low density population 2 km north-west of CIAL, is consistent with the existence of a much larger, longer established, but as yet undetected, population in the vicinity of Christchurch that is providing a source of dispersing adults. An alternative possibility is that the sampled specimens were arising from regular human-assisted arrivals of *S. lepidus* from the North Island.

Finding *S. lepidus* at Richmond was an unlikely event that arose from a chance visit by AgResearch staff. The South Island detections therefore mirror the situation in the North Island in 1996 when *S. lepidus* was fortuitously discovered by researchers, despite its widespread occurrence on farmland for at least five years beforehand (Barker et al. 1996). The apparent reliance on luck for detecting new pastoral pests, and the general absence of preparations for inevitable incursions by additional unwanted species from overseas, is cause for concern for the agricultural industry.

This work has illustrated some difficulties involved in using the public to assist with species delimitations. Feeding by adult weevils from genera such as *Atrichonotus* and *Irenimus* can cause notching in clover leaves similar to that caused by *S. lepidus*. In addition, larvae of various weevil species found in the pasture root zone, including *Listronotus bonariensis* (Kuschel), *A. taeniatulus* (Berg) and *A. sordidus* (Hustache), can also be readily confused with *S. lepidus*. Public confusion between signs of different weevil species was evident in the Nelson region where *A. taeniatulus* was abundant in our samples because, by April 2006, newspaper reports (e.g. Goodger 2006) and conversations with local farmers were incorrectly suggesting that *S. lepidus* was distributed well beyond Richmond and Rai Valley. The need for specialist diagnoses, along with the lack of public reporting of possible cases of *S. lepidus*, suggests that delimiting cryptic, soil dwelling pests would be most efficiently achieved through targeted surveys conducted by specialists.

The discovery of *S. lepidus* in the South Island generated considerable media interest, and some public interest as indicated by use of the website. However, this did not translate into obvious farmer concern, and it elicited relatively few reports of additional possible infestations. *Sitona lepidus* was probably not considered a key issue because its impacts were regarded either as ambiguous, manageable, or inevitable and immutable. This likely exemplifies a long-recognised gap between public perception of risk and the risk perceptions of scientific and policy experts (Hansen et al. 2003; Bickerstaff 2004). *Sitona lepidus* is cryptic, with the most damaging, larval stage occurring underground, so it may be difficult for farmers to rationalise the concern expressed by scientists with the absence of obvious impacts on their own farms, particularly during the early stages of *S. lepidus* population build-up. However, members of the public also tend to use scientific data in an entirely different way, incorporating broader issues into their risk assessments (Hansen et al. 2003; Anthony 2004), as was demonstrated by the farmers interviewed. Sandman (2004) drew two conclusions from similar observations made in social research on disaster management: First, disasters and near-misses can provide 'teachable moments' when efforts at education can be particularly effective. Second, 'eternal vigilance' is not feasible so precautions that only need to be made once are preferable to approaches that need constant input. Such factors obviously need to be taken into account when considering how to improve surveillance for pastoral pests.

AgResearch and industry collaborated to release the *S. lepidus* biological control agent at Richmond and Rai Valley as soon as possible after its presence was confirmed there. This was aimed at: (i) minimising the economic impact of *S. lepidus* in Nelson; (ii) maximising any inhibitive effect of parasitism on the spread of *S. lepidus*; (iii) capitalising on any opportunity for *M. aethiopoides* eggs and larvae to disperse in tandem with *S. lepidus*; and (iv) reducing the number of additional, formal releases of *M. aethiopoides* that may eventually be needed (Fagan et al. 2002). The very recent recovery of *M. aethiopoides* from Richmond and Rai Valley at the end of the first season following its release, and the remarkably rapid increase in parasitism rates, strongly suggests that it will successfully establish and that the goals of the rapid response listed above will be at least partly achieved.

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