RISKS AND BENEFITS OF INTRODUCED BIOCONTROL AGENT INTERACTION WITH NATIVE NON-TARGET HOSTS: *MICROCTONUS AETHIOPOIDES* (IRISH BIOTYPE) AND *IRENIMUS STOLIDUS* IN OTAGO, NEW ZEALAND

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Introduction

The introduction of biocontrol agents to manage pests in agricultural systems can have unintended consequences for resident communities, for example when the agent attacks non-target native insects. Conversely, however, non-target attack may also enhance the effectiveness of the biocontrol agent, particularly if it occurs when there are few target hosts present.

One instance of this appears to be the interaction of the Irish biotype of the braconid parasitoid wasp *Microctonus aethiopoides* Loan and a native weevil, *Irenimus stolidus* Broun that inhabits improved pastures in Otago, New Zealand. The Irish *M. aethiopoides* was introduced to New Zealand in 2006 to combat clover root weevil (CRW) (*Sitona obsoletus* Gmelin) that posed a significant risk to New Zealand's pastoral-based economy. Feeding exclusively on clover species, and in the absence of natural enemies, it was estimated that CRW could have cost up to $1.2B p.a., about half of the total value of clover to New Zealand (Nixon, 2015). The introduction of *M. aethiopoides* was spectacularly successful in reducing the impact of CRW to almost unnoticeable levels in areas where it has been established for some time, e.g. the North Island, to the extent that it is seldom recognised as a threat in these areas (Gerard et al., 2011). In the south of the South Island, where CRW invasion is in its final throes, rapid introduction of the wasp and obvious success within 2–3 years was crucial in combating farmer despair over CRW impacts that individually may have cost them over $100k p.a.

Irish *M. aethiopoides* are parthenogenetic, capable of producing up to 121 eggs each and of completing their life cycle in as little as 30 days (New Zealand Environmental Protection Agency, 2005). The time taken to develop from egg to adult is largely driven by temperature but population size may be limited by host availability. Their modus operandi is to lay one or more eggs into the body cavity of their adult host rapidly causing reproductive sterility and eventually killing it as the wasp larva emerges for pupation. For most of the year adult CRW are readily available to *M. aethiopoides* but in late winter adult CRW that have overwintered begin to die ultimately resulting in a scarcity of CRW in late spring before new generation adults emerge from the soil in early summer. This period of host scarcity can reduce the build-up of *M. aethiopoides* and potentially limit its effectiveness. In the North Island this is avoided as CRW numbers are initially limited by hot summers and there is sufficient heat accumulation over late summer–autumn for *M. aethiopoides* to complete four generations and reach high enough numbers to severely curtail the impact CRW would otherwise have. In the cooler far south, CRW build up is not restricted to the same extent by hot/dry summers and *M. aethiopoides* is limited to usually only three generations per year. This could suggest that biocontrol of CRW may be less successful in the south. This, however, is not the case and it is suggested here that the widespread presence of the native weevil, *I. stolidus*, acts as an alternative host for *M. aethiopoides*, thereby bridging the gap between CRW generations in spring/early summer. This enables *M. aethiopoides* to begin parasitising a new generation of CRW in summer from a higher starting point than would otherwise be the case.

From a non-target viewpoint this raises the question of what impact such parasitism may have on *I. stolidus* populations and whether or not *I. stolidus* will persist in pastures under *M. aethiopoides* attack. If not, the ongoing effectiveness of the biocontrol effort may be compromised.

Methods

Microctonus aethiopoides was released on 8 February 2010 in a ryegrass/white clover-based pasture near Mosgiel, Otago (Hardwick et al., 2016). CRW and *I. stolidus* populations were sampled monthly to determine parasitism by suction sampling an approximately 1200 m long × 0.1 m wide area using commercial leaf sucking blower vacs (Echo ES-255ES, Stihl SH56C or Stihl SH86C) fitted with net bags in the intake tubes (Gerard et al., 2012). Weevils were extracted from the litter collected in Berlese funnels (Crook and Ferguson, 2004) and subsequent hand sorting. Parasitism levels were determined by keeping up to 100 weevils of each species captive in laboratory cages for 4 weeks to allow parasitoid emergence. In addition, depending on availability, up to 50 weevils of each species were dissected to detect parasitoids and determine reproductive status of female weevils. Weevil densities were measured monthly from August 2012 by taking sixteen 20 × 20 cm turves 40 mm deep from the pasture and extracting weevils from these using Berlese funnels. From August to December 2015 weekly turf sampling was carried out over the period of *I. stolidus* eclosion and oviposition, to determine more fully the impact of parasitism of *I. stolidus* on its reproductive ability.

Results and Discussion

Parasitism of CRW and confirmation of *M. aethiopoides* establishment was recorded in February 2011. The first record of *I. stolidus* parasitism was in November 2011. Before *M. aethiopoides* release its potential for non-target parasitism of other weevil species was assessed in quarantine host range tests. Although *I. stolidus* was not included, the congeneric *I. aequalis* Broun was determined in that testing to be a potential host. Retrospective testing of *I. stolidus* confirmed it was readily parasitised, even in the presence of CRW.

Density estimates of CRW (Figure 1) consistently showed emergence of new generation adults from the soil beginning in late spring with peak emergence in January followed by a decline in July and August. Except for a density of 89/m^2 being recorded in January 2015, maximum CRW adult densities were 20/m^2 or less throughout the years of sampling. *Irenimus* *stolidus* emergence from the soil began in mid-autumn (April) (Figure 1) and peaked in early spring (September). Maximum spring densities were 20, 40, 23 and 23/m^2 from 2012–15 respectively. Reproductive *I. stolidus* females were found from April to December with the greatest proportions of reproductively mature females, as indicated by eggs in calyces, generally occurring between August and October (Figure 2), when parasitism levels were very low (<13%), (Figure 2). While low levels of parasitism were detected in overwintering *I. stolidus*, higher levels (approximately 50–70%) were evident from late October to late November, presumably as overwintering *M. aethiopoides* gave rise to a new generation. In 2015, when monitored weekly, density and parasitism of *I. stolidus* declined sharply in December coinciding with emergence of new generation CRW adults. Reproductive sterilisation of parasitised *I. stolidus* appeared very similar to that of CRW with 97% of total parasitised female *I. stolidus* dissected (n=260) having no eggs in their calyces compared to 49% (n=608) of unparasitised female weevils.

In conclusion while *M. aethiopoides* parasitises *I. stolidus* causing reproductive sterility and eventual death the potential impact of such parasitism is lessened by most female *I. stolidus* becoming reproductively mature in late winter/early spring, when adult *M. aethiopoides* are not present, and producing most of their eggs before parasitism occurs. It is mainly after this period that they provide alternative hosts that *M. aethiopoides* is able to exploit before the emergence of new generation CRW. This means that populations of *M. aethiopoides* are higher than would otherwise be the case, enabling greater parasitism of CRW. It is possible that other native weevils perform a similar role.

Figure 1.

Densities (/m^2) of adult *Irenimus stolidus* (dark line) and clover root weevil (light line)

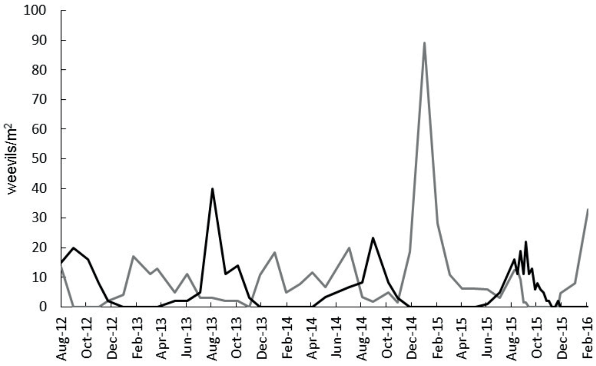
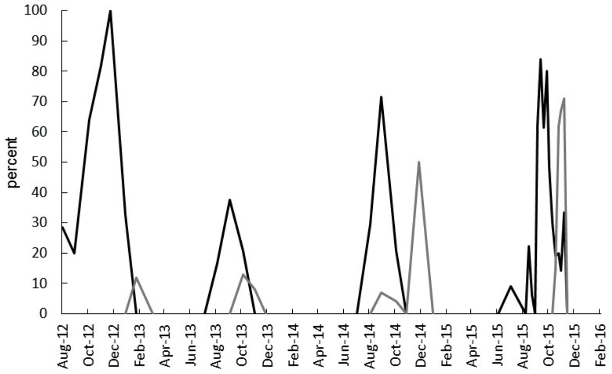


Figure 2.

Percentage of *Irenimus stolidus* females that were reproductive (dark line) and percentage of those that were parasitised (light line)



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References

Crook, K. E., Ferguson, C. M., and Barratt, B. I. P. 2004. 'Heat extraction of invertebrates from grassland turf samples', *Proceedings of the 8th Australasian Grassland Invertebrate Ecology Conference,* (eds L. M. Winder and S. L. Goldson), 102–106.

New Zealand Environmental Protection Agency 2005. Conditional release from containment the Irish strain of the parasitic wasp *Microctonus aethiopoides* for biological control of *Sitona lepidus* (clover root weevil).. http://www.epa.govt.nz/Documents/NOR05001-application.pdf. 75 pp.

Gerard, P. J., Wilson, D. J., and Eden, T. M. 2011. Field release, establishment and initial dispersal of Irish *Microctonus aethiopoides* in *Sitona lepidus* populations in northern New Zealand pastures. *Biocontrol* 56, 861–870.

Gerard, P. J., Vasse, M., and Wilson D. J. 2012. Abundance and parasitism of clover root weevil (*Sitona lepidus*) and Argentine stem weevil (*Listronotus bonariensis*) in pastures. *New Zealand Plant Prot.* 65, 180–185.

Hardwick, S., Ferguson, C. M., McNeill, M. R., and Phillips, C. B. 2016. Using mass-emergence devices to introduce an insect biocontrol agent to a new region and assist its dispersal. *J. Pest. Sci.* 89, 965.10.1007/s10340-015-0719-2

Nixon, C. 2015. How valuable is that plant species? Application of a method for enumerating the contribution of selected plant species to New Zealand's GDP. Wellington, NZ: New Zealand Institute of Economic Research.197 pp.