Cleopus japonicus: releases and distribution of the buddleia biological control agent in New Zealand

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Abstract The buddleia leaf weevil, *Cleopus japonicus*, was released in New Zealand by Scion in 2006 as a biological control agent for the weed *Buddleja davidii*. One thousand *C. japonicus* adults were released at each of five commercial forest sites in the North Island. A further 33 releases of approximately 14,910 *C. japonicus* were made between 2006 and 2011 in the North and South Islands, on both privately- and publically-owned land and sites of conservation importance. The weevil is known to have established at all sites, with the possible exception of one release made in 2007. Location data of *C. japonicus* provided by local and regional councils, DOC, forest health officers and others have provided information on the spread of *C. japonicus*. These data show *C. japonicus* has spread over 50 km from some release sites and is rapidly increasing in population density and distribution.

Keywords buddleia leaf weevil, *Cleopus japonicus*, *Buddleja davidii*, dispersal, distribution maps.

INTRODUCTION

The buddleia leaf weevil, *Cleopus japonicus* Wingelmüller was first released in New Zealand as a biological control agent for the weed buddleia (*Buddleja davidii* Franchet) in October 2006 (Gresham et al. 2009). *Buddleja davidii* is an invasive weed in exotic and indigenous forests in New Zealand. It colonises disturbed sites, competing with tree crops and displacing native pioneer species. The weed is estimated to cost the forestry industry between \$0.5 and \$2.9 million annually in control costs and loss of production (Hill et al. 2003). In addition, councils, the Department of Conservation (DOC) and other land owners and managers incur ongoing expenses associated with managing it. Successful biological control of this weed may assist the forest industry to reduce the use of chemicals

during the establishment phase of plantation forests.

Cleopus japonicus is native to central China. The larvae and adults feed on the surface of buddleia leaves and cause heavily damaged leaves to drop (Zhang et al. 1993). At the time of release there was no information about the ability of the weevil to disperse to colonise new sites, except that adult weevils are able to fly while larvae can move only short distances. Modelling of expected population dynamics of *C. japonicus* by Kriticos et al. (2009) predicted that population growth and resource consumption by the weevil would increase exponentially with time after release and that this would be greater at warmer sites than cooler sites. The model indicated that complete defoliation of *B. davidii* by *C. japonicus* would

occur at some sites, which would then lead to migration. Four different scenarios were tested, as it was unknown how rapidly adults or larvae would respond to the reduction in suitable host plant foliage.

Since 2006, *C. japonicus* release and distribution records have been accurately retained. This paper will analyse the current distribution of *C. japonicus* and its recorded patterns of dispersal from known release sites in the four and a half years since its release. From now on stakeholders and members of the public are being encouraged to re-distribute the weevil themselves, so accurate analyses of dispersal patterns will no longer be possible.

METHODS

Following approval from the Environmental Risk Management Authority (ERMA) to release *C. japonicus* in New Zealand, five release sites were initially chosen in commercial forests in the central North Island to monitor the establishment, spread and effects of the weevil under a range of climates (Figure 1) (Kriticos et al. 2009). At each site 1000 weevils were released over a 4-month period and the sites were monitored closely for 3 years. Once establishment was confirmed at all five sites, focus then turned to establishing *C. japonicus* more widely in New Zealand. Regional Councils (RC), District Councils (DC), forestry companies and DOC were given the opportunity to make releases of the weevil in suitable habitats that they managed, and together these releases totalled at least 14,910 individuals. Adults released in 2006–2007 were reared in the Scion laboratory; from 2008 all releases were of field-collected adults. Most field collections were made from the Scion nursery site, Kinleith, Whakarewarewa and Rawhiti Forests. Areas where *B. davidii* was a particular problem were targeted, but the majority of releases to date have been within the central North Island. Most release sites were revisited at least yearly and the presence of *C. japonicus* adults, larvae and feeding recorded. This involved a thorough search of the *B. davidii* in areas where the release was made (ranging from 15 min to 1 h). Site visits were carried out

by those who made the original release. A visual estimation of the percentage of foliage removed by *C. japonicus* was made by comparing affected plants with those with no damage. Establishment of *C. japonicus* was declared at a site when the agent was present 1 year after release.

The resultant distribution reported here is an amalgamation of positive *C. japonicus* identification records collected by Scion during surveys, as well as random finds by Scion staff and contacts within the forestry industry, pest surveillance officers, council staff and members of the public. Not all of the numerous releases made within commercial forest estates in the past 2 years are reported here as these have not been revisited to ascertain resultant *C. japonicus* dispersal.

RESULTS

As reported previously (Watson et al. 2009), *C. japonicus* established successfully at all release sites (Table 1), with the possible exception of one of the 2007 Upper Hutt release sites. The establishment of releases made less than a year ago has yet to be ascertained. Assuming that all new location records to date are a result of natural *C. japonicus* dispersal, the agent has dispersed between 5–50 km from each of the initial 2006 release sites in the intervening 4.5 years. Feeding damage by the weevil has been considerable, with complete defoliation of some plants.

Cleopus japonicus has now been released in many areas of the North Island and several sites on the South Island (Figure 1). The current distribution of *C. japonicus* in New Zealand is shown in Figure 2. According to observations made by land managers, dispersal from smaller releases made from 2007 onwards (250 to 500 adult weevils) was less than 10 m at all sites in the first year, ranged from 5 to 20 m in the second, 10 m to 1 km in the third, and from 10 m to 2 km in the fourth year. The most rapid dispersal from the releases made since 2007, was recorded at the Kaikoura site where the agent had spread approximately 2 km from the release plants at year 4.

Table 1 *Cleopus japonicus* release sites as at April 2011. Sites marked with * are experimental sites. RC=Regional Council, DC=District Council. Codes in brackets are Crosby regions (Crosby et al. 1976). Where more than one release was made in the same area on the same day, this is shown as (× number of release sites). ^ = many releases made at the same site over many months to give the total release number. #=many releases made at nearby sites, over a number of years. NOTE: *C. japonicus* has been located at one of the two Upper Hutt sites.

Who made release	Location	Date released	Number adults	Present after 1 year
Scion	Whakarewarewa Forest	Sep 2006	200	Yes
Scion	Whakarewarewa Forest*	Oct 2010^	1000	Yes
Scion	Kinleith Forest*(TO)	Oct 2010^	1000	Yes
Scion	Esk Forest* (HB)	Oct 2010^	1000	Yes
Scion	Rawhiti Forest* (BP)	Oct 2010^	1000	Yes
Scion	Taupo Forest* (TO)	Oct 2010^	1000	Yes
Scion	Scion grounds* (BP)	2007-2011#	4850	Yes
Greater Wellington RC	Upper Hutt (WN)	Nov 2007	250(×2)	Yes
Horizons RC	Taumarunui (TO)	Nov 2007	250(×2)	Yes
Scion	Murupara (TO)	Dec 2007	500	Yes
PF Olsen	Pyes Pa Rd (BP)	Feb 2008	250(×4)	Yes
Environment BoP RC	Tauranga (BP)	Feb 2008	500	Yes
Environment Canterbury	Kaikoura (KA)	Mar 2008	500	Yes
Tasman DC	Bishopdale, Riwaka (NN)	Apr 2008	250(×2)	Yes
Northland RC	Kaikohe (ND)	Apr 2008	500	Yes
Scion	Kaingaroa Forest*(BP)	Nov 2008^	1000	Yes
Scion	Kinleith Forest* (TO)	Nov 2008^	1000	Yes
Scion	Tauranga (BP)	Mar 2009	60	Yes
Juken Nissho	Patunamu Forest	Apr 2009	200	Yes
Environment BoP RC	Lake Rotoma (BP)	May 2009	300	Yes
Environment BoP RC	Te Urewera (NP)	May 2009	500	Yes
Hawke's Bay RC	Puketapu (HB)	May 2009	300	Yes
Rayonier	Matariki Forests (BP)	May 2009	300	Yes
Greater Wellington RC	Masterton (WA)	Apr 2010	300	–
Scion	Rotorua (BP)	Apr 2010	100(×3)	–
Scion	Rotorua (BP)	Apr 2011	200	–
Juken Nissho	Gisborne (GB)	Apr 2011	400	–
PF Olsen	Nemona Forest (BR)	Apr 2011	100(×2)	–
Newmont Waihi Gold	Waihi (CO)	Apr 2011	300	–

DISCUSSION

Cleopus japonicus has successfully established at a range of sites in New Zealand from releases of 60 to 500. It is not known why *C. japonicus* has not been relocated at one of the Upper Hutt sites. The weevil may be present at this site at very low numbers, or may have moved to another area, or may not have established at this site as it proved unsuitable for some reason.

The rate of *C. japonicus* population dispersal appears to be increasing many-fold faster with each subsequent year since the first release, presumably as each population increases exponentially in density. At first, *C. japonicus* dispersal was relatively slow. At the first five release sites made in 2006–2007 the weevil was calculated to have dispersed on average between 27 and 65 m/year (Watson et al. 2011). At the coastal

Figure 1 *Cleopus japonicus* release sites within New Zealand distinguished by year (2006–2011).

Figure 2 Distribution of *Cleopus japonicus* in central North Island at April 2011.

release site near Ohope, which is the warmest of these sites, *C. japonicus* has been particularly successful at colonising sites of previously undamaged *B. davidii*. Here *Cleopus japonicus* was found up to 1 km away by the third year and is now at least 50 km from the initial release site (Figure 2). This is consistent with predictions made by Kriticos et al. (2009). At the Whakarewarewa release site in Rotorua, the average spread was 27 m in the first 3 years, but is now present up to 40 km away (Figure 2). At the Kinleith and Esk forest release sites the dispersal is now at least 30 km. More recent releases have shown lower rates of initial dispersal, in keeping with their earlier stages of population growth and spread.

As was predicted by the population modelling (Kriticos et al. 2009) feeding damage by *C. japonicus* is strongly seasonal (Watson et al. 2011), with the greatest damage in late summer to autumn when most *B. davidii* plants, from

seedlings to very large bushes, become completely defoliated. This peak is a result of a dramatic increase in the number of larvae present at this time. Modelling by Watt et al. (2007) indicated that greater than 30% defoliation to *B. davidii* was required to reduce plant height growth as *B. davidii* can strongly compensate for defoliation. A field trial demonstrated that *C. japonicus* has the ability to suppress the growth of *B. davidii*, with a 19% reduction in plant height in un-treated compared with insecticide treated plants 463 days after trial initiation (Watson et al. 2010). The weevil has been observed by M. Watson and T. Withers in April and May flying in large numbers to locate suitable new hosts when local resources are exhausted. It has successfully located isolated plants, including tiny seedlings, and colonised new areas. Recent observations of complete defoliation of *B. davidii* bushes within 1 km of several of the original release

sites in the past two to three seasons suggests that growth suppression of *B. davidii* is likely.

The current distribution of *C. japonicus* in New Zealand is patchy, but it is hoped the agent will eventually establish in every site where *B. davidii* is present. In much of the South Island *B. davidii* is not as serious a weed as in the North Island, with the exception of some dense infestations on the South Island's north and east coasts. Similarly, this weed is only patchily distributed in Northland and the west coast of the North Island. Yet, Kriticos et al. (2005) predicted that all of New Zealand is climatically suitable for *B. davidii* other than the higher altitude mountainous areas, so it poses a potential threat to all disturbed habitats over much wider areas than its current distribution reveals. The weevil appears to be well suited to the New Zealand climate, with the greatest effect on buddleia seen at the warmer sites (Watson et al. 2011).

Land owners and managers involved with the original sites have been redistributing adult *C. japonicus* to other areas with *B. davidii* from late spring to autumn. This redistribution will further increase the spread of *C. japonicus* and bring the environmental benefits of this biological control agent to regions throughout New Zealand.

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