Dispersal of the Scotch broom gall mite *Aceria genistae*: implications for biocontrol

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Abstract The gall mite *Aceria genistae*, a biological control agent of Scotch broom *Cytisus scoparius*, was first released in New Zealand in 2007. The dispersal ability of *A. genistae* was investigated to determine whether slow dispersal might limit its ability to control Scotch broom in forestry plantations, where a rapid impact of biocontrol is required. Transects were set up from the original release plants at four sites in Canterbury, New Zealand, and the presence or absence of galled plants was recorded at increasing distances from the release plants until no more galled plants could be found. The maximum dispersal rate recorded was 83.3 m/year, which is unlikely to be fast enough to greatly benefit forestry in New Zealand. Techniques may have to be developed to enhance mite dispersal in forestry plantations.

Keywords biological control, weed, dispersal, forestry, agent impact.

INTRODUCTION

Eriophyid mites have been considered to be ideal biological control agents due to the debilitating damage they cause to plants and their largely specialized feeding habits (Rosenthal 1996). An eriophyid mite *Aceria genistae* Nalepa was given a high priority for introduction to control *Cytisus scoparius* (L.) Link, henceforth broom, in New Zealand because it produces large galls that are associated with stem dieback and even plant death in Europe, where it is native (Syrett et al. 1999). *Aceria genistae* was first introduced into New Zealand in November 2007 and pesticide exclusion plots to measure its impact have recently been established by Landcare Research.

As well as being a weed of pasture and natural ecosystems, broom is a major weed of forestry (especially *Pinus radiata* D. Don) plantations in New Zealand (Syrett et al. 1999; Watt et al. 2003), where broom seedlings regenerate from the seed bank following clear-felling, and impact on plantation growth over a 5-6 year time frame before becoming overtopped and eventually shaded out by canopy closure (Richardson 1993). To be of any benefit, a biocontrol agent must, therefore, disperse onto regenerating broom seedlings and become sufficiently abundant to reduce broom's competitive ability within 2-5 years. Biocontrol agent dispersal ability is likely to be critical for biocontrol success in disturbed habitats, where herbicide use or crop rotation may rapidly eliminate a host weed and its associated biocontrol agents (e.g. Peschken & McClay 1995). For example, ragweed leaf beetle *Zygogramma suturalis* F. populations increased rapidly following introduction into an uncultivated site in Russia but dispersed slowly and only locally suppressed

ragweed *Ambrosia artemisiifolia* L. Moreover, its impact on the target weed was negligible after crop rotation practices were resumed (Reznik et al. 2008). By contrast, the *Chondrilla* rust pathogen *Puccinia chondrillina* L., disperses readily and increases rapidly, and is highly successful in cropping situations (Cullen et al. 1973).

Eriophyid mites are wind-dispersed and other species used for weed biocontrol have dispersed slowly (e.g. *A. malherbae* Nuzzaci dispersed at a rate of only 125 m/year in North America; Paynter & Bellgard 2011). Therefore, *A. genistae* dispersal in New Zealand was investigated to determine its potential for biocontrol of broom in forestry plantations.

MATERIALS AND METHODS

Fieldwork

On 26 and 27 April 2012, four of the earliest locations where *A. genistae* was released in Canterbury, New Zealand (with release dates ranging from 12/02/2008 to 30/04/2010; Table 1), were visited. A Global Positioning System (Garmin GPSmap 60Cx) was used to relocate the original release plants at each site. The initial releases were made by tying cut galled stems (using twist ties; Snell Packaging & Safety Ltd) to living broom plants, with the exception of the Twin Bridges site (Table 1), where four infested potted broom plants had been planted within a patch of broom. The release plants could, therefore, be identified by the presence of twist ties or the potted broom plants. A transect from each release point was then set up (the direction was influenced by the availability of host plants) and, at approximately 10 m intervals, GPS coordinates were recorded and the five nearest broom plants sampled for the presence of *A. genistae* galls. This was continued along each transect until the number of galled plants dropped to zero on successive observations.

Analysis

The distance that each sample point was from the release point was measured using the Google Earth Ruler tool (http://www.google.com/earth/index.html). The proportion of infested plants was plotted against the distance along each transect and the distance dispersed per year was calculated for each site.

A model was constructed to predict how rapidly *A. genistae* would have to disperse to impact on broom within 2–3 years after a forestry crop is planted. The model assumes *A. genistae* disperses uniformly in from the edge of a 40 ha circular (radius 356.8 m) clear-felled area infested with broom. The area remaining free of *A. genistae* was calculated for each year assuming a reduction in radius due to dispersal rates of 15, 50, 100 and 200 m/year.

RESULTS

The maximum distance that *A. genistae* gall mites had dispersed from the four release sites was variable (Table 1). At Lansdowne Valley, galls were present on the original release plants, but the

Table 1 Details of the release dates, total distance dispersed (m), time since release (months) and dispersal rate (m/year) for the four locations where *Aceria genistae* was established. Dispersal rate = (distance dispersed/months since release) × 12 months.

Location	Release date	No. galls released	Total distance dispersed	Time since release	Dispersal rate
Leslie Hills Station 1 (invaded pasture) 42°38'20.10"S, 172°46'49.62"E					
	20/01/2010	200 galls	187.5	27	83.3
Leslie Hills Station 2 (invaded pasture) 42°38'41.28"S, 172°46'55.72"E					
	12/11/2008	20 galls	91.2	41	26.7
Twin Bridges (conifer plantation) 42°41'24.54"S, 172°48'00.84"E					
	12/02/2008	4 plants (ca 50 galls)	92.6	50	22.2
Lansdowne Valley (invaded pasture) 43°36'58.68"S, 172°34'57.78"E					
	30/04/2010	20 galls	3.00	24	1.5

only evidence of dispersal was one plant growing ca 3 m away from a release plant that displayed unusually stunted bud growth, which is typical of incipient gall formation. At Twin Bridges and two sites at Leslie Hills Station, gall mites were well established: all plants growing within 15 m of the release site were infested (Figure 1) and some heavily infested plants were either already dead or with dead and dying branches. At Twin Bridges and Leslie Hills Station 2, infestation rates dropped rapidly, so that most plants growing >45 m from the release site were not infested with *A. genistae* galls (Figure 1). The most rapid dispersal occurred at Leslie Hills Station 1, where galls were present almost 200 m away from the release site and 80% of plants growing between 61-75 m of the release site were infested, 27 months after the mite was released (Figure 1).

DISCUSSION

To benefit forest weed management a biocontrol agent should impact on its host weed within 2–3 years after the crop is planted. Watson et al. (2011b) showed that dispersal of the buddleia weevil *Cleopus japonicus* Wingelmüller was variable but that damage above the threshold to reduce buddleia growth occurred >150 m from two of three release sites within 2.5 years of release. It was concluded that there is potential for *C. japonicus* to colonise and damage emerging buddleia plants sufficiently rapidly to benefit forestry.

Nevertheless, because clear felled areas are typically ca 40 ha, an agent would need to cover at least 200 m per year to be most effective (Figure 2), especially for broom as it grows quickly and can regenerate at high densities. *Aceria genistae* dispersal rates recorded in the present study were consistently slower than this. Moreover, infestation rates declined rapidly along each transect, indicating that damaging mite populations with the potential to reduce the competitive ability of broom stands lag the dispersal front. These results indicate therefore, that *A. genistae* does not naturally disperse fast enough to greatly benefit forestry in New Zealand and techniques may have to be developed to enhance mite dispersal in forestry plantations. For example, in South Africa, disseminating slowly-dispersing *Dactylopius* spp. for the control of *Opuntia* cacti was greatly accelerated by the use of 'towers' containing infested plant material that allowed passive wind dispersal to occur over much greater distances compared to natural dispersal from the shorter host plant (Moran et al. 1982) or by intensively releasing agents at 10 m intervals (Foxcroft & Hoffmann 2000).

Further work is required to determine the reasons for the variation in *A. genistae* dispersal rates. As noted for *Cleopus japonicus* in New Zealand (Watson et al. 2011a), dispersal rates may accelerate if *A. genistae* populations increase exponentially. Another possible factor is release size and the timing of release. The latter is likely to be important as mite numbers peak in mid-summer

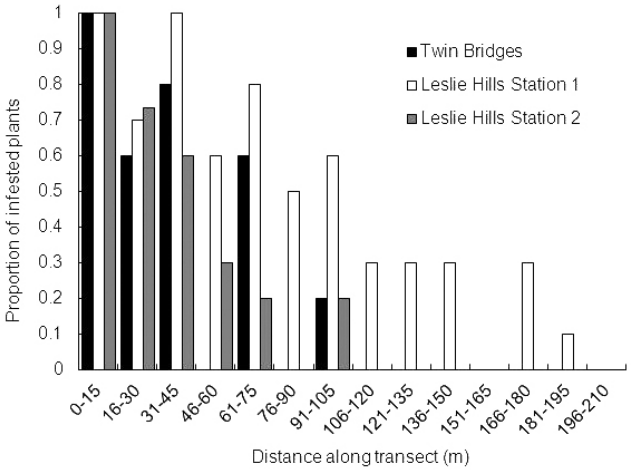

Figure 1 Proportion of plants with *Aceria genistae* galls along transects at a range of distances from the release site at three sites in north Canterbury.

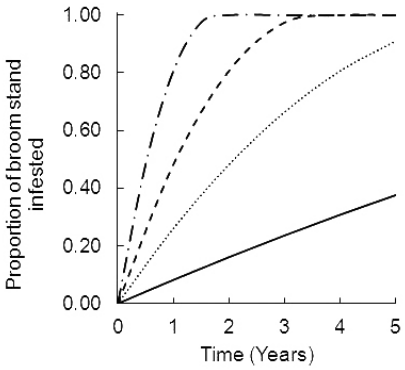

Figure 2 Predicted proportion of a hypothetical circular (radius 356.8 m; 40 ha), clear-felled area infested with broom colonised by *Aceria genistae* over 5 years, assuming uniform dispersal in from the edge of the clear-fell area at rates of 15 m/year (solid line); 50 m/year (dotted line); 100 m/year (dashed line) and 200 m/year (dot and dash line).

while galls collected in the spring and autumn contained few *A. genistae* mites (Zhi-Qiang Zhang, Landcare Research, unpublished data).

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