

Will adult feeding damage rule out introducing *Mecysolobus erro* against buddleia into New Zealand?

Toni M. Withers, Belinda A. Gresham and Michelle C. Watson

Scion, Private Bag 3020, Rotorua 3046, New Zealand

Corresponding author: toni.withers@scionresearch.com

Summary We are evaluating the potential benefits of a second biological control agent for buddleia (*Buddleja davidii* Franch.) in New Zealand in addition to the buddleia leaf weevil, *Cleopus japonicus* Wingelmüller. Adult *Mecysolobus erro* (Pascoe) feed on the terminal stem and fleshy leaf midribs and petioles of buddleia, while the larvae are stem borers, causing stem collapse. No-choice host specificity testing of adults in China predicted the insect was host specific to *Buddleja* species. However, no-choice testing within containment in New Zealand revealed significant adult feeding upon terminal shoots of non-target Scrophulariaceae, e.g. *Scrophularia auriculata* L. and *Verbascum thapsus* L., and some less closely related native plants, *Parahebe hookeriana* (Walp.) W.R.B.Oliv. and *Hebe salicifolia* (L.) Lam. The colony of *M. erro* has since died out and it may not be economically justifiable to reintroduce it to undertake the multiple choice testing that would be necessary to try and determine what the adult weevil's plant feeding preferences might be in the field.

Keywords *Buddleja davidii*, *Mecysolobus erro*, buddleia, host specificity testing, Scrophulariaceae.

INTRODUCTION

Buddleia (*Buddleja davidii* Franch.) is a significant weed of forestry plantations and natural areas of New Zealand. The buddleia leaf weevil, *Cleopus japonicus* Wingelmüller, was released in New Zealand in 2006 as a biological control agent. We are evaluating the potential benefits of a second agent, *Mecysolobus erro* (Pascoe) (Coleoptera: Curculionidae). Adult *M. erro* feed on the terminal stem and fleshy leaf midribs and petioles of buddleia (Zhou *et al.* 2000). Eggs are oviposited singly into intricately formed chambers near the tips of young stems. Females often form more than one chamber per stem, but not all contain an egg. Larvae are stem borers that feed initially within the oviposition chamber, then tunnel downwards, often completely excavating the lower part of the stem causing entire stems to collapse and die. Larvae grow up to 13 mm long.

Information gathered to date on *M. erro* suggests they have potential to be very damaging to the spring and summer growth of buddleia. Such attributes will complement the damage achievable by *C. japonicus*,

which appears to peak each autumn (Watson *et al.* 2009).

MATERIALS AND METHODS

Mecysolobus erro was imported from China into the Scion Invertebrate Quarantine and Containment Facility in 1999. No-choice oviposition and feeding assays were conducted using 30 adult pairs of the second generation of the laboratory colony that had been over-wintered at 10°C. Pairs were transferred in spring to a quarantine room maintained at 21°C and 70% RH and a 14:10 h L:D cycle, and each pair provided with one soft, current season's *B. davidii* stem, that was then changed three times a week. Plant stems were presented to each pair with their cut bases sitting in a water-filled 150 mL glass conical flask. The stem was firmly wrapped with a paper towel where it entered the neck of the flask to act as a bung. A 800 mm high sheet of mylar was rolled into a cylindrical tube and placed over the flask, and covered at the top with fine nylon mesh. Where possible, host plant stems for testing were presented as rooted cuttings with the roots submerged in the water, or as potted plants with the mylar tube sunk 1 cm deep into the potting mix.

Pairs consistently ovipositing for 3 weeks were selected for the host trials. Pairs were re-used sequentially throughout the testing, but were rotated between control and non-target plant species, with at least 1 week between non-target tests. Pairs were excluded if they failed to oviposit on *B. davidii* during that week.

For each host test, each pair was given access to two stems of the test plant for 2–3 days, after which time each stem was scored for feeding damage:

0 = no feeding evident

1 = very few feeding scars,

2 = some feeding scars, but less than would normally occur on *B. davidii*

3 = feeding scars similar to that on *B. davidii* during the same period.

The number of eggs deposited within the stem was recorded by carefully peeling back the outer layer of the stem with a scalpel, then replacing it. All stems containing eggs were labelled and transferred into water-filled vials and inspected weekly to ascertain if larvae were capable of development. Control stems

were held with their bases in water-filled vials for 3 weeks, and then those showing evidence of larval feeding (frass and feeding holes) transferred to sealed labelled plastic bags until adult emergence (Gresham *et al.* 2002).

Host plants for testing *Buddleja* has in the past had its own family Buddlejaceae, but is now considered to be in the Scrophulariaceae. New Zealand has no native *Buddleja* species. The relative palatability of eight exotic *Buddleja* spp. was tested. Eight species of indigenous plants that either were or still are classified within the Scrophulariaceae and a further seven exotic species were also tested. Three exotic plant species from other families that commonly grow in association with *B. davidii* in New Zealand were also tested, as was the host plant of one other *Mecysolobus* sp. (Table 1). In all cases, the fleshiest stems available, ideally with diameters of at least 7 mm, were preferentially chosen for the testing.

Data analysis Statistical comparisons of feeding scores and numbers of eggs laid were made using a Generalized Linear Model procedure using square-root plus $\frac{1}{2}$ transformed data to manage zero counts. Means were separated by Tukey Test (Minitab 15).

RESULTS AND DISCUSSION

Adult feeding damage *Mecysolobus erro* adults created the highest feeding damage upon *Buddleja* spp. (Table 1) and there was a significant difference according to host plant (GLM: $F = 28.04$, $P < 0.0001$). Notably, there was no significant difference in the extent of feeding damage to the *Buddleja* spp. of South African and South American origin, *B. auriculata*, *B. salviifolia* (classified into Section Chilianthus of the genus) and *B. globosa*, compared to those of South East Asian origin, *B. davidii*, *B. madagascariensis* (classified into Section Nicodema of the genus) and *B. alterniflora*.

In the less-closely related tribes of Scrophulariaceae, the highest adult feeding damage was recorded on the Northern Hemisphere weeds *Scrophularia auriculata* and *Verbascum thapsus*. These plant species were also highly palatable to the established biological control agent, the buddleia leaf weevil *C. japonicus* (Kay *et al.* 2008). There are other weevils from Europe (*Cionus* spp. Clairville, and other *Cleopus* spp.) that feed on *Scrophularia*, *Verbascum* and occasionally on adventive *Buddleja* (Kay *et al.* 2005). In the United Kingdom the only specialist lepidopteran to occasionally feed on *B. davidii* is the mullein moth *Cucullia verbasci* L., which normally has the same host range as the figwort weevils (Owen and Whiteway 1980).

Therefore, we can now add *M. erro* to the list of insects that find *Scrophularia*, *Verbascum* and *Buddleja* spp. equally palatable.

Geniostoma ligustrifolium is the only endemic representative of the family Loganiaceae, and it was not a palatable plant to *M. erro*. The most surprising result was the extent of the adult feeding damage to the New Zealand native plants *Parahebe hookeriana* and *Hebe salicifolia*. These genera were previously placed within the Scrophulariaceae, which justified their inclusion in the draft host plant testing list drawn up in the 1990s. But these large genera have now been defined as their own clade of Plantaginaceae placing them more distant from the Buddlejaceae (Stevens 2001). Feeding damage consisted of multiple holes within the terminal buds, stems, leaf bases and petioles on the backs of the leaves, resulting in stems wilting and collapsing completely. Such damage could provide an entry point for pathogens and would undoubtedly reduce the reproductive capacity of the plant as flower spikes are produced only on terminal buds.

The reason for such high feeding damage to the native plants *P. hookeriana* and *H. salicifolia* remains unknown. However the relative palatability shown under no-choice conditions was high enough that multiple choice testing on a high proportion of the species in these extensive genera is now required to ascertain the likelihood of damage in the field. In the absence of such data, it is unlikely the risk posed to the native flora by the introduction of *M. erro* would be considered justifiable.

Adult oviposition The mean number of eggs laid by *M. erro* was highest on some *Buddleja* spp. (Table 1) and there was a significant difference in mean eggs laid according to host plant (GLM: $F = 7.46$, $P < 0.0001$). The only other plant species that was accepted for oviposition was the exotic weed *V. thapsus* with a mean of 1.2 eggs laid. The acceptability of plants for oviposition, based on this no-choice test data, strongly suggests that no self-sustaining populations of *M. erro* would occur on any of the native or valued exotic species tested.

Success of rearing method Using the rearing method developed on cut stems within quarantine (Gresham *et al.* 2002), offspring production during this experiment was low even on *B. davidii*. An analysis of the fate of all eggs per female for one entire breeding season revealed survival from egg to adult ranged between 0 and 38% with a mean of 12% of eggs surviving to adult. Mean development time from egg to adult under the laboratory conditions was 66 days (SE = 0.7). Usually a maximum of one adult is produced

Table 1. Host testing results of *M. erro*. Plant species bearing an asterisk (*) are exotic to New Zealand. Mean feeding damage score and mean number of eggs laid by adult pairs within no-choice tests. Plant species with the same letter are not significantly different at $P < 0.05$ (Tukey Simultaneous test).

Family	Plant species (number pairs tested)	No. reps	Mean feeding damage	Mean number eggs laid
Scrophulariaceae	<i>Buddleja davidii</i> Franch.*	27	2.9 a	1.8 ab
Scrophulariaceae	<i>Buddleja globosa</i> Hope*	5	2.6 a	2.4 ab
Scrophulariaceae	<i>Buddleja lindleyana</i> Fortune*	3	2.3 ab	0 c
Scrophulariaceae	<i>Buddleja madagascariensis</i> Lam.*	3	3.0 a	0.7 bc
Scrophulariaceae	<i>Buddleja parviflora</i> Kunth*	3	2.3 ab	1.0 bc
Scrophulariaceae	<i>Buddleja alterniflora</i> Maxim.*	4	3.0 a	0 c
Scrophulariaceae	<i>Buddleja colvillei</i> Hook.f. & Thomson*	1	2 ab	0 c
Scrophulariaceae	<i>Buddleja salviifolia</i> (L.) Lam.*	4	2.7 a	1.5 bc
Scrophulariaceae	<i>Buddleja auriculata</i> Benth.*	4	3.0 a	0.25 c
Scrophulariaceae	<i>Scrophularia auriculata</i> L.*	2	3.0 ab	0 c
Scrophulariaceae	<i>Verbascum thapsus</i> L.*	5	2.4 ab	1.2 bc
Paulowniaceae	<i>Paulownia tomentosa</i> (Thunb.) Steud.*	3	1.7 b	0 c
Plantaginaceae	<i>Veronica spicata</i> L.*	5	1.2 b	0 c
Plantaginaceae	<i>Digitalis purpurea</i> L.*	3	0 c	0 c
Phrymaceae	<i>Mimulus repens</i> R.Br.	3	0 c	0 c
Phrymaceae	<i>Mazus radicans</i> (Hook.f.) Cheeseman	2	0 c	0 c
Plantaginaceae	<i>Ourisia colensoi</i> Hook.f.	3	1 bc	0 c
Loganiaceae	<i>Geniostoma ligustrifolium</i> A.Cunn.	3	0 c	0 c
Plantaginaceae	<i>Parahebe hookeriana</i> (Walp.) W.R.B.Oliv.	3	2.7 b	0 c
Plantaginaceae	<i>Hebe salicifolia</i> (G.Forst.) Pennell	3	2 b	0 c
Plantaginaceae	<i>Hebe diosmifolia</i> (A.Cunn.) Andersen	2	1.5 b	0 c
Plantaginaceae	<i>Hebe townsonii</i> (Cheeseman) Cockayne & Allan	3	0 c	0 c
Fabaceae	<i>Phaseolus vulgaris</i> L. ^{1*}	3	0 c	0 c
Rubiaceae	<i>Coprosma robusta</i> Raoul ²	2	0 c	0 c
Caprifoliaceae	<i>Leycesteria formosa</i> Wall. ^{2*}	6	1.7 c	0 c
Pinaceae	<i>Pinus radiata</i> D.Don. ^{2*}	3	0.5 bc	0 c

¹The host plant of another *Mecycolobus* sp.

²Other species of plant with fleshy stems growing in close association with *B. davidii* in New Zealand.

from eggs laid in any one stem, so additional eggs laid in the same stem are lost to the population. There was one exception, when two adults were reared from a single *B. davidii* stem.

Offspring production Of the 25 adult pairs used for the host testing only two pairs of adults failed to produce any viable offspring. Excluding the two non-viable pairs from analysis, the only plant stems

from which adults were reared were *B. davidii* with mean survival from egg to adult of 34% (SE = 6.6), *B. salviifolia* with one adult reared from four eggs laid (25% survival), and *B. globosa* with one small adult (that died on emergence) from 12 eggs laid.

Unfortunately we did not test the native shrub *Myoporum laetum* G.Forst. Subsequent to this host testing being undertaken, this species has been relegated to the tribe Myoporeae, within the same clade

as Buddlejaceae. But, with its narrow woody stem and short internodal length, it is unlikely to be suitable for larval development. Furthermore *C. japonicus* did not find *M. laetum* palatable for feeding or suitable for oviposition (Kay *et al.* 2008). We also did not test the native plants *Limosella lineata* Glück (Scrophulariaceae) or *Glossostigma elatinoides* Benth. ex Hook.f. (Phrymaceae; Tank *et al.* 2006) and both being within the physiological host range of *C. japonicus*, but not acceptable for oviposition by *C. japonicus* (Kay *et al.* 2008). These two native plants are semi-aquatic herbs and lack large fleshy stems. However, without including these plants in host testing we cannot rule out the possibility of some adult feeding damage from *M. erro*.

CONCLUSION

The preliminary no-choice testing undertaken in China (Zhou *et al.* 2000) indicated *M. erro* may be host specific to *B. davidii*. The no-choice testing reported herein suggests the host range may be wider and include species of *Buddleja* as well as *Scrophularia* and *Verbascum*. Of most concern was the significant feeding damage undertaken on *Parahebe hookeriana* and two *Hebe* spp. Although self-sustaining populations could not arise on these native non-target species, tip dieback and significant disruption to flowering and seed-set could result from the *M. erro* adult feeding activity causing the petioles and stems to collapse and die on palatable non-target plants. Without additional testing, the risk to non-target plants of introducing *M. erro* into New Zealand is too great. Unfortunately the *M. erro* quarantine colony has since died out. Thus, careful consideration of the economic benefits of introducing a second agent must be made before undertaking more stringent testing.

ACKNOWLEDGMENTS

Thanks to Sarah Hailes for assisting with the host testing. This research was funded by the Foundation for Research Science and Technology contracts CO4X0302 and CO4X0807 to Scion.

REFERENCES

- Gresham, B.A., Kay, M.K., Faulds, W. and Withers, T.M. (2002). The potential of *Mecysolobus erro* (Curculionidae) as a biological control agent for buddleia. *New Zealand Plant Protection* 55, 433 (Abstract).
- Kay, M.K., Gresham, B.A., Hill, R.L. and Zhang, X. (2008). The disintegration of the Scrophulariaceae and the biological control of *Buddleja davidii*. Proceedings of the XII International Symposium on Biological Control of Weeds, eds M.H. Julien, R. Sforza, M.C. Bon, H.C. Evans, P.E. Hatcher, H.L. Hinz and B.G. Rector, pp. 287-91. (CAB International Wallingford, UK).
- Owen, D.F. and Whiteway, W.R. (1980). *Buddleja davidii* in Britain: history and development of an associated fauna. *Biological Conservation* 17, 149-55.
- Stevens, P.F. (2001 onwards). Angiosperm Phylogeny. Version 9, June 2008. <http://www.mobot.org/MOBOT/research/APweb/> (last accessed 08/01/2010).
- Zhou, W., Zhang, X., Xi, Y. and Kay, M.K. (2000). Biological and ecological studies of the long-leg weevil, *Mecysolobus erro* (Pascoe) (Coleoptera: Curculionidae) in China. *Journal of Nanjing Agricultural University* 21, 38-41.
- Watson, M.C., Kriticos, D.J., Berndt, L.A. and Withers, T.M. (2009). Establishment and early spread of the buddleia leaf weevil. IUFRO International Forest Biosecurity Conference Popular Summaries, eds M. Richardson, C. Hodgson and A. Forbes, pp. 87-9. (Rotorua, New Zealand).