THE RISK TO *SOLANUM* SPP. IN NEW ZEALAND FROM *GARGAPHIA DECORIS* (HEM.: TINGIDAE), A POTENTIAL BIOCONTROL AGENT AGAINST WOOLLY NIGHTSHADE, *S. MAURITIANUM*

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ABSTRACT

Woolly nightshade, *Solanum mauritianum* (Solanaceae) is a serious environmental and forestry weed in New Zealand. The leaf-feeding lace bug, *Gargaphia decoris* (Tingidae), was released in South Africa in 1999 after rigorous host specificity testing revealed that natives and crops in the genus *Solanum* were unlikely to be attacked. All three New Zealand native *Solanum* spp. were similarly tested in South Africa. Neither *Solanum laciniatum*, *Solanum aviculare* (poroporo) nor *Solanum americanum* (small-flowered nightshade) supported feeding by nymphs or adults of *G. decoris* in no-choice tests. During multichoice tests, 97% of adults selected *S. mauritianum*, while 2% selected eggplant cv. Black Beauty (*S. melongena*). Oviposition occurred only on *S. mauritianum*. The risks of non-target attack are therefore low enough to warrant further evaluation of *G. decoris* as a biocontrol agent in New Zealand.

Keywords: *Solanum mauritianum*, *Gargaphia decoris*, biological control, non-target impact, poroporo.

INTRODUCTION

The South American tree, *Solanum mauritianum* Scop. (Solanaceae) (woolly nightshade or tobacco weed) is emerging as a serious invasive environmental and forestry weed in New Zealand. Naturalised throughout the North Island since 1883 (Healy 1974), the weed continues to spread through the South Island. It is classified as a national surveillance plant pest (Roy et al. 1998).

Control efforts are confined to herbicides and mechanical control (A.R.C. 1999). Biological control, which promises to be more sustainable and cost effective in the long term, is an option that has been explored in South Africa, where *S. mauritianum* is particularly problematic (Olckers 1996). There are a number of endemic and cultivated *Solanum* species in South Africa (Olckers 1999). Of several biological control agents tested, only the leaf-sucking lace bug *Gargaphia decoris* Drake (Tingidae), released in 1999, has proven sufficiently host specific to be released in South Africa (Olckers 1999, 2000). *Gargaphia decoris* has since established at several sites in the provinces of KwaZulu-Natal and Limpopo.

The feasibility of biological control of woolly nightshade in New Zealand will depend in part on the risks posed to congeneric native and cultivated species by the candidate agents. New Zealand has only three native species of *Solanum* (Healy 1974), *S. aviculare* Forster f. and *S. laciniatum* Aiton (section Archaeosolanum, both known as poroporo) and *S. americanum* Miller (section Solanum, small-flowered nightshade). There are also important economic crop plants such as eggplant (*S. melongena* L.) and potato (*S. tuberosum* L.). It was clearly shown by laboratory tests (Olckers 2000) that potato does not support feeding or oviposition by *G. decoris*, but the results were not as clear

New Zealand Plant Protection 55:90-94 (2002)

with eggplant. There are a number of other *Solanum* species growing in New Zealand; some are minor crop plants, but most are exotic weeds (Healy 1974). The host specificity of *G. decoris* in relation to New Zealand native *Solanum* spp. was investigated in South Africa during 2001-2002.

MATERIALS AND METHODS

Insects

Fifth instar nymphs of *G. decoris*, as well as adults that were observed to have recently moulted from the fifth instar (still white in colour before the cuticle hardened), were collected from woolly nightshade in the field at Cedara, South Africa. They were transferred individually from Petri dishes to a leaf of each test plant, using a pair of forceps.

Plants

Young plants of the species to be tested (*S. aviculare*, *S. laciniatum* and *S. americanum*) were grown from seed collected from the field in New Zealand. They were grown in a glasshouse in South Africa. The species present in South Africa (*S. melongena*, *S. pseudocapsicum* L. and *S. mauritianum*) were grown from local seed and kept in a shade house. All plants were healthy, flowering and fruiting at the time of testing. All experiments took place under both natural (skylight) and artificial lighting ($22\pm3^{\circ}\text{C}$, 14:10 h light:dark).

No-choice experiments

Twenty *G. decoris*, adults or fifth instar nymphs, were introduced onto a single leaf of either a test plant or a woolly nightshade plant standing alone in a nylon mesh/ framed cage (0.6 x 0.6 x 0.8 m). During daily inspections, presence on the plant, mortality and feeding damage was recorded. This was continued until all insects had died, except in the controls where the trials were terminated after 30 days. Where possible three replicates were carried out on each test plant species, each using a different plant. The scoring of feeding damage, ranging from 0 (no feeding), 1 (few feeding scars) up to 5 (total leaf scarring), was identical to that reported in Olckers (2000). The exotic weed *S. pseudocapsicum* (Jerusalem cherry) was also tested with adults, as it also occurs in New Zealand and was not tested by Olckers (2000).

Multiple choice trials with reproductive adults

Two replicates of a multiple choice test were run within a large (2.5 x 1.5 x 2.0 m) nylon mesh walk-in cage. Single specimens of each non-target plant were arranged at random with one in each corner of the cage, and one woolly nightshade placed in the centre. The test species were the two poroporo species, *S. americanum* and egg plant (cv. Black Beauty). One hundred and fifty mature field-caught adults were released into the cage by tipping 75 onto each of two upturned plastic buckets positioned exactly half way between the control and two test plants. The number of adults on the plants, and any feeding damage and oviposition, was recorded at least once daily for 8-10 days.

Statistical analyses

To determine the effect of plant species on *G. decoris* survival, median survival after 10 days was compared between treatments with a Kruskal-Wallis test ($P<0.05$). The significance of adult *G. decoris* preferences for woolly nightshade over the test species was assessed using a contingency table analysis, applied independently to each replicate, on the actual number of insects present on each plant at each sampling period.

RESULTS

No-choice trials

There were significant differences in survival by plant species for both nymphs ($H=10.8$, $df=3$, $P<0.05$) and adults ($H=12.83$, $df=4$, $P<0.05$). All fifth instar nymphs and newly emerged adults of *G. decoris* that were exposed to N.Z. native species died within seven days (Table 1). No feeding occurred on any native plant apart from one nymph that fed on approximately 0.5 cm² of leaf tissue of *S. aviculare*, but died before reaching

adulthood. Adults fed slightly (<1.0 cm²) on Jerusalem cherry leaflets before dying. By contrast, on woolly nightshade all fifth instar nymphs fed and reached adulthood within seven days. Adult survival on woolly nightshade exceeded 95% over the four week period, during which normal oviposition occurred. Time to 50% adult mortality was not measured in the control group because most were still alive at the conclusion of the 30-day study, but comparisons with the raw data from the longer running experiments of Olckers (2000), showed significantly higher survival on woolly nightshade than on all the test plant species ($P < 0.001$).

TABLE 1: Survival of nymphal and adult *G. decoris* on non-target *Solanum* species and *S. mauritianum* during no-choice tests.

Test plant	Stage	No. reps	Feeding score (0-5)	Days to 50% mortality (SE)	% Survival after 10 days (SE)	Mean eggs/colony after 30 days (SE)
<i>S. mauritianum</i>	Nymph	3	3	- ¹	98.3 (1.7)	-
	Adult	3	3	51.7 (16) ²	96.7 (3.3)	1045 (230)
<i>S. aviculare</i>	Nymph	3	<1	1.8 (0.4)	0	-
	Adult	2	0	3.5 (0)	0	0
<i>S. laciniatum</i>	Nymph	3	0	2.0 (0.8)	0	-
	Adult	3	0	3.7 (1.3)	0	0
<i>S. americanum</i>	Nymph	3	0	1.7 (0.2)	0	-
	Adult	3	0	3.5 (0.8)	0	0
<i>S. pseudocapsicum</i>	Adult	3	<1	2.0 (0.3)	0	0

¹All nymphs reached adulthood and most were still alive at the conclusion of the study.

²Estimated figure taken from Olckers (2000).

Multiple choice trials

The multiple choice tests showed that many adult *G. decoris* (37 and 26 out of 150 in reps one and two respectively) had located the woolly nightshade plant within 4 h. Twenty five hours after release, this was 31 and 90 (in reps one and two respectively) on woolly nightshade, compared to 0 – 15 insects on each of the non-target plants. All insects had left the release points within 11 h of release (Fig. 1). Both replicates showed that the number of adults present on each plant was significantly different from that expected if there had been no preference shown for woolly nightshade (rep. 1: $\chi^2=109$, $df=32$, $P < 0.001$; rep. 2: $\chi^2=214$, $df=32$, $P < 0.001$). After 72 h 97% of the adults that were on plants had selected woolly nightshade, and the few that were still on eggplant (1% after 72 h) displayed very little feeding (<5 cm²) and no oviposition. Oviposition, totalling six (rep. one) and four (rep. two) egg batches, was restricted to woolly nightshade.

DISCUSSION

Earlier research had demonstrated that *G. decoris* poses a negligible threat to some of the non-target *Solanum* spp. present in New Zealand (Olckers 2000). For example, potato received virtually no feeding scars in no-choice tests and 50% of adults on this plant had died within 5 days. Eggplant was fed upon within no-choice tests, and in these type of tests, adults did lay viable eggs, although less than on woolly nightshade (Olckers 2000). It was only when the preference for woolly nightshade was shown to be significantly greater than for eggplant in paired choice tests and in multiple choice tests, that *G. decoris* was considered to be sufficiently safe for release in South Africa.

The present trials also showed that neither the two species of poroporo, small-flowered

FIGURE 1: The mean ($\pm$ SE) proportion of *G. decoris* adults on the test plants and *S. mauritianum* during multi-choice tests within a large walk-in cage.

nightshade nor Jerusalem cherry are under any risk of attack from *G. decoris*, since adults failed to feed or oviposit on them in no choice tests. Also, nymphs did not feed or survive to adulthood on any of the test species used in these tests. These conclusions are supported by the very clear preferences for *S. mauritianum* demonstrated in the multiple choice tests. These preliminary studies suggest that *G. decoris* should be considered for more intensive testing. In particular, two minor crops native to southern America, pepino dulce (*S. muricatum* Aiton) and naranjilla (*S. quitoense* Lam.) (P.G. McGregor, pers. comm.), need to be exposed to *G. decoris* in both no-choice and choice arenas, as do any other cultivars of eggplant that are commercially available in New Zealand. These results, and an analysis of the potential risks posed to these crops in the field, will ultimately determine whether *G. decoris* is suitable for release in New Zealand.

ACKNOWLEDGMENTS

We thank C. Ecroyd who identified the *Solanum* plants and seeds, M. Harris who assisted with seed exporting, and colleagues for comments on the manuscript. The Plant Protection Research Institute (Cedara, South Africa) provided laboratory space and equipment for the trials. This research was supported by the FRST contract CO-9X0010 to Landcare Research.

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