# Biocontrol of *Tradescantia fluminensis* in Wellington: how are our beetles doing?

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**Introduction**

*Tradescantia fluminensis* Vell. (family Commelinaceae) is native to South America and has become a serious environmental weed in countries such as Australia, New Zealand, Portugal, South Africa and the USA (Fowler, 2012). *Tradescantia fluminensis* (also known as wandering Jew, wandering willie, and other common names) was introduced into New Zealand as an ornamental species in 1910, and six years later it naturalised to become one of the country's worst invasive species (Jackman, 2015).

*Tradescantia* (Fig. 1A–C) smothers the ground and is very shade tolerant, and prevents seedlings of native species from establishing. It causes habitats to open and be invaded by exotic shrubs and vines. Because of its invasiveness, *Tradescantia* is listed as an Environmental Weed (Howell, 2008), a National Pest Plant Accord species (banning its propagation, sale, and distribution), and is subject to Regional Pest Management Plans by local councils in several areas of New Zealand.

Various control methods have been trialled for *Tradescantia* including herbicides (Syrett, 2002; Hurrell, 2008) and increasing forest light conditions to favour native species germination (Standish, 2002). Due to the capability of *Tradescantia* to rapidly regenerate vegetatively (all remaining stem fragments left behind resprout), none of these control methods have been particularly successful. Extensive infestations coupled with a lack of natural enemies in New Zealand made biological control (biocontrol) of *T. fluminensis* a promising approach. After extensive host range testing by Manaaki Whenua – Landcare Research, to ensure they won't eat any other plant species, three leaf beetle species (Chrysomelidae) were approved for release into the New Zealand environment in 2011 and 2012 (Fowler, 2012). The three beetles, *Neolema ogloblini* (tradescantia leaf beetle), *N. abbreviata* (tradescantia tip beetle) and *Lema basicostata* (tradescantia stem beetle) occupy slightly different feeding niches, increasing their effectiveness when released together.

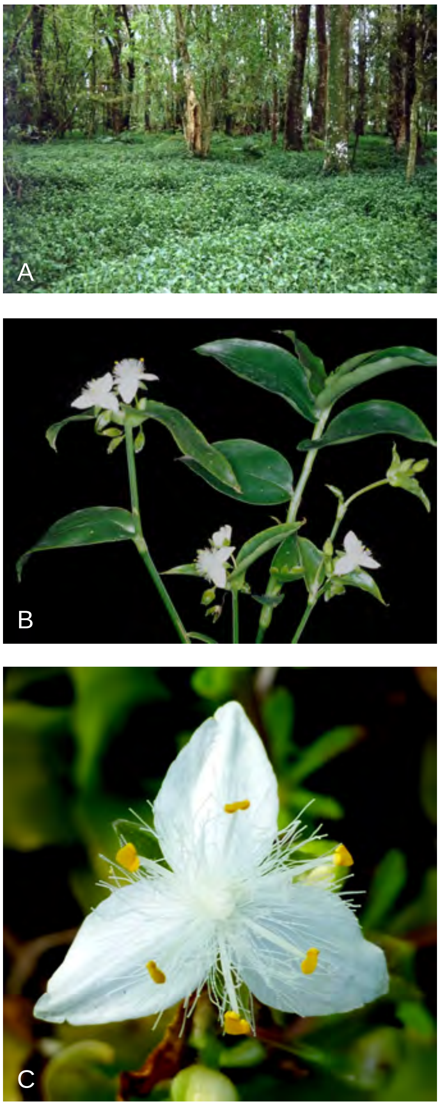


**Fig. 1** *Tradescantia fluminensis.* **A**, dense infestation. Photo: Manaaki Whenua – Landcare Research. **B**, leaves, stems and flower clusters. Photo: Peter Heenan, © Manaaki Whenua – Landcare Research 2014. **C**, close-up of flower. Photo: Murray Dawson.

Wellington's climate provides ideal conditions for *T. fluminensis* to invade, with many forest understories in the city's green spaces completely covered by the weed. Although initial control methods included the use of herbicides, environmental disturbances associated with spraying herbicide raised concerns about the impact on native invertebrate species (Standish et al., 2002). Since Wellington City Council (including Wellington Botanic Garden) pledged to reduce the amount of chemicals released into the environment, the biocontrol option provided a welcome and potentially more effective alternative. Initial releases consisted of all three species purchased from Manaaki Whenua – Landcare Research in Lincoln, Canterbury. In 2015 the Wellington Botanic Garden started a breeding project to supply additional beetles for release within Wellington City Council. Five years into the *Tradescantia* biocontrol project we monitor breeding rates of the beetles at Wellington Botanic Garden and evaluate their impact in the release sites.

**Methods**

***The beetles***

The *Tradescantia* biocontrol beetle breeding project at Wellington Botanic Garden was established with 200 *Neolema ogloblini* (tradescantia leaf beetle), 50 *N. abbreviata* (tradescantia tip beetle) and 50 *Lema basicostata* (tradescantia stem beetle) purchased from Manaaki Whenua – Landcare Research in 2015 (Fig. 2A–C). The three beetle species are briefly described below (summarised from a Manaaki Whenua – Landcare Research webpage, 2017).

***Neolema ogloblini* (tradescantia leaf beetle):** adults are 4–5 mm long and a dark shiny metallic bronze colour. Adults and larvae feed on the leaves, often skeletonising them. The eggs are

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white and hatch about a week after being laid by females on the lower surfaces of *T. fluminensis* leaves. The larvae have 4–5 instars before pupating in white, star-shaped cocoons. New adults emerge from these cocoons after about two weeks. Although the life cycle can be completed in as little as six weeks under warm conditions, it will likely be longer in typical outdoor conditions in New Zealand.


**Fig. 2** The three biocontrol beetle species. **A**, *Neolema ogloblini* (tradescantia leaf beetle). **B**, *Neolema abbreviata* (tradescantia tip beetle). **C**, *Lema basicostata* (tradescantia stem beetle). Photos: Manaaki Whenua – Landcare Research.

***Neolema abbreviata* (tradescantia tip beetle):** adults are also 4–5 mm in length and mostly black in colour with yellow and black striped wing cases. The eggs are similar to those of *N. ogloblini* and after a week the newly hatched larvae bore into the young *T. fluminensis* growing tips. After five instars, the larvae pupate with new adults emerging after two weeks. Development from egg to adult is approximately 10–12 weeks under warm conditions.

***Lema basicostata* (tradescantia stem beetle):** adults are black in colour with a knobbly appearance. The females lay yellow eggs within leaf joints on the stem, the larvae hatch after a week and immediately bore into mature *T. fluminensis* stems where they remain for 4–5 instars before emerging to pupate. As with the other two species, adults emerge from the cocoons after two weeks. Under warm conditions the life cycle is about 12 weeks.

***Breeding sites***

Glasshouse complex

Wellington Botanic Garden has a 510 m² Faber glasshouse complex divided into four independent units. Beetle breeding experiments are conducted in Glasshouse Two and Glasshouse Three where the maximum/minimum temperatures are set at 18ºC/14ºC and 22ºC/19ºC respectively. The minimum temperatures within these units are controlled by five G24 series heaters while cooling is obtained by opening overhead vents and by fans. The computerised climate control system is operated by Sarnia software. Although the maximum/minimum temperatures within these units are set, there can be considerable temperature fluctuations due to the time required to cool the units down once maximum temperatures have been reached. The Sarnia software does not record temperatures therefore DG1921G-F5# (-40°C to 85ºC) Thermochron iButtons are used to record the temperatures at 120-minute intervals. Misting units control the relative humidity within the units which is set to 70–80%.

*Tradescantia fluminensis* propagation

A permit was obtained from the Ministry for Primary Industries to propagate and exhibit the Unwanted Organism *T. fluminensis* for educational and biological control purposes. Material for vegetative propagation is collected from the established *T. fluminensis* population within the Wellington Botanic Garden. Plants are grown in a variety of containers including M150 12 cm plastic pots, 8 cm individual seedling pots and 35 × 30 cm standard punnet trays. Pots in mesh breeding bags are placed into 58 × 30 cm trays to ensure effective draining after watering. Propagated *T. fluminensis* is placed in Glasshouse Three and watered twice a week.

Beetle rearing cages and mesh breeding bags

Fine curtain mesh bags 50 × 50 cm by 100 cm tall are used for beetle breeding while 60 × 60 cm by 120 cm long Perspex insect rearing cages are used to keep surplus beetles prior to release (Fig. 3A–B). Smaller scale temperature trials were conducted in 5 litre plastic containers with mesh lids and ventilation holes.


**Fig. 3** Beetle breeding enclosures. **A**, mesh breeding bags. **B**, insect rearing cages. Photos: Wellington City Council.

***Breeding rates***

The objective was to determine the breeding rate of the beetles in Glasshouse Three and use the information to plan releases in Wellington. Mesh breeding bags were used for the breeding rate replicates which were set up on 16 September 2016 as follows:

- *Neolema ogloblini* (tradescantia leaf beetle) = 5 bags containing 15 beetles each;
- *Neolema abbreviata* (tradescantia tip beetle) = 4 bags containing 15 beetles each.

As there was insufficient *Lema basicostata* (tradescantia stem beetle) this species was excluded from the experiment. To minimise the impact of skewed sex ratios within the small samples, mating pairs of beetles where caught where possible. Monitoring was initiated after eight weeks and all adults were harvested once a week and placed in the insect rearing cages.

***Observations on the effect of temperature on beetle activity***

Based on *ad hoc* observations at the Wellington Botanic Garden it appeared that temperature can affect the reproduction and survival of all three beetle species in Wellington. To determine if this warrants further research, a trial was established under three different temperature treatments; a) Glasshouse Two, b) Glasshouse Three and c) outside. Six *N. ogloblini* (tradescantia leaf beetles) and *N. abbreviata* (tradescantia tip beetles) were placed in separate 5 litre plastic containers within each temperature treatment. Four single-stemmed *T. fluminensis* in 8 cm seedling pots were added to each container. To ensure adequate ventilation, container lids were replaced with mesh covers and additional ventilation holes were punched into the sides. Temperatures were recorded within each container at 120 minute intervals using the Thermochron iButtons. Minimum and maximum temperatures are indicated in the results section below.

***Release sites***

Close to 2,000 *T. fluminensis* biocontrol beetles were released at eight sites on Wellington City Council land between 2012 and 2016. Table 1 summarises the sites, release years, species and quantities.

Each site was visited twice during the 2016/2017 summer season by Victoria University summer scholarship student, Jessica Jenkins. Each site visit lasted a minimum of two hours, and the initial 20 minutes were spent observing the site from the perimeter for any beetle activity (beetles hide below leaf surfaces to prevent detection). After this the release site was systematically searched for damage to *T. fluminensis* which will also indicate beetle presence. The status of the beetles at each site was assessed using the guidelines described in Table 2.

**Table 1** The release sites within Wellington City Council, year(s) of beetle release, species and number released, and total number of beetles released at each site.

| Site description | Release year | Species released (and number) | Total number released at sites |
|---|---|---|---|
| Botanic Garden (Foreman's Landing) | 2015 & 2016 | *N. ogloblini* (200) | 200 |
| Botanic Garden (Quarry Path) | 2017 | *N. ogloblini* (220)<br>*N. abbreviata* (100) | 320 |
| Trelissick Park | 2012 | *N. ogloblini* (380) | 380 |
| Aro Valley | 2013 | *N. abbreviata* (200) | 200 |
| Central Park | 2013 | *L. basicostata* (200) | 200 |
| Te Ahumairangi Hill | 2013 | *L. basicostata* (200) | 200 |
| Kumutoto Forest | 2015 | *N. abbreviata* (118)<br>*N. ogloblini* (200)<br>*L. basicostata* (94) | 412 |
| Mount Victoria | 2016 | *N. ogloblini* (50) | 50 |
| **TOTAL** | | | **1,962** |

**Table 2** Criteria used to determine the status of the beetles at each release site.

| Status | Timeframe | Description |
|---|---|---|
| Pending | Less than five years | No feeding signs or beetles observed |
| Present | At least one winter since release | Beetles or feeding signs present |
| Established | At least two winters since initial release | Beetles or feeding signs present |
| Successfully established | More than three winters since initial release | Beetles or feeding signs present coupled with a visible reduction in *Tradescantia fluminensis* cover |
| Unsuccessful | More than five years since initial release | No beetles or feeding signs |

**Table 3** The number of adults, eggs, pupae and larvae under three temperature treatments after eight weeks.

| Treatment | *Neolema ogloblini* | *Neolema abbreviata* |
|---|---|---|
| Glasshouse 2 | 6 adults<br>8 pupae | 3 adults<br>2 dead adults<br>1 larvae |
| Glasshouse 3 | 27 adults<br>1 dead adult<br>2 eggs<br>2 larvae<br>26 pupae | 4 adults<br>1 egg<br>1 larvae |
| Outside | 4 adults<br>8 larvae | 3 adults<br>1 larvae |

## Results

***Breeding rates***

Under warm conditions, *Neolema ogloblini* (tradescantia leaf beetle) can complete its life cycle in 8–10 weeks compared to 12 weeks for both *N. abbreviata* (tradescantia tip beetle) and *Lema basicostata* (tradescantia stem beetle). It was therefore not surprising that the initial harvest yielded more *N. ogloblini* than *N. abbreviata*. When the experiment was concluded at 24 weeks, there was a 340% increase in *N. ogloblini* compared to a 270% increase in *N. abbreviata* (Fig. 4A–B).

***Observations on the effect of temperature on beetle activity***

The Thermochron iButtons indicated that the maximum temperatures (November 2016 – February 2017) in Glasshouse Two, Glasshouse Three and outside were 25.8ºC, 25.7ºC and 18.5ºC respectively while the minimum temperatures recorded were 14.7ºC, 17.2ºC and 12.4ºC respectively. The effect of temperature

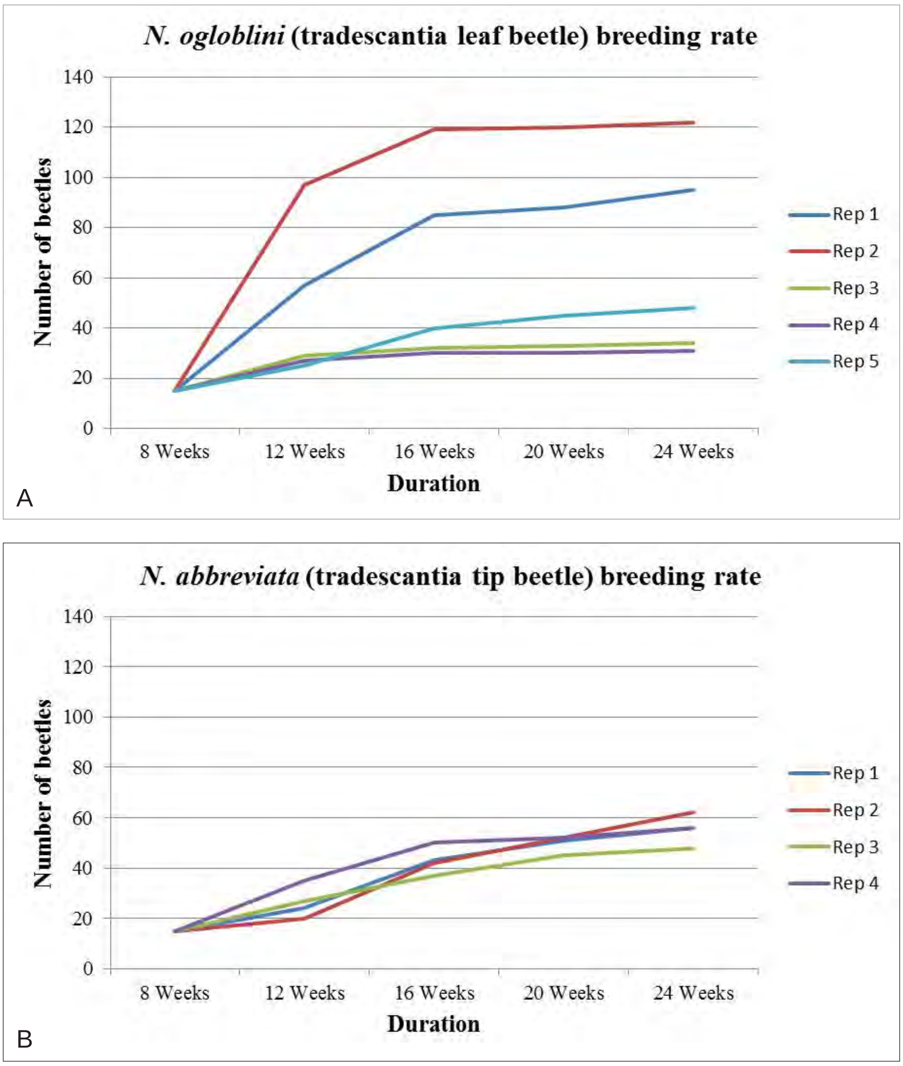


**Fig. 4** Relative rates of increase in the heated glasshouse for tradescantia beetles. **A**, *Neolema ogloblini* (tradescantia leaf beetle). **B**, *Neolema abbreviata* (tradescantia tip beetle).

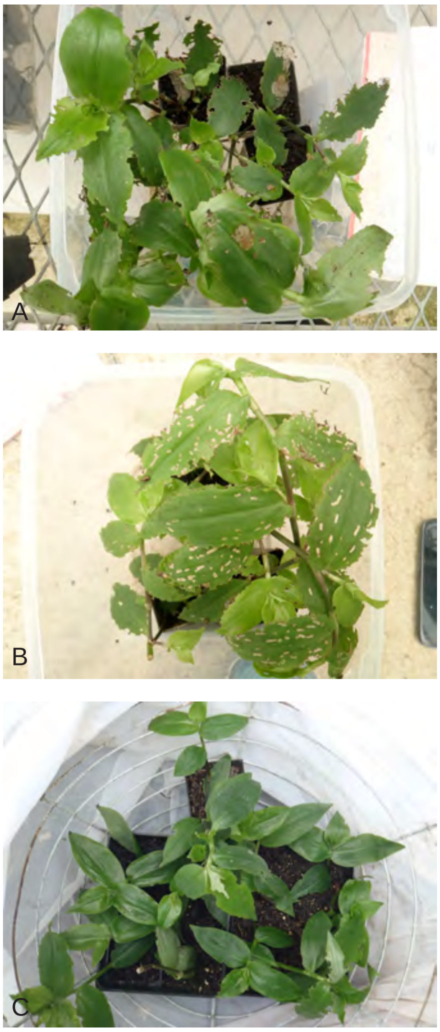


**Fig. 5** Beetle feeding damage to *Tradescantia fluminensis*. **A**, Glasshouse Two. **B**, Glasshouse Three. **C**, outside. Photos: Jessica Jenkins.

on beetle activity was visible in the relative amount of damage (Fig. 5A–C) and reproduction (Table 3).

### *Release sites*

No beetle activity or feeding damage to *T. fluminensis* was observed at four of the eight release sites. The remaining four sites had patchy leaf damage throughout the release site, but no visible decrease in *T. fluminensis* cover. The highest beetle activity and damage was recorded at the new release site (January 2017) at the Wellington Botanic Garden, Quarry Path. Close monitoring during and immediately after this release revealed that the beetles moved out of deep shade areas where *T. fluminensis* is prolific towards the edges where there is more sunlight. During the first month after the release up to 25 beetles could be seen during each monitoring session.

## Conclusions

Long day-length and a minimum of 20ºC are needed to initiate mating in both *Lema basicostata* (tradescantia stem beetle) and *Neolema abbreviata* (tradescantia tip beetle) (Lara Field, Landcare Research, pers. comm.). Mean monthly minimum, maximum and average air temperature data from Wellington's Kelburn Automated Weather Station indicate that maximum temperatures exceeding 20ºC in Wellington are limited to January and February (20.3ºC and 20.6ºC respectively) (NIWA National Climate Database). The average maximum air temperature in Glasshouse Three between 21 November 2016 and 19 January 2017 was 25.7ºC and the high breeding rate for *N. ogloblini* and *N. abbreviata* during this period was therefore expected. However, the average maximum air temperature outside the heated glasshouse over the same time period was 18.5ºC with 20 non-consecutive days above 20ºC, and beetle activity associated with these areas was much lower. Although the long term climatic data raises concerns regarding the suitability of Wellington's climate for the beetles, initial results from this study warrant further investigation. The next steps for the biocontrol beetle breeding project at Wellington Botanic Garden include:

- Long-term monitoring to evaluate the impact of temperature on the biology of *N. ogloblini*, *N. abbreviata* and *L. basicostata*. The hypothesis is that beetles reared at lower temperatures will reproduce slower but over time will increase in weight and size making them more resilient to Wellington's climate. These experiments were started in August 2017 with 50 beetles per sample;
- Determine the lethal cold time for adult beetles using an incubator. Use the results to produce a cold tolerance data map indicating

potential release and establishment areas in Wellington;

- Determine the critical life stages for survival and evaluate the effect of low temperatures on these life stages.

**Additional biocontrol options for Wellington**

In 2013, another biocontrol agent, *Kordyana brasiliensis* (Brazilian yellow leaf spot fungus) was also approved for release in New Zealand. In Brazil *Kordyana* is commonly found in wet and cold environments, and in the longer term might be a good alternative or supplemental agent for *T. fluminensis* biocontrol in the Wellington region (and elsewhere in New Zealand).

**Acknowledgements**

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**Websites (accessed December 2017)**

Landcare Research: Tradescantia: www.landcareresearch.co.nz/science/plants-animals-fungi/plants/weeds/biocontrol/research/projects/tradescantia

NIWA: The National Climate Database: https://cliflo.niwa.co.nz/

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