Phytophagous organisms associated with the woody shrub *Polygala myrtifolia* (Polygalaceae) and their potential for classical biological control in Australia

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Summary

Coastal ecosystems in southern Australia have been invaded by the South African shrub *Polygala myrtifolia* L. (Polygalaceae), leading to ecological disruptions and loss of biodiversity. Expansion of *P. myrtifolia* populations is expected unless effective containment or suppression activities are implemented. Low herbivory pressure in Australia compared to the species’ native range is likely to have contributed to the invasion success of *P. myrtifolia*. Twenty-eight phytophagous organisms are recorded from *P. myrtifolia* in South Africa and six have potential as classical biological control agents, but require formal host specificity and impact evaluation. Further understanding of seed-bank dynamics and recruitment patterns of *P. myrtifolia* in Australia would contribute to the selection of suitable biological control candidates. Seed-destroying agents were not found on *P. myrtifolia* in South Africa, but additional survey effort is warranted as seed-destroying agents could alleviate conflicts of interest between environmental protection and the ornamental garden trade.

Introduction

The South African shrub *Polygala myrtifolia* L. (myrtle-leaf milkwort) occurs naturally in a broad range of vegetation associations distributed across the coastal and near-coastal belt of southern South Africa extending into mountainous areas of KwaZulu-Natal (Drakensberg) and Lesotho and the north-western Western Cape (Bokkeveld Mountains). The species is morphologically highly variable and several infraspecific taxa have been described (Harvey 1860, Bredenkamp 2000). *Polygala myrtifolia* is a popular garden ornamental in South Africa, and is also widely used for horticultural purposes in other temperate climates, particularly Australia, New Zealand, USA and southern Europe (Esler 1988, Cervelli 2001, Meerow and Ayala-Silva 2005). In Australia, the earliest record of *P. myrtifolia* is from nursery catalogues in Adelaide in 1845 (Carter et al. 1990). The first presumed wild collections of *P. myrtifolia* in Australia were made in New South Wales at Hastings River between 1856 and 1862 (MEL 2244752), followed by a collection in Victoria between Brighton and Mentone in 1886 (MEL 2120881). *Polygala myrtifolia* is now naturalized across southern Australia with extensive infestations present in Victoria around Melbourne and in South Australia on the Eyre Peninsula. Isolated and expanding populations are widely scattered in coastal New South Wales, eastern Tasmania and south-west Western Australia (Figure 1). Dense infestations of *P. myrtifolia* disrupt ecological processes in native coastal vegetation and threaten biodiversity values.

Mechanical and chemical control techniques are utilized to suppress *P. myrtifolia*, but are generally only successful when applied to small areas where regular follow-up treatments can be implemented.

In Australia, few phytophagous arthropods occur on *P. myrtifolia*, and herbivory damage is low to negligible. Low herbivory pressure in Australia may contribute to the success of *P. myrtifolia* as an environmental weed. In contrast, phytophagous species can cause substantial damage to *P. myrtifolia* in South Africa, and several species have potential for classical biological control (Adair and Neser 1996). Although *P. myrtifolia* has not been formally accepted as a target for biological control in Australia, this form of suppression is considered the only effective long-term management option.

In this paper, the phytophagous biota associated with *P. myrtifolia* and their potential for biological control are discussed with an emphasis on potential impact on plant health and possible conflicts of interest with horticultural industries. A comparison of herbivory levels on *P. myrtifolia* in South Africa and Australia is made.

Methods

Survey for phytophagous species

Sampling of phytophagous organisms and pathogens associated with *P. myrtifolia* and other Polygalaceae was undertaken between 1996 and 2003 at 41 sites in South Africa, most of which were in the Western Cape (Figure 2). Most sites were sampled once, usually in the spring–summer period.

Figure 1. Australian distribution of *Polygala myrtifolia* based on Australia’s Virtual Herbarium (2011) records.
At a survey site, plants from the Polygalaceae were haphazardly chosen and visually searched for the presence of damaging species. Most survey sites were selected where *P. myrtifolia* was the dominant polygalaceous species present. Other species included in the survey were: *P. fruticosa* P.J.Bergius., *P. teretifolia* L.f., *P. peduncularis* Burch. ex DC., *Polygala myrtifolia* var. *pinifolia* (Lam. ex Poir.) Paiva, P. sp. (labelled as *P. empetrifolia* Houtt.), *Murlalia heisteria* (L.) DC. and *Nylandia spinosa* (L.) Dumort.

Where damage symptoms were evident, stems, twigs or roots were dissected for evidence of phytophage activity and suspected causative agents were collected. Sweep netting and beating were also utilized in instances where bushes were dense and difficult to search visually. Buds, flowers, fruits and seeds were collected, if available, and dissected for phytophagous organisms. Adult arthropods were collected, preserved and deposited with the South African National Insect Collection (Plant Protection Research Institute – Agricultural Research Council (PPRI-ARC), Pretoria) for identification. Mycological specimens were deposited with PPRI (Stellenbosch). If immature arthropod specimens were present, these were reared to adults in the laboratory using the same host taxa that they were collected from in the field as a food source. To increase the extent of the survey, all sheets of *Polygala* and *Murlalia* held at the Compton Herbarium, South African National Biodiversity Institute (SANBI), Kirstenbosch were examined for evidence of phytophage symptoms. Host and phytophage data were collected where clear identifications of phytophages could be made.

**Comparison of herbivory levels between South Africa and Australia**

In 1996, 15 sites in the Western Cape, South Africa and 12 sites in south-eastern Australia, were sampled for herbivory levels by haphazardly collecting 20–25 leaves from the canopy of 2–5 plants of *P. myrtifolia*. Sites in South Africa were sampled in January and February, and Australian sites were sampled mostly in February and March. Leaves were pressed and air-dried. Leaf damage levels were determined by scanning leaves with an ADC Area Meter (Bioscientific Ltd), and calculating leaf area removed from entire individual leaves. Levels of seed herbivory were determined by haphazardly sampling green, but full sized fruits of *P. myrtifolia* and counting the number of seeds in each capsule. Seeds were dissected and searched for signs of herbivory. At least 10 fruits were collected from each of 1–6 plants, where they were available. Inflorescence size and herbivory damage levels were determined by haphazardly sampling racemes from each of 2–4 plants of *P. myrtifolia*. Buds, flowers and fruits were counted to give a measure of inflorescence size, and all floral units were dissected for evidence of herbivory. Shed floral structures were also counted and were recognized by the presence of small bracteoles on the raceme rachis. Data from Australian and South African collections of *P. myrtifolia* were compared using a Students’ t-test assuming unequal variance to determine differences between means. Percentage data was arcsine transformed before analysis.

**Results**

**Location of survey sites**

Survey sites for phytophagous species were located across the distribution of *P. myrtifolia*, with 32 out of 41 sites present in the Western Cape, the centre of distribution for *P. myrtifolia* (Table 1). Plants of *P. myrtifolia* were found in a range of habitats from coastal strandveld, usually on rocky outcrops close to the high tide mark (Figure 3a), macchia and coastal macchia, renosterveld and mesic succulent thicket. *Polygala myrtifolia* var. *grandiflora* Hook. (see Curtis 1837) occurs naturally in coastal vegetation of southern South Africa, particularly in the Knysna region, and was located at six survey sites.

**Phytophagous species**

Twenty-eight phytophagous species from six orders were found on *P. myrtifolia* in South Africa (Table 2). Hemiptera was the best represented order with 11 phytophagous species. Sixteen out of 28 species were external feeders and 11 were internal feeders. Leaves and flowers were used as food sources by the greatest number of organisms with eight and seven species, respectively. The only pathogenic fungus found on *P. myrtifolia* was *Uredo polygalae* Kalchbr. which forms pustules on mature leaves.

**Herbivory levels**

The mean number of flowers produced on racemes, the level of floral abortion, number of seeds produced per capsule, and leaf size were not significantly different between Australian and South African populations of *P. myrtifolia* (Table 3). However, leaf and inflorescences herbivory levels of *P. myrtifolia* populations in South Africa were significantly higher than in Australian populations. Although mean leaf herbivory levels were 0.1% in Australian populations, low herbivory levels (3.3%) were also recorded for South African populations. No seed herbivory was detected in Australian and South African populations of *P. myrtifolia* (Table 3).

**Discussion**

Australian populations of *P. myrtifolia* are subject to very low levels of leaf, flower and seed damage. Stem and root herbivory was not quantified in this study, although these organs could support as yet undetected pathogens and arthropods. Release from herbivory pressure is likely to be a contributing factor to the success of *P. myrtifolia* as an invader in suitable Australian climates. A total of 28 organisms were found associated with *P. myrtifolia* in South Africa, a modest fauna tally compared to other plants from the region with size and distribution similarities.

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**Figure 2. Distribution of *Polygala myrtifolia* in South Africa (shaded) and location of survey points (○) for phytophagous organisms.**
(113 taxa from Chrysanthemoides monilifera (L.) Norl. (Scott and Adair 1990), 400 taxa from Delairea odorata Lem. (Grobbeelaar et al. 2003), 14 from Senecio madagascariensis Poir. (Marshall 1989), and 31 from Solidum limnaeunnum Hepper & P.-M.L.Jaeger, 49 from S. panduriforme Drège ex Dunal and 33 from S. incanum L. (Olkers and Hulley 1989, Olckers et al. 1995). However, more regular and intense surveys of phytophagous organisms associated with P. myrtifolia, particularly in KwaZulu-Natal and the Cedarberg Range north of Cape Town, both areas not well sampled in this study, may increase the total number of organisms known from this plant.

Six organisms found in South Africa potentially reduce growth or reproductive output of P. myrtifolia. All require further study on aspects of their biology, host-specificity or taxonomy. In addition, the impact efficacy of these agents needs to be formally assessed by incorporating potential damage attributes into modelled life-history dynamics of P. myrtifolia. This approach is outlined by Briese (2006) and McClay and Bafiunas (2006). Unfortunately, much of the data required for the construction of an informative life history model for P. myrtifolia is either unavailable or poorly detailed. The following organisms are potential biological control agents of P. myrtifolia and should receive priority for future evaluation programs:

**Diaphorina petteyi** Capener (Hemiptera: Psyllidae)
Nymphs and adults feed on the buds and flowers of P. myrtifolia causing disfiguration and abortion of fruits (Figure 3b). Early to late bud stages are attacked and many individuals may be found within a single flower bud. In heavily attacked plants, most inflorescences fail to develop and populations of D. petteyi are readily recognized by the absence of open flowers or the ‘drying off’ of inflorescence material. Diaphorina petteyi was found at 42% of survey sites across the distribution of P. myrtifolia in South Africa indicating a broad acceptance of host genotypes and climatic conditions. Only P. myrtifolia was found to be attacked by this insect indicating a high level of specificity. A sibling species, **D. florae**, is recorded from the flower heads of P. fruticosa (Capener 1970), which can occur sympatrically with P. myrtifolia. Diaphorina petteyi is parasitized, often heavily, by a *Pseudotorymus* sp. (Torymidae) and an unidentified braconid in South Africa.

**Aceria myrtifoliae** Meyer & Ueckermann (Acanthacarida: Eriophyidae)
Immatures and adults feed in terminal and axillary buds causing rosette-like structures of fleshy, crinkly, leaves (Meyer and Ueckermann 1996) (Figure 3c). Both floral and vegetative buds are attacked resulting in South Africa.

<table>
<thead>
<tr>
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<th>Site name</th>
<th>Location</th>
<th>Host</th>
</tr>
</thead>
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</tr>
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<td>Pm</td>
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<td>Pm</td>
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Figure 3. Biological control of *Polygala myrtifolia*. a) Low stature plants on pebble beach at Betty’s Bay, Western Cape Province. b) *Diaphorina petteyi* damage to flowers and buds. c) Shoot galls formed by *Aceria myrtifoliiae*. d) *Coryphodema* sp. larva in split basal stem of *P. myrtifolia*. e) *Duffyoemida barkeri* from *P. fruticosa*. f) Shoot-tip galls formed by *Dasineura* sp. g) Leaf lesions of *Uredo polygalae* from *P. myrtifolia* at Betty’s Bay.
Table 2. Phytophagous species collected on *Polygala myrtifolia* in South Africa.

<table>
<thead>
<tr>
<th>Order/family</th>
<th>Species</th>
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<td></td>
<td>Eriophyiidae</td>
<td>A. myrtifoliae Meyer &amp; Ueckermann</td>
<td>Pm, Pmg</td>
<td>S</td>
<td>shoots, buds</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Tetranychidae</td>
<td>T. urticae (Koch)</td>
<td>Pf</td>
<td>R</td>
<td>leaves, seedlings</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>Uredinales</td>
<td>U. polygalae (Koch)</td>
<td>Pm, Pmg, Pf</td>
<td>S</td>
<td>leaves</td>
<td>S</td>
</tr>
</tbody>
</table>

Hosts listed in bold are those where specimens were collected and submitted for identification. 1. *Polygala fruticosa* in Compton Herbarium Sheet 3573. 2. Record based on herbarium specimens showing symptoms of attack the same as those seen in field specimens. 3. An unidentified Cecidomyiidae that galls flowers of *P. myrtifolia* var. *pinifolia* may be also present on this host. 4. *Ophiomyia* sp. with similar gall symptoms was reared from *M. heisteria* (AcUCT526). 5. Gall-forming *Aceria* from *P. fruticosa*, *P. virgata* and *N. spinosa* can be distinguished morphologically from *A. myrtifoliae*. B = abundant (often in high numbers), C = common (at most sites but in small numbers), S = sporadic (at a small number of sites, but sometimes in abundance), R = rare (few sites in abundance), K = capable of killing host, D = debilitates host but recovery usually occurs, N = negligible impact.
### Table 3. Herbivory levels from *Polygala myrtifolia* collected from South Africa and southern Australia.

<table>
<thead>
<tr>
<th>Site</th>
<th>State/Province</th>
<th>No. flowers/raceme</th>
<th>Inflorescence herbivory</th>
<th>Floral shedding</th>
<th>No. seeds/capsule</th>
<th>Seed herbivory</th>
<th>Leaf herbivory</th>
<th>Leaf area&lt;sup&gt;10&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merimbula</td>
<td>NSW</td>
<td>7.1 ± 1.2</td>
<td>0.5 (217)</td>
<td>28.1 ± 9.3</td>
<td>1.7 ± 0.03</td>
<td>4 (145)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Coolart</td>
<td>VIC</td>
<td>9.6 ± 0.2</td>
<td>0.4 (250)</td>
<td>34.1 ± 13.1</td>
<td>1.6 ± 0.3</td>
<td>4 (111)</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Mornington</td>
<td>VIC</td>
<td>10.2 ± 1.6</td>
<td>0 (258)</td>
<td>34.1 ± 10.2</td>
<td>1.5 ± 0.3</td>
<td>4 (43)</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Victor Harbour</td>
<td>SA</td>
<td>9.5 ± 1.5</td>
<td>0.3 (308)</td>
<td>23.0 ± 6.6</td>
<td>1.5 ± 0.1</td>
<td>3 (60)</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Point Nepean</td>
<td>VIC</td>
<td>11.2 ± 1.3</td>
<td>0 (202)</td>
<td>42.1 ± 9.4</td>
<td>1.8 ± 0.3</td>
<td>3 (42)</td>
<td>0</td>
<td>0.13</td>
</tr>
<tr>
<td>Quakers Hut</td>
<td>NSW</td>
<td>9.9 ± 0.5</td>
<td>0 (258)</td>
<td>46.2 ± 12.5</td>
<td>1.5 ± 0.5</td>
<td>3 (44)</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Rye</td>
<td>VIC</td>
<td>10.7 ± 1.6</td>
<td>0 (262)</td>
<td>21.9 ± 7.4</td>
<td>1.6 ± 0.2</td>
<td>3 (72)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dalrymple</td>
<td>NSW</td>
<td>6.2 ± 2.4</td>
<td>0 (178)</td>
<td>n/a</td>
<td>1.7 ± 0.06</td>
<td>2 (24)</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Swan Lake</td>
<td>VIC</td>
<td>7.3 ± 1.6</td>
<td>6.7 (179)</td>
<td>22.2 ± 3.8</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>Sandy Beach</td>
<td>TAS</td>
<td>11.5 ± 3.8</td>
<td>0 (413)</td>
<td>34.7 ± 12.7</td>
<td>1.7 ± 0.1</td>
<td>4 (63)</td>
<td>0</td>
<td>0.13</td>
</tr>
<tr>
<td>Casula</td>
<td>NSW</td>
<td>4.3 ± 0.8</td>
<td>0 (151)</td>
<td>25.1 ± 11.1</td>
<td>1.7 ± 0.2</td>
<td>3 (57)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>John Forest</td>
<td>WA</td>
<td>11.7 ± 2.8</td>
<td>0.4 (263)</td>
<td>10.2 ± 3.5</td>
<td>1.9</td>
<td>1 (23)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goukamma</td>
<td>WC</td>
<td>5.9 ± 1.7</td>
<td>11.6 (69)</td>
<td>n/a</td>
<td>1.6 ± 0.5</td>
<td>1 (28)</td>
<td>5.1</td>
<td>235.3 (3)</td>
</tr>
<tr>
<td>Cape Agulhas</td>
<td>WC</td>
<td>3.4 ± 0.4</td>
<td>2 (17)</td>
<td>31.2 ± 13.6</td>
<td>1.7 ± 0.5</td>
<td>2 (6)</td>
<td>0.7</td>
<td>125.3 (3)</td>
</tr>
<tr>
<td>Franskaal</td>
<td>WC</td>
<td>10.0 ± 0.5</td>
<td>3 (15)</td>
<td>33.1 ± 14.8</td>
<td>1.8 ± 0.2</td>
<td>3 (25)</td>
<td>1.7</td>
<td>157.5 (3)</td>
</tr>
<tr>
<td>Gouritz River</td>
<td>WC</td>
<td>9.4 ± 3.7</td>
<td>6 (23)</td>
<td>40.8 (144)</td>
<td>28.4 ± 14.9</td>
<td>1 (29)</td>
<td>6.7</td>
<td>55.3 (3)</td>
</tr>
<tr>
<td>Fairy Knowe</td>
<td>WC</td>
<td>7.1 ± 2.8</td>
<td>45.5 (77)</td>
<td>71.7 ± 8.6</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>4.8</td>
</tr>
<tr>
<td>Kariega</td>
<td>EC</td>
<td>3.7 ± 0.4</td>
<td>42.3 (78)</td>
<td>28.7 ± 4.2</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>3.5</td>
</tr>
<tr>
<td>Rhodes Memorial</td>
<td>WC</td>
<td>8.4 ± 2.1</td>
<td>18.2 (99)</td>
<td>29.2 ± 10.2</td>
<td>1.59 ± 0.5</td>
<td>1 (27)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Hermanus</td>
<td>WC</td>
<td>8.8 ± 1.8</td>
<td>9.8 (132)</td>
<td>39.0 ± 8.5</td>
<td>1.7 ± 0.2</td>
<td>2 (23)</td>
<td>3.3</td>
<td>149.9 (2)</td>
</tr>
<tr>
<td>Millers Point</td>
<td>WC</td>
<td>9.1 ± 2.2</td>
<td>15.4 (52)</td>
<td>n/a</td>
<td>1.5 ± 0.2</td>
<td>2 (23)</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Sandy Point</td>
<td>WC</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>1.4 ± 0.4</td>
<td>3 (29)</td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> VIC = Victoria, NSW = New South Wales, SA = South Australia, WA = Western Australia, TAS = Tasmania, WC = Western Cape, EC = Eastern Cape

<sup>2</sup> Mean maximum number of floral units per raceme ± standard deviation. Includes abortion scars.

<sup>3</sup> Number of plants sampled (total number of racemes per site)

<sup>4</sup> Mean percentage herbivory in buds, flowers and fruits (seeds excluded) (total number of floral organs sampled)

<sup>5</sup> Mean percentage of floral units shed per raceme ± standard deviation

<sup>6</sup> Mean number of seeds per capsule ± standard deviation

<sup>7</sup> Number of plants sampled for capsules (total number of capsules sampled)

<sup>8</sup> Mean number of seed herbivory

<sup>9</sup> Mean percentage of leaf area destroyed by herbivory

<sup>10</sup> Mean leaf area (mm<sup>2</sup>) (number of plants sampled)

n/a data not available

### Table 4. Comparison of herbivory levels between Australian and South African populations of *Polygala myrtifolia*. Data are means from sites sampled in each country ± standard deviation. NS = means not significantly different. Superscripts follow Table 3.

<table>
<thead>
<tr>
<th></th>
<th>No. flowers/raceme&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Inflorescence herbivory&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Floral dehiscence&lt;sup&gt;5&lt;/sup&gt;</th>
<th>No. seeds/capsule&lt;sup&gt;6&lt;/sup&gt;</th>
<th>Seed herbivory&lt;sup&gt;8&lt;/sup&gt;</th>
<th>Leaf herbivory&lt;sup&gt;9&lt;/sup&gt;</th>
<th>Leaf area&lt;sup&gt;10&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>9.1 ± 2.3</td>
<td>0.7 ± 1.9</td>
<td>29.2 ± 10.3</td>
<td>1.7 ± 0.1</td>
<td>0</td>
<td>0.1 ± 0.2</td>
<td>164.1 ± 36.8</td>
</tr>
<tr>
<td>South Africa</td>
<td>7.3 ± 2.4</td>
<td>20.5 ± 17.8</td>
<td>38.7 ± 15.1</td>
<td>1.6 ± 0.2</td>
<td>3.3 ± 1.9</td>
<td>154.0 ± 74.1</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>NS, P = 0.1</td>
<td>P = 0.004</td>
<td>NS, P = 0.3</td>
<td>NS, P = 0.6</td>
<td>NS, P = 0.7</td>
<td>NS, P = 0.7</td>
<td></td>
</tr>
</tbody>
</table>

<sup>2</sup> Mean maximum number of floral units per raceme ± standard deviation. Includes abortion scars.

<sup>4</sup> Mean percentage herbivory in buds, flowers and fruits (seeds excluded) (total number of floral organs sampled)

<sup>5</sup> Mean percentage of floral units shed per raceme ± standard deviation

<sup>6</sup> Mean number of seeds per capsule ± standard deviation

<sup>8</sup> Mean number of seed herbivory

<sup>9</sup> Mean percentage of leaf area destroyed by herbivory

<sup>10</sup> Mean leaf area (mm<sup>2</sup>) (number of plants sampled)
in stunted growth and a substantial reduction in flower and fruit production. Aceria myrtifolii was found on P. myrtifolia in the Western Cape, growing in garden situations while natural occurrences were found at 11 sites across a broad climatic range. Polygala myrtifolia var. grandiflora was severely galled by A. myrtifolii in Gauteng in garden situations. Polygala virgata Thunb. is galled by A. virgatae (Meyer and Ueckermann 1996) in South Africa. Evidence of eriophyid damage to shoot tips was found on a herbarium specimen of P. leptophylla Burch. (Compton Herbarium Sheet Number 115452) from Vioolsdrift in the Northern Cape, but whether this was caused by A. myrtifolii remains to be determined. In exploratory tests, Australian accessions of P. myrtifolia var. myrtifolia collected from Anglesea (Victoria) were susceptible to A. myrtifolii, with galls forming in shoot and floral apexes within several weeks from inoculation. Biotypes of A. myrtifolii galls collected from the Cape Peninsula from the Western Cape form of P. myrtifolia failed to give rise to galls on P. myrtifolia var. grandiflora. Aceria from shoot galls on the Australian native Polygalaceae species Comesperma volubile Labill. and P. japonica Houtt. and the South African species N. spinosa and M. heisteria are distinguishable from A. myrtifolii using morphological features, but require more detailed examination including biological and molecular characteristics to determine if all belong to a single variable species, or to a complex of sibling species (Craemer 2001).

Corphodema sp. (Lepidoptera: Cossidae) The larvae of Corphodema are conspicuously red-coloured and feed on woody tissue in the roots, crown, trunk and branches of P. myrtifolia (Figure 3d). Large tunnels are created by larvae and infected plants may contain many individuals at various developmental stages and mostly in the Western Cape. Cerambycid feeding damage similar to that caused by D. barkeri on P. myrtifolia was found on P. fruticosa, P. myrtifolia var. pinifolia and M. heisteria, but specimens were not obtained for identification.

Dasineura sp. – shoot tip gallers (Diptera: Cecidomyiidae) Several Cecidomyiidae species were collected from P. myrtifolia in South Africa, but the most abundant and most damaging species was a gall-forming Dasineura sp., which induces stunted stem growth and in some cases death of the stem meristems (Figure 3f). Galls consist of crowded, rosette-like structures of overlapping leaves which are reduced in size and bunched together to form a bulbous swelling around 20 mm diameter. Larvae feed in a smooth cup-like cavity in the centre of the gall around the shoot meristem and are gregarious. Active galls are present on P. myrtifolia during spring and summer. Shoot growth can resume from the gall after the completion of feeding by cecidomyiid larvae. Galls were widespread on P. myrtifolia and were found from the far western Cape to Boesmansriviermond in the Eastern Cape. Shoot-tip galls with identical morphology were found in the field on P. myrtifolia var. pinifolia and P. penicularis and on herbarium specimens of P. teretifolia and P. sp. (labelled as P. empetrifolia Houtt., a name of uncertain application). While Cecidomyiidae are generally highly specific to a single host species or closely related taxa (Gagné 1989), it is unclear whether one or a number of species are responsible for shoot-galls on Polygala in South Africa. Galls were utilized by a Pseudococcidae and early instar stages of Torrixis sp. which would have contributed to herbivory pressure to the host plant. In addition, Clonidiopsis sp. (Cecidomyiidae) was reared from Dasineura galls and is assumed to be a predatory inquiline, not a primary gall former.
Other Polygala species (P. fruticosa, P. chamaebuxus L. and hybrids (P. × Dalmaisiana)) are also used in Australian horticulture. Planned biological control of P. myrtifolia needed to take into account possible conflicts of interest with those that derive benefits from this plant. In South Africa, P. myrtifolia is reported as an ethnomedicinal plant having inhibition activity against the human respiratory bacteria Mycobacterium tuberculosis (Lall and Meyer 1999). While naturalized P. myrtifolia currently has negligible commercial and ecological value in Australia, non-target impacts to closely related taxa, require careful assessment. Horticultural forms of Polygala myrtifolia are at most risk from potential biological control agents. Although P. myrtifolia and cultivars are permitted in Australian horticulture, a review of the potential threat posed by P. myrtifolia and other invasive plants is under consideration in some jurisdictions (Weiss et al. 2004). As the large-flowered horticultural forms of P. myrtifolia produce viable seeds and seedlings in Australia, and are not sterile, as commonly believed, there is a risk that these forms will become naturalized, and may have already done so in southern Victoria (Molenaar 1996). Australian native Polygala are likely to be at little risk from stenophagous organisms selected from P. myrtifolia, as most have vastly different life strategies (annual and herbaceous versus perennial and woody), have allopatric distributions due to large differences in eco-climatic limits, and differ considerably in morphological features such as leaf and flower size.

In the absence of capability to effectively contain Polygala myrtifolia infestations in Australia, classical biological control has been recommended (Scott and Delfosse 1992, Adair and Neser 1996), although the species is not yet formally accepted as a target. Others have ranked P. myrtifolia as a low priority for classical biological control (Paynter et al. 2009) as the species had relatively low importance at a national scale. However, impacts at a regional scale are significant and escalating, and the low Weeds of National Significance score used in the national assessment (Paynter et al. 2009) should not preclude P. myrtifolia for consideration as a target for biological control.

The distribution of P. m. var. myrtifolia in southern Australia is scattered, with expanding populations, particularly in coastal areas. The application of classical biological control has the potential to reduce the rate of spread into new areas, as well as reducing the ecological impact in established infestations. Early intervention by application of biological control before P. m. var. myrtifolia reaches its full distribution in Australia would therefore be a highly cost-effective management option. Utilization of inundative biocontrol approaches with existing organisms, such as Cylindrocladium pauciramosum C.L. Schoch & Crous (teleomorph Calonectria pauciramosa C.L. Schoch & Crous) or a generalist pathogen known to infect P. myrtifolia in Europe (Polizzi and Crous 1999, Perez-Sierra et al. 2006), and also present in Australia (Cunnington 2003), is worthy of consideration.

Acknowledgments
The South African National Biodiversity Institute is thanked for use of distribution data for P. myrtifolia from the National Herbarium, Pretoria (PRE) Computerized Information System (PRECIS). Ottilie Neser kindly identified hymenopterous parasitoids reared from Polygala collections. We thank Raymond J. Gagné (USDA), Alan Wood, Ian Millar, Michael Stiller, Charnie Craemer and Beth Grobbelaar at little risk from stenophagous organisms selected from P. myrtifolia, as most have vastly different life strategies (annual and herbaceous versus perennial and woody), have allopatric distributions due to large differences in eco-climatic limits, and differ considerably in morphological features such as leaf and flower size.

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