Barrier to restoration: the decomposition rate of bridal creeper's root system

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Summary Bridal creeper (*Asparagus asparagoides* (L.) Druce) is an environmental weed with extensive rhizomes and storage tubers forming underground mats. This geophyte has been recognised as a Weed of National Significance in Australia as it has the potential to dominate native vegetation both above and below-ground. The litterbag technique was used to determine the decomposition rate of bridal creeper's belowground biomass. After a rapid loss of about 40% of biomass in the first three months, decomposition then slowed dramatically, indicating that decomposition may take many years for completion. In Western Australia, the nutrient concentrations of this belowground biomass were similar to other geophytes, except for high levels of iron and manganese. The belowground dry weight of bridal creeper was estimated at 2.99 ± 0.32 kg m^{-2}. This biomass was concentrated in the top 20 cm of the soil profile. Weed control methods and restoration activities will need to take into account the residual effect of this biomass.

Keywords *Asparagus asparagoides*, geophyte, nutrients, tubers, weed impacts.

INTRODUCTION

The widespread form (see Kleinjan and Edwards 1999) of bridal creeper, native to southern Africa, is a serious environmental weed in Australia. As with other geophytes, the storage organs (tubers) of bridal creeper reserve energy to support the production of foliage. In hot, dry conditions, bridal creeper's foliage begins to senesce. In southern Australia, it is its tuber reserves which enable it to survive over summer and then undergo rapid shoot development in the following autumn (Morin *et al.* 2006a).

This perennial belowground system consists of many tubers (modified roots) densely packed along a central rhizome (underground stem) (Morin *et al.* 2006a). The distal end of the tubers continues as conventional roots. This system becomes entwined together and forms thick mats just below the soil surface and can be more than 87% of the plant's total biomass (Raymond 1996). Turner and Virtue (2006) observed that dead tubers remained in trial plots eight years after the weed had been killed with herbicide. This may have affected native seedling establishment and may have formed a barrier to the natural recovery of the invaded area.

This study aimed to estimate the decomposition rate of the belowground biomass of bridal creeper as part of an initial assessment of its impact on the environment. As root chemistry has been suggested to be the primary controller of root decomposition (Silver and Miya 2001), the nutrient levels of the belowground biomass were also determined.

MATERIALS AND METHODS

All future references to root biomass in this paper relate to the total belowground biomass including the associated tubers and rhizomes. Root biomass of bridal creeper was sampled from four sites across southern Western Australia (WA) where bridal creeper had yet to come under substantial attack from the biological control agents. The first site was located in Glenlynn Conservation Reserve (GC) (34.002°S, 116.155°E) with the other three sites all located in or adjacent to Fitzgerald River National Park. The Quell Creek (QC) site (34.254°S, 119.414°E) was an isolated area within the park. The Quaalup Homestead (QH) site (34.263°S, 119.410°E) was in private property that was surrounded by the park. The fourth site, Gairdner River (GR) (34.373°S, 119.427°E) was on local government land, but managed as part of the park.

At each site, 20 random soil cores, 9.5 cm in diameter were taken within relatively homogeneous stands of bridal creeper to a depth of 20 cm. Soil was sieved through 1 cm mesh and the root biomass of bridal creeper was removed. To determine the dry weight of each sample, the biomass was washed to remove soil, dried at 70°C for seven days, and then weighed.

To determine the decomposition rate, dried root biomass was placed within mesh bags (10 cm × 20 cm, mesh size 1.5 mm), with 17.8 ± 0.2 g per bag. This amount was chosen as it was sufficient to fill the litterbag and mimic the tight packing of the tubers. A total of 63 bags were prepared for three sites (QC, GC and GR). At each site, 16 bags were buried 5 cm below the soil surface within the existing live bridal creeper root mat at the site from which they were

collected. The root biomass in the remaining five bags per site was dried again at 70°C to determine initial dry weights. Approximately every three months the sites were revisited and four bags per site were collected. Biomass removed from the bags was washed and dried at 70°C to determine dry weight. To date, 32 bags have been recovered. Silver and Miya (2001) investigated 152 studies on root decomposition, of these 87% used this buried litterbag method. Results were analysed with simple linear regression and ANOVA (GenStat 2003).

In March and June 2005 additional collections of the root biomass were made at GC and GR. This fresh material was sent to CSBP laboratories (W.A.) for chemical analysis. The dead biomass recovered from GC and GR six months after burial was also analysed. The concentrations of nitrogen (Sweeney and Rexroad 1987), phosphorus, potassium, magnesium, manganese and iron (McQuaker *et al.* 1979) were determined. The nutrient levels were then compared to studies on other geophytes as well as the levels in the decomposed root biomass.

RESULTS

Dry weights of the belowground biomass in WA ranged from 2.3 to 3.7 kg m^{-2} (Figure 1). The decomposition of the belowground biomass was rapid in the first three months, however the rate of decomposition then slowed dramatically with no significant change for the next six months (Figure 2; $F_{2,29} = 1.11$, $P = 0.342$).

The nutrient concentrations in bridal creeper's belowground root biomass were similar to other species, except for the high levels of manganese (Mn) and iron (Fe) (Table 1). Nutrient concentrations in the living root biomass were comparable to the decomposing biomass.

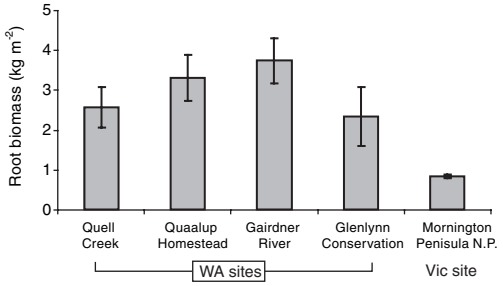

Figure 1. Dry weight of bridal creeper's total belowground biomass (mean ± SE) across four Western Australian sites in 2005 and compared to a Victorian site (determined in 1992 and 1993 by Raymond 1999).

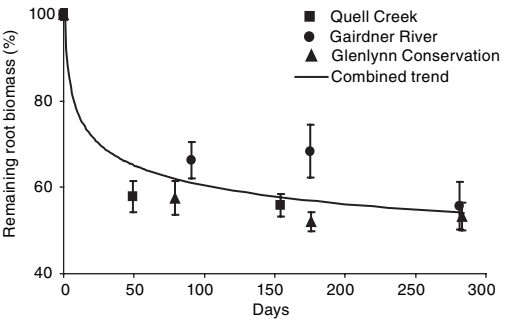

Figure 2. Decomposition of bagged bridal creeper belowground biomass across three Western Australian sites. After log10 transformation, a negative trend was evident across combined sites; $y = -0.11x + 2.00$; $R^2 = 0.90$; $F_{1,9} = 82.2$; $P < 0.0001$.

DISCUSSION

The total belowground biomass of bridal creeper is considerable – in Victoria it was estimated at 836 g m^{-2} in Mornington Peninsula National Park (Raymond 1996). If the observed decomposition rate (Figure 2) continues, 50 years after bridal creeper has been killed approximately 35% or 1.04 kg m^{-2} of total belowground biomass would remain at these WA sites. It is therefore important from a control perspective to determine the threshold levels needed whereby this biomass would no longer have a significant impact on native plants. Glasshouse experiments currently underway will assess the impact of dead and alive belowground biomass, across a gradient of densities, on native species.

Nutrient concentrations in bridal creepers' root biomass are similar to other species, except for high levels of Mn and Fe (Table 1). Bridal creeper's tuber reserves are not easily depleted (Morin *et al.* 2006a). Bridal creeper mechanically defoliated every five weeks for eight months produced a few tubers and regrowth still occurred (Raymond 1999). Fe and Mn are very important for photosynthesis and chlorophyll formation (Epstein 1972). High levels of Fe and Mn seen here could explain how bridal creeper is able to rapidly produce aboveground growth in autumn and re-shoot even after many defoliation episodes.

The soils where the biomass was collected for nutrient analyses were high in Fe (GR 1707 mg kg^{-1}; GC 7357 mg kg^{-1} P.J. Turner unpub. data). Fe is usually referred to as a trace element as plants normally require small quantities of this micronutrient (Shaw 1989). When metals like Fe cannot be excluded from

Table 1. Nutrient element concentrations in bridal creeper's belowground biomass (dry weight; mean ± SE) and belowground storage organs and roots of other species. The nutrient concentrations of decomposing belowground biomass of bridal creeper are also included.

Plant species	Collection location	Nutrient element						Source
		N mg g^{-1}	P mg g^{-1}	K mg g^{-1}	Mg mg g^{-1}	Mn mg kg^{-1}	Fe mg kg^{-1}	
A. asparagoides (Asparagaceae)	southern WA	14.2 ± 1.0	0.7 ± 0.1	8.4 ± 0.5	2.7 ± 0.3	447.0 ± 75.9	8915 ± 1616	This study
A. racemosus Willd. (Asparagaceae)	northern WA	3.0	0.8	12.7	6.8	–[A]	–	Pate and Dixon 1982
94 geophyte species across 30 plant families	across all WA	13.1	1.2	17.1	1.8	–	–	Pate and Dixon 1982
Haemanthus pubescens L.f. (Amaryllidaceae)	South Africa	13.5	11.8	19.6	0.2	59.1	280	Ruiters 1995
Anemone nemorosa L. (Ranunculaceae)	Sweden	–	–	15.2	3.9	941.0	2700	Tyler 1976
Sparaxis grandiflora Ker Gawl. (Iridaceae)	South Africa	6.1	1.0	7.0	1.5	55.7	47	Ruiters and McKenzie 1994
A. asparagoides after six months decomposition	southern WA	15.5 ± 0.4	0.6 ± 0.1	3.4 ± 1.5	2.6 ± 0.3	768.7 ± 37.2	12978 ± 148	This study

[A] Measurement not made.

entering the plant and reach high concentrations, plants have strategies to tolerate these levels. One approach is to remove these metals away from sites of active metabolism, usually storing them in the root system (Shaw 1989, Fitter and Hay 2002). Therefore, the high concentrations of Fe could relate to long-term accumulation. It is unknown what effect large concentrations of Fe have on the decomposition rates of the root system or if they are present in bridal creeper roots at other sites with lower levels.

This study only reports on the nutrient contents in the root system – further chemical analysis of this biomass may be warranted, given that aqueous root extracts from *A. officinalis* L. and *A. racemosus* have been shown to inhibit seed germinations of lettuce *Lactuca sativa* L. (Hazebroek *et al.* 1989). This suggests the presence of allelopathic compounds in the roots. Another *Asparagus* species, *A. curillus* Buch.-Ham. ex Roxb. also has potential allelopathic compounds in its roots (Sati and Sharma 1985). The chemistry of the residual biomass of the decomposing roots must also be considered. Decaying *A. officinalis* root tissue was found to be approximately 90% lower in weight in an asparagus field where production ceased ten years previously when plants were ploughed into the soil, compared to another where plants were ploughed only one year earlier. However, extracts from the ten year old root residues still caused a significant inhibition of root growth of garden cress, *Lepidium satium* L. (Blok and Bollen 1993).

This study has shown that the quantity of the belowground biomass and slow decomposition may pose a problem for many years after its control. Willis *et al.* (2003) suggested that fire could be used to deplete the tubers reserves by destroying the new season's foliage in autumn, followed by treating the re-growth with herbicide. The biocontrol agent *Puccinia myrsiphylli* (Thuem.) Wint. acts as a resource sink through the absorption of nutrients (Morin *et al.* 2006b), and shown to significantly reduce bridal creepers' vegetative growth as well as decreasing the tuber biomass (Morin *et al.* 2002). Different weed management methods will have different effects on decomposition rates and restoration activities need to take this into account.

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