Control of bridal creeper *Asparagus asparagoides* on Kings Park Scarp and limiting factors on its growth and spread

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Summary The dominant weed along the Kings Park limestone escarpment in Perth, Western Australia, is *Asparagus asparagoides* (L.) Wight (Asparagaceae) a South African rhizomatous geophyte. A three year research program was initiated to establish limiting factors affecting its growth and spread, and to determine control measures. Research indicated that the preferred habitat of bridal creeper is characterised by high soil and litter moisture content and low light intensity, which equates to a longer growing and reproductive season. Disturbed and native habitats with high shade factors are ideal for establishing new populations and subsequent spread. Opening up the canopy to increase light levels above 1000 µmol sec^{-1} m^{-2} significantly reduces its invasive capacity and assists the establishment of native understorey species.

Some knowledge on the control of bridal creeper in Kings Park bushland had been established as early as 1991. Further trials conducted in 1997 in late autumn, winter and early spring were designed to establish if a range of non-selective herbicides at low rates would kill bridal creeper without too much off-target damage to indigenous species. Brush-off (600 g kg^{-1} metsulfuron methyl) achieved the best results overall. When sprayed in July at a rate of 1 or 2.5 g ha^{-1} up to a 100% reduction in above ground biomass of bridal creeper was recorded with little off target damage. The results also indicated a much larger window of opportunity (May to July) when spraying at the higher rate of 2.5 g ha^{-1}. Implementing these results on an operational scale has resulted in high death rates and reduced the estimated above ground biomass of bridal creeper on the scarp by 85%.

Keywords Bridal creeper, *Asparagus asparagoides*, light intensity, Brush-off, moisture, herbicide control, weed control.

INTRODUCTION

Bridal creeper *Asparagus asparagoides* was recognised as a major environmental weed in Australia since the early 1990s, and has been present on the Kings Park escarpment since possibly as early as 1934 (Wycherley 1992). It has expanded rapidly on the scarp over the last 25 years, also spreading to the adjacent bushland. Recommendations for its control were made in Kings Park Bushland Management Plan 1995–2005.

The first herbicide trials were conducted in 1991 using a range of non selective herbicides and mixtures with various wetting agents to establish their efficacy. Results indicated glyphosate 360, 1 in 100 and Brushoff (metsulfuron methyl) 5 g ha^{-1} and mixtures containing these herbicides gave excellent kill rates. Further and separate trials in 1992 confirmed glyphosate, and Ally (metsulfuron methyl) showed 70.0 to 77.5% reduction in above ground biomass. Observations at the time indicated many native monocots survived, probably due to foliage shadowing effect, the thick litter layer, charcoal, and microbial activity which would assist in chemical breakdown. Observations also indicated that Brushoff often takes considerable time to work and it is not until the following year confirmation of results are clear. Plants receiving some spray but not killed by glyphosate and metsulfuron methyl regrowing the following autumn/winter are usually stunted with yellow foliage and may take the whole growing season to recover or die (Dixon 1996). A previous study (Pritchard 2002) had similar findings, and also found that the live root rate reduction using glyphosate was far higher than with metsulfuron methyl.

This study reports additional trials undertaken in 1997–2001, which attempted to determine the critical physical parameters underpinning local bridal creeper distribution and density along the escarpment. Further herbicide trials were also conducted.

MATERIALS AND METHODS

Study site Trials were established along the top of the limestone escarpment at Kings Park, Western Australia. Soils are shallow to deep loose colluvial sands over yellow sands, with soil surface pH varying from 6 to 8 on exposed limestone. A series of 33 study plots (10 m^2) were established along the escarpment for weed assessments.

Physical parameters Plots were grouped in terms of presence/absence of bridal creeper/veil and stem density of bridal creeper. Density was scored by counting the number of living stems in 1 m^2 quadrats placed at each corner and in the centre of each plot. Plots were compared in terms of the following parameters: litter depth, litter pH, litter moisture, soil depth, soil pH, soil moisture, and plot light intensity. Light penetration was measured at ground level and 1 m above ground level for each plot from 10 a.m. to midday over a three week period in spring 1997, on cloud-free days. Five readings were taken at each corner and in the centre of each plot, using a LiCor 250 quantum sensor recorded as the 15 second moving average (expressed as mean μmol s^{-1} m^{-2}). Temporal variation in light penetration during a day and seasonally was not determined, neither was the effect of canopy shadows. Litter and soil moisture was determined by sampling in the same plots using the dry weight method. Differences were tested using a two-tailed t-test for equal or unequal variances as appropriate. Differences in variances were first tested using an *F*-test.

Herbicide control Trials were established at a site heavily infested with bridal creeper to examine the effects of season of application and application rates of different herbicides on kill rate. Three 4 m^2 plots per treatment were established for each of the following treatments: Triquat® 4 mL L^{-1}; Lontrel® 300 mL ha^{-1}, Lontrel 100 mL ha^{-1}, Lontrel 50 mL ha^{-1}, Brush-off® 2.5 g 100 mL^{-1}, Brush-off 1 g 100 mL^{-1}, Agral® 1 mL L^{-1}, Control. Agral was used as a penetrant with each herbicide.

Plots were assessed by scoring the stem density of bridal creeper immediately before spraying and after application (6 months, 12 months). Plots were separated into season of application – start of the growing season in May, peak growth in mid-July, and the end of growth in September during flowering/fruiting.

RESULTS

Physical parameters Figure 1 shows that the majority of plots are clustered at the x–y axis indicating both ground level and 1 m height light levels were mostly below 500 μmol s^{-1} m^{-2}. A smaller cluster groups plots to the top right showing ground level and 1 m height light levels above 1500 μmol s^{-1} m^{-2}. Table 1 shows that *Asparagus* spp. was absent where ground-level light exceeded 1000 μmol sec^{-1} m^{-2} and 1 m above ground light levels exceeded 1200 μmol sec^{-1} m^{-2} at the time of measurement. Above-ground light showed a stronger statistically significant effect on bridal creeper distribution (Table 1).

Table 1. Presence/absence of bridal creeper in relation to physical parameters.

Parameter	Bridal creeper present, n=23 Mean ± SE	Bridal creeper absent, n=10 Mean ± SE	t-statistic
Litter moisture %	46.6 ± 1.5	35.3 ± 2.4	4.127***
Light, ground level (μmol s^{-1} m^{-2})	547.6 ± 60.2	1002.5 ± 174.8	-2.461*
Light, 1m (μmol s^{-1} m^{-2})	645.6 ± 79.1	1279.3 ± 180.5	-3.215**

* P<0.05, ** P<0.01, ***P<0.001.

Spring litter moisture levels were significantly lower in plots in which *Asparagus* spp. were absent (Table 1). Light and moisture availability are likely to be interactive effects. Soil depth, litter depth, soil moisture and pH had no significant effect on presence/absence.

To determine whether the overriding factor determining bridal creeper distribution is likely to be moisture or light, it is instructive to compare plots which were scored as positive for bridal creeper/veil having either low litter moisture (i.e. <38%) and/or high light (>800 μmol sec^{-1} m^{-2} ground level light and >100 μmol sec^{-1} m^{-2} light at 1 m) (Table 1). Low moisture plots included plots 2, 11, 13 and 18. All but plot 2 had light levels below the critical range, suggesting low spring moisture levels can be compensated by heavier shade, i.e. light is more important than moisture. Three plots met the criteria of high light, i.e. plots 2, 16 and 25. The latter two plots had high litter moisture content (in the case of plot 16, due to irrigation overflow). Therefore, the only exceptional plot where bridal creeper occurred was plot 2 where light levels were high and moisture levels were low.

Regression analysis showed that bridal creeper density, scored as the number of living stems/m^2, showed a strong positive correlation to soil moisture, indicating water availability is a key limit to growth for this weed species (Figure 2). A weak correlation occurred for litter moisture.

Significant negative correlations were also shown for bridal creeper density and light intensity recorded

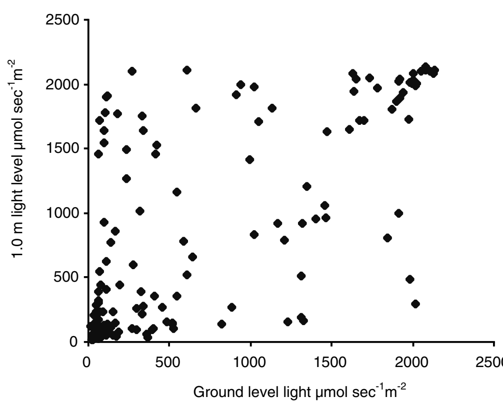

Figure 1. Scatter distribution of plots in relation to ground level spring light intensity, and light intensity at 1 m height above ground.

at 1m above-ground height in spring (Figure 2). Data show that stem density was significantly higher in plots with light levels <600 µmol sec^{-1} m^{-2}, and was very low or absent in plots with light levels above 1000 µmol sec^{-1} m^{-2}. Canopy cover of vegetation therefore explains a considerable proportion of bridal creeper and bridal veil density along the scarp.

Anova comparison showed a strongly significant difference between the presence of live stems, and ground level light intensity at the end of the growing season in October 1998 (F=4.0727, n=22, P=0.0005). This shows that bridal creeper growing in low light areas has a longer growing and reproductive season than in high light situations.

Herbicide control Results of herbicide experiments show excellent control of bridal creeper using Brush-off at 2.5 g 100 mL^{-1}, and at 1 g 100 m^{-1} when applied in July (Figure 3); this is substantially lower than rates used successfully in previous trials (Dearman 1994, Earl 1994, McQuinn 1994). Other herbicides had no or minimal effect.

Month of application had a strong effect on kill rates, with May and July showing 100% effectiveness for Brush-off at 2.5 g 100 mL^{-1}, and 80% and 100% respectively for Brush-off at 1 g 100 mL^{-1}. No native species were killed with Lontrel or Brush-off herbicides, at the application rates tested (data not presented). All herbs were killed with Triquat. Some leaf damage was observed in *Thysanotus divaricata* with Lontrel at 300 g L^{-1}.

DISCUSSION

Considerable progress towards control of bridal creeper can be achieved by limiting excessive moisture and excessive shading. While certain areas of the escarpment are naturally shadier (e.g. *Eucalyptus* Woodland assemblages) and wetter (e.g. seepage zones), many areas have excessively high densities of tall species due to a continual disturbance:pioneer recruitment cycle. Other areas have excessively high soil moisture content due to run-off from the irrigated Gardens, carparks and lawns above. Therefore, control of bridal creeper, and protection of native assemblages, will require urgent control of drainage and run-off to the escarpment, and through 'habitat rejuvenation', or removal of native and exotic trees to recover light intensities more typical of undisturbed sites.

The most effective herbicide was Brush-off applied in winter at a rate of either 2.5 g 100 mL^{-1}, or 1 g 100 mL^{-1}. Following the success of these trials and resulting recommendations (Meney 1999), implementation of a large-scale works program was undertaken to eradicate bridal creeper. This was difficult due to the steep and unstable terrain, the demanding timeframe for completion of works, requirement for exotic tree removal and other weeds; the necessity for road closures to gain access, the lack of suitably trained

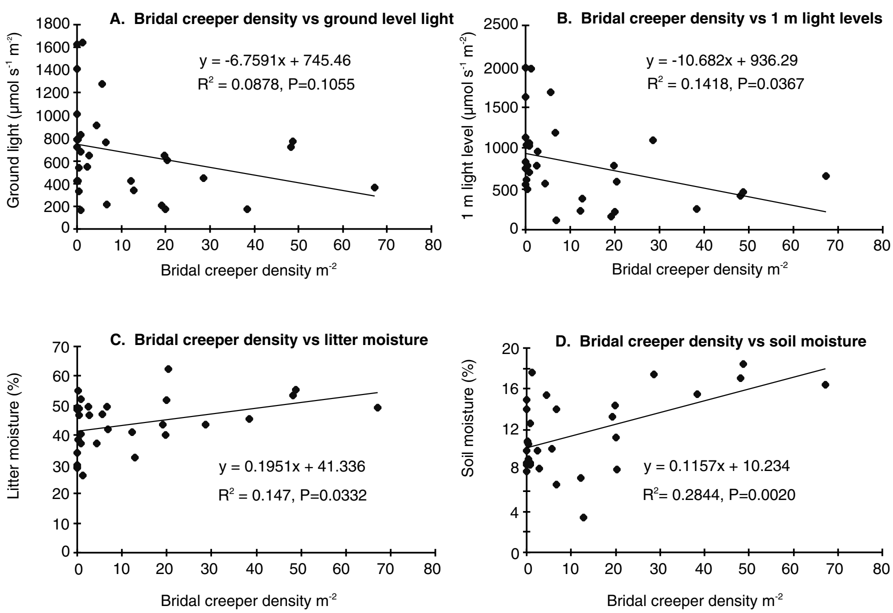

Figure 2. Correlation between bridal creeper stem density and A. ground level light; B. 1 m level light; C. litter moisture; and D. soil moisture.

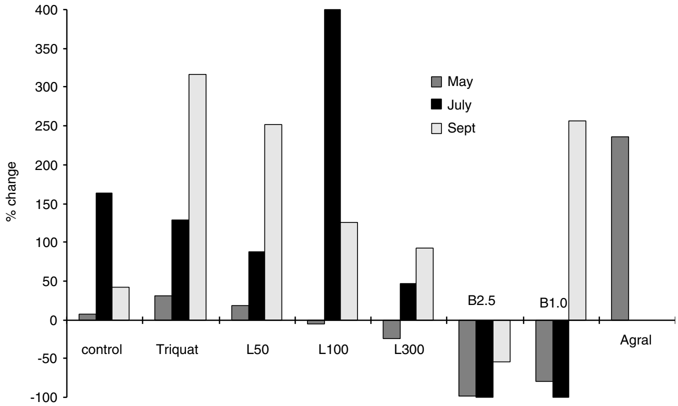

Figure 3. Percentage change in bridal creeper (*Asparagus asparagoides*) stem density (1997 herbicide spray) after application of various herbicides. Control = water application only; Triquat applied at 4 mL 100 mL; L50–300 = Lontrel at 50, 100 or 300 mg L^{-1}; B2.5 and B1.0 = Brush-off at 2.5 g ha^{-1} and 1 g ha^{-1}; Agral used at 1 mL L^{-1} (wetting agent added to all herbicide treatments); May and July treatment plots scored in spring, Spring plots scored the following winter.

spraying contractors, and contract organisation and safety requirements.

Some of these problems were alleviated by bringing some of the spraying programs forward a year, assisting in the training of spraying contractors, and mixing herbicides to target a number of weeds in one spraying operation. For example Brush-off was also used to control bulbous weeds such as *Freesia* and *Sparaxis* and the grass selective herbicide Fusilade was mixed with it to control perennial veld grass *Ehrharta calycina* and annual veld grass *Ehrharta longifolia*. Safety and access issues were addressed by using fall arresters for spraying contractors, as well as using radio controlled reel spraying units to pull the hose as well as the operator up the scarp.

Extension of these trials across the escarpment at operational scale over a three-year period showed an overall reduction in stem density from 12.8 live stems m^{-2} to 0.2 live stems m^{-2} and an average of 85% reduction in ground biomass. Spot spraying with Brushoff amongst native plants caused very little off target damage apart from *Templetonia retusa* on highly alkaline soil (Brown *et al.* (2002) found the same when spraying to control *Lachenalia reflexa*). An initial spray followed up the following year or two years later may be more cost effective due to the lack of above ground biomass to target as also discussed by Pritchard (2002). Biological control (leaf hoppers and rust) will now be used in isolated pockets in difficult terrain where sprayers cannot penetrate. In irrigated areas spraying can be targeted much earlier in the growing season. Because the underground biomass breaks down in two years, causing erosion in shallow limestone and loose rocky areas, greenstock planting is essential within this timeframe.

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