Sparaxis bulbifera (Iridaceae) invading a clay based wetland on the Swan Coastal Plain – control methods and observations on the reproductive biology

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Summary

***Sparaxis bulbifera*, a cormous geophyte from the Cape Region of South Africa, is a serious invasive weed of clay based wetlands on the Swan Coastal Plain. Where it invades these wetlands it forms dense monocultures, displacing much of the rich native herbaceous flora. Herbicide trials were conducted in the Brixton Street Wetlands south east of Perth, where it is invading shrublands and herblands, and impacts of treatments on co-occurring native species recorded. Metsulfuron methyl was trialed at 1.0 g ha^{-1} and at 2.5 g ha^{-1} and chlorsulfuron at 2.5 g ha^{-1}. All treatments significantly reduced the number of juvenile and adult plants of *S. bulbifera*. Metsulfuron methyl at 2.5 g ha^{-1} was the most effective reducing the number of adult plants per plot from a mean of 25.4 to 0.4 and the number of juvenile plants from a mean of 373.2 to 28.8.**

There were 27 species of native taxa scattered across the trial plots and only two taxa, *Sowerbaea laxiflora* and *Philydrella drummondii* appeared to have been adversely affected by the herbicide treatments. The results however were compounded by the spatial distribution and the seasonal nature of the native flora. Additional information on the reproductive biology and spread of the weed was also recorded.

Introduction

The Brixton Street Wetlands lie 20 km south east of Perth at the foot of the Darling Scarp. A small 19 ha remnant on the winter wet flats of Guilford formation clays, the wetlands have an exceedingly diverse flora of 307 native taxa (Keighery and Keighery 1995). Species rich herblands cover the winter-wet claypans, herb rich shrublands the clay flats and *Eucalyptus calophylla* woodland the higher ground where the soil is well drained (Keighery and Keighery 1991). With this kind of habitat almost entirely cleared on the Swan Coastal Plain the area is of outstanding conservation value (Keighery and Keighery 1991, Gibson *et al.* 1994). One of the major threats to the native flora and to the plant communities of the wetlands is invasion and competition from weeds such as *Sparaxis bulbifera*. This South African cormous species is a serious invader of clay based wetlands on the Swan Coastal Plain (Hussey *et al.* 1997). Once established it forms dense monocultures displacing herbaceous flora in particular. Given that around 50% of the native flora at Brixton Street comprises annual or perennial herbs, many of them rare or restricted taxa (Keighery and Keighery 1995), *S. bulbifera* poses a significant threat to conservation values of the wetland.

Options for control of a weed growing closely among native plants in a wetland situation are limited. At Brixton Street any control program needs to take place over a short time at the beginning of October as the wetland begins to dry out and before *S. bulbifera* comes into full flower. Hand removal at this time is one option and is a particularly useful tool for removing small isolated populations growing in relatively undisturbed bushland. However hand removal is labour intensive and consequently needs to be integrated with a carefully targeted chemical control program. Trials in recent years have indicated that the sulfonylurea group of herbicides can be quite effective against a number of introduced bulbous and cormous species (Pritchard 1991, Dixon 1996, Pritchard 1996, Peirce 1998, Meney 1999, Brown *et al.* 2002). Observations and data indicate that some introduced bulbous or cormous species invading bushland can be controlled with sulfonylurea herbicides with minimal impact on the native flora (Dixon 1996, Meney 1999, Moore 1999). Brown *et al.* (2002) in detailed studies on the control of *Lachenalia reflexa* with metsulfuron methyl at 5 g ha^{-1} in a *Banksia* woodland found indications of minimum impact on co-occurring native species.

With little published information on herbicide control of *S. bulbifera* this study aimed to trial the effectiveness of two herbicides, metsulfuron methyl and chlorsulfuron on *S. bulbifera* and to investigate the impacts of these herbicides on co-occurring native species in the Brixton Street Wetlands.

Methods

Trial plots (1 m × 1 m) were laid out in a randomized block design (control and three treatments) with five replicates of each treatment. In August 2000, before treatment, the number of *S. bulbifera* adults (flowering plants) and juveniles (non flowering plants) in each plot was counted and a cover estimate (Braun-Blanquet) scored for each species (native and introduced) in each plot. In early October 2000 the herbicide was carefully spot sprayed in each treatment. As this weed grows very closely amongst the native herbs and shrubs these were also subject to herbicide application. Metsulfuron methyl (Brushoff®, 600 g kg^{-1} metsulfuron methyl) was applied from a 15 litre backpack sprayer at 2.5 g ha^{-1} and at 1.0 g ha^{-1} and chlorsulfuron (Glean®, 750 g kg^{-1} chlorsulfuron) was applied at 2.5 g ha^{-1}. All were applied with the penetrant Pulse® (1000 g L^{-1} polydimethylsiloxane) at 2 mL L^{-1}. The plots were rescored in September 2001. Differences in counts between treatments and years were analysed using Kruskal Wallace ANOVA with post hoc Mann-Whitney U-tests used to determine significance between individual treatments. Plant nomenclature generally follows Paczkowska and Chapman (2000).

Plants of *S. bulbifera* were also monitored over time to determine bulbil and seed production and methods of spread.

Results

Sparaxis bulbifera control

All herbicide treatments significantly reduced the number of both adult and juvenile *S. bulbifera* plants in the trial plots. Metsulfuron methyl at 2.5 g ha^{-1} was the most effective followed by chlorsulfuron at 2.5 g ha^{-1} then metsulfuron methyl at 1.0 g ha^{-1}. Metsulfuron methyl at 2.5 g ha^{-1} was significantly more effective than metsulfuron methyl at 1.0 g ha^{-1} in controlling adult plants (Figure 1). Apart from this there were no significant differences between treatments. Although all treatments significantly reduced the number of juvenile plants, a mean of 28.8 (±15.08) individuals per plot still remained following the most effective treatment (Figure 2).

Herbicide impacts on native plants

There were 27 species of native plants recorded from across the trial site; five shrubs, 14 perennial herbs (seven of those geophytes) and eight annual herbs. Not all species occurred in all plots. Of the five shrubs, three species remained unchanged or increased in cover across all the herbicide treatment plots they were present in. Seedling recruits of *Viminaria juncea* and *Pimelia imbricata* var. *major* were observed in some treatment plots. Of the remaining two taxa, *Verticordia densiflora* fluctuated in cover across the chlorsulfuron plots while *Kunzea micrantha* subsp. *micrantha* decreased in cover, across both metsulfuron treatments and fluctuated across the controls.

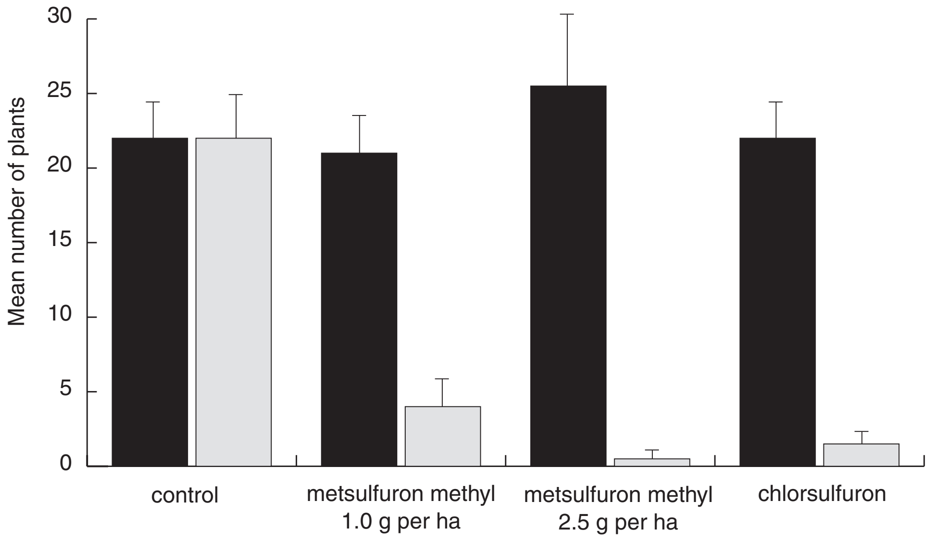

Figure 1. Mean number (with standard error bars) of mature *Sparaxis bulbifera* plants in treatment plots (1 × 1 m) before (dark) and after (pale) herbicide treatments.

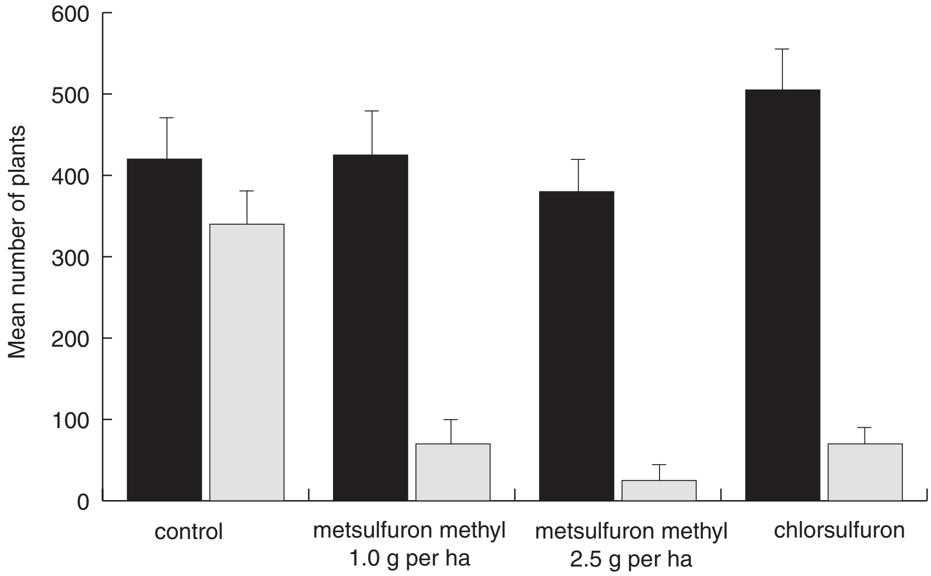

Figure 2. Mean number (with standard error bars) of juvenile *Sparaxis bulbifera* plants in treatment plots (1 × 1 m) before (dark) and after (pale) herbicide treatments.

Of the 14 perennial herbs present, eight taxa retained or increased cover within all treatment plots in which they occurred (Table 1). Cover fluctuated across one or more herbicide treatment plots for two taxa, *Borya scirpoidea* and *Drosera menziesii* subsp. *menziesii. Sowerbaea laxiflora* decreased in the control plots it occurred in and cover class fluctuated under both metsulfuron methyl at 2.5 g ha^{-1} and chlorsulfuron at 2.5 g ha^{-1}. In one of the chlorsulfuron treatment plots cover of *Sowerbaea laxiflora* decreased from 25–50% cover to zero. For one taxon, *Cyathochaeta avenacea*, cover fluctuated across control plots only. Of the remaining two perennial herbs, *Utricularia menziesii* decreased in cover across all plots it occurred in including controls. *Philydrella drummondii* decreased in all the metsulfuron methyl (2.5 g ha^{-1}) and chlorsulfuron (2.5 g ha^{-1}) treatment plots in which it occurred (Table 1).

There was a high level of recruitment into both control and herbicide treatment plots of annual herbs with four taxa retaining cover or recruiting into the treatment and control plots over 2000/2001 (Table 1). One taxon, *Hydrocotyle alata*, recruited into control and metsulfuron (1.0 g ha^{-1}) treatments with cover fluctuating under the other two treatments. Of the remaining three taxa, two retained cover in all treatment plots they occurred in and one, *Drosera glanduligera*, decreased in cover in the only treatment plots in which it occurred, metsulfuron methyl (1.0 g ha^{-1}) (Table 1).

Observations on reproductive biology and spread

Observations over the period of our study have provided insights into some aspects of the reproductive biology of *S. bulbifera* including seed biology, mechanisms of dispersal and patterns of invasion within the wetland. Although plants produce small bulbils up the stems as they die down at the end of each season, populations appear to spread mainly by seed. Each plant produces around 75 soft thin papery coated seeds in late spring and within the wetlands at least, water appears to be a major dispersal agent. The seed has been observed floating in standing and flowing water and maps reveal populations moving mainly through low lying wet areas including creeks and drains. Sheet water flow occurring across the wetland in winter may well explain small populations of *S. bulbifera* appearing in undisturbed bushland. There is also evidence that human activities are playing a role in the spread of the population with dense infestations occurring along walking tracks.

Interestingly the seed appears to be relatively short lived in the soil, generally germinating the first season following ripening. Prolific seedling recruitment was observed throughout populations of *S. bulbifera* before the management program began. One year following removal of all flowering plants from isolated populations little or no seedling recruitment was observed in those populations.

Discussion

Effectiveness of treatments and impacts on native taxa

It is clear that the herbicides tested all effectively controlled *S. bulbifera* at the trial sites, with metsulfuron methyl at 2.5 g ha^{-1} the most effective. The high number of juvenile plants remaining in the treatment plots indicates that there will need to be follow up control and any successful management strategy will require a commitment of on-ground resources over a number of years.

As not all native taxa occurred in all treatment or control plots, impacts of the three herbicide treatments on the native flora at Brixton Street is unclear. This is compounded by the highly seasonal nature of the wetland flora. Nevertheless the results do indicate that effective control of *S. bulbifera* is possible with minimum impacts on a range of native taxa. The only shrub at the site that gave an indication of being affected by metsulfuron treatments, *Kunzea micrantha* subsp *micrantha,* also showed a fluctuation in cover across the control plots, increasing in some and

Table 1. Changes in cover class among co-occurring native taxa following the three herbicide treatments to *Sparaxis bulbifera*.

Taxa	Life form	Control	Metsulfuron methyl 1.0 g ha^{-1}	Metsulfuron methyl 2.5 g ha^{-1}	Chlorsulfuron 2.5 g ha^{-1}
Acacia lasiocarpa var. *bracteolata*	shrub	≥	–	≥	≥
Aphelia cyperoides	annual herb	–	–	≥	≥
Borya scirpoidea	perennial herb	≥	±	≥	–
Burchardia congesta	perennial herb-geophyte	≥	–	–	–
Burchardia multiflora	perennial herb-geophyte	–	≥	–	–
Centrolepis aristata	annual herb	≥	≥	≥	≥
Chorizandra enodis	perennial herb	≥	≥	≥	≥
Chorizandra multiarticulata	perennial herb	–	≥	r	r
Cyathochaeta avenacea	perennial herb	±	≥	≥	–
Drosera glanduligera	annual herb	–	<	–	–
Drosera menziesii subsp. *menziesii*	perennial herb- geophyte	≥	±	≥	r
Goodenia micrantha	annual herb	r	r	r	≥
Hydrocotyle alata	annual herb	r	r	±	±
Isolepis cernua	annual herb	r	r	r	r
Kunzea micrantha subsp. *micrantha*	shrub	±	<	<	–
Lomandra spp.	perennial herb	–	≥	–	–
Meeboldina canus	perennial herb	–	≥	–	~
Mesomelaena tetragona	perennial herb	–	≥	–	–
Pimelea imbricata var. *major*	shrub	≥	–	r	≥
Philydrella drummondii	perennial herb-geophyte	≥	r	<	<
Schoenus odontocarpus	annual herb	r	r	r	r
Siloxerus humifusus	annual herb	–	r	–	r
Sowerbaea laxiflora	perennial herb-geophyte	<	–	±	±
Tribonanthes longipetala	perennial herb-geophyte	r	–	r	r
Utricularia violacea	perennial herb-geophyte	<	<	<	<
Verticordia densiflora	shrub	≥	≥	≥	±
Viminaria juncea	shrub	r	r	r	–

– not present in any plots before or after treatment, ≥ maintained or increased cover class in all plots it was present in, ± decreased in cover class in some and increased in others following treatment, < decreased cover class in all plots it was present in, r new recruit in plots in 2001.

decreasing in others, indicating that factors apart from herbicide application were impacting on the growth of the plants.

With annual taxa in particular, it is difficult to determine if change in cover over two years is seasonally related or treatment related. Of the eight annual species present all but one maintained or increased in cover and this at least indicated that the herbicide treatments were not adversely affecting those species. Changes in cover of perennial herbs, geophytes in particular could also be seasonally related. *Utricularia violacea*, for example, disappeared from all plots it occurred in including controls. Trials were scored almost a month later in 2001 and this wetland perennial geophyte had probably died back to its bulb. However the geophytes *Philydrella drummondii* and *Sowerbaea laxiflora* both appear to have been adversely affected by the metsulfuron methyl (2.5 g ha^{-1}) and chlorsulfuron treatments and the impacts of these herbicides on these species requires further investigation.

Although the data is limited and difficult to interpret due to seasonal effects, there are indications that *S. bulbifera* can be effectively controlled without impacting on a range of co-occurring native taxa present at the study site. Given the high flora conservation values of these wetlands this is an area worthy of further investigation.

An integrated approach

Importantly, chemical control techniques are only one part of an effective strategy for managing the spread of weeds such as *S. bulbifera* into relatively undisturbed bushland. For the last three years bush regenerators have been employed through September/October in the wetlands to manually remove small isolated populations in undisturbed areas. The wetland soils are still soft in early spring and entire plants including corms come out quickly and easily with minimal soil disturbance. At the same time a spray contractor with a knowledge of the flora and a background in bushland work has carried out chemical control on heavier infestations of *S. bulbifera* in more disturbed areas.

Effectiveness of the project over the three years has been reliant on workers having an understanding of the distribution of *S. bulbifera* across the Brixton Street Wetlands. The populations were mapped at the start of the project, in 1998. The maps helped set priorities and allowed for a carefully targeted works program revisiting small isolated populations over a number of years. The maps also allowed accurately recorded work to be carried out over time and provided some information on the effectiveness of the management strategy.

A detailed understanding of the reproductive biology and the mechanisms for dispersal of *S. bulbifera* is also an important part of any effective management strategy. The observation that most seed of *S. bulbifera* germinates the season after ripening and is relatively short lived in the soil imply that once the adult population has been controlled follow up work could be over in a three to five years. Workers in South Africa have found that among natural populations with in the Cape Region of South Africa, the seeds of most geophytes do not display dormancy, generally germinating the season after ripening (Keely and Bond 1997).

Although observations indicate that water flow plays a major role in dispersal, fire also probably facilitates the spread of *S. bulbifera* in the wetland. Bond and van Wilgen (1996) noted that South African geophytes that occurred in the fire prone environment of the Cape Region of South Africa were well adapted to surviving summer fires. Soil offers very effective insulation to the summer dormant corms and some have contractile roots that pull the storage organs of young plants deeper into the soil helping them avoid lethal fire temperatures. Fire can break down bulb dormancy in some South African geophytes (Pearce 1963) and can stimulate flowering followed by prolific seed production in others (Goldblatt 1978, Richardson 1984, Le Maitre and Brown 1992). The post fire environment then offers space and light where seeds can germinate and seedlings can establish in the absence of larger trees and shrubs (Goldblatt and Manning 1998). Keeping frequent fire out of the wetlands is probably quite important in preventing further spread of *S. bulbifera*.

Weed control is a part of an overall site restoration program at Brixton Street. The protection of native plant communities is the focus rather than simple elimination of the weed. Species moving into the gap created as *S. bulbifera* is removed will need to be carefully monitored.

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