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A baseline study for controlling the indigenous encroacher *Stoebe vulgaris* in the natural grasslands of Southern Africa

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ABSTRACT

South African natural grasslands are being encroached by *Stoebe vulgaris,* a hardy, indigenous dwarf-shrub thriving in nutrient deficient soils with a history of poor veld management. This baseline study investigates selected management options and associated costs for controlling *S. vulgaris* in Bankenveld grassland. Control measures examined include 50% removal, 100% removal, and application of herbicide. Four spatially separated study sites were randomly selected within encroached areas. At each study site, two 25 × 25 m plots were demarcated, one of which was enclosed to prevent access by large ungulates. Sixteen 4 × 4 m sub-plots were placed within each of the eight demarcated plots. Veld condition and density of *S. vulgaris* were determined in all sub-plots prior to the application of control measures. Various control measures were applied, and after twelve months, the veld condition and density of *S. vulgaris* were again ascertained for comparison to pre-treatment values. Effects of herbivore presence and slope were investigated for the different control measures. Results indicate that to control *S. vulgaris* over the short term, either 100% removal or herbicide application is effective. We suggest a combination of these control measures, accompanied by ongoing monitoring and follow up treatments to ensure long-term success.

1. Introduction

Stoebe vulgaris is a hardy, multi-stemmed dwarf-shrub that grows to an average height and width of 60 cm (Schmidt et al., 2007). It is indigenous to South Africa, but has become naturalised throughout the southern African sub-region and occurs as far north as Angola (Kamundi and Victor, 2011; Koekemoer, 2001). According to Badenhorst (2004), *S. vulgaris* can be found as far afield as Madagascar and the United States of America where it has managed to establish. The plant thrives in disturbed, nutrient poor soils as a result of poor veld management practices (Roux, 1969; Wepener, 2007; Snyman, 2009).

S. vulgaris is recognised as a dire problem in agricultural lands, recently becoming an issue in natural and protected areas. It is known to encroach on natural grasslands and cultivated areas, posing a serious threat to these areas. This dwarf shrub has the ability to convert productive grasslands into unproductive shrublands (Avenant, 2015). Mature stands of *S. vulgaris* are unpalatable to most wild and domesticated ungulates. This leads to an increase in the grazing pressure placed on remaining grasslands, which results in overgrazing and competition for resources (Snyman, 2009). Areas that are encroached by *S. vulgaris* have lower carrying capacities and reduced plant biodiversity (Avenant, 2015).

Recently there have been disconcerting reports about the rapid spread of this plant in grassland areas that are in good condition (Wepener, 2007; du Toit, 2012a,b). According to regulation 16 of the Conservation of Agriculture Resources Act 43 (South Africa, 1983), *S. vulgaris* is listed as a proclaimed encroacher plant. The Act prescribes that where it encroaches on natural vegetation, it is the responsibility of the landowner to control it.

According to Snyman (2012) and Avenant (2015), there is no single cost effective method for controlling *S. vulgaris*. Limited control is possible using costly granular formations containing the active ingredient Tebuthiuron for soil application or suspension agents such as Metsulfuron-methyl for foliar application. Such methods have little impact on seed banks or seed dispersal of the plant from infested areas into cleared areas, resulting in the need for long-term follow up treatment (du Toit and Sekwadi, 2012). Use of the non-selective herbicide Tebuthiuron has had limited success in controlling *S. vulgaris* (du Toit, 2012a). The efficacy of herbicides in the control of *S. vulgaris* over the long-term should be weighed up against the negative consequences that these herbicides have on the environment. Negative consequences

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include the impact on non-target plant species, insects, soil micro-fauna, macro-fauna, and even distant aquatic species that are affected by runoff from treated areas (Boutin et al., 2014; Egan et al., 2014; Prosser et al., 2016).

Fire and the presence of large grazing ungulates may contribute towards the control of *S. vulgaris* infestations, especially when used in combination with other control measures (Avenant, 2015). Fire and large grazing ungulates are vital to ecosystem functions in grasslands, shaping vegetation structure and keeping woody plants at bay (Vaeret et al., 2009). However, the timing of fire treatments and the animal species involved are important (Sawadogo et al., 2005). Jordaan (2009) and Snyman (2011) are not proponents for using fire to control *S. vulgaris* and suggest that fire leads to increased germination rates of seeds without the total eradication of mature plants due to their robust root systems, causing plants damaged by fire to re-coppice after fire events. Snyman (2009b) however, states that fire has the ability to kill young *S. vulgaris* plants. Increased stocking rates of large grazing ungulates that consistently exceed carrying capacity of an area over the long-term has the potential to cause land degradation or desertification (Keya, 1998).

A combined approach using different management strategies aimed at controlling *S. vulgaris* holds promise and warrants further investigation. Since studies that investigate the control of *S. vulgaris* in natural areas are noticeably lacking in the literature, we decided to do a baseline study in a nature reserve. Because no studies exist for nature reserves, it is not possible to compare our findings to similar studies; however, we do compare our findings to those done in cultivated areas. In this study, we investigate a combination of different control strategies in an attempt to find the most effective and economically viable option, or combination of options, for controlling the *S. vulgaris* in natural areas. Methods tested include 50% removal, 100% removal, and the use of herbicide. Fire was not a control measure considered in our study due to reserve management's policy to not burn at the time. Control methods were applied to level and inclined areas. Half of our study sites were exposed to the reserves ungulates and half were enclosed to prevent access by ungulates. Due to the cost and time implications associated with the different control measures, we also investigate the costs involved with implementing the different control strategies. Finally, we make recommendations for further research into alternative control strategies not investigated in this study.

2. Materials and methods

2.1. Study area

This study was done between February 2015 and March 2016 in the Bankenveld grassland of Telperion Nature Reserve, located between 25° 38′ and 25° 45′ South, and between 28° 55′ and 29° 03′ East (Coetzee, 2012). Telperion Nature Reserve is in the Mpumalanga Province of South Africa (Fig. 1). The perennial Wilge River forms the western boundary of the reserve (Grobler, 1999). In addition to the Wilge River, several perennial streams and natural springs originate in the reserve, forming a myriad of accompanying and resultant wetlands in the reserve. The geology of Telperion consists of the Wilge, Ecca and Dwyka formations of the Waterberg and Karoo groups (Grobler, 1999). Lithology for Telperion is dominated by red coloured dystrophic and mesotrophic Arenite-Conglomerate soils (Grobler, 1999). Mean summer rainfall ranges from 650 to 700 mm per annum. Temperatures range from 3 to 28 °C. According to Mucina and Rutherford (2006), Telperion is located within the Rand Highveld Grassland, and is part of the Mesic Highveld Grassland vegetation unit. Acocks (1988) considers Telperion to be a transition zone between the grassland and savanna biomes, both of which are present on the reserve. The reserve constitutes many old farmlands interspersed with rocky outcrops. Evidence of cattle farming and crop production are visible in areas surrounding remnants of old farm homesteads. Disturbed areas at Telperion harbour noticeable infestations of *S. vulgaris* that have an effect on the productivity and biodiversity of the reserve.

2.2. Placement of study sites and sub-plots

Four study sites (Fig. 2) were randomly selected in areas infested with *S. vulgaris*. Since *S. vulgaris* infestations at Telperion occur in two distinct landscape types, level terrain, and inclined areas (less than 15°), two study sites were placed on level terrain and two were placed on inclined areas. A 10 m wide firebreak was created around each study site in an attempt to prevent unplanned fires from affecting our research.

At each of the four study sites, two 25 × 25 m plots were demarcated. One of the plots at each study site was fenced off (enclosed) with 1.5 m high diamond mesh fencing to prevent access by grazing ungulates. This type of fencing only excludes large grazing ungulates, not insects and small mammals. Adjacent to the enclosed plot we placed a second 25 × 25 m open (non-enclosed) plot that was accessible to grazing ungulates. The placement of two plots at each study site resulted in eight 25 × 25 m plots being placed in the field. The non-enclosed plots were part of the larger landscape in which they were placed, allowing normal grazing by ungulates similar to a study done by De Klerk et al. (2001).

Within each of the eight large plots, we placed 16 sub-plots that were 4 × 4 m in size. Within each sub-plot we applied a randomly selected method to control *S. vulgaris*. Pathways of 1.5 m wide were cleared between all of the sub-plots to prevent the various control measures from affecting one another.

2.3. Control measures

A combination of 'control' plots and three different treatment regimes were applied to the various sub-plots. At each site (enclosed and non-enclosed) four control sub-plots were left with no treatment affected. Treatment options allocated to the various 'treatment' sub-plots included 50% removal (four sub-plots at each site – enclosed and non-enclosed), where half of all above and below ground *S. vulgaris* plant material was removed by cutting and grubbing; 100% removal (four sub-plots at each site – enclosed and non-enclosed), where all above and below ground *S. vulgaris* plant material was removed by cutting and grubbing; and herbicide treatment (four sub-plots at each site – enclosed and non-enclosed), where foliar application of Metsulfuron-methyl was applied to all *S. vulgaris* plants in the sub plots. This herbicide was applied to the foliage of actively growing plants at a rate of 25 g per 100 litres of water during the 2015 growing season. Herbicide and plant material removal treatments were applied once off when the study was initiated.

Effects of slope and herbivore presence/absence were investigated for the different control measures. Non-enclosed plots were accessible to the large ungulates present on the nature reserve. Since *S. vulgaris* is an unpalatable plant, grazing animals were not affected by herbicides that were applied. The effect of the control measures on the vegetation (species composition, density and veld condition) in enclosed and non-enclosed plots after the application of control measures was recorded.

2.4. Field data collection

S. vulgaris density data were collected from all sub-plots prior to applying any control measures. The first data were collected a month after the treatments and continued on a monthly basis until the end of the project. All *S. vulgaris* plants in each of the sub-plots were physically counted.

Using the Step Point Method (Mentis, 1984; Dankwerts and Teague, 1989), herbaceous species composition data were collected at the beginning of the study period prior to any control measure application and again at the end of the study period. The four corners of each sub-