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Original Research

# Evaluating the Potential Use of *Seriphium plumosum* L. as Forage in the Semiarid Grassland of Gauteng Province, South Africa ☆

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ABSTRACT

Strategies and mechanisms are needed to enhance encroaching shrub species use by ruminants. *Seriphium plumosum* crude proteins, neutral detergent fibers, total phenolics, and condensed tannins were determined from combined fine leaves and stems collected during the dry and wet seasons, from burned and unburned areas. *S. plumosum* crude protein was higher during the wet season on postburned areas. Neutral detergent fiber was higher during the dry season and similar in both postburned and unburned areas. The mean total phenolics and condensed tannins were higher during the dry and wet seasons, respectively. These results have shown that *S. plumosum* forage quality in the wet season is sufficient to meet ruminants nutrient requirements, but the opposite is true for the dry season; hence, the need to include it in livestock feed with other protein and energy supplements to improve its forage quality beyond ruminant maintenance requirement.



## Introduction

Woody plant encroachment is a worldwide phenomenon (Archer et al. 2017), which has serious implications on local pastoral economics, regional and global climate, biogeochemical cycles, biodiversity, and human health (Eldridge et al. 2011). These implications are, however, dependent on woody plant functional traits (Nelson 2002). *Seriphium plumosum* L (syn. *Stoebe vulgaris*) is the most aggressive of the 34 *Seriphium* species indigenous to South Africa in the Asteraceae family (Snyman 2010). *S. plumosum* is also reported in other southern African countries, Madagascar, and the United States (Schmidt et al. 2002). Its encroachment reduces grazing capacity and production potential of rangelands (Snyman 2012), thereby compromising the ecological and economic value of rangelands (Clark et al. 2020).

Woody plants contain nutrients and plant secondary metabolites (Schmitt et al. 2016), which vary seasonally and in response to biotic and abiotic factors (Duda-Chodak et al. 2015). For example, *S. plumosum* has aromatic, volatile oils, which makes it unpalatable to browsers, except at certain growth stages (Badenhorst 2009). Nutrient concentrations increase in postfire regrowth (Schindler et al. 2004), especially during the first growing season (Snyman 2015). The interaction effects of fire and season on *S. plumosum* forage quality remain unexplored, thus limiting efforts to process its forage materials after mechanical control for use in formulating feed for browsing animals in captivity and domestic ruminants such as goats. Hence, it is prudent that we explore the forage quality of *S. plumosum* (Cummings et al. 2007) to enhance its use by ruminants (Estell et al. 2012).

This study explored how season and fire interact to influence *S. plumosum* L. crude protein (CP), neutral detergent fiber (NDF), total phenolics (TPs) and condensed tannins (CTs) concentration in the semiarid grassland community of Gauteng Province, South Africa. The study hypothesises that the post-burn wet season *S. plumosum* regrowth will have higher CP and lower NDF and plant secondary metabolites concentrations.

## Materials and Methods

### *Study area*

The study was conducted in Rand Highveld Grassland (Mucina and Rutherford 2006), approximately 50 km east of Pretoria

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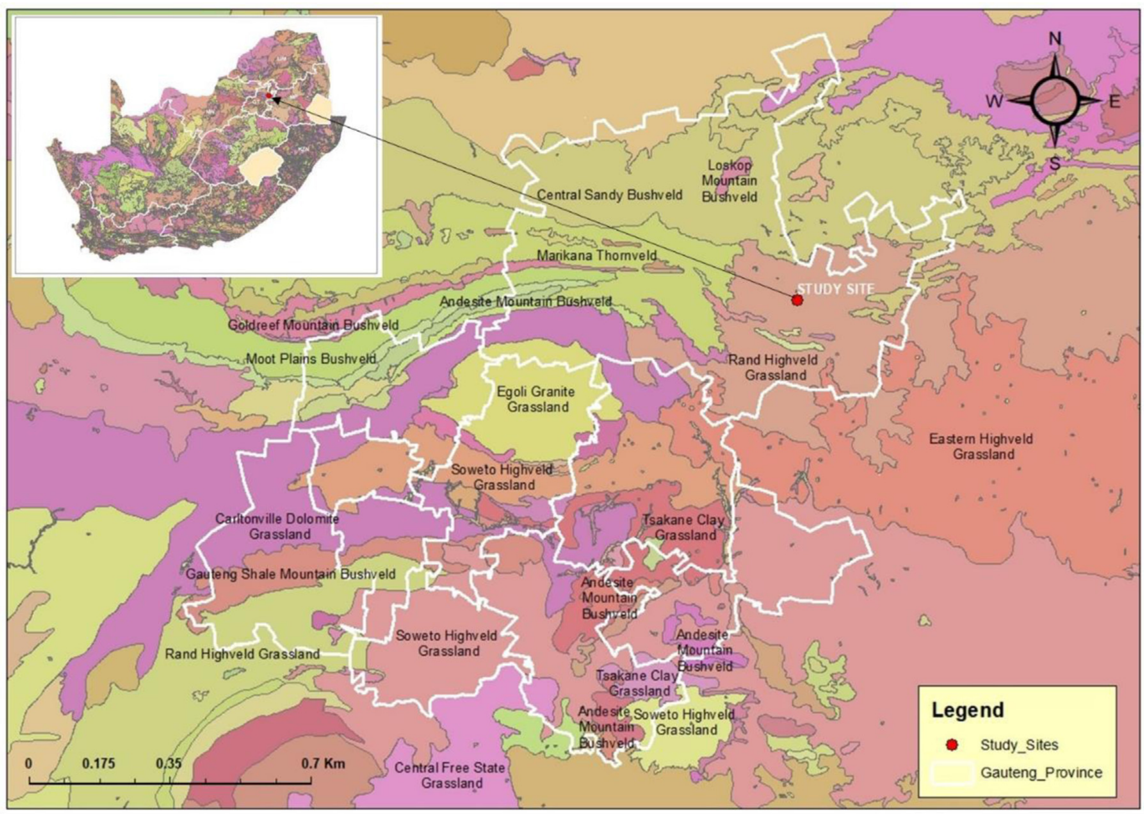


**Fig. 1.** Vegetation map of Gauteng Province showing the experimental site at Rand Highveld Grassland.

(28.67918°E, 25.76907°S), in Bronkhorstspruit, Gauteng Province, South Africa (Fig. 1).

The elevation at the study area is on average 1 457 m. The average rainfall at the site is 654 mm per annum, falling almost exclusively in summer, from October to April. The Rand Highveld Grassland experiences mean minimum and maximum temperatures of 10°C and 28°C in winter and summer, respectively. The soils are from the Quartzite ridges of the Witwatersrand Super group that support the soils of varying quality such as Glenrosa and Mispah, especially along the rocky ridges (Mucina and Rutherford 2006). The study site is encroached by *S. plumosum* and has a history of cattle grazing and unplanned, generally biennial fires. Before vegetation sampling (i.e., dry season of 2014), one side of the study site experienced unplanned fires, while the other remained unburned. Cattle grazing was withdrawn immediately after accidental fire has occurred until the end of data collection (2015). The road separating the burned and unburned treatment areas explained the occurrence of fire on one side of the experimental site, with the sampling areas located approximately 50 m away from the road on opposite sides. *S. plumosum* encroaches mostly on north-facing slopes (Avenant, 2015); hence, the study site was located on a north-facing slope (Pule et al. 2018). Sampling areas in different slope positions were 100 m to 120 m apart.

*Data collection*

A combination of *S. plumosum*'s fine leaves and twigs from previously burned and unburned ($n = 116$) areas were sampled from randomly selected plants during the wet ($n = 58$) and dry ($n = 58$) seasons, respectively. The 58 samples were from burned ($n = 29$) and unburned ($n = 29$) treatment areas. *Seriphium plumosum* samples were from the current (2015) wet/growing season on previously burned areas, while on unburnt areas, samples were from previous (2014) wet/growing season. The minimum distance between sampled *S. plumosum* plants at each sampling site was approximately 10 m.

The samples were oven dried at 60°C for 24 h. They were ground to pass through a 1-mm mesh sieve (Scogings et al. 2015) before being analyzed for CP, NDF, condensed tannins (CTs), and TPs concentrations. Condensed tannins were determined using the acid-butanol assay (Porter et al. 1985), with purified *Sorghum* as standard (Hattas and Julkunen-Tiitto 2012). Total phenolics concentrations were determined using the Prussian blue assay (Price and Butler 1977), with a Gallic acid standard (Scogings et al. 2013).

*Data analysis*

*Seriphium plumosum* samples ($n = 116$) were analyzed for the effect of season (dry and wet), fire (burnt and unburnt), and their interactions on CP, NDF, TP, and CT with a factorial analysis of variance (ANOVA) using GLMM procedures (SAS 2011). The data met the assumption of ANOVA concerning homogeneity of variance, normality, and independence before being analyzed. In instances where ANOVA produced significant results, the effect of season, fire, and their interaction on *S. plumosum* CP, NDF, TP, and CT were compared using Tukey's honestly significant difference test. The differences between means were declared significant at $P \leq 0.05$.

## Results

The mean TP was significantly higher (14.44 mg $g^{-1}$ dry weight [DW] ± 1.03 standard error) during the dry season than during the wet season (11.08 ± 1.07 mg $g^{-1}$ DW). In contrast, CTs were significantly higher (1.56 mg $g^{-1}$ DW ± 0.13) during the wet season and lower during the dry season (1.00 mg $g^{-1}$ DW ± 0.03). CP was significantly higher (6.69% $g^{-1}$ DW ± 0.20) and lower (5.22% $g^{-1}$

**Table 1**
Analysis of variance *F* and *P* values for the effects of season, fire, and their interaction on *Seriphium plumosum* total phenolics (TPs), condensed tannins (CTs), crude protein (CP), and neutral detergent fiber (NDF). Significant values are shown in bold.

| Factors | | TP | | CT | | CP | | NDF | |
|---|---|---|---|---|---|---|---|---|---|
| | DF | F | P | F | P | F | P | F | P |
| Season | 1 | 5.21 | **0.02** | 14.7 | **0.02** | 44.19 | **< 0.01** | 85.21 | **< 0. 01** |
| Fire | 1 | 3.65 | 0.06 | 0.35 | 0.56 | 11.59 | 0.09 | 0.6 | 0.44 |
| Season × Fire | 1 | 0.4 | 0.53 | 0.43 | 0.51 | 5.21 | **0.02** | 3.87 | **0.05** |

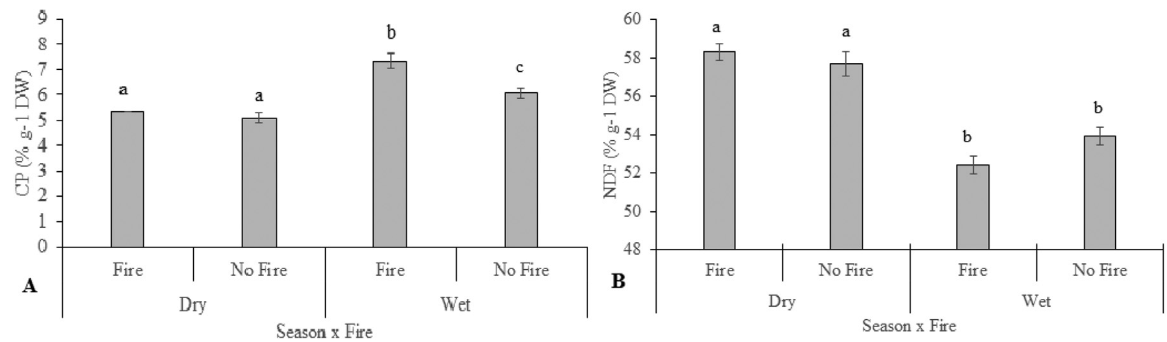


**Fig. 2.** **A**, *Seriphium plumosum* mean percentage crude protein (CP) and **B,** neutral detergent fiber during the dry season in burned and unburned areas and during the wet season in burned and unburned areas. Bars represent standard errors. Different letters on the error bars mean that $P \leq 0.05$.

DW ± 0.13) during the wet and dry seasons, respectively. NDF was significantly lower (53.17% $g^{-1}$ DW ± 0.34) and higher (58.01% $g^{-1}$DW ± 0.41) during the wet and dry seasons, respectively. Fire did not have any significant effect on forage quality parameters.

There was a significant interaction effect of season × fire on TPs, CP, and NDF ($P < 0.05$), but not on CT concentrations ($P > 0.05$; Table 1).

The effect of dry season × fire (5.34 % $g^{-1}$ DW ± 0.18 standard error), as well as dry season × no fire (5.09 % $g^{-1}$ DW ± 0.18), on CP percentage were insignificantly different. However, the wet season postburning had significantly higher CP (7.33% $g^{-1}$ DW ± 0.31) than the wet season on unburned treatment (6.08% $g^{-1}$ DW ± 0.20; Fig. 2a).

There was a significantly higher NDF concentration during the dry season on postburned (58.31% $g^{-1}$ DW ± 0.41) and dry season on unburned (57.69% $g^{-1}$ DW ± 0.62) than wet season postburning (52. 43% $g^{-1}$ DW ± 0.45) and no-burning (53.91% $g^{-1}$DW ± 0.47) treatments (see Fig. 2b).

## Discussion

*S. plumosum* CP concentrations were higher during the wet season than the dry season, and the opposite was true for NDF. The higher CP concentrations during the wet season compared with the dry season might be due to a higher photosynthetic rate and moisture content, which increase plant nitrogen uptake (Anele et al. 2009). Season influences the availability and the quality of forage (Osoro et al. 2013). The highest *S. plumosum* CP (7.33% $g^{-1}$ DW) concentrations during the wet season on burned areas meet ruminant CP requirements (> 7% $g^{-1}$ DW) for maintenance. These suggest that the use of unpalatable woody species such as *S. plumosum* might require protein supplements to increase fiber digestion, forage intake, and growth performance (Yue-ming et al. 2005). Furthermore, we propose that such species be included as an ingredient for ruminant feed formulation. This may contribute to the management of *S. plumosum* encroachment on South Africa, with implications for other unpalatable woody plant species encroaching in semiarid grassland communities.

*Seriphium plumosum* CT concentrations during the wet season were high, and so were its TP concentrations during the dry season. Woody plant defenses are costly (Endara and Coley 2011), hence *S. plumosum* may be investing in one defense mechanism at a time. Although higher CT concentrations (> 5% DM) affect the nutritional value and acceptability of browse (Mellado 2016), their concentrations in actively growing *S. plumosum* during the wet (1.41%) and dry (0.10%) seasons were too low to serve as antinutritional factors. Instead, they might increase efficiency of protein digestion and absorption in the ruminant's small intestine (Naumann et al. 2013).

CP concentration was higher post burn, in the wet season than on unburned areas, as well as during the dry season on burned and unburned areas. Woody plant regrowth post burn is highly palatable and nutritious, which might increase the likelihood for their use as forage by livestock (Nyamukanza and Sebata 2020). Fire reduces *S. plumosum* encroachment (Clark et al. 2020) while also increasing its CP concentrations during the wet season. The CP concentrations of *S. plumosum* in the wet season are adequate for ruminants' maintenance requirements and might require additional provision of higher nutrient supplements in the dry season.

An interaction effect of season and fire on *S. plumosum* NDF concentrations was also significant, but the differences were limited to the main factor of season. *S. plumosum* NDF concentrations (58.31%) during the dry season on burned and unburned areas were high enough (55–60%) to reduce intake rate by rendering biting, chewing, and digestibility costly to herbivores (Shipley and Yanish 2001). However, NDF concentrations (53.16%) during the wet season on burned and unburned areas are marginally below (< 55%) the levels that may reduce forage intake by herbivores (Banakar et al. 2018). Consequently, postburned *S. plumosum* edible materials may be used to formulate diet and control its encroachment on South African semiarid grasslands. However, forage sampling in the burned and unburned sites was not completed in the same year, which is a limitation of this study. As such, more research that replicates fire treatments, while accounting for years of sampling and other environmental factors on *S. plumosum* plant chemical response is still needed.

### *Management implications*

The results from this study demonstrated the potential for manipulating *S. plumosum* forage quality during the dry season using fire, followed by mechanical harvesting of plant material during the wet season for formulating fodder for ruminants. This study has prospects for contributing to the management of *S. plumosum* encroachment. Future studies aiming at providing supplements to browsing herbivores are needed to increase the use of chemically defended *S. plumosum* plants post burning in the field.

## Declaration of Competing Interest

The authors declare that there is no conflict of interest with this manuscript.

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