International Grassland Congress Proceedings

XXIV International Grassland Congress / XI International Rangeland Congress

The Diversity of Poisonous Plant Patches in the Arid Rangelands of Namaqualand, South Africa

T. Jamalie
University of the Western Cape, South Africa

M. I. Samuels
Agricultural Research Council, South Africa

C. F. Cupido
Agricultural Research Council, South Africa

F. L. Müller
Agricultural Research Council, South Africa

W. L. Engelbrecht
Agricultural Research Council, South Africa

See next page for additional authors

The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

Presenter Information

T. Jamalie, M. I. Samuels, C. F. Cupido, F. L. Müller, W. L. Engelbrecht, T. Dube, and R. S. Knight

The diversity of poisonous plant patches in the arid rangelands of Namaqualand, South Africa

Jamalie, T[*]; Samuels, MI[†]; Cupido, CF[†]; Müller, FL[†§]; Engelbrecht, WL[†]; Dube, T[¶]; Knight, RS[*]
*Department of Biodiversity and Conservation Biology, University of the Western Cape, South Africa; [†]Agricultural Research Council–Animal Production: Range and Forage Sciences, South Africa; [§]Agricultural Research Council–Animal Production: South African National Forage Genebank, South Africa; [¶]Department of Earth Sciences, University of the Western Cape, South Africa

Key words: plant diversity, poisonous plants, plant associations, biodiversity hotspot, pastoral rangeland

Abstract
The Namaqualand region in South Africa is part of the richest arid biodiversity hotspot in the world. Plant distribution and diversity here are impacted by various biophysical and anthropogenic factors. In these landscapes, poisonous plant patches, which pose serious threats to livestock, are widespread but their contribution to the regions biodiversity are not fully understood. This study assessed their plant diversity and compared its matrix. This study was conducted in the semi-arid to arid Steinkopf pastoral area located in Namaqualand where livestock is still herded daily. Twenty-five paired sites were selected based on the dominance of poisonous plants within the genera *Tylecodon, Euphorbia* and *Adromischus.* Within these sites, the number and abundance of different plant species were recorded and categorised into different plant functional types. Results showed a significant difference in Shannon Wiener plant diversity where poisonous plant patches displayed a greater diversity compared to sites sampled in the matrix. We interpret these findings as a consequence of herding in the region, where herders do not allow their animals to graze on or near poisonous plant patches. As such, palatable plants, which are absent or low in abundance in the surrounding landscape have a refuge where they can survive and set seed. This study provides evidence that the ethnobotanical knowledge of herders and palette of livestock are also major contributors to the spatial distribution and diversity of plant species in the arid biodiversity hotspot.

Introduction
Poisonous plants are distributed worldwide and are found in almost all plant communities. These plants however pose a significant economic risk to the livestock farming industry (Kellerman 2009). Livestock losses that occur because of the ingestion of poisonous plants include, but are not limited to livestock fatalities, decreased productivity, increased abortions, birth defects, and increased management costs (Walelign and Mekuriaw 2016). As a preventative measure, some farmers have taken to remove poisonous plants from the landscape owing to the risks they pose for livestock (Kellerman 2009). The full extent of the ecological consequences of removing these poisonous plants from the landscape remains unknown. Thus, understanding the diversity of poisonous patches in relation to the rest of the landscape will ultimately lead to a better understanding of the role that poisonous plants play in these ecosystems. In arid ecosystems, vegetation is generally arranged in what is referred to as a two-phase mosaic. This mosaic is made up of patches of high plant cover scattered within a matrix characterized by low plant cover (Sala and Aguiar 1996). These patches are scattered throughout the landscape as either bands or clumps of dense vegetation patches. The underlying drivers of the two-phase mosaic include the redistribution of seeds, nutrients, and water from sources to what is referred to as sinks in landscape. Variations in the degree to which either of these drivers play a role determines whether a pattern is banded or clumped (Aguiar and Sala 1999). Furthermore, studies have shown dominant woody plants to protect plants preferred by livestock from grazing in vegetated patches (Parker 1982). However, little is known of the role poisonous plants play in patch dynamics in arid ecosystems. This study tested the hypothesis that poisonous plants not only protect palatable plants from grazing but act as islands of diversity in an arid grazing system. Specifically, the study aimed to assess the association between poisonous plants and palatable forage species, and to determine whether poisonous plant patches could be considered 'islands of diversity'.

Methods and Study Site

The study was conducted in the Steinkopf pastoral area which is 582 634 hectares in size (Piers et al. 2020). There are about 50 000 resident pastoral livestock that are herded from permanent to temporary stockposts that are scattered throughout the rangeland. Within the Steinkopf pastoral area, 25 sites were selected in the winter rainfall shrublands and were based on patches dominated by large poisonous plants within the genus *Tylecodon,* and *Euphorbia.* These patches were found along grazing routes recommended by herders and livestock farmers in the area. At each site, a 225 m^2 plot was laid out, which was further divided into 20 subplots using 2 x 2 m quadrats. Within each quadrat plant species were recorded- specifically the name and number of occurrences. Each recorded species was then placed into functional groups based on palatability and growth form. This process was then repeated for non-poisonous plant patches (in the matrix) at each of the 25 sites. The statistical analysis of this data included independent sample t-tests comparing the diversity (calculated using the Shannon-Weiner Index (H')) of species sampled on poisonous plant patches to that of species sampled in the matrix. Similarly, a t-test comparing the diversity of functional groups on and off poisonous plant patches was also conducted. Furthermore, Coles Index (C7) derived from (Cole 1949) was used to determine which species are associated with poisonous plants found on poisonous plant patches.

Results

The results in figure 1 indicate that poisonous plant patches have a significantly higher mean alpha diversity than the surrounding matrix (mean matrix species diversity = 1.34 and mean poisonous patch diversity = 1.94, $t = -5.54$, $p < 0.05$). Similarly, figure 2 shows poisonous patches have a significantly higher mean growth form diversity than its surrounding matrix (mean matrix growth form diversity = 0.94 and mean poisonous patch growth form diversity = 1.46, $t = -7.34$, $p < 0.05$). Coles Index (C_7) analyses (Table 1) indicate the plants associated with these poisonous plants across the 25 sites sampled. *Adromischus, Euphorbia, Tylecodon paniculatus* and *Tylecodon reticulatus* are highly associated with species in the genus *Lampranthus*- a dwarf succulent, with the exception of *Tylecodon wallichii* which is highly associated with a species in the genus- *Pentzia*. This association is based on the degree to which these species joint occurrence become more frequent.

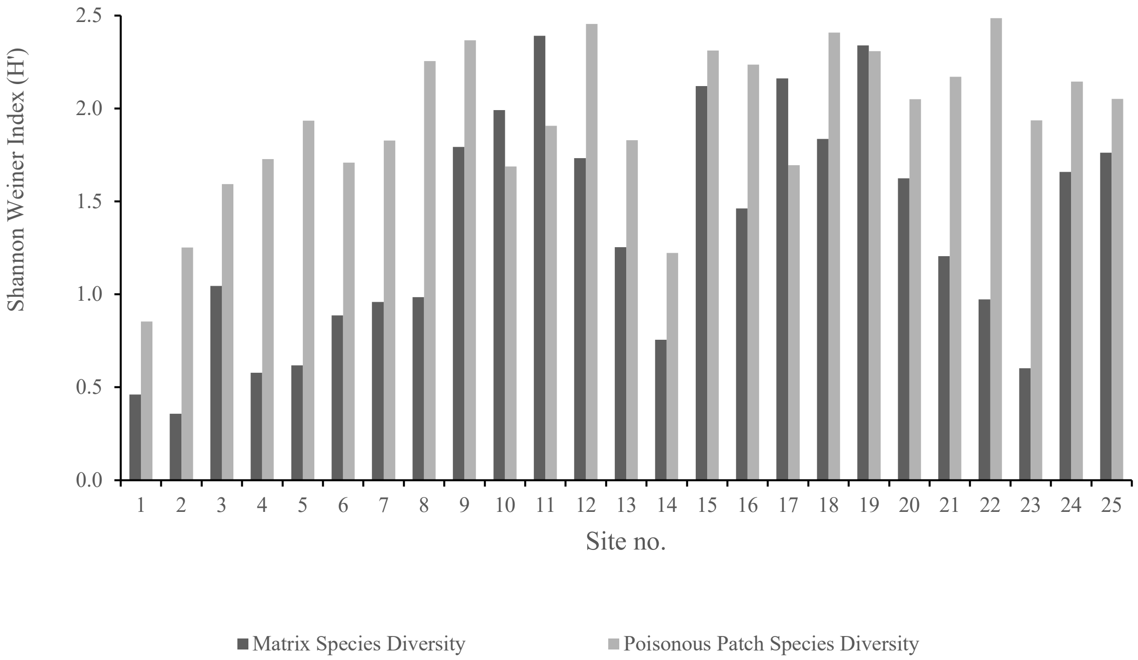

Fig 1. The diversity of plant species in poisonous plant patches compared to patches sampled within the matrix**.**

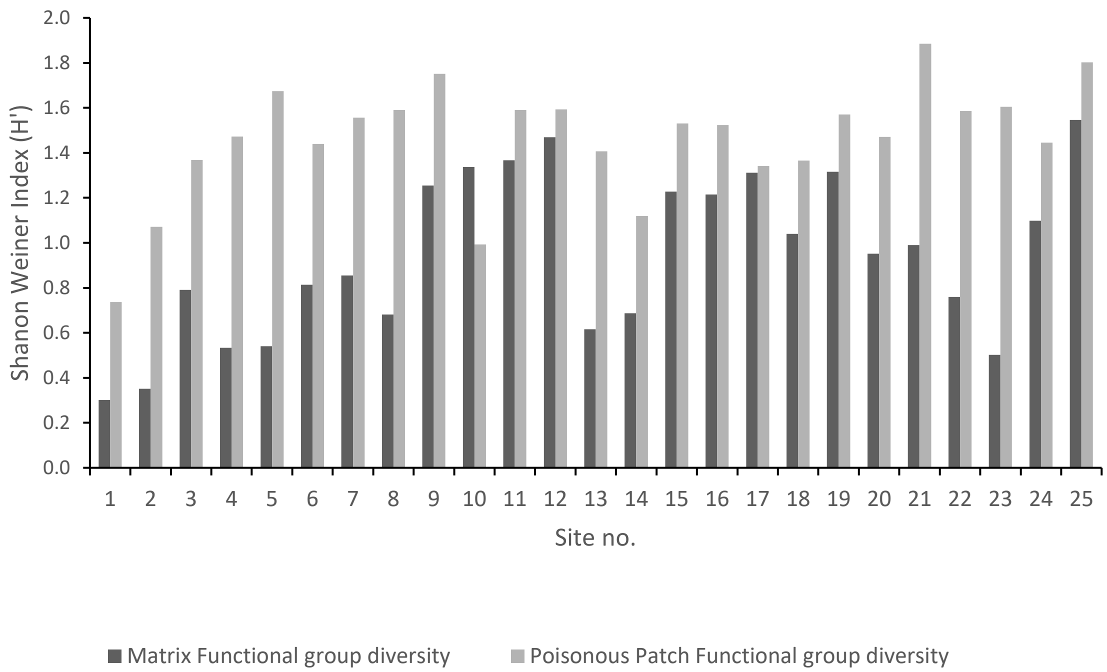

Fig 2. The diversity of plant functional groups (growth forms) in poisonous plant patches compared to patches sampled in the matrix.

Table 1. Coles Index of associated species sampled in the poisonous patches.

Target Species	Associated species	χ2 Value	Coles Index
Adromischus alstonii	*Lampranthus otzenianus*	48,029	0,827
	Euryops sp. 1	52,497	0,614
	Lampranthus stipulaceus	43,305	0,573
	Cheiridopsis denticulata	23,721	0,515
Euphorbia mauritanica	*Lampranthus otzenianus*	98,385	0,780
	Cheiridopsis denticulata	25,987	0,510
	Calobota sericea	66,572	0,470
	Lampranthus stipulaceus	27,358	0,462
Tylecodon paniculatus	*Lampranthus otzenianus*	19,757	0,821
	Euphorbia gariepina	13,572	0,461
	Tetraena retrofracta	29,025	0,441
	Roepera sp.	34,961	0,420
Tylecodon reticulatus	*Lampranthus stipulaceus*	11,339	0,796
	Jordaaniella cuprea	5,274	0,384
	Ruschia sp.	3,727	0,362
	Cotyledon orbiculata	7,360	0,355
Tylecodon wallichii	*Pentzia* sp.	219,771	0,860
	Wiborgia monoptera	249,161	0,804
	Small succulent	197,138	0,790
	Cheiridopsis denticulata	69,956	0,567

Discussion

From the results it becomes apparent that poisonous plant patches have a significantly greater mean alpha diversity than patches that occur in the matrix. Furthermore, there is a significantly greater growth form diversity on poisonous patches compared to that of the matrix- where only site 10 boasts a greater growth form diversity within the matrix. From these results, we may consider poisonous plant patches as islands of diversity. This diversity may be driven by patch dynamics, where resources are concentrated on patches as result of the redistribution of water, seeds and nutrients in the landscape. The conditions in these patches facilitate growth allowing for the establishment of vegetation (Aguiar and Sala 1999). The diversity in these patches may also be driven and maintained by the presence of poisonous plants. These plants may act as a deterrent for livestock that may potentially graze on the palatable plant species on these patches thus, preferring rather to graze within the matrix on certain species. By preventing herbivory, poisonous plants may allow for the establishment of a greater diversity of species and growth forms on patches. The five target plant species are poisonous to livestock and are typically avoided. The positive associations observed by using the Coles index may be due to the target poisonous species having a positive effect on the associated palatable species. The target species may have also modified the patches in such a way so as to facilitate the growth of the associated species (Soosairaj et al. 2005). Alternatively, these associations may also be due to overlapping environmental tolerance variables ultimately forcing both to occupy the same area (Soosairaj et al. 2005). In conclusion, the results of this study provide evidence that poisonous plant patches promote species and growth form diversity possibly due to deterring grazers. It also sheds light on which palatable plants are associated with poisonous plants in the Steinkopf communal area. An understanding of which palatable plants are associated with poisonous plants may allow herders to better identify areas where poisonous plant species occur as some palatable plants stand out more from a distance than some poisonous plants and thus, herders could prevent livestock fatalities by avoiding these areas.

Acknowledgements

We thank the NRF as well as the Agricultural Research Council for funding this project.

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