Prosopis Species in South Africa

Subjects: Green & Sustainable Science & Technology | Plant Sciences

Contributor: Khuliso Ravhuhali

The infestation of invasive plants such as Prosopis species does not only affect the groundwater levels but also threatens the grazing capacity and species richness of most of the semi-arid areas around South Africa. Though Prosopis is invasive, it is however of good nutritive value and can serve as an alternative source of protein and minerals for livestock during the dry season. Bush encroachment by browsable invasive species can be controlled through biological methods by using organisms such as livestock.

Keywords: Prosopis species ; livestock ; nutritive value ; invasive species ; environment ; semi-arid

1. Introduction

The genus *Prosopis* has several species and hybrids, and in South Africa, the dominant ones are *Prosopis glandulosa* (Honey mesquite) and *Prosopis velutina* (Velvet mesquite) [1]. The *Prosopis* species were initially introduced to South Africa from South, Central, and North America in the late 1880s, mainly to provide fodder (pods in drought years), shade for livestock, windbreak, wood for fuel, timber for furniture, and a nectar source for honey production [2][3][4][5]. The plant was of great value to all stakeholders until the 1960s [6][7], before its negative invasive impact on ecosystem services, biodiversity, and local people's livelihoods was observed [8][9]. The species has invaded arid and semi-arid parts of Southern Africa, as well as other parts of the world [10]. The high invasive capacity is derived from its vigorous growth and high seed production and efficient dispersal mechanism, while the absence of natural seed-eating insects preserves the seed for extended periods [11]. Other than overwhelming the grazing land, devouring excessive amounts of groundwater, and reducing biodiversity, *Prosopis* is a very noxious invader, with areas of high infestation resulting in surrounding indigenous plants failing to deliver valuable ecosystem services for that ecological niche [12].

Besides its invasive problem, *Prosopis* still provides some nutritional benefits to livestock [13], and therefore, any control programme should not ignore its contribution to the smallholder livestock farmers in semi-arid areas. Furthermore, beneficial ecosystem services such as the reduction of soil erosion are obtained from this invasive plant [14].

2. The Expansion of Invasive Species

Shackleton et al. [15] highlighted that even though some of these invasive species can be beneficial, there are some detrimental aspects that can create vulnerability in social–ecological systems. The detrimental and beneficial aspects of *Prosopis* invasive plant species on a widespread extent, especially on livestock and underground water, have been reported in numerous locations of the world [16][17][18]. Hence, the invasive woody alien plant species, as non-native organisms that increase from the point of introduction and become much more abundant, have a great potential to cause harm to the environment, as they are the key drivers of environmental change, disrupting ecosystem functioning, being detrimental to grazing lands, and tending to threaten the native biological diversity (being the main causes of biodiversity losses around the world), economics, and human and animal health [9][19][20][21][22].

3. Different *Prosopis* Species

In South Africa, three different *Prosopis* plant species were introduced from North, South, and Central America in the last 1800s, namely, *P. glandulosa*, *P. chilensi*, and *P. velutina* (**Figure 1**) [23]. The study of Visser [1] reported that of the above-mentioned species, as well as their crossbreeds, there are only two species that prosper in South African environmental conditions, specifically *Prosopis velutina* and *Prosopis glandulosa* var. *torreyana*.

Figure 1. *Prosopis velutina*, Mafikeng municipality NW province. Photo taken by K.E. and H.S.

4. The Habitat of *Prosopis* Species around South Africa

The genus has invaded several hectares of the western half of South Africa, forming extensive and impenetrable thickets over vast areas [24][25]. The study of Nel et al. [26] reported that numerous plant species have amplified their ranges within the past few centuries due to human activities.

It is estimated that the spreading rate of *Prosopis* species in South Africa ranges from 18 to 40% per annum [18]. Van den Berg [27] stated that once the *Prosopis* species have set up in rangeland, the density of the infestations rapidly spreads at yearly rates of 3–10%. In the Northern Cape, Van den Berg [27] showed that the average annual rate of spread of *Prosopis* is very high, being approximately 15% in upland areas and up to 30% in riparian areas. Several estimations of provinces invaded with *Prosopis* species have been made over the decades [24][25]. With the use of biome-based procedures when ranking invasive plant species in South Africa [28], Robertson [29] stated that in South Africa, *Prosopis* plant species were ranked the second species in the Nama-Karoo biome and the third in the Succulent Karoo biome. Martin [30] reported that *Prosopis* seed may last a long time and may gain in mass over time to sizeable seed storage, which can endure for a minimum of 20 years without deteriorating. As per the study of Roberts [31], the measure of seed storage in South Africa changes over the distributional range of *Prosopis* species and is influenced by the existence or non-existence of animals, with accumulations of as numerous as 2500 seeds/m^2 in some few regions.

5. Ecophysiology, Drought, and Salt Tolerance

Several authors highlighted the adaptability of this species in dry areas with more saline soils unsuitable for cultivation [10][32][33]. For example, Lauenstein et al. [34] stated that *Prosopis* species, especially *flexuosa*, grow and develop in a broader range in the flatlands where there is no additional water contribution. This could be linked to moderate plasticity at physiological and xylem anatomical levels and a positive absolute value in key drought tolerance characteristics. According to Villagra et al. [35], some of these species can survive the desert steppe with extremely severe low temperatures during winter times. *Prosopis* species have a defence mechanism or a system against drought strain, which involves alterations in gas exchange, stomata opening, osmotic adjustment, and leaf area [36]. *Prosopis* species are extremely tolerating salt [37], e.g., *P. juliflora*, *P. tamarugo*, *P. laevigata*, *P. alba*, and *P. pallida*, and can grow in saline soil regimes comparable to seawater [38][39][40].

6. The Negative Impact Associated with *Prosopis* Species

The negative effects of *Prosopis* invasions to the environment and biodiversity include the reduction in plant species richness, density, and diversity in arid areas [41], as well as increased local tree mortality due to increased competition for water, nutrients, and land with existing local vegetation [16][20][42][43][44]. The ecosystem activities, i.e., water supply, soil quality, and grazing areas, have been negatively impacted by *Prosopis* invasions, resulting in a range of negative results for native farmers [18][45][46][47].

7. *Prosopis* as an Invasive Species

According to Pasiecznik [10], several key factors that are favourable for invasive species to dominate over the area include climate change, land-use changes, and competitive ecological advantages. For instance, in South Africa, the widespread occurrence of *Prosopis* invasive plant species takes place mostly in the areas where there is a scant herbaceous layer available and where the conditions for establishment and germination are favourable [4][48]. According to Harding [49], seed production is predicted at 600,000 to 1,000,000 seeds per mature tree each year. It was highlighted that those seeds are most likely to sprout when they are scoured, as they pass throughout the digestive tract and are released into the humid faeces of ruminants [50].

8. *Prosopis* Ecosystem Services

8.1. Prosopis as a Feed Source for Livestock Production

Prosopis pods play a great beneficiary role in livestock production, society, and the general economies in arid areas [51]. Several uses have been reported over the years for *Prosopis* plant species such as animal feed [52][53][54], due to their high carbohydrate and protein content and their bioactivities, along with their medicinal properties [55][56][57][58][59][60]. Due to their higher nutritive value than pasture, the pods and leaves of *Prosopis* species are very edible and are consumed voluntarily by goats, sheep, camels, and cattle. Pods can also be fed to monogastric animals as well [10].

8.2. Prosopis Species for Medicinal Purposes

Various reports are highlighting that *Prosopis* species have provided treatments for several years, treating various ailments [61][62][63]. Over many years, the plant species have been utilised for traditional medicines, usually using their pods, leaves, roots, and seeds for treating various maladies [64][65]. In South Africa, *Prosopis* pods have been utilised to stabilise blood sugar levels in humans as an indigenous medicine (manna) [66]. Bioactive compounds found in *Prosopis* species play a substantial role in indigenous medical systems [67][68]. Technically, the plant species has a vast history in medical practices and its versatile uses in local areas [69][70].

9. The Anti-Nutritional Factors Associated with *Prosopis* Species

Ehsen [71] stated that anti-nutritional factors (ANFs) are secondary plant metabolites and are considered to be biologically active substances. The fruits, seed, and other plant parts produce these substances [72][73]. A study conducted by Anhwange et al. [74] revealed that *Prosopis* species contain ANFs, i.e., saponins, alkaloids, tannins, and oxalates, in varying quantities. The utility of *Prosopis* species is limited as animal feed by the existence of ANFs. According to Aganga and Tswenyane [73], ANFs reduce livestock productivity, but they can cause toxicity or confinement if animals eat large amounts of feed rich in these substances.

10. Livestock as a Tool to Control Invasive Species

Many studies have been conducted in an attempt to reduce and control the increase in invasive species. Livestock grazing in low invasive species abundance and separate species zonation common in wetland ecosystems may permit the superior achievement and targeted control of invasive species [75]. Zedler and Kercher [76] suggested that livestock could be useful resources for handling the influences and increase in invasive species in marshes where monoculture-forming invasive species are ordinary and drive large-scale ecosystem alteration. On the other hand, livestock is considered as one of the chief contributors to the spread of invasive species, as they can introduce pods from outside the area [45].

In the African continent and other continents, usage of livestock to manage invasive species has been fundamentally limited to world grasslands, where this technique has been met with diverse success [75][77]. Although small stock alone as a treatment cannot successfully eradicate invasive species, few authors have documented the use of goats. Mayo [78] used goats to control *Sericea lespedeza*, and a reduction in seed production was witnessed. Results by Rathfon et al. [79] suggested that goats give an effective and environmentally friendly method to control invasive species.

11. Summary

The control of invasive alien species is based on their contribution to the ecosystem and also on the negative impact associated with the species. For the development of better control, approaches, well-trained personnel, and knowledge of the species and the spreading process are very important. As far as *Prosopis* is concerned, their nutritive value to livestock makes it a valuable component of the rangelands for resource-constrained communal farmers. It is therefore important to develop utilisation strategies that consider the effective age or stage of development for the maximum control of spread and are also of benefit to ruminants. Therefore, managing the spread of these invasive species can be accomplished by the use of livestock as biological control while improving the productivity of ruminant animals. There is also a need to balance its use as a protein supplement and its negative impact on herbaceous biomass production. Additional control strategies such as physical ones can be applied to reduce the number of *Prosopis* plants to a level where optimum herbaceous biomass for livestock production can be achieved and the potential impact on soil erosion is minimised. Hence, these invasive *Prosopis* species control will assist in maximising the grazing capacity while maintaining the species diversity in arid and semi-arid environments.

References

1. Visser, N. Potential Controls for Prosopis in the Arid and Semi-Arid Parts of the Karoo—A Literature Review; The Department of Agriculture: Western Cape, South Africa, 2004; Volume 1, pp. 3–6.
2. Zimmermann, H.G. Biological control of mesquite, Prosopis spp. (Fabaceae), in South Africa. Agric. Ecosyst. Environ. 1991, 37, 175–186.
3. Shiferaw, H.; Teketay, D.; Nemomissa, S.; Assefa, F. Some biological characteristics that foster the invasion of Prosopis juliflora (Sw.) DC. at Middle Awash Rift Valley Area, north-eastern Ethiopia. J. Arid Environ. 2004, 58, 135–154.
4. Zimmermann, H.G.; Hoffmann, J.H.; Witt, A.B.R. A South African perspective on Prosopis. Biocontrol. News Inf. 2006, 27, 6–9.
5. Zachariades, C.; Hoffmann, J.H.; Roberts, A.P. Biological control of mesquite (Prosopis species) (Fabaceae) in South Africa. Afr. Entomol. 2011, 19, 402–415.
6. Wild, A.J.; du Plessis, C.G. Information Sheets: Prosopis; Department of Agriculture: Western Cape, South Africa, 2007. Available online: http://www.elsenburg.com/info/els/043/043e.html (accessed on 15 March 2021).
7. Haile, Z.M. Invasion of Prosopis juliflora (SW.) DC and Rural Livelihoods. Master's Thesis, Norwegian University of Life Sciences, Ås, Norway, 2008.
8. Van Wilgen, B.W.; Richardson, D.M.; Le Maitre, D.C.; Marais, C.; Magadlela, D. The economic consequences of alien plant invasions: Examples of impacts and approaches to sustainable management in South Africa. Environ. Dev. Sustain. 2001, 3, 145–168.
9. Shackleton, R.T.; Le Maitre, D.C.; Pasiecznik, N.M.; Richardson, D.M. Prosopis: A global assessment of the biogeography, benefits, impacts and management of one of the world's worst woody invasive plant taxa. AoB Plants 2014, 6.
10. Pasiecznik, N.M.; Felker, P.; Harris, P.J.; Harsh, L.; Cruz, G.; Tewari, J.C.; Cadoret, K.; Maldonado, L.J. The Prosopis juliflora-Prosopis pallida Complex: A Monograph; HDRA: Coventry, UK, 2001; p. 172.
11. Lloyd, J.W.; van den Berg, E.C.; Badenhorst, N.C. Mapping the Spatial Distribution and Biomass of Prosopis in the Northern Cape Province, South Africa, with the Aid of Remote Sensing and Geographic Information Systems; Report No. GW/A/98/68; Agricultural Research Council—Institute for Soil, Climate and Water: Pretoria, South Africa, 2002.
12. Matthews, S.; Brand, K. The Growing Danger of Invasive Alien Species; The Global Invasive Species Program: Cape Town, South Africa, 2004; p. 79.
13. Ditlhogo, M.K.; Setshogo, M.P.; Mosweunyane, G. Comparative nutritive value of an invasive exotic plant species, Prosopis glandulosa Torr. var. glandulosa, and five indigenous plant species commonly browsed by small stock in the BORAVAST area, south-western Botswana. Botsw. J. Agric. Appl. Sci. 2020, 14, 7–16.
14. Zengeya, T.; Ivey, P.; Woodford, D.J.; Weyl, O.; Novlona, A.; Shackleton, R.T.; Richardson, D.; van Wilgen, B. Managing conflict generating invasive species in South Africa: Challenges and trade. Bothalia Afr. Biodivers. Conserv. 2017, 47, 1–11.

15. Shackleton, R.T.; Shackleton, C.M.; Kull, C.A. The role of invasive alien species in shaping local livelihoods and human well-being: A review. J. Environ. Manag. 2019, 229, 145–157.

16. Dean, W.R.J.; Anderson, M.D.; Milton, S.J.; Anderson, T.A. Avian assemblages in native Acacia and alien Prosopis drai nage line woodland in the Kalahari, South Africa. J. Arid Environ. 2002, 51, 1–19.

17. Shackleton, R.T.; Le Maitre, D.C.; van Wilgen, B.W.; Richardson, D.M. The impact of invasive alien Prosopis species (mesquite) on native plants in different environments in South Africa. S. Afr. J. Bot. 2015, 97, 25–31.

18. Wise, R.M.; van Wilgen, B.W.; Le Maitre, D.C. Costs, benefits and management options for an invasive alien tree speci es: The case of mesquite in the Northern Cape, South Africa. J. Arid Environ. 2012, 84, 80–90.

19. Stafford, W.; Birch, C.; Etter, H.; Blanchard, R.; Mudavanhu, S.; Angelstam, P.; Blignaut, J.; Ferreira, L.; Marais, C. The economics of landscape restoration: Benefits of controlling bush encroachment and invasive plant species in South Afri ca and Namibia. Ecosyst. Serv. 2017, 27, 193–202.

20. Inderjit, S. Plant invasions: Habitat invasibility and dominance of invasive plant species. Plant Soil. 2005, 277, 1–5.

21. Richardson, D.M.; Hui, C.; Nunez, M.A.; Pauchardm, A. Tree invasions: Patterns, processes, challenges and opportunit ies. Biol. Invasions 2014, 16, 473–481.

22. Rejmánek, M.; Richardson, D.M. Trees and shrubs as invasive alien species—2013 update of the global database. Div ers. Distrib. 2013, 19, 1093–1094.

23. Mampholo, R.K. To Determine the Extent of Bush Encroachment with Focus on Prosopis Species on Selected Farms in the Vryburg District of North West Province. Master's Thesis, North-West University, Potchefstroom, South Africa, 200 6.

24. Pasiecznik, N.M. Prosopis-pest or providence, weed or wonder tree? ETFRN News 1999, 28, 12–14.

25. Versfeld, D.B.; Le Maitre, D.C.; Chapman, R.A. Alien Invading Plants and Water Resources in South Africa; Report No. TT 99/98; Water Research Commission Publisher: Pretoria, South Africa, 1998.

26. Nel, J.L.; Richardson, D.M.; Rouget, M.; Mgidi, T.N.; Mdzeke, N.; Le Maitre, D.C.; van Wilgen, B.W.; Schonegevel, L.; H enderson, L.; Neser, S. A proposed classification of invasive alien plant species in South Africa: Towards prioritising spe cies and areas for management action. S. Afr. J. Sci. 2004, 100, 53–64.

27. Van Den Berg, E.C. Detection, Quantification and Monitoring Prosopis spp. in the Northern Cape Province of South Afri ca Using Remote Sensing and GIS. Master's Thesis, North-West University, Potchefstroom, South Africa, 2010.

28. Henderson, L. Invasive, naturalized and casual alien plants in southern Africa: A summary based on the Southern Afric an Plant Invaders Atlas (SAPIA). Bothalia 2007, 37, 215–248.

29. Robertson, M.P.; Henderson, L.; Higgins, S.I.; Fairbanks, D.H.K.; Zimmermann, H.G.; Le Maitre, D.C.; Shackleton, C. M.; Villet, M.H.; Hoffmann, J.H.; Palmer, A.R.; et al. A proposed prioritization system for the management of invasive ali en plants in South Africa: Research in action. S. Afr. J. Sci. 2003, 99, 37–43.

30. Martin, S.C. Longevity of velvet mesquite seed in the soil. Rangel. Ecol. Manag. 1970, 23, 69–70.

31. Roberts, A.P. Biological Control of Alien Invasive Mesquite Species (Prosopis) in South Africa: The Role of Introduced S eed-Feeding Bruchids. Doctoral Thesis, University of Cape Town, Cape Town, South Africa, 2006.

32. Ahmed, N. Mesquite (Devi): Prosopis juliflora A Potential Source of Livelihood in Thar; China Agricultural University: Bei jing, China, 2017.

33. Salazar, P.C.; Navarro-Cerrillo, R.M.; Grados, N.; Cruz, G.; Barrón, V.; Villar, R. Tree size and leaf traits determine the f ertility island effect in Prosopis pallida dryland forest in Northern Peru. Plant Soil. 2019, 437, 117–135.

34. Lauenstein, D.A.L.; Fernández, M.E.; Verga, A.R. Drought stress tolerance of Prosopis chilensis and Prosopis flexuosa species and their hybrids. Trees 2013, 27, 285–296.

35. Villagra, P.E.; Vilela, A.; Giordano, C.; Alvarez, J.A. Ecophysiology of Prosopis species from the Arid Lands of Argentin a: What do we know about adaptation to stressful environments? Desert Plants 2009, 321–340.

36. Carevic, F.C. The role of ecophysiological studies in the genus Prosopis: Implications for the conservation of drought-pr one species. Idesia 2014, 32, 77–81.

37. Reginato, M.; Sgroy, V.; Llanes, A.; Cassán, F.; Luna, V. The American halophyte Prosopis strombulifera, a new potenti al source to confer salt tolerance to crops. In Crop Production for Agricultural Improvement; Ashraf, M., Öztürk, M., Ahm ad, M., Aksoy, A., Eds.; Springer: Dordrecht, The Netherlands, 2012; pp. 115–143.

38. Valadez, M.; Felker, P.; Degano, C. Evaluation of Argentine and Peruvian Prosopis germplasm for growth at seawater s alinities. J. Arid Environ. 2003, 55, 515–531.

39. Ríos-Gómez, R.; Salas-García, C.E.; Monroy-Ata, A.; Solano, E. Salinity effect on Prosopis laevigata seedlings. Terra L atinoam. 2010, 28, 99–107.

40. Devinar, G.; Llanes, A.; Masciarelli, O.; Luna, V. Different relative humidity conditions combined with chloride and sulfat e salinity treatments modify abscisic acid and salicylic acid levels in the halophyte Prosopis strombulifera. Plant Growth Regul. 2013, 70, 247–256.

41. Muturi, G.M.; Poorter, L.; Mohren, G.M.J.; Kigomo, B.N. Ecological impact of Prosopis species invasion in Turkwel riveri ne forest, Kenya. J. Arid Environ. 2013, 92, 89–97.

42. Belton, T. Management Strategy for Mexican Thorn (Prosopis juliflora) on Ascension Island: An Assessment of this Spe cies, and Recommendations for Management; RSPB: Bedfordshire, UK, 2008.

43. Schachtschneider, K.; February, E.C. Impact of Prosopis invasion on a keystone tree species in the Kalahari Desert. Pl ant Ecol. 2013, 214, 597–605.

44. Shackleton, R.T.; Le Maitre, D.C.; Richardson, D.M. Prosopis invasions in South Africa: Population structures and impa cts on native tree population stability. J. Arid Environ. 2015, 114, 70–78.

45. Geesing, D.; Al-Khawlani, A.; Abba, M.L. Management of introduced Prosopis species: Can economic exploitation contr ol an invasive species? Unasylva 2004, 217, 289–299.

46. Ndhlovu, T.; Milton-Dean, S.J.; Esler, K.J. Impact of Prosopis (mesquite) invasion and clearing on the grazing capacity of semiarid Nama Karoo rangeland, South Africa. Afr. J. Range For. Sci. 2011, 28, 129–137.

47. Ayanu, Y.; Jentsch, A.; Müller-Mahn, D.; Rettberg, S.; Romankiewicz, C.; Koellner, T. Ecosystem engineer unleashed: P rosopis juliflora threatening ecosystem services? Reg. Env. Chang. 2014, 15, 155–167.

48. Kahi, H.C.; Ngugi, R.K.; Mureithi, S.M.; Ng'ethe, J.C. The canopy effects of Prosopis juliflora (dc.) and Acacia tortilis (h ayne) trees on herbaceous plants species and soil physico-chemical properties in Njemps flats, Kenya. Trop. Subtrop. Agroecosyst 2009, 10, 441–449.

49. Harding, G.B. The Genus Prosopis spp. as an Invasive alien in South Africa. Ph.D. Thesis, University of Port Elizabeth, Port Elizabeth, South Africa, 1988.

50. Felker, P. Management, Use and Control of Prosopis in Yemen; Mission Report, Project Number: TCP/YEM/0169 (A); Mission Report DFID, UK funded Project: London, UK, 2003.

51. Silbert, M. A Mesquite Pod Industry in Central Mexico: An Economic Development Alternative; Felker, P., Moss, J., Ed s.; Prosopis: Semi-Arid Fuelwood and Forage Tree; National Academy of Sciences, Building Consensus for the Disen-Franchised: Washington, DC, USA, 1996; pp. 11–660.

52. Mahgoub, O.; Isam, T.K.; Neil, E.; Dawood, S.A.; Naseeb, M.A.; Abdullah, S.A.; Kanthi, A. Evaluation of Meskit (Prosopi s juliflora) pods as a feed for goats. Anim. Feed Sci. Technol. 2005, 121, 319–327.

53. Khobondo, J.O.; Kingori, A.M.; Manhique, A. Effect of incorporation of ground Prosopis juliflora pods in layer diet on wei ght gain, egg production, and natural antibody titer in KALRO genetically improved indigenous chicken. Trop. Anim. He alth Prod. 2019, 51, 2213–2218.

54. Al-Harthi, M.A.; Attia, Y.A.; Al-Sagan, A.A.; Elgandy, M.F. Nutrients profile, protein quality and energy value of whole Pro sopis pods meal as a feedstuff for poultry feeding. Ital. J. Anim. Sci. 2018, 18, 30–38.

55. Girma, M.; Urge, M.; Animut, G. Ground Prosopis juliflora pods as feed ingredient in poultry diet: Effects on growth and carcass characteristics of broilers. Int. J. Poult. Sci. 2011, 10, 970–976.

56. Ali, A.S.; Tudsri, S.; Rungmekarat, S.; Kaewtrakulpong, K. Effect of feeding Prosopis juliflora pods and leaves on perfor mance and carcass characteristics of Afar sheep. Kasetsart J. Nat. Sci. 2012, 46, 871–881.

57. Cattaneo, F.; Costamagna, M.S.; Zampini, I.C.; Sayago, J.; Alberto, M.R.; Chamorro, V.; Pazos, A.; Thomas-Valdés, S.; Schmeda-Hirschmann, G.; Isla, M.I. Flour from Prosopis alba cotyledons: A natural source of nutrient and bioactive phy tochemicals. Food Chem. 2016, 208, 89–96.

58. Henciya, S.; Seturaman, P.; James, A.R.; Tsai, Y.H.; Nikam, R.; Wu, Y.C.; Dahms, H.U.; Chang, F.R. Biopharmaceutical potentials of Prosopis spp. (Mimosaceae, Leguminosa). J. Food Drug Anal. 2017, 25, 187–196.

59. Wood, C.D.; Matthewman, R.; Badve, V.C.; Conroy, C. A review of the nutritive value of dry season feeds for ruminants in Southern Rajasthan. BAIF Bull. 2000, 1–8. Available online: https://assets.publishing.service.gov.uk/media/57a08d51 e5274a31e00017b8/R6995d.pdf. (accessed on 15 March 2021).

60. Gutteridge, R.C.; Shelton, H.M. Forage Tree Legumes in Tropical Agriculture; The Tropical Grassland Society of Austral ia Inc.: Queensland, Australia, 1998.

61. Nielsen, T.R.; Kuete, V.; Jäger, A.K.; Meyer, J.J.M.; Lall, N. Antimicrobial activity of selected South African medicinal pla nts. BMC Complement. Altern. Med. 2012, 12, 1–6.

62. Elmezughi, J.; Shittu, H.; Clements, C.; Edrada-Ebel, R.A.; Seidel, V.; Gray, A. Bioactive natural compounds from Prosopis africana and Abies nobili. J. Appl. Pharm. Sci. 2013, 3, 40–43.

63. Preeti, K.; Avatar, S.R.; Mala, A. Pharmacology and therapeutic applications of Prosopis juliflora: A review. J. Plant Sci. 2015, 3, 234–240.

64. Ribaski, J. Agroforestry system combining P. juliflora and buffel grass in the Brazilian semi-arid region: Preliminary results . In The Current State of Knowledge on Prosopis juliflora, Proceedings of the II International Conference on Prosopis, Recife, Brazil, 25–29 August 1986; Mario, A.H., Julio, C.S., Eds.; FAO: Rome, Italy, 1988.

65. Wickens, K.; Pennacchio, M. A search for novel biologically active compounds in the phyllodes of Acacia species. Conserv. Sci. W. Aust. 2002, 4, 139–144.

66. Dahms, H.; Sethuraman, P. Pharmacological potentials of phenolic compounds from Prosopis spp.—A review. J. Coast Life Med. 2014, 2, 918–924.

67. Kohli, R.K.; Batish, D.R.; Singh, H.P.; Dogra, K.S. Status, invasiveness and environmental threats of three tropical American invasive weeds (Parthenium hysterophorus L., Ageratum conyzoides L., Lantana camara L.) in India. Biol. Invasions 2006, 8, 1501–1510.

68. Kohli, R.K.; Batish, D.R.; Singh, J.S.; Singh, H.P.; Bhatt, J.R.; Singh, S.P.; Tripathi, R.S. Plant invasion in India: An overview. In Invasive Alien Plants: An Ecological Appraisal for the Indian Subcontinent; Bhatt, J.R., Singh, J.S., Singh, S.P., Tripathi, R.S., Kohli, R.K., Eds.; CABI: Cambridge, MA, USA, 2012; pp. 1–9.

69. Bartle, J.; Cooper, D.; Olsen, G.; Carslake, J. Acacia species as large-scale crop plants in the Western Australian wheatbelt. Conserv. Sci. West. Aust. 2002, 4, 96–108.

70. Bargali, K.; Bargali, S.S. Acacia nilotica: A multipurpose leguminous plant. Nat. Sci. 2009, 7, 11–19.

71. Ehsen, S.; Qasim, M.; Abideen, Z.; Rizvi, R.F.; Gul, B.; Ansari, R.; Khan, M.A. Secondary metabolites as anti-nutritional factors in locally used halophytic forage/fodder. Pak. J. Bot. 2016, 48, 629–636.

72. Makkar, H.A.; Becker, K. Nutrional value and antinutritional components of whole and ethanol extracted Moringa oleifera leaves. Anim. Feed Sci. Technol. 1996, 63, 211–228.

73. Aganga, A.A.; Tshwenyane, S.O. Feeding values and anti-nutritive factors of forage tree legumes. Pak. J. Nutr. 2003, 2, 170–177.

74. Anhwange, B.A.; Kyenge, B.A.; Kukwa, R.E.; Ishwa, B. Chemical Analysis of Prosopis Africana (Guill &Perr.) Seeds. Nig. Annal. Pure Appl. Sci. 2020, 3, 129–140.

75. Silliman, B.R.; Mozdzer, T.; Angelini, C.; Brundage, J.E.; Esselink, P.; Bakker, J.P.; Gedan, K.B.; van de Koppel, J.; Baldwin, A.H. Livestock as a potential biological control agent for an invasive wetland plant. Peerj 2014, 2, 567.

76. Zedler, J.B.; Kercher, S. Causes and consequences of invasive plants in wetlands: Opportunities, opportunists, and outcomes. CRC Crit. Rev. Plant Sci. 2004, 23, 431–452.

77. Reiner, R.; Craig, A. Conservation easements in California blue oak woodlands: Testing the assumption of livestock grazing as a compatible use. Nat. Areas J. 2011, 31, 408–413.

78. Mayo, J.M. The Effects of Goats Grazing on Sericea lespedeza. In Symposium Proceedings. Sericea Lespedeza and the Future of Invasive Species; Kansas State University Department of Agronomy: Manhattan, KS, USA, 2000; pp. 14–15.

79. Rathfon, R.A.; Greenler, S.M.; Jenkins, M.A. Effects of prescribed grazing by goats on non-native invasive shrubs and native plant species in a mixed-hardwood forest. Restor. Ecol. 2021, e13361.
