Harvesting site influenced the concentration level of nitrogen and mineral status of woody species in semi-arid areas of South Africa.

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Feed shortages in semi-arid areas cause a major set-back for livestock production. An understanding of the nutritive value of woody species in most parts of savanna regions can be vital to predicting what these species can offer for livestock productivity. The study assessed the variation in nitrogen and mineral concentration of leaves of woody species as influenced by harvesting site in South Africa. The study sites were communal areas in Limpopo and North West provinces. A total of 52 browse species were selected and used for this study. All statistical tests showed that there was a significant effect of species and site on both nitrogen and mineral concentrations of species. In Limpopo Province, the concentration of phosphorus and calcium was high in *Adansonia Digitata* species, while *Androstachys Johnsonii* had the lowest concentration of P and Ca. The highest ($P<0.05$) nitrogen level was obtained in *Berchemia discolour*, while the lowest ($P<0.05$) value was obtained in *Euclea divinorum* in Limpopo province. *Bridelia mollis H.* had the highest ($P<0.05$) zinc (Zn) concentration, whereas *Berchemia zyheri* had the lowest ($P<0.05$) Zn value in Limpopo province. *Searsia lancea* and *Searsia pyroides* in North-West sites had higher P when compared to all other species in the same sites. *Diospyros lycioides* also exhibited the highest ($P<0.05$) magnesium concentration level of all other species in the same sites. *Prosopis velutina* had the highest ($P<0.05$) copper (Cu) and zinc (Zn) compared to all other species in the same NW sites. *Senegalia caffra*, *Grewia flava*, *Vachellia karroo*, *Vachellia nilotica* subsp. *kraussiana*, *Searsia leptodictya*, and *Melia azedarach* found in the Limpopo province had the highest ($P<0.05$) phosphorus level when compared to the same species found in the North-West province. *Senegalia caffra*, *Peltophorum africanum*, *Grewia. flava*, *Vachellia hebeclada*, and *Terminalia sericea* found in the North-West province sites had the highest ($P<0.05$) iron levels when compared to the same species found in Limpopo province. Nitrogen concentration was regulated by the harvesting location and woody species. With the exception of *Terminalia sericea*, *P Peltophorum africanum* from Limpopo province, all browse species from all sites exhibited N concentrations more than 1.28%. There is a need to provide supplementation to those animals exposed to species that have a lower concentration of certain elements.

Introduction

Globally, the majority of browse species' leaves supply much-needed nutrition for domestic livestock like sheep, cattle, and, most crucially, goats. The leaves provide year-round sustenance for these animalsespecially during the dry season that is characterised by reduced quantity and quality of feed (Ravhuhali et al., 2020). It is not clear whether the nutritional content, notably minerals, of some of these species vary with regions. Given the high cost of commercial supplements for resource-poor communal farmers, knowing the mineral content of main browse species will assist to determine the accurate quantity to supplement. In addition to seasonal changes in climatic variables, soil type, elevation, herbivore activities, and tree species are some of the factors responsible for nutritional composition variation in browse (Mudau et al., 2021, Ravhuhali et al., 2022). Despite the widespread use of native browse species, most of them have traditionally been devalued, primarily due to less understanding of their potential feeding value because of scant documentation of their potential nutritional value across regions. The knowledge of the nutritional composition of different types of browse species will aid in creating a nutritional baseline database that will be critical when estimating levels of mineral supplements for livestock grazing natural pastures in semi-arid regions. As a result, the goal of this study was to examine the effect of geographical location on the mineral concentration of browsable woody species in semi-arid regions of South Africa. It was hypothesised that locations varying in climate and soils will affect the mineral status of the browse species leaves.

Materials and methods

Study site: At **North West** province harvesting was carried out in communal areas at Ratlou and Mahikeng Local Municipality. The villages were Loporung (S 25˚45˙37''E 24˚59˙54˙˙) in Ratlou Municipality and Tsetse (S 25˚44˙07˙˙ E 25˚39'40'') and Six Hundred (S 25˚42˙43˙˙ and E 25˚37'32˙˙) in Mahikeng Municipality. These areas have an annual average temperature range of 2˚C to 36˚C and sunny dry days and cold nights during winter. Average annual rainfall varies from 250mm to 500mm. The vegetation was described as a mixture of Eastern Kalahari Bushveld, Mafikeng Bushveld and Thornveld (Mucina and Rutherford, 2006). The **Limpopo** province harvesting sites were Makhado and Thulamela Local Municipality. At Makhado Municipality, browse leaves were harvested at Mpheni village (S 23°08'10" and E 30°03'18"), while in Thulamela Municipality Mutele (S 22°28'35" E 30°50'24") and Lamvi (S 22°39'49.85" E 30°45'21.88") villages were used. In these villages average annual temperature range from 13°C in winter to 36°C in summer and rainfall ranges between 200mm to 500mm. The vegetation was described as mixture of Soutpansberg Mountain Bushveld and Makuleke Sandy Bushveld (Mucina and Rutherford, 2006). For each woody browse species five trees were chosen and harvested manually. Only 52 species were found in both sites and used for this study. The species were: *Adansonia digitata*, *Androstachys johnsonii*, *Balanites maughamii*, *Berchemia discolor*, *Berchemia zeyheri*, *Bridelia mollis* hutch, *Carissa edulis*, *Catha edulis*, *Colophospermum mopane*, *Combretum Imberbe*, *Combretum molle*, *Combretum collinum*, *Dalbergia melanoxylon*, *Dichrostachys cinerea*, *Diospyros lycioides*, *Diospyros mespiliformis*, *Euclea divinorum*, *Flueggea virosa*, *Grewia flava*, *Grewia flavescens*, *Grewia monticola*, *Grewia occidentalis*, *Melia azedarach*, *Peltophorum africanum*, *Prosopis velutina*, *Pseudolachnostylis maprouneifolia*, *Pterocarpus rotundifolius*, *Schinus molle*, *Schotia brachypetala*, *Sclerocarya birrea*, *Searsia lancea*, *Searsia leptodictya*, *Searsia pyroides*, *Senegalia caffra*, *Senegalia galpinii*, *Senegalia mellifera*, *Senegalia nigrescens*, *Senegalia polyacantha*, *Strychnos madagascariensis*, *Terminalia sericea*, *Trichilia emetic*, *Vachellia erioloba*, *Vachellia hebeclada*, *Vachellia karroo*, *Vachellia nilotica*, *Vachellia nilotica* subsp. *Kraussiana*, *Vachellia rechmanniana*, *Vachellia robusta*, *Vachellia tortilis*, *Vachellia tortils* subsp. *raddiana*, *Vangueria infausta*, and *Ziziphus mucronata*. Only 14 species (*Grewia flava*, *Combretum mole*, *Dichrostachys cinerea*, *Melia azedarach*, *Peltophorum africanum*, *Searsia leptodictya*, *Senegalia caffra*, *Senegalia galpinii*, *Terminalia sericea*, *Vachellia hebeclada*, *Vachellia karroo*, *Vachellia nilotica*, *Vachellia tortilis* and *Ziziphus mucronata*) were found to be common in both harvesting site. The samples in a labelled brown bag were air dried at room temperature up to a constant weight before being ground using 1mm sieve milling and kept in sample labelled bottles pending chemical tests. For accuracy, the mineral tests were repeated three times. The mineral content was assessed using methods recommended by the Agri-Laboratory Association of Southern Africa (AgriLASA, 1998) using the samples used to measure dry matter (AOAC 2012). The analysis of nitrogen was done using the Kjedahl method (AOAC 2012). The mineral composition data of browse species that were not found in both harvesting sites were analyzed using a one-way ANOVA for a completely randomized design, and those browse species common in both harvesting sites were analyzed using a two-way factorial design (SAS 2010). To evaluate the impact of species and harvesting site on mineral concentrations, multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) were also utilized. All measured parameters were expressed in dry matter (DM).

Results and discussion

To ensure livestock growth, reproduction, and health, mineral requirements should be met. Julian et al. (2020) emphasized the detrimental effect of mineral shortage on the livestock industry's economy. In Limpopo sites, the P concentration ranged from 0.10 to 0.29% DM, with *A. digitata* having the highest percentage. In North-West sites, the P concentration ranged from 0.10 to 0.15% DM. According to the

NRC (1994), the recommended level needed by various kinds of livestock is in the range of 0.12-0.48 %. Due to their low level of phosphorus, species such as *A. Johnsonii, Diospyros mespiliformis,* and *Vachellia rechnanniana* may limit animal productivity at both sites. In North West sites, the calcium concentration of browse species ranged from 0.86 (*Searsia Lancea*) to 2.85% DM (*Prosopis Velutina*), while in Limpopo, it ranged from 0.40 (*A. johnsonii*) to 3.29% DM (*Adansonia digitata*). According to Yazzie et al. (1994), *A. digitata* is recognized to have better nutrient content when compared to many other plants. Together with P, calcium gives bones and teeth their rigidity and structure. Calcium is a necessary component of bone and teeth. The Ca:P ratio must be kept constant for the body to operate normally. The salt requirements for animals range from 0.06 to 0.08 % (NRC 1984). In this study, sodium levels in all species were higher than animal requirement, and this may have a negative impact on animals, particularly on rumen function (Mueller-Harvey et al., 1986) and reproductive health by encouraging inflammatory factors in the placenta that affect pregnancy (Abdelnour et al. 2020). The North West and Limpopo sites' forages had Mg contents ranging from 0.19 to 0.73 % DM, with *A. digitata* being the highest among browse species. The NRC recommend a range of Mg for lactating cows of between 1.2 and 2.1 %, which is greater than the ones observed in this study. Due to differences in K concentration , all species from this study may either fulfil or surpass the K requirements. K levels varied between 0.40% (*D. melanoxylon*) to 2.35% DM (*Catha edulis*) in both locations. Potassium needs for domestic ruminants, particularly sheep or cattle, should not exceed 0.5% (Ward 1966).

Results for micro elements at both harvesting locations differed per species. Iron concentration ranged from 45 mg kg DM in Limpopo to 279 mg kg^{-}DM in North West sites, while Zn concentrations ranged from 5.97 mg kg DM in Limpopo sites to 83.14 mg kg DM in North West sites and Mn ranged from 14.03 (*B. zeyheri*) to 550 mg kg DM (*P. Maprouneifolia*) in Limpopo sites. Normally, these trace elements dosage recommendations vary with animal species. *B zeyheri, C. mopane, S. lancea, S. brachypetala,* and *V. infausta* all had manganese levels that were within the acceptable range for cattle (MSD vet Manual, 2020). The zinc concentrations in *Vachellia tortilis, A. digitata, B. mollis H,* and *C. edulis* were also within the acceptable range for an animal's biological function.

For those species found in both sites. the concentration of minerals in browse plants was influenced by the harvesting location. Of contrast to the flat environment in the North West, the Limpopo sites are mountainous and have slopes that range from steeper to undulating. When compared to the sites in North West, the harvesting locations near Limpopo had a high canopy cover. Most browsing species in Limpopo are either overlapping or have the same P concentration values as sites in the North West. Few species (*V. hebeclada* on P and Ca*; V. nilotica subsp. kraussiana, S. galpinii, M. azedarach, Z. mucronata* on K and P; *P. africanum* and *S. galpinii, S. molle* on Mg and *G. flava* on Na) were found in the North West sites with the highest concentration levels of specific elements. This may have been influenced by the variation in harvesting site. For instance, the vegetation type, high species density, slope, and altitude of the collected locations were projected to result in the highest mineral concentration in the majority of the browsing species from Limpopo. It is also known that altitude influences the abiotic environment (Roukos, 2017). According to Roukos et al. (2017) and Hadjigeorgiou et al. (2005), soil qualities can be influenced by mountainous, steep to undulating slopes with lower altitude and high plant species density, such as Limpopo harvesting locations, likely to result in high mineral levels on foliage. Nine out of the 14 species (*S. galpinii, V. karoo, V. nilotica subsp. kraussiana, S. leptodictya, M. azedarach, Z. mucronata, S. molle, D. cinerea,* and *V. tortilis*) had higher concentrations of Fe compared to the North West sites, whereas only three browse species in the North West sites showed the highest Co values.

Nitrogen concentration was regulated by the harvesting location and type of browse woody species. With the exception of *T. sericea, P. africanum, A. johnsonii* and *E. divinorum* from Limpopo province, all browse species from all sites exhibited N concentrations more than 1.28% DM, which is greater than the minimum protein requirement of 80 g kg DM for optimum rumen microbial activity. For species found in both harvesting sites, the multivariate tests (Pillai's Trace; Wilks' Lambda; Hotelling's Trace and Roy's Largest Root) showed the significant effects ($P < 0.0001$) of species, harvesting location, and the interaction effect between species and harvesting sites for all mineral parameters tested. Similar to this study, Mudau et al. (2022) discovered substantial variations in the bioactive chemicals (tannins and phenols) using the same multivariate testing.

Conclusion

Each harvesting site contained different species, each of which varied in mineral content. In Limpopo sites, *Adansonia digitata* showed higher mineral concentrations while *B. zeyheri* had the lowest concentrations. All statistical tests revealed that there were substantial variations between the effects of species, harvesting site, and their interactions, as well as the concentration of all the minerals in browse species that were common to both sites. Animals that are exposed to species with lower concentrations of specific minerals need to be supplemented.

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