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Ethnoveterinary survey of plants used for the control of gastrointestinal nematodes in sheep at three agro-ecological zones in the Eastern Cape Province of South Africa

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Background: With exception of the desert biome, all of South Africa's biomes occur in the Eastern Cape. The province is known to have high numbers of livestock that are mostly found in communal farming areas. Multi-drug resistance of gastrointestinal nematodes against major classes of conventional anthelmintics and the high cost of synthetic drugs calls for an urgent search for different control strategies of nematodes.

Aim: A survey was conducted to identify and document plant species used to control gastrointestinal nematodes of livestock in Ciko, Goso and Upper Ngqumeya communities in the Eastern Cape Province.

Setting: The study included filed observations and transect walks, as well as a standardized questionnaire given to 48 sheep farmers.

Methodology: Forty-eight livestock farmers including men and women of mixed ages were interviewed. The information was obtained through the use of a structured questionnaire, field observations and transect walks. Data generated were analysed using descriptive statistics with frequency of citation (FC) and relative frequency of citation (RFC) as quantitative.

Results: A total of 11 plant species from different genera were reportedly available and used to control gastrointestinal nematodes. *Aloe ferox* (0.67) and *Zanthoxylum capense* (0.44) had the highest values of RFC followed by *Strychnos henningsii* (0.23) and *Elaphantorhhiza elephantine* (0.21) and were widely known by the people of the study areas. The three most frequently used plant parts were leaves, roots and bark accounting for about 36.4%, 27.3% and 27.3%, respectively. The ethnoveterinary medicines were prepared in the form of decoctions and infusions. Oral administration of the concoctions was the only route of administration. The major constraints of sheep production as perceived by the farmers were prevalence of internal (36%) and external parasites (18.1%). All medicinal plants used were native and collected from the wild. The most dominant life forms were trees (45.4%), followed by herbs (36.4%) and shrubs (18.2%). Homestead expansion was ranked as the major threat (26%) to medicinal plants followed by firewood (21%). *In-situ* (protection through rangers) was the most frequently mentioned (67%) conservation practice used by farmers to protect the loss of medicinal plants followed by *ex-situ* (33%).

Conclusion: In the light of data gathered on the surveyed plants, it appeared the plants play a role in the healthcare of sheep in rural communities. Further studies are required to analyse the plants for their chemical composition and biological properties.

Keywords: ethnoveterinary; indigenous; internal parasites; medicinal plants; sheep farmers; survey.

Introduction

The Eastern Cape Province (ECP) is situated in the south-eastern part of South Africa (SA) and is the second largest province in SA (Statistics South Africa [Stats SA] 2016 to 2019). The province covers about 15.9 million ha, which is about 13% of the total land area of SA (122 million ha). The province is the home for about 12.7% of the human, and because of its diverse climatic conditions,

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it holds more than 29% of the livestock population in SA (Department of Forestry and Fisheries (DAFF) 2019; Stats SA 2019). The ECP is recognised as the only province which has diverse agro-ecological zones that are suitable to perform various agricultural activities, especially livestock production.

Despite the province having diverse natural and livestock resources, sheep production per unit area under the communal sector is low compared to the commercial sector (Bembridge 1989; Mthi et al. 2020; Nowers, Nobumba & Welgemoed 2013). Among other factors, high prevalence of diseases, poor nutrition and poor animal health management are the major constraints that hinder the productivity of livestock under the communal sector (Ajala 2004; Ben & Smith 2008; Mthi & Nyangiwe 2018; Nsoso & Madimabe 2003). Infestations by gastrointestinal nematodes constitute a major threat to the health and welfare of sheep in tropical and subtropical regions of the world (Jansen et al. 2020; Worku et al. 2017). The *Strongyloides spp*., in particular, the *Haemonchus spp*. and *Fasciola spp*. are considered as highly pathogenic nematode and trematode of ruminants that are responsible for morbidity and mortality in sheep (Githiori, Athanasiadou & Thamsborg 2006) and may have negative effects on the performance and productivity of livestock (Akhtar et al. 2000; Gorsich, Ezenwa & Jolles 2014; Perry et al. 2002; Sissay, Uggla & Waller 2007).

The use of plants and their extracts for the treatment of a variety of human and livestock gastrointestinal parasites has been in existence for a long time (Waller et al. 2001). The currently available synthetic drugs have been widely used against gastrointestinal nematodes for many years. However, because of repeated use and incorrect dosage rate, gastrointestinal nematodes have developed a degree of resistance against synthetic available drugs (Ahmed 2010; Vattaa et al. 2001) coupled with problem of chemical residue in animal products (Falowo & Akimoladun 2019; Federal Ministries of Agriculture, Environment and Health [FMAEH] 2017). The residual chemicals may produce conditions such as vomiting, nausea, dizziness and gastrointestinal irritation in humans consuming meat (Gogoi et al. 2014). Synthetic drugs may also result in environmental pollution because of the degradation issues associated with synthetic organic compounds (WHO 2012). High cost and unavailability of synthetic drugs are among the major constraints in the use of synthetic drugs by resource-limited farmers for their livestock (Graf et al. 2004; Sori et al. 2004). These led farmers to seek alternative ways of control specifically using natural products to protect their livestock from diseases (Maphosa & Masika 2010; Mthi et al. 2020).

Because of the diverse flora and fauna of the Eastern Cape, livestock farmers have a long history of using plants to treat animal ailments (Dold & Cocks 2001). This practice has been considered an integral part of South African culture (Masika & Afolayan 2003). According to WHO (2010), it is estimated that more than 70% of people living in developing countries depend on traditional medicine to treat their animals and human ailments. Generally, medicinal plants are affordable, accessible to use and acceptable in the communities. Furthermore, medicinal plants have lesser side effects compared to synthesised medicines (Nisar, Sultan & Rbab 2017). Medicinal plants possess a vast number of biologically active compounds (Uy & Villazorda 2015) known as phytochemicals (glycosides, terpenes, phenolic, alkaloids and anthocyanins) that are responsible for the defence mechanism in plants (Mazid, Khan & Mohammad 2011). They are viewed as potential sources of new natural drugs, antibiotics, insecticides and herbicides (Dewick 2002).

Transfer of indigenous knowledge from older people through the word of mouth is one of the major concerns that can lead to the loss of the information (Van Wyk, Van Ousdtshoorn & Gericke 2002) as there are no documentations. There is therefore a crucial need for documentation of plants used to manage various diseases of livestock, so that knowledge can be preserved while plants are conserved sustainably for future generation reference database. This article presents information on medicinal plants used to manage gastrointestinal nematodes of sheep in the ECP of SA.

Materials and methods

Study areas and research design

The study was conducted between November 2013 and February 2014 in three villages, namely Upper Ngqumeya, Ciko and Goso located in the Amathole and O.R. Tambo District Municipalities (DM) of the ECP (Figure 1). The informants were purposively selected with the assistance of extension officers, community elders and local authorities. The selected informants were well known in the communities for providing animal health-related services. The economic activities include mixed farming, which broadly includes the cultivation of vegetables, crops and the production of livestock. Alternatively, the collection of timber and non-timber products is practiced.

The villages, Upper Ngqumeya, Ciko and Goso, were purposefully selected as people who live in these villages depend highly on traditional medicine for their livelihoods and health and possess many skills acquired from grandparents. Besides considering their knowledge on the wide use of medicinal plants, the lack of access to healthcare services because of poor infrastructure was used as selection criteria for these communities. Additionally, willingness to participate, accessibility and livestock corridors were other criteria used.

Upper Ngqumeya village

The Upper Ngqumeya village is located 10 km south of Keiskammahoek and falls under the administration of Amahlathi Local Municipality in Amathole DM. The village is situated at 32°43′08.87″ S and 27°07′42.14″ E, with annual

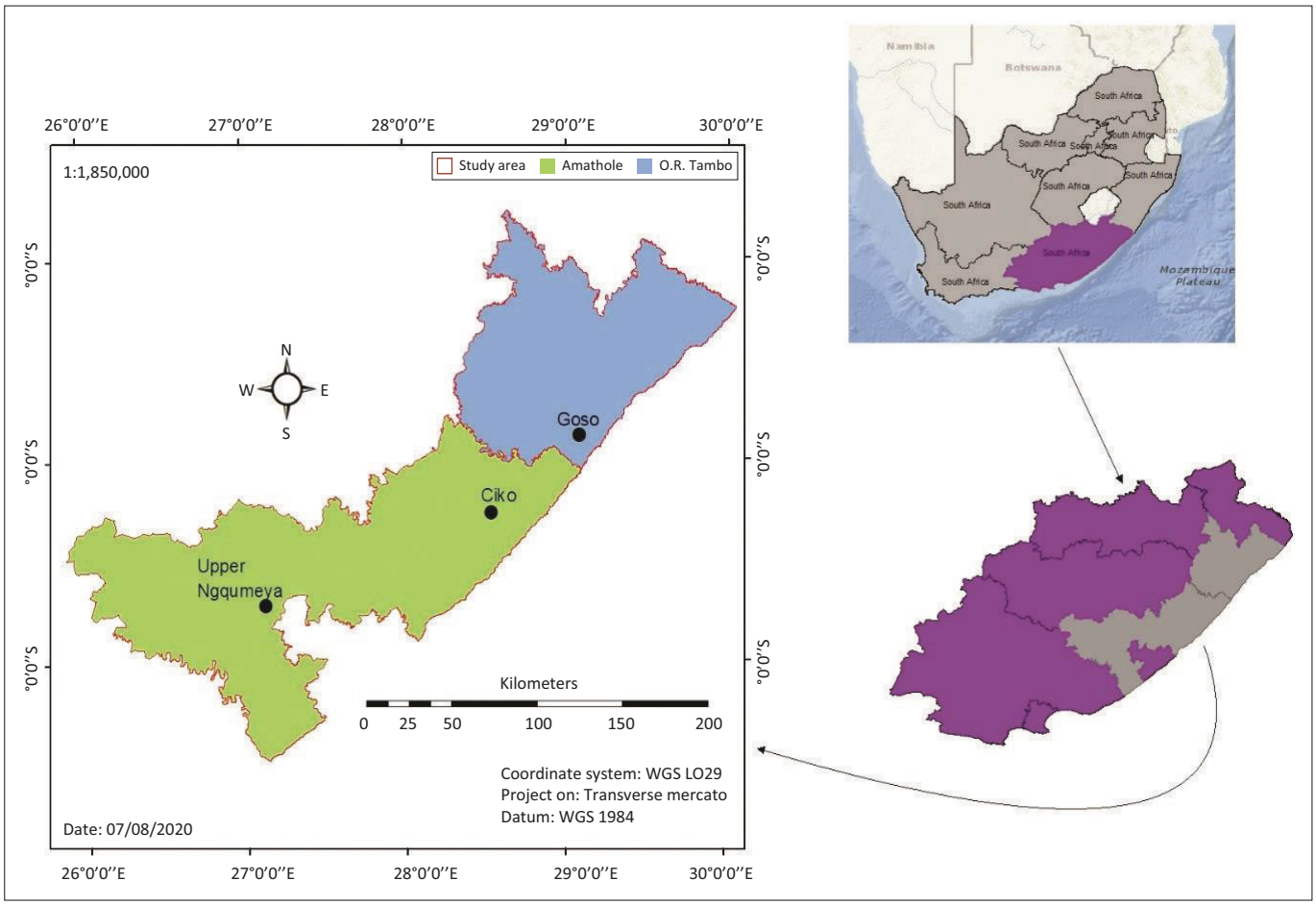

FIGURE 1: South African map showing the study sites.

rainfall ranging between 500 mm and 840 mm, at an altitude of 544 m – 700 m. The mean temperatures for Keiskammahoek are 32.3 °C and 5.3 °C for March and July, respectively (Mucina & Rutherford 2006). The vegetation in upper Ngqumeya is characterised by steep slopes on the river valley in highly dissected hills and moderately undulating plains which falls under the Buffels Thicket and Bisho Thornveld (Mucina & Rutherford 2006).

Ciko village

Ciko village is located 7 km east of the town of Willowvale and falls under the administration of Mbhashe Local Municipality in Amathole DM. The village lies at 32°16'11.18" S and 28°32'03.22" E, and annual precipitation ranges from 500 mm to 900 mm with altitude 544 m – 700 m. December is the warmest month with an average temperature of 37 °C and June is the coldest with an average temperature of 4.0 °C. The area falls under two veld types, namely Bhisho Thornveld and Great Fish Thicket (Mucina & Rutherford 2006). Landscape in terms of vegetation is characterised by semi-deciduous savanna woodlands in a mosaic thicket, often succulent and dominated by Euphorbia and Aloe. Some parts within some areas are characterised by small trees of *Vachellia natalitia* with a short to medium, dense and sour grassy under the tree canopy, usually dominated by *Themeda triandra* (Mucina & Rutherford 2006).

Goso village

Goso village is located 15 km south of the town of Lusikisiki and falls under the administration of Ingquza Hill Local Municipality. Goso is located at 31°22'49.38" S and 29°35'48.57" E, annual rainfall ranges between 700 mm and 1100 mm with an altitude of 400 m – 900 m. The mean temperatures for Goso 37.3 °C and 4.9 °C for March and July, respectively (Mucina & Rutherford 2006). Vegetation structure is characterised by dense, tall grasses dominated by unpalatable species such as *Aristida junciformis*. Woody plant species are found in valleys at lower altitudes (Mucina & Rutherford 2006). Goso occurs within a significant region of floristic endemism, namely the Pondoland Centre (Van Wyk & Smith 2001).

Data collection

A cross-sectional study was conducted from November 2013 to February 2014 using a pretested semi-structured questionnaire to gather information on medicinal plants used for the control of gastrointestinal parasites. Each participant was interviewed using their vernacular language (IsiXhosa) and later tranßslated to English at the Döhne Agricultural Development Institute (DADI). The information that was recorded included demographic characteristics, names of the plants used, their local uses, parts of the plants used, the mode of preparation and route of administration and

perception of the constraints associated with livestock production.

Plant collection and preservations

The medicinal plant specimens were collected, pressed, dried and mounted on standard herbarium sheets and later identified using Flora of SA as illustrated in the published book 'Trees of South Africa' (Van Wyk, Van Wyk & Van Wyk 2014). The correctly identified specimens were deposited in the herbarium, DADI, Stutterheim in the ECP. The voucher numbers are depicted in Table 2.

Data analysis

Data was captured on Microsoft Excel 2013 computer package, coded and analysed using the Statistical Package for Social Science (SPSS 2011) to generate descriptive statistics such as frequencies, graphs, percentages and charts. Quantitative statistical analysis was performed for the following indices: frequency of citation (FC) and relative frequency of citation (RFC).

The frequency of the species of plants being utilised was evaluated using the following formula:

$$FC = \frac{\text{No. of times a particular species was mentioned}}{\text{Total number of times that all species were mentioned (Bibi et al. 2014).}} \times 100. \quad [\text{Eqn 1}]$$

The RFC of species was calculated by dividing the FC (the number of informants mentioning a useful species) by the total number of informants in the survey (*N*). This RFC index ranges from 0 (when a species is not referred by any user as useful) to 1 (when all respondents mentioned the species as useful).

The following formula was used to calculate the RFC index (Vitalini et al. 2013):

$$RFC = \frac{\text{Frequency citation}}{\text{Total number of informants interviewed.}} \times 100. \quad [\text{Eqn 2}]$$

TABLE 1: Demographic data of respondents.

Category	*n*	%
Gender		
Male	31	72
Female	17	28
Age (years)		
< 35	-	20.8
35–50	-	31.3
> 50	-	47.9
Educational level		
Primary	-	56
Junior high scholars	-	40
Post-matric	-	4
Marital status		
Single	-	38
Married	-	44
Divorced	-	12
Widow	-	6

Ethical considerations

Before the commencement of data collection, ethical clearance was obtained from the Research Ethics Committee at Döhne Agricultural Development Institute (Registration number: 01/2012). In order to protect the rights and welfare of the interviewees, guidelines based on the protection of indigenous knowledge bill (B6-2016) were followed. Consent was sought from the farmers prior the commencement of the trial using a language of their choice. The farmers were assured of the confidentiality of the information provided during the study period.

Results

As shown in Table 1, a total of 48 respondents were interviewed, 64.6% were male and 35.4% were female. The age of the respondents ranged between 20 and 73 years and the majority (47.9%) were in the older age group (41–60 years). The results indicated that all the respondents (100%) were literate and more than 50% had primary education, 39.58% were junior high scholars and 4.16% had post-matric. The majority of respondents were married (44%), 38% were single, 12% were divorced and 6% were widowed. The perceptions of the respondents on the constraints associated with sheep production are shown in Figure 2. The results showed that the most reported sheep constraints in descending order are prevalence of internal parasites (36%), prevalence of external parasites (18.1%), lack of infrastructure (14%), high cost of

TABLE 2: Inventory of indigenous plants used for treatment of gastrointestinal nematodes in the Eastern Cape province.

Plant botanical name	Local name	Habitat	Voucher no.	Origin	FC	RFC	Preparation	Administration
Elephantorrhiza elephantina	uHlololwane	Wild	1786	Native	10	0.21	Decoction	Oral
Zanthoxylum capense	umLungumabele	Wild	1786	Native	21	0.44	Decoction	Oral
Aloe ferox	iKhala	Wild	1789	Native	32	0.67	Decoction	Oral
Cussonia spicata	umSenge	Wild	1787	Native	3	0.06	Infusion	Oral
Gunnera perpensa	iPhuzilomlambo	Wild	1791	Native	5	0.10	Decoction	Oral
Strychnos henningsii	Umnonono	Wild	1782	Native	11	0.23	Decoction	Oral
Ziziphus mucronata	Umphafa	Wild	1795	Native	2	0.04	Infusion	Oral
Agapanthus praecox	uMkhondo	Wild	1799	Native	3	0.06	Infusion	Oral
Bulbine abyssinica	uMaweni	Wild	1777	Native	7	0.15	Decoction	Oral
Harpephyllum caffrum	uMgwenya	Wild	1788	Native	2	0.04	Decoction	Oral
Rumex lanceolatus	Idolo lenkonyane	Wild	1790	Native	1	0.02	Decoction	Oral

FC, frequency citation; RFC, relative frequency citation.

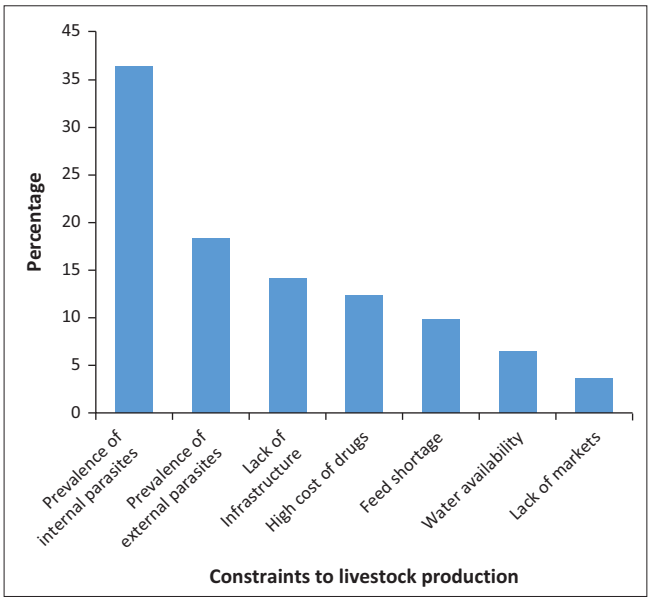

FIGURE 2: Perceived constraints with livestock production in the study sites.

drugs (12.2%), feed shortage (9.7%), water unavailability (6.4%) and lack of markets (3.6%).

As shown in Table 2, a total of 11 ethnoveterinary medicinal plant species belonging to 11 families were documented for the control of gastrointestinal nematodes in sheep. All medicinal plants used to treat gastrointestinal nematodes were native to the area and collected from the wild. As shown in Figure 3, trees form the highest proportion of medicinal plant species (45.4%) followed by herbs (36.4%) and shrubs (18.2%).

From this study, as shown in Figure 4, the respondents revealed that the parts of the plants most frequently used for treating gastrointestinal nematodes were leaves (36.4%), roots (27.3%) and bark (27.3%). The least reported plant parts used were tubers (9.1%). Various methods of remedy preparation were documented (Table 2), decoction (72.7%) being the most commonly used method followed by infusion (27.3%).

Table 2 depicted that the highest value of RFC was recorded for *Aloe ferox* (0.67), followed by *Zanthoxylum capense* (0.44), *Strychnos henningsii* (0.23), *Elephantorrhiza elephantina* (0.21), *Bulbine abyssinica* (0.15) *and Gunnera perpensa* (0.10). *Cussonia spicata* and *Agapanthus praecox* had 0.06 each, followed by *Ziziphus mucronata* and *Harpephyllum caffrum* which had 0.04 each. The least reported plant species used was *Rumex lanceolatus* with a 0.02 RFC value (Table 2). The results in Table 3 show that the cutting of plants as timber for expansion of homestead (26%), collection of firewood (21%), medicine (19%), drought (18%) and overutilisation through human usage (8%) was the most rated threat. The least threatening factors were the use of the plant for fencing (5%) and veld fires (3%). Conservation of medicinal plants is very important because it is connected to the survivability of a larger number of people as they depend on plants for their livelihood. Loss of medicinal plants will not only affect healthcare and economic spin-offs but also destroy the hope for the discovery of the new drug and other diseases that affect livestock.

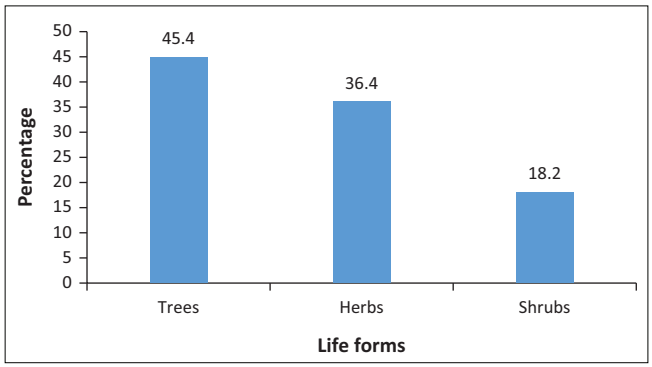

FIGURE 3: Life forms of medicinal plants used to control gastrointestinal nematodes in the three study sites.

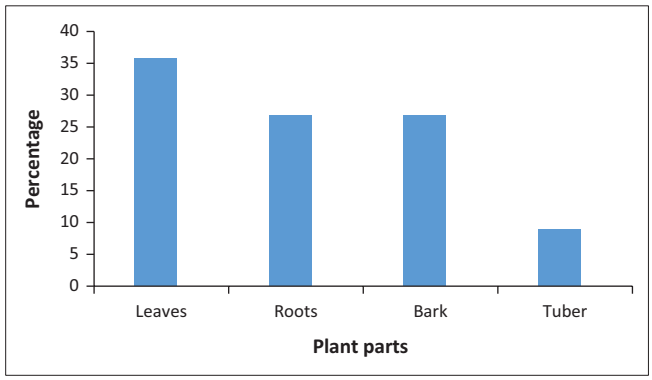

FIGURE 4: Parts of plants used for controlling gastrointestinal nematodes.

Protection of indigenous forestry by rangers (67%) and cultivation of medicinal plants in the home gardens (33%) was perceived to be potential conservation methods to protect the loss of certain medicinal plants (Figure 5).

Discussion

Men have more knowledge of medicinal plants in this study than women. The male supremacy in ethnoveterinary knowledge may be because of cultural expectations that when a woman marries, she will not inherit the knowledge of the household. These findings are in conformity with several previous researchers who observed that knowledge of medicinal plants is mostly transmitted from father to son and limited to older people (Ahmad et al. 2016; Bartha et al. 2015; Chitura et al. 2018; Garedew & Abebe 2018). High number of respondents who can read and write can play a major role on improving animal health-related diseases through record-keeping, measurement of dosage, adoption and practice of new technologies that may enhance livestock production under communal sector. These results are in agreement with those of Keter and Mutiso (2012) and Andriamparany et al. (2014) where the majority of respondents had primary education in Lower Eastern Province, Kenya and Mahafaly region of south-western Madagascar.

Findings from the present study are in agreement with those of previous researchers who indicated that internal parasites are a serious challenge in communal livestock production systems (Chitura et al. 2019). Infrastructure is viewed as one

TABLE 3: Factors perceived as threats to medicinal plants (1 = most important and 6 = least important).

Factors	Frequency	Frequency (%)	Rank
Veld fires	3	3	6
Drought	21	18	3
Overutilisation (grazing and browsing)	10	8	5
Medicine	25	19	4
Firewood	23	21	2
Expansion of homestead	31	26	1
Fencing	6	5	7
Total	**119**	**100**	-

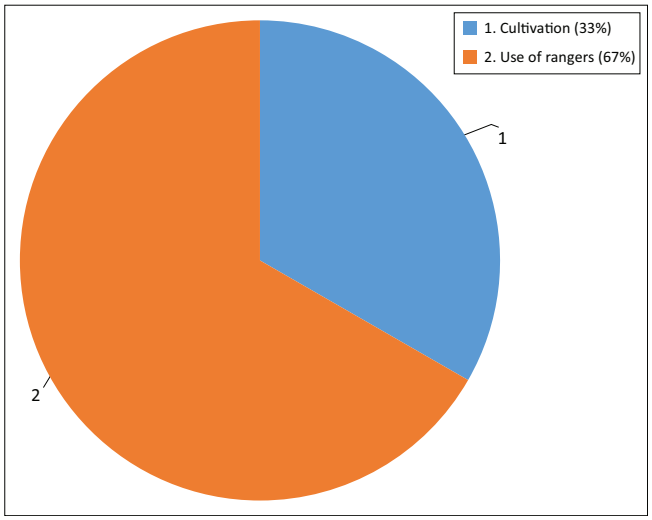

FIGURE 5: Perceived conservation practices of medicinal plants in the three study sites.

of the key pillars for livestock enterprise profitability (Coetzee, Montshwe & Jooste 2005). The findings from the present study on the lack of infrastructure as a major constraints agree with those of Wani et al. (2009), Fikru and Omer (2015) and Ngqulana (2017). The fourth constraint raised by respondents was high cost of drugs. The results from the study correlate with Maingi and Njorobe (2010) and Aphunu, Okoedo and Okojie (2011). About 3.6% of the respondents reported that lack of market access hampers livestock production. This is in line with the findings of Khapayi and Celliers (2016) and Mapiye et al. (2018), who found that more than 80% of farmers in communal farming systems cited market access as a major constraint to livestock production.

All the 11 medicinal plants belong to different families that are among the most reported families used for ethnoveterinary remedy preparation in SA (Maphosa & Masika 2010; Masika & Afolayan 2003; McGaw, Jäger & Van Staden 2000; Van Wyk et al. 2002). Some of the mentioned plants have been reported in the literature to possess anthelmintic properties, while others possess properties ranging from anti-inflammatory, antibiotic, purgative, muscle relaxing and parasiticides (Maphosa & Masika 2010). The same species have been in SA and other countries to treat a variety of ailments, some of which are human-related. Based on various tests performed by McGaw et al. (2000), Masika and Afolayan (2003), Shangali et al. (2008), Semenya et al. (2013a) and Olivier (2017), *A. ferox*, *R. lanceolatus*, *Z. capense*, *E. elephantina* and *Z. mucronata*, were reported to have anthelmintic properties. A study conducted by Hutchings et al. (1996) and Maroyi (2016) reported that *Z. capense*, *C. spicata* and *G. perpensa* have parasiticidal properties. *Z. capense*, *H. caffrum* and *A. praecox* have been reported to have anti-inflammatory effect, while *S. henningsii* has been reported to have purgative and muscle relaxing effects (Van Wyk et al. 2002). Research by Masika and Afolayan (2003) revealed that *E. elephantina* has antibiotic properties.

The high preference for leaves in remedy preparations is a common exercise in other parts of SA as reported in Eastern Cape (Maphosa & Masika 2010), Limpopo (Chauke et al. 2015) and KwaZulu-Natal (Nyakudya et al. 2020). The use of leaves compared to other plant parts might be because of the high concentration of secondary metabolites as leaves are the only site where photosynthesis takes place (Boadu & Asase 2017; Ghorbani 2005). However, in contrast to this study, Lulekal et al. (2008) postulated that roots are the most used parts. Many researchers reported that the concentration of secondary metabolites varies from plant to plant species and even in the different parts of the same species. Lucini et al. (2015) reported that *A. ferox* leaf skin extract exhibited the highest antioxidant activity as compared to flowers or inner parenchyma and whole leaf extract. A similar trend of results in the case of *A. praecox* has also been achieved (Basma et al. 2011; Chew et al. 2011). Furthermore, it is also important to note that there is a strong correlation established between the geographical locations in which the plant grows with the phytochemical secondary metabolites it accumulates. Genetic factors such as plant species, plant organ, phenological stage and environmental factors like climatic conditions, biotic and abiotic stresses occurring during plant growth are believed to considerably influence secondary metabolites in plants (Muhammad et al. 2018).

In support of our results, Guarrera and Savo (2013) reported that plants collected from the wild are rich in health properties compared to cultivated plants. This finding is in agreement with findings reported in other studies from Lesotho and SA, where it was indicated that most plant species used for ethnoveterianry medicine were collected from the wild (Kose, Moteetee & Van Vuuren 2015; Maroyi 2017). Methods of herbal remedy administration may vary according to place, culture and plant material used. Oral administration was the only route of remedy administration in the study areas. Similar results were reported by Van Andel et al. (2015) and Busia (2016). The high usage of trees could be an indication of their abundance in the study areas. This agrees with the findings of Ketame et al. (2018) and Kirpkore et al. (2014) where trees were dominant species used to prepare herbal medicine in Ethiopia and Kenya, respectively. In contrast with our findings, Tugume and Nyakoojo (2019) reported high usage of herbs in Uganda.

The documented medicinal plants were used in preparation for 11 herbal remedies mainly in the form of decoctions and infusions. Various methods of remedy preparation have been reported by Busia (2016) that decoctions and infusion have been commonly used methods worldwide. Decoctions were prepared by boiling the plant material in water for a few

minutes, while the infusion is soaked plant material in water for a few hours or overnight. These findings are in line with a previous study (Boadu & Asase 2017) that decoction is the common method of remedy preparation. Factors threatening medicinal plants are both human and natural causes (Agisho, Osie & Lambore 2014). This finding agrees with Semenya et al. (2013b) that homestead expansion was the most common threatening factor to medicinal plants' survival. The high expansion of homestead might be caused by the high demand for shelter because of the increase in the human population. *In-situ* protection of natural habitats through the use of ranger concurs with the findings of Geldmann et al. (2013). *Ex-situ* conservation through the cultivation of medicinal plants was similar to those reported by Van Wyk and Prinsloo (2018) in SA and Kasagana and Karumuri (2011) in India.

Conclusion and recommendations

The study revealed that the use of medicinal plants to control gastrointestinal nematodes of livestock is a common practice among the communal farmers in the three study areas. Within the context of this study, it is recommended that various concentrations of extracts obtained from *A. ferox, Z. capense*, *S. henningsii and Elephantorrhiza* should be assayed for the phytochemical and biological activity for validation of the ethnomedicinal claims. To test and validate scientifically various concentrations of extracts obtained from the above-mentioned plants, more in *in vivo* toxicity assays and trials, including genotoxicity, should be conducted.

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Competing interests

The authors declare that there are no competing interests.

Authors' contributions

Conceptualisation – S.M., J.M.R., Z.D. and N.N.; methodology – S.M., S.T., N.N., Z.M. and L.T.T.; formal analysis – S.M., M.Y. and L.T.T; investigation – S.M. and T.M.; writing original draft – S.M.; visualisation – S.M., J.M.R. and S.T.; project administration – S.M.; validation – S.M., Z.D., S.T. and J.M.R.; data curation – S.M., resources – S.M.; writing and review & editing – S.M., J.M.R., S.T., N.N., L.T.T., Z.D., M.Y., Z.M. and T.M.; supervision – J.M.R.; funding acquisition – S.M. All authors have read and agreed to the published version of the manuscript.

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Data availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Disclaimer

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