Ethnoveterinary botanical medicine in South Africa: a review of research from the last decade (2009 to 2019)

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Abstract

Ethnopharmacological relevance: Ethnoveterinary medicine (EVM) practices remain a common feature of South African animal husbandry, particularly in rural livestock healthcare. This review provides an update of research undertaken on South African EVM from 2009 until 2019.

Aim of the study: This review collates information and investigates trends in the increasing field of EVM research in South Africa over the last decade.

Materials and Methods: A literature search was conducted using available databases including ScienceDirect, PubMed, Scopus and Google Scholar. Dissertations, theses, books and technical reports were also searched.

Results: In the past decade, ethnoveterinary surveys conducted in South Africa report the use of 139 plants from 50 families used against 21 animal diseases and conditions. Leaves, roots and bark have remained popular plant parts used for EVM. In terms of livestock species reported, the major focus was on cattle, goats and poultry. Only four of the nine provinces in the country have been surveyed.

Conclusions: Relatively few publications reporting on ethnoveterinary surveys have originated from South Africa. These papers refer to many plants used for a variety of commonly encountered animal diseases and afflictions. With reference to recently published guidelines on conducting ethnobotanical surveys, several recommendations can be made to improve the robustness of surveys documenting the use of plants for EVM in South Africa.

Keywords: Ethnoveterinary medicine, Fabaceae, livestock, South Africa, traditional medicine

1. Introduction

Traditional methods of animal husbandry and medication are increasingly being recognised for their potential usefulness in contributing to animal well-being, particularly at the level of primary animal healthcare. Greater interest has been shown recently in documenting ethnoveterinary medicine (EVM), as with ethnobotanical medicine used in treating humans. This enhanced research effort is largely owing to the fragility of oral traditions associated with traditional medicine systems, which leads to the risk of losing such important knowledge which cannot be regained. As defined by the anthropologist Constance McCorkle, EVM comprises a multifaceted system of beliefs, practices, knowledge and skills relevant to animal husbandry as well as general animal care (McCorkle, 1986). Much research attention in recent years has focused on the traditional use of plants to prevent and control animal diseases, although the definition of EVM is wider, including animal husbandry practices, diagnostic procedures and traditional veterinary theory (Schillhorn van Veen, 1996; Van der Merwe et al., 2001).

In 2008, a literature review was published in which the use of plants in South African EVM was detailed, as were the biological activity investigations relating directly to their ethnoveterinary use (McGaw and Eloff, 2008). In this review, it was mentioned that for common animal afflictions such as wounds, skin diseases, mild diarrhoea and intestinal worms, EVM may play an important role. The shortcomings of employing such a system include inefficacy or toxicity of remedies, uncertainty over dosing regimens and lack of standardisation, as well as unavailability of plant material during certain seasons of the year (Martin et al., 2001). However, the potential benefits to be achieved in promoting the incorporation of EVM into primary animal health care, as part of a “One Health” approach, are sufficiently appreciable to motivate research into closing these gaps in knowledge.

Most non-commercial, rural livestock-keepers treat their own animals with predominantly plant-based remedies, and South Africa has a wide diversity of plant species that may be used for animal medications. As highlighted by McGaw and Eloff (2008), even though EVM surveys have taken place in certain areas of the country, it is crucial to continue this research in the rest of the country to complete the documentation of the EVM pharmacopoeia of South Africa. Biological activity studies targeting animal diseases and other afflictions such as wounds need to be conducted in tandem with toxicity studies to identify active remedies with little to no toxicity, which was often neglected in earlier studies. McGaw and Eloff (2008)

found that up until 2008, over 200 plants were reported to be used in South African EVM, but only 27 (approximately 13%) of these species had been tested for bioactivity in assays relating to veterinary afflictions. In addition, several of these plants were only tested in a limited *in vitro*-based bioassay system and more investigations are necessary to fully evaluate these plants for potentially useful bioactivities and interesting purified active compounds.

The recognition of ethnoveterinary practices, and in particular the use of medicinal plants, is an increasingly popular research area worldwide. Recently, the Royal Botanic Gardens at Kew, United Kingdom, enlisted the help of British veterinarians to provide information about EVM and feed supplements used in traditional rural culture (Woodmansey, 2019). This Ethnoveterinary Medicine Research Project aims to record the use of wild or cultivated plants across the British Isles in treating animal diseases. The objective of the project is to record this knowledge before it is lost as it is commonly passed down orally from generation to generation, as is the case with many traditional medicine systems around the world. It was stated that "this knowledge could also be used practically in animal management (livestock, pets), to improve their health and the economy" (Woodmansey, 2019).

The majority of ethnoveterinary research appears to have been conducted in Africa, Asia and North America (Pieroni et al., 2004; Lans, 2016; McGaw and Abdalla, 2020). In these regions, local farmers generally rely on plant-based home remedies for treating their livestock due to limited access to modern veterinary medicine (Maphosa and Masika, 2010).

With rising demand for organic farming products, coupled with increasing regulations controlling use of synthetic antimicrobials as growth promoters in animal production, alternative approaches such as medicinal plants for treatment of livestock and their incorporation into feed are being investigated, particularly in Europe. Mayer et al. (2014) reported that 590 plant species belonging to 102 families are used for animal treatment in Europe. This systematic review highlighted a number of promising plant species for future veterinary phytotherapy research (Mayer et al., 2014). Interestingly, a large percentage of research papers originated from Italy, while central Northern and Eastern Europe were identified as areas where further ethnoveterinary research is necessary.

A recent study from Europe compared knowledge of plants used in Swiss EVM in Italian speaking regions with those of north-western German speaking regions (Mayer et al., 2017). Several factors including geographical, linguistic, social and farm-structural conditions

influenced regional ethnoveterinary knowledge. A further comparative paper discussed contemporary knowledge of farmers in certain areas of Switzerland in relation to knowledge contained in ancient and recent literature (Stucki et al., 2019). Plants used were mostly those having a long history of veterinary use, in many cases fulfilling the criteria of "traditional use" defined for human medicinal products in European regulations. This was suggested by the authors to potentially serve as a foundation for development of a Traditional European Veterinary Herbal Medicine and perhaps also assist in promoting a simplified registration of Traditional European Veterinary Herbal Medicinal Products (Stucki et al., 2019). Maintenance and improvement of animal health and welfare is a crucial aspect of animal production in which medicinal plants may play a vital role. An ethnoveterinary research project investigating this issue in Eastern Tyrol, Austria, highlighted the importance of the diversity of plant sources that were previously available as feed and fodder (Vogl et al., 2016). The study led to the conclusion that the potential health benefits of various plants used in ethnoveterinary practices need further investigation (Vogl et al., 2016).

South Africa is home to an extremely diverse range of plant species as well as cultural groups, providing fertile ground and unlimited potential for research on the traditional use of plants for human and animal health. South Africa has an estimated 24 000 plant species comprising more than 10% of the world's vascular plant flora (Germishuizen and Meyer, 2003). Many of these have not been explored previously for biologically active metabolites, and hence traditional ethnoveterinary use of plants allows a mechanism to inform selection of plants for studies relating to animal health issues. The upsurge of interest in EVM and the need for improvements in primary animal healthcare in developing countries motivated the current review to determine the extent to which EVM has been documented and evaluated in South Africa since the review of McGaw and Eloff (2008) was published. Acceptance of EVM by the Western-trained veterinary profession, as well as by respective government departments responsible for promoting primary animal healthcare, will only be able to progress once traditional animal healthcare practices and plant-based remedies have been appropriately documented and investigated for efficacy and toxicity. The promotion and encouragement of the use of EVM remedies as an additional tool in the work-box of primary animal healthcare solutions needs to be fostered through relevant collaborative research endeavours between scientists and practitioners of EVM. Thus, the current review focused on the collation of existing (since 2009 till date) information and critically analysing the trends in the growing field of EVM research in South Africa.

2. Materials and Methods

Information was retrieved from scientific databases such as ScienceDirect, Google Scholar, Scopus, PubMed and Chemical Abstracts Services. Books, dissertations, theses and technical reports contained in the libraries of the University of Pretoria and North West University were also consulted. Keywords used for the search engines were "South Africa" or "southern Africa" in conjunction with "ethnoveterinary", "livestock", "traditional animal medicine" and "ethnoveterinary medicine". Knowledge of researchers involved in conducting ethnoveterinary research in South Africa was also employed to source relevant information. The search was conducted initially in February to April 2018 as part of an MSc dissertation (Khunoana, 2018) and a more comprehensive search was undertaken by all the authors of this study from April to December 2019.

To be included in the review, a publication was expected to include details of a specific veterinary use or indication, for example, a plant used for tick control or to expel intestinal parasites in animals. The Latin name of the plant species should have been supplied and the method of preparation and administration should preferably have been recorded. In the surveys collected, the animal species or "livestock species" was grouped into cattle, goats, sheep, horses, dogs, poultry and donkeys. "Mentions" was described as the count of each livestock species, if indicated, in the surveys. The indication, disease treated, disease condition or ailment were assumed to be interchangeable terms for all the surveys as different terms were used by different researchers. Each time a specific "disease condition" was mentioned it was recorded as a new ailment, for example diarrhoea.

From each paper, the following information was collected: Latin names of plants used, plant parts, indication or disease treated, animal/livestock species treated, dosage and method of administration. The classification of the indication, disease condition or therapeutic use was employed as done by the researchers conducting the survey to avoid bias and misinterpretation of data. For example, it is not known whether "gall sickness" as mentioned in several surveys referred to "anaplasmosis" as is the correct veterinary term for gall sickness, or whether it referred to an enlarged gall, as has been our personal observation in field surveys. In this review, following the guidelines proposed by Mayer et al. (2014), we defined our research unit "use report" as follows:

One use report = *(mandatory: 'scientific paper or reference' x 'plant species with unambiguous veterinary use') x (if available: 'plant part used' x animal/livestock species' x 'disease condition').*

3. Results and Discussion

3.1. Ethnoveterinary surveys conducted from 2009 to 2019

Several relevant internet search engines were mined for information relating to ethnoveterinary surveys conducted in South Africa in the past decade. Many publications were initially located but, as expected, several duplicates were present. After these were discarded and other papers and information located through contact with active researchers in the field as well as searching theses and dissertations and other primary publications, Thirteen (13) papers were included in this review.

3.1.1. Inventory and diversity of plants used for ethnoveterinary purposes

In the years since 2009, 139 plant species from 50 families were recorded in ethnoveterinary surveys in South Africa **(Supplementary Table S1)**. **Table 1** provides a summary of the surveys reviewed with information on the interview methods and numbers of species and families identified in the surveys. The most used ethnoveterinary plant species are highlighted in **Table 2**, where those with a research unit of three or more are listed. Most of the plants were from the family Fabaceae/Leguminosae (16%), Asteraceae (8%) and Xanthorrhoeaceae (6%). The Fabaceae family had the highest number of plant species used in EVM, which is unsurprising as it is one of the largest plant families in South Africa. Dominance of the Fabaceae as the most common family was also evident in some of the surveys (Magwede et al., 2014; Ramovha and Van Wyk, 2016). Magwede et al. (2014) logically attributed the popularity and high preference of the members of the family Fabaceae to their availability and abundance.

Maphosa and Masika (2010) identified 28 plant species from 20 families used as EVM. The largest number of plant species used for formulating remedies belonged to the Xanthorrhoeaceae family with *Aloe* the most frequently used plant species (Maphosa and Masika, 2010). Similar plant species were also identified in another survey by Sanhokwe and colleagues (Sanhokwe et al., 2016). The diversity of local knowledge on use of wild and cultivated plants in six villages of the Eastern Cape was investigated by Maroyi in 2017. From a total of 123 useful plant species recorded, 23 were identified to be used as ethnoveterinary medicines but further details were not provided (Maroyi, 2017). Semi-

structured questionnaires and field observations were used to document six plant species used to treat bacterial diseases of livestock in 48 households in three areas of the Eastern Cape (Mthi et al., 2018). Communities of the Pondoland, Eastern Cape (Xhosa-speaking) were surveyed for their use of indigenous plant species for ethnoveterinary purposes, and 23 plants from 18 families were reported to be used to treat livestock (Kambizi, 2016). Various villages were sampled in this survey, but details are lacking on the number of people interviewed.

Table 1. Ethnoveterinary surveys (2009-2019) comprising an overview of the reviewed publications in terms of various parameters where available

Author(s) and year of publication	Province	Ethnic group	Interviewee recruitment method	Interview method	Interviewee number	Number of research units	No of plant species	No of plant families	No of disease conditions noted
(Kambizi, 2016)	Eastern Cape	Xhosa	Snowball	Semi-structured interviews	Not specified	22	22	19	11
(Khunoana et al., 2019)	Mpumalanga	Tsonga, Shangaan	Rapid Rural Appraisal	Semi-structured interviews	50	11	11	7	9
(Luseba and Tshisikhawe, 2013)	Limpopo	Vhavenda, Tsonga, Tshipedi	Snowball	Focus group discussions	37	45	34	22	47
(Magwede et al., 2014)	Limpopo	Vhavenda, Tsonga, Tshipedi	Snowball	Open ended questions and semi-structured questionnaire	42	27	27	14	1
(Maphosa and Masika, 2010)	Eastern Cape	Xhosa	Snowball	Structured questionnaires and general conversation	30	28	28	20	1
(Matlebyane et al., 2010)	Limpopo	Vhavenda, Tsonga, Tshipedi	Snowball	semi-structured questionnaires	27	9	8	7	9
(Moyo and Masika, 2009)	Eastern Cape	Xhosa	Snowball	Structured questionnaires	59	2	2	2	1
(Mthi et al., 2018)	Eastern Cape	Xhosa	Purposive sampling technique	Semi-structured questionnaire and field observations	48	6	6	6	2
(Mwale and Masika, 2009)	Eastern Cape	Xhosa	Stratified random sampling	Structured questionnaire	62	9	9	7	2
(Ndou, 2018)	North West	Setswana	Snowball	Semi-structured interviews	21	72	31	17	25

(Ramovha and Van Wyk, 2016)	Limpopo	Vhavenda	Rapid rural appraisal	Semi-structured interviews	Not specified	20	20	10	1
(Sanhokwe et al., 2016)	Eastern Cape	Xhosa	Snowball sampling	Structured questionnaire	53	9	9	8	2
(Soyelu and Masika, 2009)	Eastern Cape	Xhosa	Snowball sampling	Structured questionnaire	83	13	13	11	2

Table 2. Most used ethnoveterinary plant species (16) based on a use report* of three or more.

Family	Species	Plant part	Area	Indication(s)	Preparation and administration	Reference
Amaryllidaceae	*Boophone disticha* (L.f) Herb.	Bulbs	Mahikeng Local Municipality, North West	Uterine cleansing after abortion	Bulbs are crushed and soaked in warm or cold water for a while and then 1 L infusion is administered orally to the animal	(Ndou, 2018)
		Bulbs	Mahikeng Local Municipality, North West	Retained placenta	The bulb is crushed and put in either warm or cold water, left for a while and then 1-2 L of the infusion is administered orally to the animal. The treatment is given only once and the retained placenta would fall off.	(Ndou, 2018)
		Bulbs	Mahikeng Local Municipality, North West	Fracture	Scales of the bulb are wrapped around the fracture line before applying the splint made of *Acacia (Vachellia) karoo* bark.	(Ndou, 2018)
Apocynaceae	*Acokanthera oppositifolia* (Lam.) Codd	Leaves	Kwezi and Ntambethemba villages, Eastern Cape	Intestinal parasites in goats	Leaves are ground and boiled. Animals are drenched at a dose of 1 L bottle for adults and 0.3 L bottle for kids	(Sanhokwe et al., 2016)
		Leaves	Eastern Cape	External parasites in goats	Grind leaves, boil, cool and drench the animals. Dose	(Sanhokwe et al., 2016)

					with 1 L bottle for adults and a 0.3 L bottle for kids.	
		Leaves	Eastern Cape	Blackquarter in cattle	Leaves are crushed with water and administered orally to cattle	(Mthi et al., 2018)
Apocynaceae	*Gomphocarpus fruticosus* (L.) Aiton f. subsp. *fruticosus*	Roots	Mahikeng Local Municipality, North West	Retained placenta in cows	The root is crushed and boiled in water and given to an animal orally after cooling in a 2 L bottle.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Gala (general ailments) in goats	The plant is dug with its roots and boiled till it changes colour to brown and given to animals in their drinking water.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Gala (general ailments) in chickens	The plant is dug with its roots and boiled till it changes colour to brown and given to animals in their drinking water.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Respiratory diseases in chicken	The plant is dug out with its roots and boiled until it changes colour to brown and given to animals in their drinking water	(Ndou, 2018)
Asteraceae	*Dicoma galpinii* F.C. Wilson	Roots	Mahikeng Local Municipality, North West	Diarrhoea	Root decoctions are mixed with *Senna italica* root, crushed and mixed with cold water and the infusion is dosed with 1 L for adult cattle. Calves and goats are given 0.5 L.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Blood cleansing	Roots of *Dicoma galpinii* are combined with those of *Ziziphus zeyheriana*, *Senna italica* and *Cadaba aphylla*, boiled and 2 L given to animals.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Stomach pains in livestock	The root is crushed and boiled in water and given to an animal orally after cooling in a 2 L bottle.	(Ndou, 2018)

Combretaceae	*Terminalia sericea* Burch. ex DC.	Root, bark	Vhembe district, Limpopo	Redwater (mali) in cattle	Bark from roots are soaked in cold water to yield an infusion, or dried bark are ground to a powder which is then mixed with cold water	(Ramovha and Van Wyk, 2016)
		Roots	Vhembe region, Limpopo	Diarrhoea	Boil the roots, and give 1 L to adult animal, and 0.5 L to young ones (mixed with milk).	(Luseba and Tshisikhawe, 2013)
		Roots	Vhembe region, Limpopo	Ticks	Ground roots are mixed with water and applied on the ticks and wounds	(Luseba and Tshisikhawe, 2013)
		Roots	Vhembe region, Limpopo	Wounds	Ground roots are mixed with water and applied on the ticks and wounds	(Luseba and Tshisikhawe, 2013)
Fabaceae	*Philenoptera violacea* (Klotzsch) Schrire	Bark	Vhembe region, Limpopo	Wounds on cattle	Bark is boiled in water. The solution is then used to wash the wounds	(Magwede et al., 2014)
		Bark	Bushbuckridge, Mpumalanga	Gall sickness	Ground bark infused in water over night. 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Bark	Bushbuckridge, Mpumalanga	Diarrhoea in cattle	Ground bark infused in water over night. 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Bark	Bushbuckridge, Mpumalanga	General ailments in cattle	Ground bark infused in water over night. 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Stem bark, root bark	Vhembe district, Limpopo	Redwater (mali) in cattle	Bark is cooked or soaked in cold water to produce a red decoction/infusion	(Ramovha and Van Wyk, 2016)

Fabaceae	*Schotia brachypetala* Sond.	Bark	Bushbuckridge, Mpumalanga	Foot and mouth disease in cattle	Ground bark is boiled in water and 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Bark	Bushbuckridge, Mpumalanga	Black-quarter in cattle	Ground bark is boiled in water and 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Bark	Bushbuckridge, Mpumalanga	General ailments in cattle	Ground bark is boiled in water and 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Stem bark, root bark	Vhembe district, Limpopo	Redwater (mali) in cattle	Bark, preferably from the root, is cooked to make a decoction	(Ramovha and Van Wyk, 2016)
Fabaceae	*Senna italica* Mill.	Roots	Bushbuckridge, Mpumalanga	General ailments in cattle	Roots are boiled in water and 1 L in a bottle is given to adults and 0.5 L to calves orally	(Khunoana et al., 2019)
		Whole plant, root	Mahikeng Local Municipality, North West	General ailments in cattle.	Plant or roots is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)
		Whole plant	Mahikeng Local Municipality, North West	Gall sickness in cattle.	Plant is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)
		Root	Mahikeng Local Municipality, North West	Diarrhoea in cattle	Root is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)

		Whole plant	Mahikeng Local Municipality, North West	Retained placenta	Plant is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)
		Whole plant	Mahikeng Local Municipality, North West	Abortion in cattle and small stock	Plant is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)
		Whole plant	Mahikeng Local Municipality, North West	Gastrointestinal parasites for calves, sheep and goats	Plant is boiled in water until the water changes to a brownish colour and administered to cattle when cooled. For calves, 0.5 L is given and 1-2 L for adult cattle orally	(Ndou, 2018)
		Whole plant	Vhembe district, Limpopo	Redwater (mali) in cattle	The whole plant is cooked to produce a decoction, or added to hot water to soak for a while	(Ramovha and Van Wyk, 2016)
Fabaceae	*Vachellia karroo* (Hayne) Banfi & Gallaso	Bark	Mahikeng Local Municipality, North West	Fracture repair	The bark is used as splints by placing them over the fracture line to prevent movement of fractured bones.	(Ndou, 2018)
		Leaves	Amatola Basin, Eastern Cape	Wound infection in cattle	Leaves are crushed in water, mixed with “Madubula” and administered	(Soyelu and Masika, 2009)
		Leaves	Amatola Basin, Eastern Cape	Diarrhoea in cattle	Leaves are crushed in water, mixed with “Madubula” and administered	(Soyelu and Masika, 2009)
Pedaliaceae	*Harpagophytum procumbens* (Burch.) DC. ex Meisn.	Roots	Bushbuckridge, Mpumalanga	Diarrhoea in cattle	Chopped roots are infused in water overnight and 1 L is given to adults and 0.5 L to calves using a bottle	(Khunoana et al., 2019)

		Roots	Bushbuckridge, Mpumalanga	Black quarter	Chopped roots are infused in water overnight and 1 L is given to adults and 0.5 L to calves using a bottle	(Khunoana et al., 2019)
		Roots	Bushbuckridge, Mpumalanga	If the cow is not eating or ruminating	Chopped roots are infused in water overnight and 1 L is given to adults and 0.5 L to calves using a bottle	(Khunoana et al., 2019)
Rhamnaceae	*Ziziphus mucronata* Willd. subsp. *mucronata*	Leaves	Eastern Cape	Intestinal parasites in goats	Infusion	(Maphosa and Masika, 2010)
		Bark, leaves	Vhembe region, Limpopo	Wounds on cattle	Bark is soaked in water, ground into pulp and used for wound dressing.	(Magwede et al., 2014)
		Leaves	Mahikeng Local Municipality, North West	Abscess ripening	Softer leaves and branches are crushed and placed on a hard abscess	(Ndou, 2018)
Santalaceae	*Thesium* spp.	Whole plant, roots	Mahikeng Local Municipality, North West	Diarrhoea in calves and cows	The plant is boiled in clean water until the water changes to a brownish colour (tea colour) and administered orally to cattle when cooled to room temperature.	(Ndou, 2018)
		Roots	Mahikeng Local Municipality, North West	Gastrointestinal parasites in calves	The roots are crushed and boiled in water, cooled and administered orally to calves.	(Ndou, 2018)
		Leaves	Vhembe region, Limpopo	Eye problems	Leaves are ground and mixed with water, and given to animal	(Luseba and Tshisikhawe, 2013)
Solanaceae	*Solanum incanum* L.	Fruits	Vhembe region, Limpopo	Eye problems in goats	Fruits are ground and applied to the eyes.	(Luseba and Tshisikhawe, 2013)

		Fruits	Vhembe region, Limpopo	Eye problems in sheep	Fruits are ground and applied to the eyes.	(Luseba and Tshisikhawe, 2013)
		Fruits	Vhembe region, Limpopo	Eye problems in cattle	Fruits are ground and applied to the eyes.	(Luseba and Tshisikhawe, 2013)
Xanthorrhoeaceae	*Aloe ferox* Mill.	Leaves	Kwezi and Ntambethemba villages, Eastern Cape	External parasites in goats	Leaves are crushed and the juice is applied to the skin (mites and ticks) or mixed with drinking water and administered	(Sanhokwe et al., 2016)
		Leaves	Amatola Basin, Eastern Cape	Wound infection in cattle	Infusion as a wash and applied as dressing on wounds	(Soyelu and Masika, 2009)
		Leaves	Centane district, Eastern Cape	Internal parasites in chickens	Leaves are chopped and mixed with cold water; or mixture is boiled before giving to birds as drinking water	(Mwale and Masika, 2009)
		Leaves	Centane district, Eastern Cape	Tick control	Leaves are crushed and soaked in cold water overnight (infusion) and sprayed topically on cattle	(Moyo and Masika, 2009)
Xanthorrhoeaceae	*Aloe zebrina* Baker	Leaves	Mahikeng Local Municipality, North West	Ripening of abscess	The leaves are put on fire to heat them up and then placed on a hard abscess to “ripen” and after it becomes soft, it will be opened and the pus removed	(Ndou, 2018)
		leaves	Mahikeng Local Municipality, North West	Fleas	Leaves are placed in drinking water	(Ndou, 2018)
		leaves	Mahikeng Local Municipality, North West	Gastrointestinal parasites	Leaves are placed in drinking water	(Ndou, 2018)
		leaves	Mahikeng Local Municipality, North West	For general health in poultry	Leaves are placed in drinking water	(Ndou, 2018)
Xanthorrhoeaceae	*Bulbine abyssinica* A.Rich.	Leaves	Eastern Cape	Intestinal parasites in goats	Decoction	(Maphosa and Masika, 2010)

	Roots	Mahikeng Local Municipality, North West	Blood cleansing	Root infusion are made and combined with roots of *Solanum lichtensteinii* and *Withania somnifera*. 2 L of the remedy is administered orally.	(Ndou, 2018)
	Roots	Mahikeng Local Municipality, North West	Internal sores	Root infusion are made and combined with roots of *Solanum lichtensteinii* and *Withania somnifera*. 2 L of the remedy is administered orally.	(Ndou, 2018)

*Use report refers to a reference to a particular plant species and plant part being used to treat a particular ailment in a named species, i.e. (*mandatory*: 'scientific paper' x 'plant species with unambiguous veterinary use') x (*if available*: 'plant part used' x 'animal species treated' x 'disease condition').

3.1.2. Ethnoveterinary uses of plants across the different ethnic groups and provinces

Relatively few surveys were published in available literature during the period 2009-2019 and those conducted were generally confined to certain areas of the country without representing a wide distribution amongst the various ethnic groups of South Africa. In South Africa, the major ethnic groups include the Xhosa, Zulu, Basotho (or Southern Sotho), Bapedi (or Northern Sotho), Tswana, Venda, Tsonga, Swazi and Ndebele. This diversity of people is reflected in their different cultures as well as attitudes and practices regarding animal healthcare. However, this review identified only a limited selection of ethnic groups surveyed for their knowledge of ethnoveterinary remedies. Of the nine provinces of South Africa, published surveys on EVM since 2009 only covered four provinces, namely North West, Eastern Cape, Limpopo and Mpumalanga. When compared to the previous review (McGaw and Eloff, 2008), only minimal improvement has been witnessed in term of the number of provinces covered in South Africa **(Fig. 1)**.

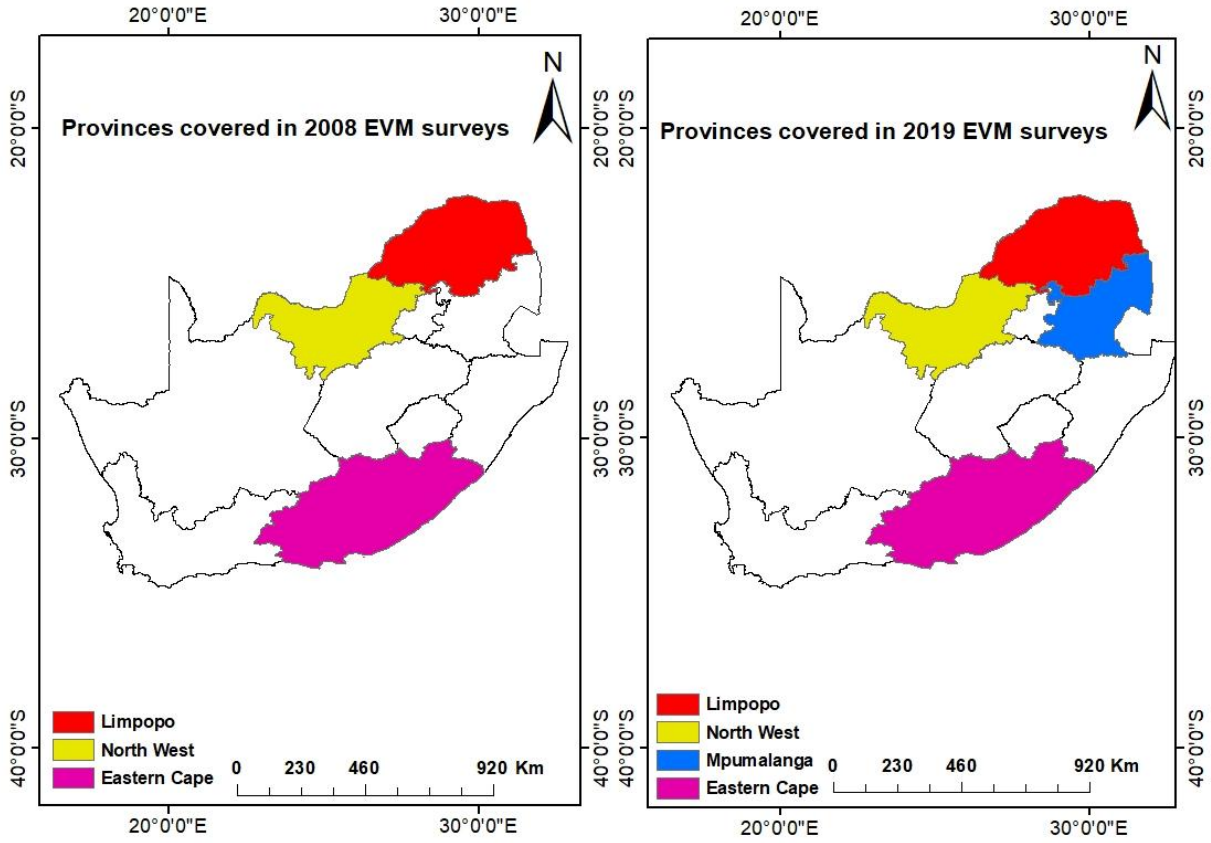


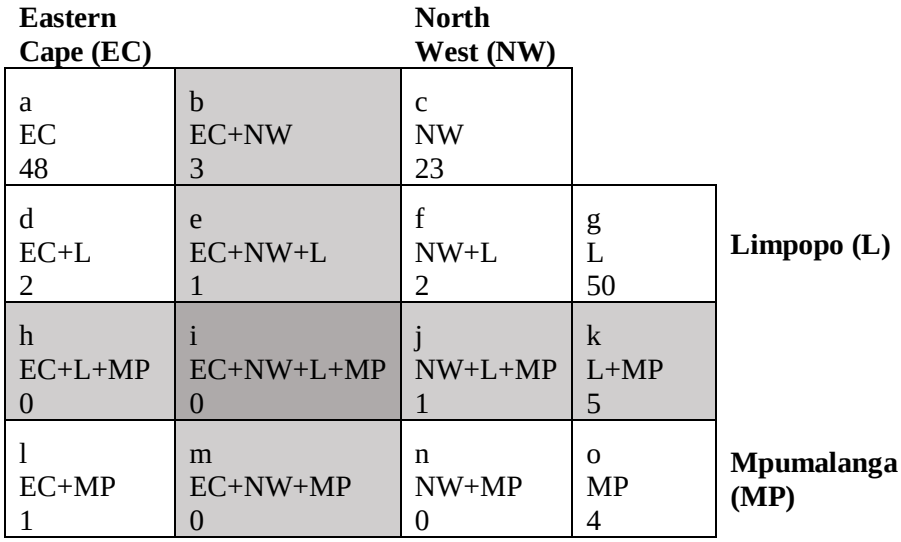
Figure 1. Provinces in South Africa with evidence of ethnoveterinary surveys

Of the thirteen (13) studies in available literature containing useful information on ethnoveterinary medicine, seven of these (54%) were conducted in the Eastern Cape, which is mainly inhabited by Xhosa-speaking people. Four surveys (31% of the 13 studies) were done in Limpopo while one each was conducted in the North West and Mpumalanga provinces. Limpopo is predominantly inhabited by the Bapedi people, but this varies according to districts within the province. For example, the Vhembe district, where several ethnoveterinary surveys have been done, comprises mostly Venda and Tsonga people. In a survey interviewing 37 individuals in the Vhembe (Venda speaking) region in Limpopo, over 33 plant species belonging to 21 families were used as EVM (Luseba and Tshisikhawe, 2013). Matlebyane et al. (2010) used semi-structured interviews to rank indigenous knowledge of available browse, grass species and shrubs used in medicinal and ethnoveterinary practices in three chief areas of the Capricorn region of the Limpopo province (Matlebyane et al., 2010).

In the study from North West, Ndou (2018), a veterinarian, interviewed EVM practitioners in four villages of the Mahikeng Local Municipality. Use of 31 plant species, three non-plant remedies and nine procedures was documented, with the procedures including obstetrics, surgery, fracture reduction and four metaphysical procedures (Ndou, 2018). Interestingly, the dissertation also reports on a follow-up survey of Western trained animal health practitioners to gauge the level of knowledge concerning EVM. These professionals were largely sceptical of the effectiveness of EVM and reportedly perceived EVM as lacking a scientific base (Ndou, 2018). This prompted a recommendation from the author to integrate EVM into the curriculum of veterinary and para-veterinary education. This is in fact in progress at the only Faculty of Veterinary Sciences in South Africa, at the University of Pretoria, where a module on EVM was introduced to the undergraduate veterinary curriculum in 2019.

The single ethnoveterinary study reported from Mpumalanga in the period 2009 to 2019 that could be identified from available literature was conducted by Khunoana et al. (2019). Fifty people were interviewed at state-run dipping tanks in the Mnisi area of Bushbuckridge. Interestingly, nearly half of the participants reported the use of *Elephantorrhiza obliqua* (Fabaceae) for diarrhoea in livestock (Khunoana et al., 2019). Most of the farmers and livestock-keepers used single plants in preparing remedies, and decoctions and infusions were the most common methods of preparation.

Figure 2 represents the overlap of the number of plant species reported to be used in EVM in each of the four provinces surveyed in the papers currently reviewed. A significant number of plants were unique to Limpopo, Eastern Cape and North West provinces (Supplementary Table 2). Some of the plants observed in Eastern Cape have also been reported in the Limpopo, North West and Mpumalanga province.



a EC only
Information on 48 plant species reported only in EC are available in Supplementary Table 2

b EC+NW
Bulbine abyssinica
Elephantorrhiza elephantina
Vachellia karroo

c NW only
Information on 23 plant species reported only in NW are available in Supplementary Table 2

d EC+L
Prunus persica
Tagetes minuta

e EC+NW+L
Ziziphus mucronata subsp *mucronata*

f NW+L
Tarchonanthus camphoratus
Thesium spp.

g L only
Information on 50 plant species reported only in L are available in Supplementary Table 2

h EC+L+MP
No species in common

i EC+NW+L+MP
No species in common

j NW+L+MP
No species in common

k L+MP
Aloe marlothii
Cissus quadrangularis
Elephantorrhiza obliqua
Philenoptera violacea
Schotia brachypetala

l EC+MP
Clutia pulchella

m EC+NW+MP
No species in common

n NW+MP
No species in common

o MP only
Albizia sp.
Gymnosporia sp.
Harpagophytum procumbens
Synadenium grantii

Figure 2. Overlap of plant species reported in the four South African provinces surveyed (2009 – 2019)

3.1.3. Disease conditions in livestock treated with plants

Based on the data in **Table S1**, the 139 recorded medicinal plants were used against 21 disease conditions in livestock. The five most often mentioned diseases connected to the recorded medicinal plants were intestinal parasites (20%), wounds (17%), gastrointestinal tract/digestive (11%), redwater/babesiosis (7%), and gynaecological problems (6%). However, the diseases connected to the medicinal plants varied across the different areas where the surveys were conducted. In the Vhembe district of Limpopo province, the focus was on traditional use of medicinal plants used to treat tick infestations (Magwede et al., 2014). Another ethnoveterinary study of knowledge held by Venda cattle farmers in Limpopo identified 20 medicinal plant species used for the treatment of redwater (Ramovha and Van Wyk, 2016). It was concluded that, because of similar clinical symptoms, "wet gall sickness" (bovine anaplasmosis) and "dry gall sickness" (impaction of the omasum) were frequently confused with redwater and in these misdiagnosed cases, treatment with plant medicines was generally ineffective (Ramovha and Van Wyk, 2016). In an earlier ethnoveterinary survey, gall sickness was highlighted as the most common ailment treated with plant-based medications, particularly in summer months (Masika and Afolayan, 2003). The authors noted that the term "gall sickness" was used by farmers in the area to denote a wide range of ailments associated with icterus (or jaundice), distension of the gall bladder with bile, as well as diseases such as heartwater, redwater or mixed infections (Masika and Afolayan, 2003). This strengthens the rationale for having a veterinary or para-veterinary professional available during consultations with livestock-keepers to ensure that the correct indication(s) is noted.

Some of the surveys specifically focused on particular disease conditions in livestock (Maphosa and Masika, 2010; Sanhokwe et al., 2016). In a study conducted in three districts of the Eastern Cape (with three villages included in each district), 30 people were interviewed for their knowledge on use of plants to treat gastrointestinal diseases in goats (Maphosa and Masika, 2010). The authors documented 28 plants as remedy against the disease. The largest number of plant species used for formulating remedies belong to the Xanthorrhoeaceae family with *Aloe* the most frequently used species (Maphosa and Masika, 2010). Similar plant species were also identified in another survey, including both intestinal and external

parasites in goats, of 50 farmers and 3 herbalists in Kwezi and Ntambethemba villages in the Eastern Cape province (Sanhokwe et al., 2016). Moyo and Masika (2013) investigated ethnoveterinary control of fleas in chickens in the Eastern Cape, discovering that *Clutia pulchella* and *Calpurnia aurea* had good efficacy against flea infestations (Moyo and Masika, 2013).

In a survey undertaken in the Centane district of the Eastern Cape on ethnoveterinary control of parasites in chickens, it was reported that over 80% of the poultry owners surveyed used medicinal plants (Mwale and Masika, 2009). Nine plant species were recorded as being used to reduce chicken parasites and the most popular plant was *Aloe ferox*, owing to its perceived efficacy in controlling gastrointestinal parasites (Mwale and Masika, 2009). Other methods were also used to rid chickens of parasites, including snuff, Jeyes fluid and insecticidal chalk (Mwale and Masika, 2009). Interestingly, while 17.7% of farmers used both Western and traditional methods to control the most problematic (internal) parasites in chickens, 32% of the farmers used only traditional practices (Mwale and Masika, 2009).

In the Amatola Basin (Xhosa-speaking) in the Eastern Cape where another survey was conducted, *Aloe ferox* was the most commonly used plant along with *Prunus persica* and *Phytolacca heptandra* (Soyelu and Masika, 2009). Nearly 70% of the participants used traditional remedies for treatment of these conditions and about a quarter of them used a combination of traditional remedies with conventional medicines (Soyelu and Masika, 2009). Despite the relatively large number of interviewees in the survey, only 13 medicinal plants belonging to 11 families were identified as being used to treat cattle wounds and myiasis in the area (Soyelu and Masika, 2009). *Aloe ferox* was also reported to be used to rid animals of ticks and mites by the farmers in Kwezi and Ntambethemba villages in the Eastern Cape Province (Sanhokwe et al., 2016).

3.2 Methods used in ethnoveterinary surveys (2009 to 2019)

Ethnopharmacological field studies have been conducted for an extended period of time and there is a need to critically assess the conceptual basis, methods used and standards required to perform these studies satisfactorily (Heinrich et al., 2009). Purely descriptive studies have limited value and the potential of such research is not truly developed in a simple listing of local traditional uses of plants and other materials (Heinrich et al., 2009). Studies comparing

the use of plants in neighbouring groups of people sharing similar environments would be useful to investigate how varying cultural forces affect use of the natural environment. Quantitative and statistical analysis of surveys is highly recommended to indicate which plant species are most popular in traditional use to define a strong basis for use and potential clinical effects. While a variation in approaches used and methods of conducting ethnopharmacological research may be advantageous in terms of scientific diversity, such research should adhere to defined quality standards and reproducible methods (Weckerle et al., 2018). The recently published Consensus Statement on Ethnopharmacological Field Studies (ConSEFS) offers a guideline for best practice regarding studies investigating local traditional medicinal substances aiming to document the knowledge for the purpose of identifying plants with potential for future development into medicines or botanicals, or aiming to contribute to improved healthcare at a community level (Heinrich et al., 2018). Comprehensive recommendations are given in terms of conducting and reporting ethnopharmacological field studies (Heinrich et al., 2009). A discussion on insights relevant to ethnopharmacological field studies, complementary to the ConSEFS, was highlighted recently (Weckerle et al., 2018) but with more emphasis on requirements of the Journal of Ethnopharmacology.

As noted by Weckerle et al. (2018), researchers with a non-medical background often report their own interpretation of illnesses described by healers and categorise them according to etic (the researcher's external) criteria as opposed to emic categories, which describe ailments according to indigenous definitions. In ethnopharmacological and ethnoveterinary field studies, although funding limitations often preclude this, it would be optimal to include a medically trained person or veterinarian respectively in the research team as diagnoses made by healers or indigenous livestock-keepers could be translated more easily into conventional medical or veterinary terms. As an example, several references in the surveys studied from 2009 to 2019 are made by rural farmers to "gall sickness" or "gall disease". In veterinary terms, gall sickness refers to the tick-borne disease anaplasmosis (caused by *Anaplasma marginale*). An enlarged gallbladder, on the other hand, can result from a variety of non-specified ailments that stop animals from eating, which in turn causes enlargement of the gallbladder. This is perhaps what is referred to in some cases where gall sickness is referred to by indigenous livestock-keepers. Only two of the surveys noted since 2009 on South African ethnoveterinary medicine apparently incorporated the involvement of a veterinary professional.

Preferably, field studies should be conducted over an extended period of at least a year to capture a full cycle of seasonal differences in illnesses experienced as well as availability of plant material (Weckerle et al., 2018). However, this is rarely possible under realistic conditions, but limitations of studies not conducted for a whole year should be discussed in the manuscript. Such limitations were not discussed in the surveys covered in this review.

In conducting field studies that involve questioning people on their practices and beliefs, ethical considerations are vital, and it is strongly recommended that surveys first pass through a recognised ethical committee and that issues of informed consent are dealt with before the study commences. Related to this are permits required for collecting botanical specimens for accurate identification of plant material. To confirm full botanical identity of plants used, voucher specimens should be collected and deposited in a recognised herbarium. Similar arrangements should be made for animal parts and other materials used in traditional healthcare. Another important aspect is that an understanding of the sociocultural context of the ethnic group is an essential element of ethnopharmacological field studies (Heinrich et al., 2009). Surprisingly, less than half of the surveys discussed in this review mentioned granting of ethical permission or conducting the study in terms of international ethical guidelines. Also concerning is that only about two-thirds of the studies reported lodging of voucher specimens at a recognised herbarium and not all the studies included records of authorities as well as families of the plant species identified. Encouragingly however, most of the surveys incorporated some discussion of the socioeconomic circumstances of the population studied.

In addition to conclusions being drawn from reports on local medicinal use of plants in ethnobotanical and ethnoveterinary surveys, contributions should also be made to an understanding of the cultural basis (Heinrich et al., 2009). Information about the cultural importance of the species used, for example giving the frequency of citation of plant use, is useful. A larger number of citations may indicate that the plants are more effective, used for a common disease or ailment, easily available, or have a special cultural significance (Heinrich et al., 2009). To allow comparison between studies, data sets should be recorded with a comparable scientific approach and methods, i.e. using clearly documented methodology, a representative sample size and some quantification of data – preferably documenting the number of recorded use reports (Heinrich et al., 2009). A useful set of “tools” for the quantitative analysis of ethnopharmacological field studies have been provided (Andrade-

Cetto and Heinrich, 2011). Some level of quantitative analysis of plant species recorded in EVM in South Africa since 2009 was conducted in only six (38%) of the surveys discussed.

3.3 Preparation and administration of plant based remedies in surveys from 2009 to 2019

In the surveys discussed, the most used plant part was the leaves and the remedies were largely prepared as decoctions and infusions. Boiling plant material in water to form a decoction may promote extraction of water soluble plant constituents or it could detoxify harmful substances (Maphosa and Masika, 2010). It is often presumed that water-based plant extracts may be ineffective as little evidence supports their biological activity *in vitro*. However, farmers do not generally sieve the remedies before administering them so they will contain small remnants of plant material which are easily digested, particularly by ruminants who are able to digest the plant cell wall, making plant compounds available to the animal (Luseba and Tshisikhawe, 2013). Bioavailability of medicines given orally, for example as drenches to livestock, is a major factor influencing efficacy as well as toxicity *in vivo* (McGaw and Eloff, 2010).

During the surveys, it was also found that some ethnic groups used a combination of two or more plant species during preparation to ensure that the treatment becomes effective, while other ethnic groups used single plant species (Maphosa and Masika, 2010; Luseba and Tshisikhawe, 2013). Plants were generally collected from the wild and fresh material was used to prepare remedies although in many cases this was not mentioned in the surveys. The rationale for using fresh plant material is most likely that farmers only prepare EVM remedies when necessary for their own animals, obviating the need for storage in dried form (Luseba and Tshisikhawe, 2013).

There is sometimes a relationship between plants which are used for animal health care and plants which are used for human health care. *Hippobromus pauciflorus* (Sapindaceae) is used to treat diarrhoea in humans (Bisi-Johnson et al., 2010) while it is also used to wash wounds in animals (Soyelu and Masika, 2009). The Vhembe community use *Turraea obtustfolia* (Meliaceae) to treat wounds in animals by directly applying it on the wound (Luseba and Tshisikhawe, 2013) while it is also used by the people of Pondoland to treat diarrhoea (Madikizela et al., 2012). Some plants such as *Ziziphus mucronata* (Rhamnaceae) and

Bulbine abyssinica (Asphodelaceae) are used for similar ailments such as diarrhoea and gastro-intestinal parasites (McGaw and Eloff, 2008; Maphosa and Masika, 2010).

3.4 Comparison of ethnoveterinary plants reviewed in 2008 and those in the current review

Many plants documented in the present review were also recorded in the previous review of ethnoveterinary surveys conducted in South Africa up until 2008 (McGaw and Eloff, 2008). Forty-two plants out of a total of 139 (equivalent to 30%) documented in the past decade had already been recorded previously, with some plants (e.g. *Aloe marlothii*) frequently used for similar ailments. Interestingly, different diseases and afflictions were in some cases reported for the same plant species **(Table 3)**. For example, *Ximenia americana* was recorded to be used to treat intestinal parasites (Van der Merwe et al., 2001) while the farmers of the Vhembe district of Limpopo use the same plants to treat wounds and calving difficulties (Luseba and Tshisikhawe, 2013).

Table 3: Comparison based on plant part(s) used and indication(s) of the 42 plants mentioned in both the previous (McGaw and Eloff, 2008) and current review

Family	Species	Plant part(s)		Indication(s)	
		2008	2019	2008	2019
Agapanthaceae	*Agapanthus praecox*	Roots	Leaves, roots	Diarrhoea in sheep and goats	Intestinal parasites in goats and black-quarter in cattle
Amaryllidaceae	*Boophone disticha*	Bulb, root, bulb scales	Bulbs	Redwater in cattle, constipation in cattle, used to facilitate healing of broken limbs abortion	Uterine cleansing after abortion
Apocynaceae	*Acokanthera oppositifolia*	Leaves, roots	Leaves	Heartwater in goats and sheep, redwater in cattle, snakebite, anthrax, tapeworm, swollen limb	Intestinal, external parasites in goats and black-quarter in cattle
Araliaceae	*Cussonia spicata*		Bark	Leaves applied in hot fomentations to goats paralyzed in their hind quarters; bark used for retained placenta in stock, leaves used to treat endometritis and/or vaginitis in cows, bark decoction for gallsickness in cattle	Intestinal parasites in goats
Capparidaceae	*Capparis sepiaria*	Root decoctions	Roots	Used by Xhosa for gallsickness in stock	Intestinal parasites in goats
Combretaceae	*Terminalia sericea*	Leaves, roots	Root, bark	Wounds, diarrhoea	Redwater (mali) in cattle
Ebenaceae	*Diospyros mespiliformis*	Bark	Roots	For milk production	Redwater (mali) in cattle
Euphorbiaceae	*Croton gratissimus* var. *gratissimus*	Leaves, roots	Leaves	Pneumonia, tonic, fertility enhancement	For fertility in livestock
Euphorbiaceae	*Jatropha curcas*	Seeds	Latex	Drench for constipation in cattle and goats	Wounds on cattle
Euphorbiaceae	*Synadenium cupulare*	Milky latex	Branch	Eye infection, blackquarter	Black-quarter
Fabaceae	*Calpurnia aurea*	Unspecified parts	Leaves	Zulus use plant to destroy maggots in sores	Wound infection in cattle

Fabaceae	*Cassia abbreviata* subsp. *beareana*	Bark	Bark	Drench for worm infestations	Wounds on cattle
Fabaceae	*Elephantorrhiza elephantine*	Roots, aerial parts and bulb	Bark or Roots	The Xhosa use roots for diarrhoea and dysentery in cattle, horses and humans, root given to cows for mange; heartwater, blackquarter, appetite stimulant or tonic; diarrhoea, heartwater, coughing, pneumonia	Intestinal and external parasites in goats
Fabaceae	*Peltophorum africanum*	Bark, root bark	Bark	Tonic, diarrhoea	Wounds on cattle
Fabaceae	*Pterocarpus angolensis*	Bark	Bark	General illness, gallsickness, intestinal worms, blackquarter	Not eating in cattle, Wounds on cattle
Fabaceae	*Schotia brachypetala*	Not specified	Bark	Infectious diseases in cattle (van der Merwe, pers. comm.)	Foot and mouth disease, black quarter and general ailments in cattle, Redwater (mali) in cattle
Fabaceae	*Schotia latifolia*	Bark decoction	Bark	Redwater in cattle	intestinal parasites in goats, Wound infection in cattle
Fabaceae	*Senna italic*	Bark, roots	Roots	Diarrhoea and gall sickness, intestinal diseases, heartwater, anthrax, pneumonia	General ailments and gall sickness in cattle. Diarrhoea in cattle. Retained placenta. Treat cattle and small-stock after abortions. Gastrointestinal parasites for calves, sheep and goats. Redwater in cattle
Geraniaceae	*Pelargonium reniforme*	Root decoction	Tuber decoction	Diarrhoea in goats and cows, heartwater in cattle, liver disorders in cattle and sheep	Intestinal parasites in goats
Gunneraceae	*Gunnera perpensa*	Roots	Tuber	Used to facilitate expulsion of afterbirth in animals and women	Intestinal parasites in goats
Lamiaceae	*Leonotis leonurus*	Roots, leaves, drops	Leaves	To prevent sickness in poultry, gall sickness in cattle, eye inflammation	Intestinal parasites in goats

		used from squeezed leaf for eyes			
Loganiaceae	*Strychnos henningsii*	Bark infusion	Bark	Heartwater and diarrhoea in cattle	Intestinal parasites in goats
Malvaceae	*Grewia flava*	Roots	Roots	Fertility enhancement	Calf diarrhoea
Malvaceae	*Grewia occidentalis*	Leaves	Bark	Gall sickness in stock	Intestinal parasites in goats
Olacaceae	*Ximenia Americana*	Roots	Leaves	Internal parasites	Wounds
Pedaliaceae	*Dicerocaryum eriocarpum*	Aerial parts, roots, whole plant	Stem, leaves	Dystocia, drench for retained placenta	Worms in cattle
Pedaliaceae	*Harpagophytum procumbens*	Fruit	Roots	Retained placenta	Diarrhoea, black quarter, if the cow is not eating or ruminating
Pittosporaceae	*Pittosporum viridiflorum*	Bark decoction	Bark	Gall sickness	Intestinal parasites in goats
Rhamnaceae	*Ziziphus mucronata*. subsp. *mucronata*	Roots, leaves	Leaves	Fertility enhancement, sores, burns	Intestinal parasites in goats
Rhamnaceae	*Ziziphus zeyheriana*	Root-stock	Roots	Diarrhoea, internal parasites, general ailments	Blood cleansing
Rosaceae	*Prunus persica*	Leaf decoctions, roots	Leaves	Leaf decoction for diarrhoea in lambs and kid goats, roots for broken bones	Wounds in cattle
Rutaceae	*Ptaeroxylon obliquum*	Wood	Leaves	Anthrax remedy, for ticks in cattle	Intestinal parasites in goats
Rutaceae	*Zanthoxylum capense*	Leaves, root decoction	Roots	Gall sickness in stock	Intestinal parasites in goats
Solanaceae	*Solanum aculeastrum*	Fruits	Fruits	Ringworm in cattle and horses and also for anthrax	Wounds on cattle
Solanaceae	*Solanum incanum*	Roots	Fruits	Sores	Eye problems in goats, sheep and cattle
Solanaceae	*Solanum lichtensteinii*	Aerial parts	Roots	Respiratory problems	Blood cleansing, internal sores caused by gastrointestinal parasites

Solanaceae	*Withania somnifera*	Unspecified parts, roots	Tubers	Used to stimulate milk production in cows; roots used for black gall sickness in cattle; diarrhoea	Internal sores
Vitaceae	*Cissus quadrangularis*	Aerial parts	Aerial parts, stem, leaves	Used by Zulus as a drench for sick horses, aerial parts used as poultice for wounds, lumpy skin disease and as tick repellent	Wounds on cattle, Redwater in cattle
Xanthorrhoeaceae	*Aloe arborescens*	Leaf decoctions	Leaves	Used to drench sick calves	Intestinal parasites in goats
Xanthorrhoeaceae	*Aloe ferox*	Leaves, juice from leaves	Leaves	Typhoid, ticks and lice in poultry, redwater in cattle; redwater, intestinal worms	Intestinal and external parasites in goats, wound infections in cattle, internal parasites in chicken
Xanthorrhoeaceae	*Aloe marlothii*	Leaves	Leaves	Newcastle disease in chickens; gall sickness, parasites, diarrhoea, constipation, retained placenta, dystocia, maggots	Gall and diarrhoea
Xanthorrhoeaceae	*Aloe zebrina*	Fresh leaves, roots, whole plant	Leaves	Wounds and maggots; burns, general ailments, blood cleansing, internal parasites, eye infections	Ripening of abscess, gastrointestinal parasites, for general health in poultry, against fleas

In the current review, a lower number of plant families (50) were recorded when compared to the previous review with 76 families (McGaw and Eloff, 2008). However, families such as Fabaceae/Leguminosae, Asteraceae and Xanthorrhoeaceae/Asphodelaceae generally had the highest number of plants used for ethnoveterinary remedies in both cases. Among the 17 different plant parts **(Fig. 3)**, the leaves, roots and bark were the major plant organs used for treating livestock diseases. The frequency (%) for the three most common plant parts was leaves (29%), roots (27%) and bark (19%) in the current review. On the other hand, roots (28%), leaves (24%) and bark (15%) were the most popular plant parts in the review by McGaw and Eloff (2008).

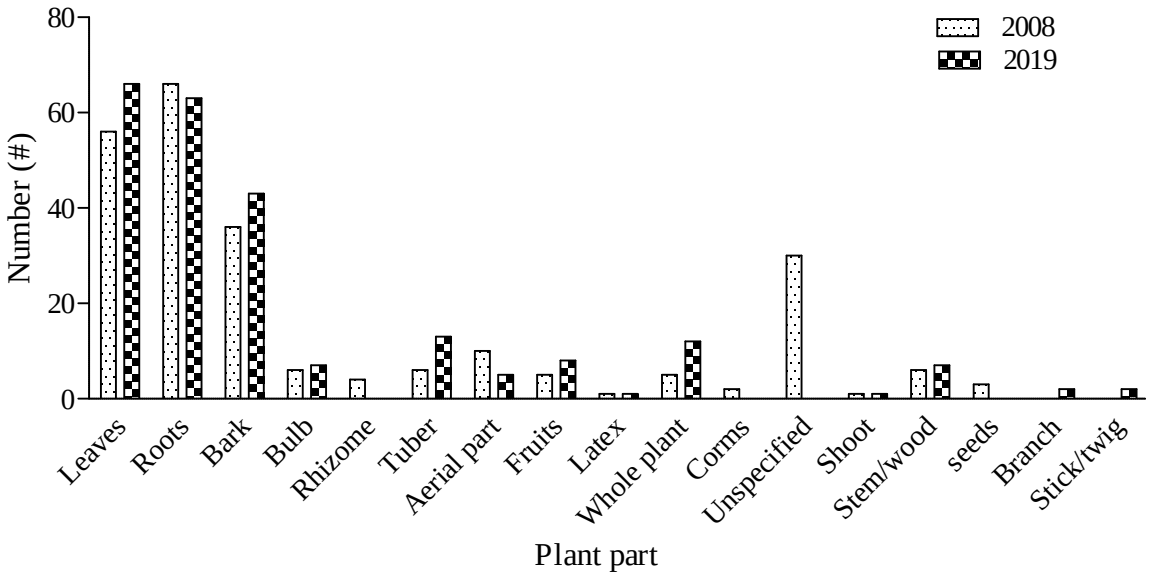


Figure 3. Comparison of plant parts from ethnoveterinary surveys in South Africa.

(The number in the y-axis refers to the number of use reports, or times the specific plant part is mentioned in the surveys reviewed.)

In this review, we recorded 7 livestock species (making a total of 169 use reports) that were treated in the different surveys **(Fig. 4)**, compared to 7 livestock (with 119 use reports or mentions) documented by McGaw and Eloff (2008). In both studies, cattle made up more than 60% of the livestock treated with medicinal plants. In other words, where animal species were recorded in the surveys, of all total animals (100%) indicated, cattle were mentioned six times out of ten. Goats, sheep and poultry also contribute significantly to the population of

livestock that have been the focus of ethnoveterinary surveys in South Africa. On the other hand, animals such as donkeys, horses and dogs have received little attention.

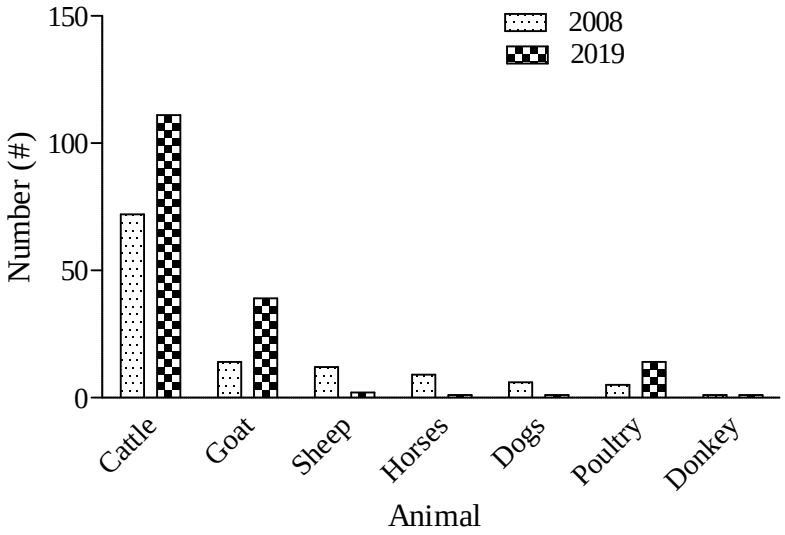


Figure 4. Comparison of livestock species recorded from ethnoveterinary surveys in South Africa. (The number in the y-axis refers to the number of use reports, or times the specific livestock species is mentioned in the surveys reviewed.)

In terms of disease conditions affecting these aforementioned livestock, McGaw and Eloff (2008) documented 27 disease conditions in 2008 while 21 different ailments were recorded in the current study. A high incidence of using medicinal plants for treating diseases such as intestinal parasites, GIT/digestive problems/diarrhoea, gynaecological problems, gall sickness and eye problem/conjunctivitis were evident in both the previous and current reviews. This is an indication that these diseases remain major health challenges faced by the livestock farmers in these areas.

4. Conclusions and recommendations

Few surveys from South Africa specific to EVM were identified from 2009 to 2019. Of these, 31% were conducted in the Limpopo province and 54% in the Eastern Cape. Less than half of the nine provinces in South Africa have therefore been investigated for ethnoveterinary practices over the past decade. It should also be kept in mind that where specific surveys have been conducted in particular areas, perhaps only a certain number of people in one or a few

representative villages or districts may have been surveyed. Nevertheless, 139 plant species were identified from the past decade of ethnoveterinary surveys in South Africa to be used to treat a wide variety of animal diseases and conditions.

As ethnoveterinary surveys are relatively costly to conduct, it is logical that most surveys have been carried out in areas close to centres where researchers are based, for example the University of Fort Hare in the Eastern Cape and the Universities of Venda and Limpopo in the Limpopo province. It is, however, necessary to promote the preservation of ethnoveterinary knowledge in other areas of the country, and these can perhaps be combined with more general ethnobotanical surveys as has been done in some instances. In any survey conducted, the selection of people to be interviewed and the time of year will undeniably affect the outcome of the survey. As a result, there remain many regions requiring more intensive investigation for the presence of interesting ethnoveterinary practices and medicinal plant use.

Recommendations for future planned ethnoveterinary studies in South Africa include the necessity for obtaining appropriate ethical permission as well as permission from the local traditional authority and community leaders. Shortcomings such as the lack of surveying done throughout all seasons of the year, lack of veterinary oversight to assist in interpreting traditional diagnoses, and limited numbers of people interviewed need to be discussed. Following stringent criteria for performing ethnoveterinary (and ethnobotanical) studies will provide a trustworthy and valuable database of plants to be interrogated for trends and patterns in plant species used as a means of prioritising plant remedies for *in vitro* and *in vivo* testing. This will assist with enhancing acceptability and status of EVM from the viewpoint of Western veterinary practice, in addition to aiding incorporation of EVM into conventional animal healthcare systems and the curriculum in the higher education sector.

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Author contribution list

LJM (lyndy.mcgaw@up.ac.za) and AOA (aredeyemi@yahoo.com) conceived the idea. IMF (adeyerimi@gmail.com) and ETK (thatokhunoana@gmail.com) conducted primary literature searches and information collation. All authors collated and analysed results, and wrote different sections of the manuscript.

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