Chapter

Sustainable Utilization of Indigenous Plants to Mitigate Ticks and Tick-Borne Diseases amongst Selected Rural Households of KwaZulu-Natal Province, South Africa

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Abstract

The objective of the study was to explore IK used to control ticks and associated diseases. A structured questionnaire (n = 250) were administered randomly to collect IK amongst the households active in goat production. Challenges on the use of ethno veterinary plants were also captured using focus group discussions. There was an association between goat ownership and gender, males used IK (70%) more than their female counterparts. Ticks were ranked as the major ectoparasites affecting goat productivity. Amongst ticks, *Amblyomma* species were ranked as the most important. *Cissus quadrangularis. Lin* (32%), *Gomphocarpus physocarpus E. Mey* (27%) and *Portulaca pilosa L.* (25%) plants had the highest FL values for their use to control ticks. Four plant species were identified to treat goats against tick-borne diseases. *Pittosporum viridiflorum Sims* and *Boophane disticha* were reported to treat heart water. *Aloe marlothii A.Berger* and *Erythrophleum africanum (Benth.) Harms* plants cure anaplasmosis. Livestock farmers hold substantial knowledge of ethno-veterinary plants to control ticks and their associated challenges. More research is required to affirm the acaricidal properties claimed to promote and optimize sustainable use of these medicinal plants.

Keywords: animal diseases, heart water medicinal plants, skin damage, treatment, wounds

1. Introduction

The production of goats is increasing in the developing countries due to several key drivers of change in the livestock production sector [1]. One of which is the unforeseeable drastic effect of changing climates. Thus, addressing the issues of climate change in the context of livestock intensification involve rearing of species that are robust and adaptable to changing extreme conditions such as severe drought, increase temperatures and water scarcity issues [2] faced in the world. Goats are, therefore, more appropriate under such environments. Goats are inexpensive to raise

and are, thus, a viable option for resource-limited households. Their high fecundity and relatively small space requirements and exceptional ability to produce under marginal environments such as mountainous and degraded lands are other attributes. The importance of goats is even higher in drier agro ecological zones where crop production is unreliable due to low and poorly distributed rainfall patterns coupled with droughts. Goats are also able to feed on grasses, bushes, shrubs, tree leaves and crop residues which would otherwise go to waste.

Although, goats are suitable under marginal lands, their productivity is still low owing to several constraints such as infectious diseases and parasites [3]. Communal production systems are characterized by poor management and low productivity. Farmers in communal production systems hardly use drugs to treat goats, consequently, diseases and ectoparasites are rife and major threats to goat production. Surveys have indicated that ticks are one of the constraints that limit goat productivity [4]. Ticks cause substantial losses such as diseases, reduced productivity through high mortalities and they are economically the most important ectoparasites of goats. Ticks suck blood, which damages the quality of the skin and hides and introduce toxins into goats [5]. In goats, skin lesions, particularly between the hooves, lead to secondary infections and may cause lameness [6].

The most common methods used to control ticks are through commercial acaricides. In developing countries, however the supply of acaricides are inconsistently available or not available at all [1]. Goats owned by resource-limited farmers are reared on communal rangelands where they browse extensively in mixed pastures with cattle. During dipping of cattle, goats are often ignored yet these species graze together. Many resource-limited farmers cannot afford acaricides and depend extensively on indigenous knowledge (IK) and practices. Indigenous knowledge is critical in goat health and it enhances cost-effective management of ticks [1]. Over centuries, resource-limited communities have learnt how to survive in difficult environments. They know appropriate varieties of crops to plant, when to sow, which plants are poisonous, which can be used for control of diseases in livestock [7]. Though such knowledge is valuable, however government veterinary services are an impediment to the development and use of IK as they regard it as based on mythology due to lack of scientific validation. As such, farmers are exposed to modern veterinary services leading to infrequent application due to failure to purchase the acaricides and at times under dosing, thus contributing to the development of resistance of ticks to acaricides.

The use of ethno-veterinary plants, which is part of IK is, however, important because it is easily accessible and locally available [1]. The study, therefore, will assist through the use of IK and its practices to eradicate ticks in goats, thereby enhancing global food security through provision of healthy chevon. Information obtained can also be used to design cost effective control programmes, which are locally available and affordable to farmers. Indigenous knowledge could also be blended with conventional knowledge (CK) to strengthen veterinary livestock care. Gathering IK could also increase the choices for farmers to control ticks and associated challenges in goats without only depending on CK. Indigenous knowledge could be useful because it controls even parasites that have developed resistant to acaricides. The objective of the study was to explore the use of IK used to control ticks and tick-borne diseases in goats.

2. Materials and methods

2.1 Ethical clearance consideration

The respondents' rights, religions, culture and dignity were respected. The respondents were assured that no confidential information would be disclosed,

and they had a right to stop the interview whenever they did not feel comfortable. The experimental procedures were performed according to the ethical guidelines specified by the Certification of Authorization to Experiment on Living Humans provided by the UKZN Social Sciences – Humanities & Social Sciences Research Ethics Committee (Reference No: HSS/0852/017).

2.2 Study site

The study was conducted at Jozini municipality of uMkhanyakude district in the KwaZulu-Natal Province of South Africa. Jozini lies at 27º 24' 06.9' S; 32º 11' 48.6 E, and covers about 3 082 km^2, with an altitude ranging from 80 to 1900 m above sea level. Jozini experiences subtropical climate, with an average annual rainfall of 600 mm. Although the area receives rainfall throughout the year, most rains are received between January and March, with the months of June and July being dry and cool. Highest mean monthly temperature is recorded in January (30°C) and lowest in July (11°C). The average daily maximum and minimum temperatures at Jozini are 20 ºC and 10 ºC, respectively. The vegetation type of the area is mainly coastal sand-veld, bushveld and foothill wooded grasslands [8]. Agricultural practices in this district include production of field crops, vegetables and extensive livestock farming.

2.3 Study design and data collection

Eight communities were visited across the Jozini Area. Scheduled meetings with local authorities such as chiefs and local headmen were arranged to gain access to communities. The visited communities were Biva, Nyawushane, Mkhonjeni, Gedleza, Mkhayane, Makhonyeni, Mamfene and Madonela. They were randomly selected amongst communities active in goat production. Households were identified by the local chiefs and selected based on their personal experience on indigenous knowledge systems (IKS) to control ticks. The sampling technique involved approaching participants with extensive knowledge on the use of ethno-veterinary plants in goats. Enumerators were obtained from the local villages to ensure that farmers are comfortable to participate during the study. The questionnaire was pre-tested for accuracy and clarity of questions. Structured questionnaires were used to collect data from 250 households.

Data collection included household demographic information such as gender, age, source of income and employment status. Effects of ticks in goats, tick species and tick-borne diseases prevalent in the study area. Factors that limit the use of IK were also captured. Indigenous methods and practices used to control ticks and associated tick challenges were also captured. Information such as the (1) Local names of plants (2) part of the plant used (3) method of preparation and dosage were also captured during the survey. Apart from the questionnaires, further information on challenges with ethno-veterinary plants was collected through focus group discussions (FGD) with knowledgeable persons from the communities.

2.4 Plant collection and identification

Following the survey with the selected key respondents, 13 plant specimens were identified and collected. During collection of plant parts, leaves and bark were collected to ensure that plants continues to grow. The specimens were harvested, prepared, packaged and stored according to the herbarium rules and regulations. Plants specimens were then pressed and transported to the University of Kwa Zulu–Natal for botanical identification. For each plant species collected, a voucher specimen was prepared by The Bews Herbarium of the University of KwaZulu-Natal, Pietermaritzburg, South Africa.

2.5 Statistical analyses

All data were analyzed using SAS [9]. The PROC FREQ procedure for chi-square was used to compute association between households' demographic profile and IK use and challenges of IK. Mean rank scores for the effects of ticks on goat productivity, reasons of keeping goats, goat production constraints, common external parasites and common ticks and tick-borne diseases in the study site were determined using PROC MMEANS of SAS [9].

Fidelity level (FL) values were determined to capture the most used ethnoveterinary plants, as this could demonstrate their possible efficacy. Fidelity level is the percentage of respondents who use a certain plant for the same function [10] and was calculated as:

$$\frac{Na}{N} \times 100 \quad (1)$$

N_a - is the number of respondents who claim the use of a plant species to treat a particular ailment; N - is the number of respondents who use the plant as medicine for any ailment.

3. Results

3.1 Household socio-demographic information of respondents

Table 1 shows the association between household socio- demographic information and IK use of the farmers in the study site. There was an association ($P < 0.05$) between

Household demographic parameters		IK use	χ^2	Significance
Goat ownership	Male	69.7	5.96	**
	Female	30.3		
Marital status	Married	35.9		
	Not married	64.1	3.89	*
Educational status	Informal education	59.9		
	Formal education	40.2	1.20	*
Religious belief	Tradition	55.6		
	Christianity	54.4	1.25	ns
Sources of income	Salary	10.3		
	Livestock farming	23.4		
	Crop farming	20.0	4.06	ns
	Government grant	46.3		
Employment status	Employed	20.0		
	Unemployed	45.9	3.45	ns
	Self-employed	34.1		

NS: not significant ($P > 0.05$);
**$P < 0.05$;*
***$P < 0.01$.*

Table 1.
Socio-economic characteristics of respondents and association with indigenous knowledge use (n = 250). This result originated from the authors own work.

goats' ownership and gender, males were using IK (70%) more than females. The association between marital status and IK use was ($P < 0.05$). Farmers that were not married used IK more than those that are married. There was an association ($P < 0.05$) between educational status and IK use in the study area. Farmers that did not receive formal education were found to depend on IK more than those that received formal education. Unexpectedly, there was no association ($P > 0.05$) between IK use and religious belief. Although farmers that believed in tradition were using IK (56%) more than Christians. There was also no association between sources of income and IK use ($P > 0.05$), however farmers that depended on government grant (46%) used IK more. Even though there was no association ($P > 0.05$) between IK use and employment status, however farmers that were unemployed were more (46%) likely to use IK.

3.2 Livestock inventory and effects of ticks on productivity of goats

As expected, households owned different types of livestock (**Figure 1**). Livestock species owned by respondents consisted of cattle, goats, sheep, chickens, pigs, ducks and donkeys. Cattles (89%) were the most kept livestock species in the study area, followed by goats (80%), chickens (61.3) and sheep (51%) in that chronological order of importance. Ducks (28%), pigs (24%) and donkeys (10%) were least important species in the study area.

Table 2 shows the effects of ticks on goat productivity as ranked by farmers. Wounds were ranked the first. The loss of body condition due to ticks were reported as the second effect of ticks that thwarts goat productivity. Challenges of limping were ranked the third, followed by transmission of tick-borne diseases (**Table 2**). Skin irritation, destroying teats and anemia were least important.

3.3 Constraints to goat production

The most important external parasites constraining goat productivity are shown in **Figure 2**. Farmers ranked ticks as the most important external parasites affecting goat productivity. Lice were ranked the second and mites as the third constraint. Whilst the flies were ranked the least external parasites affecting goats productivity. **Table 3** shows the mean rank scores of different tick species

Figure 1.
Livestock numbers kept per household in the study site (N = 250). This result originated from the authors own work.

Conditions	Mean rank scores
Wounds	1.84 (1)
Limping challenges	1.90 (3)
Skin irritation	2.21 (5)
Destroyed teats	2.29 (6)
Loss of body condition	1.86 (2)
Anemia	3.10 (7)
Tick-borne diseases	1.95 (4)

The lower the 1 mean ranked score (rank) of a use the greater its use. Values in parentheses indicates means ranks.

Table 2.
Effects of ticks on goat productivity. This result originated from the authors own work.

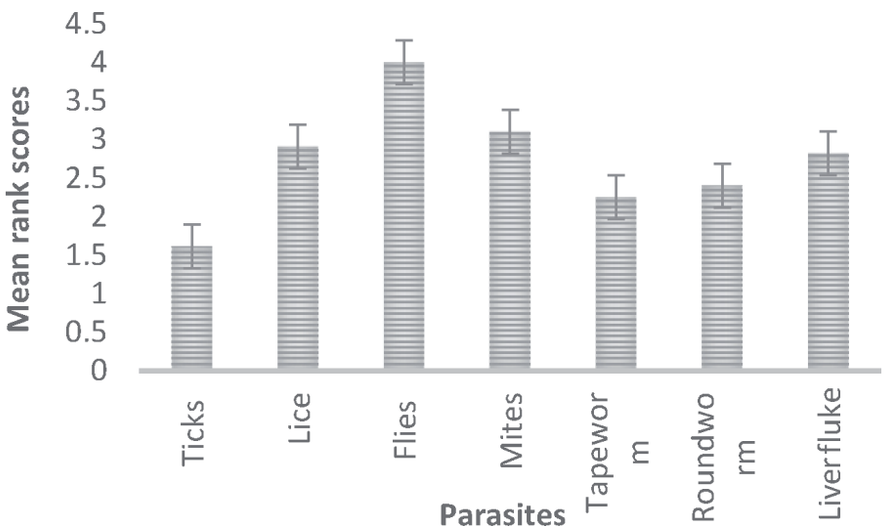

Figure 2.
Common parasites prevalent in the study site. This result originated from the authors own work.

Ticks	Mean rank score
Amblyomma	1.5 (1)
Hylomma	2.5 (3)
Rhipicephalus evertsi evertsi	2.0 (2)
Tick-borne diseases	**Mean rank score**
Heart water	1.8 (1)
Anaplasmosis	2.7 (2)
Babesiosis	3.3 (3)

The lower the 1 mean ranked score (rank) of a use the greater its use. Values in parentheses indicates means ranks.

Table 3.
Mean rank scores of ticks and tick-borne diseases. This result originated from the authors own work.

and associated tick- borne diseases affecting goat productivity in the study site. *Amblyomma* species were ranked as the most important amongst the ticks, followed by *Rhipicephalus evertsi evertsi* ranking the second and the least being the *Hylomma* species. Amongst tick-borne diseases, heart water was ranked as the most important, followed by anaplasmosis and babesiosis in that descending order.

Scientific name	Family name	Local name	Accession No	Parts used, preparation, dosage, and effectiveness	Conditions treated
Cissus quadrangularis L.	Vitaceae	Inhlashwana	NU0068142	Fresh leaves grind and mix together and apply on the body parts of the goat, every effective	Ticks, wounds
Stapelia gigantea N.E.Br.	Apocynaceae	Uzililo	Yet to be identified	Crush fresh leaves and apply paste topically on the skin, moderately effective	Ticks
Portulaca amilis Speg.	Portulacaceae	Ushisizwe	Yet to be identified	Crush fresh leaves and topically apply paste on the goat skin, very effective	Ticks
Gomphocarpus physocarpus E. Mey	Apocynaceae	Phehlachwathi	NU0068162	Crush fresh leaves and topically apply paste on the goat skin where there are ticks, very effective	Ticks, wounds
Drimia altissima (L.f.) Ker Gawl.	Asparagaceae	Umahlanganisa	Yet to be identified	Crush fresh leaves or roots and apply treat on the wound, very effective	Wounds
Spirostachys africana Sond.	Europhorbiaceae	Umthombothi	NU0068154	Crush fresh leaves or roots and apply the paste on the wound, very effective	Wounds
Achyranthes aspera L.	Celastraceae	Isinamane	NU0068139	Crush fresh leaves and feed solution to goats, effective	Ticks
Aloe marlothii	Asphodelaceae	Inhlaba	NU0068166	Crush the leaves and collect the juice apply on the wound	Wounds
Maytenus acuminata (L.f.) Loes	Celastraceae	Isinamane	Yet to be identified	Crush fresh leaves and feed solution to goats, effective	Ticks

Table 4.
Ethno-veterinary plants used to control ticks. This result originated from the authors own work.

3.4 Ethno-veterinary control of ticks and tick related conditions in goats

Nine plant species belonging to eight families were identified to control ticks and related tick challenges. Six medicinal plants were used as tick repellents from goats namely, *Cissus quadrangularis. Lin, Stapelia gigantea N.E. Br., Portulaca pilosa L., Gomphocarpus physocarpus E. Mey, Achyranthes aspera L and Maytenus acuminata (L.f.) Loes.* **Table 4** shows methods of plant preparation and dosages used. In addition, three ethno-veterinary plant species were identified to treat tick wounds: *Cissus quadrangularis. Lin, Drimia altissima (L.f.) Ker Gawl.* and *Spirostachys africana Sond.* Other plant species are broad spectrum, for example *Cissus quadrangularis. Lin,* which is used to control ticks can also be effectively used to treat wounds. The use of plant leaves was most prominent in the study area, followed by barks. *Cissus quadrangularis. Lin* mixture is smeared on the wound to prevent maggot development. Leaves from *Aloe marlothii A.Berger* are applied on the wounds.

The juicy liquid from *Aloe marlothii A.Berger* is then applied topically on the wounds to prevent the development of maggot. The wound was cleaned before the prepared mixture of *Drimia altissima (L.f.) Ker Gawl.* is applied (**Table 4**). Fidelity level values were determined to estimate the ethno-veterinary plants use values (**Table 5**). *Cissus quadrangularis. Lin* (32 %), *Gomphocarpus physocarpus E. Mey* (27 %), *Portulaca pilosa L.* (25 %) were the plants having the highest FL values for their use to control ticks. *Maytenus acuminata (L.f.) Loes* had the least FL value of 17 %, followed by *Stapelia gigantea N.E. Br* (3 %), respectively. Leaves were the most frequently used plant parts, constituting (55 %), followed by barks (25 %). Roots had a frequency of (13 %) and lastly the fruits constituting (7 %).

3.5 Ethno-veterinary plants used to treat tick-borne diseases in goats

Table 6 shows ethno-veterinary plants, methods of preparation and dosages used for treatment of tick-borne diseases in goats. The *Boophane disticha* is administered orally to kill the *Ehrlichia ruminantium* bacterium *spp* that causes heart water. *Pittosporum viridiflorum Sims* is widely used to treat heartwater in the study area. *Aloe marlothii A.Berger* plant is used to cure anaplasmosis.

3.6 Challenges of using indigenous knowledge

During group discussions, farmers acknowledged that there are numerous challenges pertaining to the use of ethnoveterinary plants. Farmers attributed some of the challenges to lower rainfall patterns that have led to the limitation of ethno-veterinary plants used to make remedies for both ticks and other associated challenges

Plant species	Condition	Na	N	FL in % [(Na/N)]
Cissus quadrangularis. Lin	Ticks	11	34	32. 3
Stapelia gigantea N.E. Br	Ticks	1	36	2.77
Portulaca pilosa L.	Ticks	1	4	25
Gomphocarpus physocarpus E. Mey	Ticks	60	225	26.7
Maytenus acuminata (L.f.) Loes	Ticks	1	6	16.6

Na – Indicates the number of respondents who claim a use of plant species for a particular ailment, N – indicates the number of informants who use the plant as medicine for any ailment, FL – Fidelity level.

Table 5.
Fidelity level indices of ethno-veterinary plant species used to control ticks in goats. This result originated from the authors own work.

Scientific name	Family name	Local name	Voucher No	Parts used, preparation, dosage, and effectiveness	Disease
Boophane disticha	Amaryllidaceae	Ingcotho	NU0068143	Fresh crushed leaves mixed, add water to form a solution and drench ¼ cup to kids, every effective	Heart water
Erythrophleum africanum (Benth.) Harms	Fabaceae	Umkhwango	NU0068159	Dry bark and fresh leaves are used, add water and mix, feed solution to goats, very effective	Anaplasmosis
Aloe marlothii A.Berger	Asphodelaceae	Inhlaba	NU0068166	Crush the leaves and collect the juice oral administration 1 cup/goat, very effective	Anaplasmosis
Pittosporum viridiflorum Sims	Pittosporaceae	Umfusamvu	NU0068132	Boil fresh bark and wait for it to cool and feed goat 0.5 L 1×day for 2-3 days, very effective	Heart water

Table 6.
Ethno-veterinary plants used to treat tick-borne diseases. This result originated from the authors own work.

including tick-borne diseases. For example, ethno-veterinary plants such as *Croton sylvaticus Hochst.* (Ugibeleweni), *Leonotis leonurus (L.) R.Br* (umhlahlampethu), *Erythrophleum lasianthum Corbishley* (Umkhwango), *Pittosporum viridiflorum Sims* (Umfusamvu) are found in the wild. Due to lower rainfall patterns coupled with increased drought occurrence, ethno-veterinary plants are becoming scarce. The scarcity of plants is also exacerbated by increasing human population, overharvesting and deforestation. The exorbitant increase in the human population that are using IK has two limitations to ethno-veterinary plants. Firstly, the number of settlers in the area is increasing and they remove important plants during preparation and building of shelters. Secondly, as the number of people who uses IK increases, some of the people harvest plants inappropriately whereby one uproots the whole plant, which then destroys plant growth.

4. Discussion

Ethno-veterinary knowledge and practices contribute gigantically to the veterinary management of goats and the use of IK is capturing much popularity. For example, about 80% of farmers living in sub-Saharan Africa today depend on ethno-veterinary plants for their livestock health [11]. Indigenous people do not reveal IK effortlessly as it is a source of their livelihood [12]. Indigenous knowledge is normally transferred and passed to the next generation through oral conversations. As a result, a vast of IK remain undocumented. Indigenous knowledge is also restricted to the elderly generation, thus with the demise of older generation, there is fear and danger that IK will rapidly vanish while not promoted to enforce policies for sustainable development of livestock veterinary care, hence the need for the current study. The observed association between goat ownership and gender, with males using IK more than females was anticipated. This finding corroborates with that of Mkwanazi et al. [1]. The probable explanation could be that in resource-limited areas men are usually the head of households and therefore, culturally obligated to take decisions on livestock including goats. Women are culturally not allowed to enter livestock kraals, thus making it difficult for women to participate and make purposeful decisions. In addition, there is a belief that ethno-veterinary plants should not be collected by menstruating women as this would reduce the healing power of the plants [13]. Women, however, should not be deprived of such a privilege, because in the modern society men are scantly at home as they migrate to seek for better opportunities in urban areas, as a result woman remain behind and enforce decisions. Moreover, most households nowadays are headed by women, therefore, men should be encouraged to educate women on IK and livestock management.

The finding that most unmarried household heads used IK more could be influenced by the lack of additional household income, resulting in farmers opting to use IK so that the negligible remittances that they receive could be used to purchase essential things such as food and paying school fees for children. The observation that farmers with informal education used IK more was not surprising because most of them grew up using IK to control tick and associated challenges in goats, hence their high dependency on ethno-veterinary plants. The observed finding that traditionalists were using IK more as opposed to Christians is not surprising. Christian converts associate IK use with demons. This is rather worrisome given that young people are easily lured to Christianity as opposed to learning African ways of living. Therefore, this presents a threat of disappearance of IK for the future generations. The observation that unemployed farmers use IK more could be linked with the nature of the sources of income in resource-limited areas, most unemployed

farmers are old and therefore, depend on sales from farming and government grant incentives for survival. This observation resonates with that of Sanhokwe et al. [4].

The observation that cattle were the most popular livestock species is influenced by social status, since in resource-limited areas cattle are an emblem of wealth. Therefore, cattle are considered very important because of the economic roles they perform [14]. They perform multiple roles such draught power, slaughtered during burial of chiefs, kings and generally men who are heads of households and in wedding ceremonies. Although goats are an alternative for farmers who do not afford to keep cattle, but they are usually referred as poor man's cow [15]. The finding that chickens were the third livestock species kept by farmers deviates from the work of Nyahangare et al. [14], who reported chickens as the most populous species kept by resource-limited farmers. Chickens have low input requirements, which makes it easier for farmers to accommodate them in their homesteads. Despite the lowly rank of other species such as ducks, pigs and donkeys, however but they still contribute substantially. The study area experiences frequent droughts; therefore, donkeys occupy a very important niche of transporting water during water shortages.

The observation that the primary reason for keeping goats was to perform cultural ceremonies resonates with Mdletshe et al. [16]. In resource-limited areas, goats are used to communicate with ancestors and are scantly slaughtered outside the context of traditional ceremonies. Keeping goats for sales confirm the notion that farmers sell their goats in times of need and generate cash income, which is generally used to purchase food and other essentials. The observation that milk ranked the least concurs with Mahanjana and Cronje [17] and Masika and Mafu [18]. Most farmers do not milk goats for human consumption, hence the need to educate farmers on the importance of goat's milk as it has therapeutic properties and is more digestible than cow milk. Thus, dissemination of information to farmers on goat milk can ensure continued access to high quality protein by the less fortunate and those allergic to lactose, particularly young children.

The observation that experts showed awareness and could identify the effects associated with ticks suggest that these challenges are evident in the study area. The observation that farmers ranked wounds as the major effect of ticks on goat productivity could be influenced by that ticks gouge through the skin leading to the development of wounds. In resource-limited areas farmers use traditional practices such as the use of thorns and scissors to remove ticks from goats, however such practices tend to destroy the stomach part of the tick only while leaving the head inside the skin. Therefore, goats would rub themselves trying to appease the pain, thus causing the wound. The finding that ticks cause loss of body condition demonstrates the seriousness to include goats in tick control programs. This is important to consider because availing resources to goats will help improve their productivity and hence their contribution to livelihood. The loss in body condition could be due to that ticks suck blood, thereby denying goats adequate nutrients. Subsequently, making goats vulnerable to diseases. The observed challenge of limping in goats could be due to that ticks attach between the hoofs, causing wounds that may lead to hoof rot. Eventually making goats to limp and unable to reach mountains and grazing areas for browsing. Jongejan et al. [6] recorded 89% of goats suffering from lameness due to predilection of ticks between their feet. The observation that tick-borne diseases ranked the fourth should not be taken light, because in the past goats, especially Nguni breeds have been assumed to be resistant tick-borne diseases. Hence, there is a need for further research to be done on tick-borne diseases in goats.

Farmers can identify different tick species in their goats using color patterns [19, 20]. The finding that ticks were ranked as the most external parasites affecting goats agrees with Mkwanazi et al. [1]. The probable explanation could be that

goats are hardly dipped in resource-limited areas and much priority given to cattle, although these species graze together in communal rangelands [1]. High infestation of ticks could also be due to that during the cool-dry season, where water and feed resources are deficient, goats travel far to mountains and valleys where ticks are abundant [21]. Ticks were scored high and perceived as a major cause of mortality in kids under communal farming conditions in South Africa [22]. The observation that lice were ranked the second contradicts findings by Sanhokwe et al. [4] who reported mites to be second challenge after ticks on goats. It should be alluded that prominence of external parasites in the study area could be influenced by poorly managed rangelands where parasites burden is rife. The observation that *Amblyomma* tick species were ranked as the most important amongst the ticks agrees with Jongejan et al. [6] who reported *Amblyomma* as the predominant adult tick species on goats with a relative proportion of 66%.

Goats in resource-limited areas have been found to be infested with a large population of *Amblyomma* and *Rhipicephalus evertsi evertsi* [1]. The observation that farmers mentioned the presence of *Hylomma* infestation on goats in the study site was rather befuddling because Horak et al. [23] reported that *Hyalomma* species are not present in the study area as farmers suggested. In particular areas where the *Hyalomma* has been spotted, goat infestation is very low; less than 2 ticks per goat. Secondly, *Hyalomma* that infests dogs are not common in the study area [23] suggesting that although farmers have knowledge on ticks, they often confuse different tick species. Perhaps the most striking finding was that most of the IK experts did not directly connect ticks with the spread of tick-borne diseases. Farmers, however, were able to define tick-borne diseases using clinical symptoms, but it should be borne in mind that some diseases exhibit differential diagnosis. Thus, affecting the accuracy of the diagnosis.

The observation that heart water ranked the first amongst tick-borne diseases could be influenced by the high prevalence of *Amblymma* species in the study area that is known to be the carrier of *Ehrlichia ruminantium* bacteria transmitting heartwater in goats. The observation that farmers could rank anaplasmosis the second was surprising, considering that anaplasmosis in goats is a subclinical and non-pathogenic disease of little economic importance [23]. Infected animals show few clinical signs of the disease. Consequently, the correlated symptoms such as slimy mucous around the nose, lying down, weakness and shivering of goats form part of a range of signs by which heart water can be identified.

Nine common ethno-veterinary plant species were identified to be used by farmers to control ticks and related challenges. These plants are from different families *Vitaceae, Asphodelaceae, Apocynaceae, Portulacaceae, Apocynaceae, Asparagaceae, Europhorbiaceae* and *Celastraceae.* Other plant species have a broad-spectrum nature. For example, *Cissus quadrangularis Lin* from *Vitaceae,* is used to control ticks and treat wounds. Similarly, *Aloe marlothii A.Berger* is used to treat anaplasmosis and tick wounds. Plants from the genus *Aloe* have been successfully used throughout the world due to their biologically active ingredients [24]. *Cissus quadrangularis. Lin* has many biological activities, including antioxidant, anti-bacterial and anti-inflammatory activity. *Drimia altissima (L.f.) Ker Gawl.* plant is known to have various biological activities such as antioxidant, anti-bacterial, anti-inflammatory activity, anti-fungal and cytotoxic effects. In addition, the plant has been reported to have insecticidal activities with properties including L-azatidine-2-carboxilic acid and bufadienolides, scillirosidin and proscillaridin A [25].

The effects against ticks from other plants including *Stapelia gigantea N.E. Br*, *Portulaca amilis Speg.* and *Achyranthes aspera L.* have not been reported in literature, however, farmers indicated that their leaves are excellent tick repellents. Therefore, there is a need of in-depth research on their potential efficacy

as tick repellents. The observation that FL values of *Cissus quadrangularis. Lin*, *Gomphocarpus physocarpus E. Mey* and *Portulaca pilosa L.* (25%) were high, showed that most farmers in the study area generally prefer these plants and they constantly utilize them to control ticks. The observation that *Maytenus acuminata (L.f.) Loes* had the least FL value disagrees with Mkwanazi et al. [1]. Some of the medicinal plants have low FL values because some farmers did not know their preparation methods and dosages. Acaricidal validation of these plants is essential to isolate their active ingredients and thus, used to produce drugs.

The four plants; *Boophane disticha, Erythrophleum africanum (Benth.) Harms* and *Pittosporum viridiflorum* Sims. *Boophane disticha* were identified to treat goats against heartwater and have intensive usage in the traditional medicine practice of indigenous people around the world. For example, *Boophane disticha* has been widely used in cattle to treat babesiosis, however in this study it is used against heartwater. This is possibly due to its antimicrobial and anti-inflammatory activities [26]. *Pittosporum viridiflorum* Sims is reported to repel ticks [27, 28] and to have acaricidal properties against larvae of *Rhipicephalus appendiculatus* [27]. In the current study, however, it is reported to treat heartwater. Multiple properties including wound healing, anti-inflammatory, antibacterial and low toxicity [29] have been found in *Pittosporum viridiflorum* Sims.

The observation that leaves and bark were common plant parts used to prepare these remedies agrees with Maroyi et al. [29]. The high use of leaves could presumably be due to strong seasonality of rainfall that hinders the growth of many plant species during the dry season. Leaves are also readily available. Leaf harvesting does not inhibit the growth and survival of the whole plant species [30] as compared to roots, which could be another plausible reason for their greater usage in remedy preparations. The most common preparation method used was boiling the plant in water. This could possibly because boiling allows time for the active compound to infuse to the water through detaching the chemicals and making the solution potent.

The limited plant availability because of lower rainfall patterns could mean that different plant species respond differently to changes in climatic conditions [31]. Some plant species are still available in the same place, however, have adapted to new climatic conditions through selection. Other plant species moved to greater latitudes or altitudes. This could be the case with some medicinal plants such as *Croton sylvaticus Hochst*, *Pittosporum viridiflorum Sims* and *Erythrophleum africanum (Benth.) Harms* that are now found in far areas. *Croton sylvaticus Hochst* was reported to be found in far-away mountains and no longer widely accessible. This could be attributed to climate change, causing some plants to migrate to higher areas until there are no further places to inhabit.

Despite the use of these ethno-veterinary plants, however majority are threatened by anthropogenic disturbances [32]. The extensive use of medicinal plants is the most common threat to its availability. The most serious issues or threats with regards to extracting medicinal plants is habitat degradation and over harvesting. As a result of over harvesting, for example, many of these plant species with fewer exceptions are now harvested from the wild habitat. In addition, plant materials are being lost due to lack of systematic conservation, hence the need of conserving the erosion of the remaining plant species. Proper conservation strategies for plants that are widely used such as *Aloe marlothii A.Berger* and *Cissus quadrangularis. Lin* should be done.

5. Conclusions

The study showed that there is still a considerably strong use of IK of plant-based remedies to control ticks and associated tick challenges in livestock,

including goats. Nine plant species were identified to control ticks and related challenges such as wounds, using *Cissus quadrangularis. Lin, Gomphocarpus physocarpus E. Mey* and *Portulaca pilosa L.* being populous across. Heartwater was a major disease of economic importance. Heartwater is more of a recent introduction to the area, hence experts had a more scientifically informed understanding of the disease, gleaned from veterinarians and animal health technicians. The high dependence on ethno-veterinary remedies and practices on ticks and their associated challenges highlights the need to support IK in veterinary care. There is a need, for government institutions to collaborate with IK experts to identify and standardize IK practices in wider use for effective control of ticks and diseases in livestock.

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Conflict of interest

The authors declare that there is no conflict of interest.

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