



# Indigenous knowledge to mitigate the challenges of ticks in goats: A systematic review

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## ABSTRACT

The review collates the documented use of IK used in goats for controlling ticks and records the bioactivity testing that has been carried out on these plants. A literature survey was conducted on the use of IK whereby ethno-veterinary medicine (EVM) is used as well as on the investigations relating to the potential efficacy of the used plants. In Sub-Saharan Africa (SSA), ticks rank the first amongst the ectoparasites that limit goat productivity. Infrequent and overuse of acaricides have resulted in the development of resistance in ticks as well as environmental impacts. To combat these impacts, contribution of IK needs to be appreciated. In total 21, ethno-veterinary plant species, belonging to 16 families were identified to control ticks. These included plants such as *Lippia javanica* (Burm.f.) Spreng, *Cissus quadrangularis* .L, and *Aloe ferox* Mill, *Grandifolia* Warb, *Terminalia brownii* Fresen and *Aloe volkensii* Engl. Efficacy of plant species such as *Pelargonium reniforme* Curtis and *Eucomis punctata* L'Hér is enhanced by mixing them with substances like potassium permanganate and river salt to enhance the effectiveness of the extract. Ethno-veterinary plants have a wide range of phytochemicals, which include alkaloids, tannins, flavonoids, anti-microbial and pesticidal effects that produces tick repellent effects. The most common plant parts used during preparations are roots, leaves, barks, fruits and young shoots and to a lesser extent flowers, although the use of leaves usually takes precedence. Non-plant materials involve the use of methods such as traditional practices where ticks are manually removed. using hand picking. Oral administration and direct application on the infested site are used. It is, thus important to conduct more work on the conservation of ethnoveterinary plants, IK information gathering and dissemination.

## 1. Introduction

Goats are indispensable to the livelihoods of rural communities as they aid to food variability and availability (Durawo, Zindove & Chimonyo, 2017). Goats are, however, extremely infested with several parasitic insects and acarine species that limit their productivity (Mkwanzazi, Ndlela & Chimonyo, 2019; Wanzala, 2017). Amongst external parasites, ticks are ranked the highest (Sanhokwe, Mupangwa, Masika, Maphosa & Muchenje, 2016). Goats are alternative hosts for several tick species when the appropriate host is unavailable. Tick species such as *Rhipicephalus microplus* affect cattle, however they can complete their life cycle in goats (Nyangiwe & Horak, 2007). Their potential deleterious effects include skin damage, skin irritation, causing wounds, and reduction of goat productivity (Wanzala, 2017). Ticks also act as vectors of a variety of tick-borne diseases (TBD's), for example *Amblyomma* tick species known to be carrier of the bacteria *Ehrlichia*

*ruminantium* transmit heartwater in goats (Jongejan et al., 2020). Consequently, farmers seldom benefit from the sales and products of their goats due to poor health conditions. In goats, ticks are prevalent due to low levels of management and inadequate veterinary measures.

The recurrent increase in global temperatures is likely to reduce availability of water and feed resources (Mseleku, Ndlela, Mkwanzazi & Chimonyo, 2019). Rainfall amounts and distribution are also expected to become erratic and unreliable in most region of the world, particularly in SSA regions. Degradation of soils and lands is expected to increase (Vilakazi, Zengeni & Mafongoya, 2019). The change in climate is likely to cause an acceleration of tick life cycle as the temperature is the driving force behind the growth, development and behaviour of ticks. Goat rearing is, therefore, likely to become important (Mkwanzazi et al., 2019). It is advisable for governments and other stakeholders to focus on goat enterprise as the species of choice to meet the increasing demands of meat and milk. Goats are resilient, adaptable and invaluable resource

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to ensure sustainable livestock production. Their smaller body size and ability to survive in marginal areas are other attributes they possess.

The use of indigenous knowledge (IK) to control ticks is often the only option available for most farmers (Mkwanazi et al., 2019). To date, the growing world population predominantly rely on IK for the welfare of their livestock, including goats (Wanzala, 2017). This is even more common in developing countries where goats are important for several reasons, foremost being cultural ceremonies followed by the production of meat and then milk. In cattle, ticks are usually controlled using acaricides. The emergence of resistance to acaricides has, however, motivated the revival of IK to control ticks. There is also evidence suggesting that acaricides pollute the environment (Sanhokwe et al., 2016). Pastoralists usually keep cattle and goats grazing together in rangelands. During dipping, goats are often ignored, and priority given to cattle (Mkwanazi et al., 2019). One approach to mitigate these challenges could be the exploitation of IK.

The influence of ticks, although well acknowledged, has received little attention. Goats are often regarded as resilient to ticks and tick-borne diseases. As such tick issues are linked to cattle. It is, important to give the required attention to ticks in goats so as to enhance economic sustainability and profitability of goat enterprises. Throughout history, IK has contributed to the advancement of veterinary care substantially although its value has not been fully recognized and utilized. Indigenous

knowledge is practiced because it is locally available, biodegradable and user-friendly. It is less systematic and formalized, usually passed orally from one generation to the next generation (Vilakazi, Zengeni & Mafongoya, 2019). Indigenous knowledge system approaches are holistic and based upon interconnections with the respect of the environment.

Integrating existing information on IK used to control ticks assists in implementing policies promoting sustainable goat productivity and health management. Developing indigenous knowledge systems (IKS) creates opportunities to complement and integrate conventional knowledge with IK. Both systems can be incorporated into educational and lifelong learning systems. Traditional healers, farmers and veterinarians can benefit if IK is developed. The review focuses on the contribution of IK to goat veterinary care. The review also identifies possible aspects that require further research to enhance application of IK to improve goat health.

## 2. Materials and methods

### 2.1. Search strategy and research question

In the paper, the word indigenous knowledge refers to what local people know, and use for survival, having evolved through wide range of

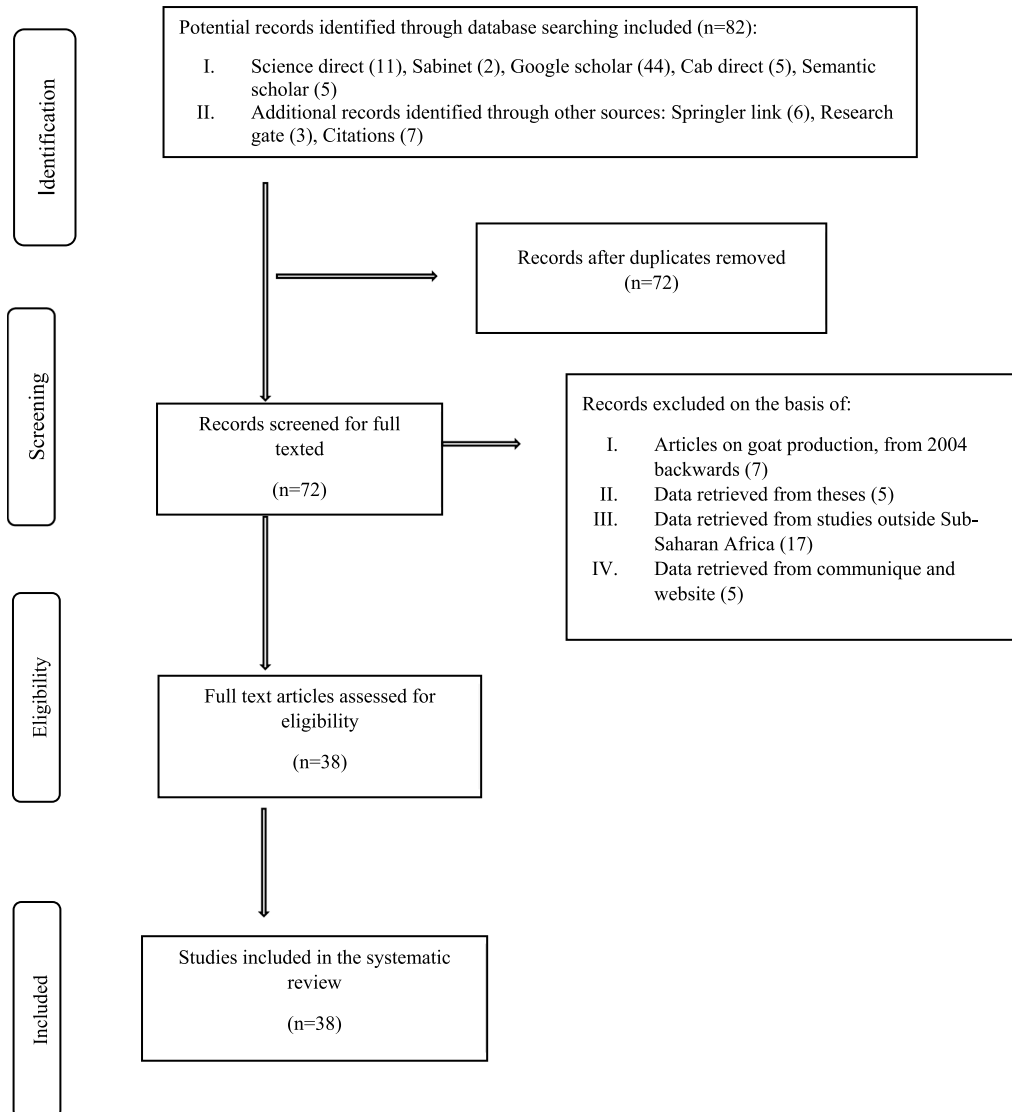


Fig. 1. Flow diagram of the screening process of the literature.

testing and error, however proven beyond doubts to deal with changes occurring in their environments. The systematic review was performed following the PRISMA guidelines (Fig. 1). Scientific databases such as Google scholar, Science direct, Cab direct, Sabinet, Sematic scholar were used to search for the information.

To ensure a wide range of articles from different sources, additional searches were sourced through the reference lists of key articles. Other sources such as Springer links and Research gate were used in cases where articles were not obtainable from scientific databases. Key words used during article search included: tick-borne diseases, medicinal plants, ethno-veterinary plants, heartwater, anaplasmosis, indigenous knowledge, traditional animal health care, *Amblyomma*, role of goats, goat production. During the search stage preprints were not considered. The research questions in the review are: What are the roles of goat in ensuring food security and income generation in sub-Saharan Africa? What are the different tick species and tick-borne diseases affecting goats? Which indigenous knowledge is used to mitigate against tick challenges in goats? What is the efficacy of indigenous knowledge used?

## 2.2. Eligibility assessment of studies and inclusion criteria

After the search was completed authors (MVM, SZN, MC) removed all duplicated publications. Prior to the qualitative synthesis, information on article titles, authors, journal, type of publication, publications in English and focus on indigenous knowledge on ticks, goat functions and roles were collected. Full article texts were evaluated and rejected based on the following exclusion criteria: studies presenting data out of the scope of the research question, studies on goat production, however conducted from 2004 backwards was excluded as new work developments have surfaced and performed outside the study areas (for example studies from Europe and American countries were excluded).

Data retrieved from studies on countries in sub-Saharan Africa and Middle East were excluded (for example, if data was collected both in Israel and Ethiopia was excluded and Data retrieved from both PhD and MSc theses were excluded. All relevant articles in full texts were reviewed and summarized using a standardized data extraction table in word document. Reference lists of included articles were screened for additional records.

## 2.3. Quality assessment of articles

The critical appraisal skills programme (CASP) was applied for quality assessment (Appendix 1). For the article assessment, they were aggregated into a quality score based on the four criteria: aim, method, result and application of the literature. Yes, No and cannot tell are assessment outcomes. With 6 questions, the score was categorized into groups: weak means (1) < 50% having “yes” answers, (2) moderate means 50–75% having “yes” answers, (3) and high means >75% having “yes” answers. The quality ranking was classified into three groups: High meant >75% of all six sub-criteria were met, moderate meant 50–75% were met and weak meant <50% of criteria were met.

## 3. Results

### 3.1. Article screening process

Our search strategies identified a total of 82 articles were retrieved (Fig. 1). After duplicates were removed and an initial review of titles and abstracts for relevance was conducted and thirty articles were found to be eligible for full-text screening based on the inclusion criteria and were found to be relevant and retained. An initial review of titles and abstracts for relevance was conducted and 30 articles were found to be eligible for full-text screening based on the inclusion criteria (Appendix 1).

### 3.2. Importance of goats

Goats play a fundamental role of improving livelihoods, particularly for women and children through enhancing food and nutrition security and generation of household income.

#### 3.2.1. Enhancing food and nutrition security

Food security continues to be a major challenge in most parts of Sub-Saharan Africa (Mwaniki, 2006) and comprises of three branches namely food availability, accessibility and adequacy. Food availability refers to the sufficient quantities of food of appropriate quality supplied through domestic production and imports (Ngambi, Alabi & Norris, 2013). Accessibility is whereby households and individuals have access to appropriate foods for a healthy or nutritious diet. For households and individuals to be food secure, food access should consistently be adequate at all times both in quantity and quality. An estimated 2.8 million households are vulnerable to food insecurity in South Africa, with 72% residing in rural areas.

In Zimbabwe, 4.2 million people are estimated to be food insecure (Mwaniki, 2006). Goats, therefore, play a major function in the three dimensions of food security. They enhance the ability of households to have access to nutritious meat and milk with low levels of saturated fatty acids (Ngambi et al., 2013). Meat from goat is less consumed compared to beef, chicken and pork but undoubtedly goat meat is widely consumed amongst resource-poor households (Webb, 2014). Table 1 shows the proximate composition of goat meat from Boer, Savanna and Angora goats. One of the contributions of goat milk to human nutrition is its great excess of calcium and phosphorus in relation to energy for infants. Milk is one of the important food sources for children and is known to contain almost all essential nutrients (Mwaniki, 2006). Owing to their greater contribution towards food and nutrition security, efforts to enhance goat productivity to ensure food availability and access across poor communities is needed.

#### 3.2.2. Generation of household income

Goats provide security against crop failures and economy fluctuations as they are sold in cases of emergency to meet household income needs (Durawo et al., 2017). Goat rearing is the most useful way of women generating earning and income. Women can invest from sales of goats and products to improve diversity in household consumption as well as for their children's education. During periods of difficulties, goats are sold to purchase food and medicines. Income generated from goats can vary with households depending on the number of goats sold, size of goats, sex, season and function (Slayi, Maphosa, Fayemi & Mapfumo, 2014). There has been a great interest in women and youth empowerment through goat keeping, partly prompted by the need of gender equality and unemployment. In Sub-Saharan Africa most women are socially and economically disadvantaged and affected by chronic hunger and malnutrition (Tefera, 2007). Goats are efficient browsers that exploit the veld well, so there is no little need for supplementary feeding, lower veterinary costs. Most of the plants consumed during browsing have medicinal properties.

When men migrate to urban areas in search of employment opportunities. Women, therefore, must bear the responsibility for all farm-related work, though they receive little remittances for their contributions. Tefera (2007) reported that in a study targeting on improving

**Table 1**  
Proximate composition of chevon from Boer, Savanna and Angora goats.

	Nutrient (g/kg)			
	Moisture	Protein	Fat	Ash
Boer goat	694	228	105	9.5
Savanna goat	698	243	79	9.7
Angora goat	642	291	44	10

Source: Webb (2014).

women through a goat project, women were able to generate income from goat sales. Women were able to purchase assets and even diversified to raising poultry and cattle production. Women were able to empower themselves and enhance their ability to provide nutritious food for their households. Involving women in goat production projects also empowers them to develop entrepreneurial skills.

### 3.3. Common ticks affecting goats

Inasmuch as goats possess worth attributes, the issue of diseases and parasites in the developing countries still constraint goat's productivity (Nyahangare, Mvumi & Mutibvu, 2015). The most widely distributed tick species come from genus *Amblyomma*, *Rhipicephalus*, *Haemaphysalis* and *Hyalomma* (Jongejan et al., 2020). Nyangiwe and Horak (2007) identified *Amblyomma hebraeum*, *Rhipicephalus microplus*, *Rhipicephalus appendiculatus* and *Rhipicephalus evertsi* infesting goats in South Africa. *Amblyomma* ticks have visible eyes, long mouth parts and festoons.

The *Amblyomma* tick has a 3- host life cycle and are the only species known to transmit heartwater in goats, with Bont tick being the common tick of the genus *Amblyomma* (Walker et al., 2003). *Rhipicephalus* species are characterized by short mouth parts, eyes and festoons with male having ventral plates. *Rhipicephalus* species also called blue ticks are one host ticks that are regarded as most economically important as they damage the quality of the hide, however the extent of their economic importance has not been clearly determined, due to limited research in goats.

The *Rhipicephalus microplus* was reported in South Africa to affect cattle, however, can complete its life cycle on goats (Nyangiwe & Horak, 2007). While *Hyalomma* species can be identified by their long mouth parts, visible eyes as well as festoons and ventral plates in males. *Hyalomma* use two different host species to complete its life cycle. Amongst the *Rhipicephalus* genus, *Rhipicephalus evertsi* is the most widespread of all ticks in Africa and has the largest host ranges (Walker et al., 2003). Knowledge on tick diversity, geographic distribution, and infections they carry is important for the prevention and their effective control in goats.

### 3.4. Effects of ticks in goats

The impacts of ticks on goats include physical effects such as skin irritation, damage to the skin and hide, limping and wound development. Ticks further suck blood from goats and thereby predisposing them to anaemia. In addition, ticks act as vectors for a variety of tick-borne diseases.

#### 3.4.1. Physical effects of ticks on goats

Ticks suck blood daily and one female can suck more blood than 30 times of her body weight during engorgement causing marked losses in body weight. Loss of blood result to stunted growth. Ticks attach themselves to goats, their mouth parts damage the skin Mkwanazi et al. (2019). Wounds later predispose the host to attacks from blowflies, screwworms and secondary bacterial infections. In some cases, wounds occur in the inner part of the hoofs leading to foot rot. When goats are predisposed to foot rot, they suffer from limping and lameness (Jongejan et al., 2020) which reduces their ability to search for feed and water in rangelands. Consequently, reduced feed intake leads to productivity losses characterized by reduction in body condition. Information pertaining to the effects of ticks on growth performance, carcass characteristics and physiological responses in goats is unavailable. Infestation with *Hyalomma marginatum isaaci* were found around the anus and vulva causing oedema and abscess formation at the site of the bite and severe bleeding during tick removal (Kioko, Baker, Shannon & Kiffner, 2015). Schwalbach, Greyling and David (2003) reported that Toggenburg kids were more affected by abscesses than the South East African indigenous breed goats. This incidence of abscesses was found to be caused by *Amblyomma* spp, which mainly attach on the udder, perineum (base of

the tail and vulva lips) and inter digital spaces, where most abscesses were observed.

#### 3.4.2. Transmission of tick-borne diseases

Ticks have potential to spread a wide range of infectious vector borne diseases in goats (Wanzala, 2017). Tick-borne diseases (TBD) are diseases, which can spread between goats from a bite of infected tick (Yunker, 1996). Ticks become infected by feeding on goats that are either having the disease or the parasite in their bloodstream, making them carriers of the disease. Tick-borne diseases affect goats enormously with heartwater being the most economically important disease in goats (Jongejan et al., 2020; Mkwanazi et al., 2019). For example, in South Africa, a huge number of goat improvement projects have collapsed because of this deadly disease. This led to farmers being encouraged by the veterinary services to sell more of their goats as a control measure.

Studies on tick borne fever, babesiosis and anaplasmosis are not well characterized in goats as they are not perceived as important as they are in cattle. Tick borne fever is not known to occur in goats, babesiosis is highly susceptible in sheep than in goats. Anaplasmosis in goats is a subclinical, non-pathogenic, mild febrile disease with little economic importance (Barry & Van Niekerk, 1990). Ticks and their associated challenges are controlled mainly using conventional acaricides in cattle with goats often being ignored. The emergence of resistance and consumers demand for meat products, which are safe has led to one school of thought proposing use of IK.

### 3.5. Importance of indigenous knowledge in the control of ticks

Custodians in possession of the knowledge include herbalists, experts with veterinary knowledge and pastoralists (Gakuubi and Wanzala, 2012). Indigenous knowledge custodians have knowledge of the habitat and life cycles of plants and livestock and various other aspects of other resources (Wanzala, 2017). Indigenous knowledge is not fully exploited and appreciated by government, veterinary services and other stakeholders such as policy makers. Indigenous knowledge needs to be recognised, developed, promoted and properly documented. Indigenous methods of controlling ticks include use of (1) ethno-veterinary remedies and (2) non-plant materials.

#### 3.5.1. Use of ethno-veterinary remedies to control ticks

Exploring the use of EVM has gained popularity in recent decades due to their local availability and accessibility (Nyahangare et al., 2015). Ethno-veterinary practices are common because of various socio-economic challenges, foremost being inadequate veterinary services. The value of these EVM lies in various chemical substances that either repel or kills ticks. Such substances include properties such as alkaloids, saponins, flavonoids and other phenolic compounds that fight diseases and parasites (McGaw and Eloff, 2008). Plants are collected by farmers from bushes, around the kraal or used as fence to the homestead for ease of access (Kuma, Birhanu & Hirpa, 2015; Magwede, Tshikhawe, Luseba & Bhat, 2014). There are number of plant remedies that have been recorded that are used to control ticks in goats. In South Africa and Zimbabwe, for example *Lippia javanica* (Burm.f.) Spreng is widely used to get repel of ticks and other ectoparasites (Madzimumbe et al., 2011).

In total 21, ethno-veterinary plant species, belonging to 16 families were identified to control ticks. These included plants such as *Lippia javanica* (Burm.f.) Spreng, *Cissus quadrangularis* .L, and *Aloe ferox* Mill, *Grandifolia* Warb, *Terminalia brownii* Fresen and *Aloe volkensii* Engl. Other plant species such as *Pelargonium reniforme* Curtis and *Eucomis punctata* L'Hér are used in combination and are mixed with other substances such as potassium permanganate and river salt to enhance the effectiveness of the extract. Ticks are sprayed with crushed leaves mixed with water. Plants such as *Cissus grandifolia* Warb, *Terminalia brownii* Fresen and *Aloe volkensii* Engl. are widely used to control TBD's (Masika & Afolayan, 2003). Many resource-limited farmers have used plants to control ticks.



In some cases, the traditional use has been confirmed, in other cases, only the traditional use has been documented. Some ethno-veterinary plants are only available during the rainy season (Kioko et al., 2015). The different extractions and plant parts used as well as the efficacy where available is listed in Table 2.

### 3.5.2. Efficacy and quality of ethno-veterinary remedies

The efficacy and quality of ethno-veterinary plant materials used may depend on intrinsic and external factors. For example, contamination by microbes, chemical agents and other plant species may compromise the quality, safety and efficacy (Madibela, 2017). It is evident that farmers are aware of toxicity of some ethno-veterinary plants and therefore, counteract by adding more water during herbal preparations and boil or cook the plant material before it can be administered to the goat. From the list of plants listed in Table 2, some plants are safe to use. Safe to use implies that there is no harm that can happen to the person using the plant. Other plants need to be handled with care, implying that necessary precautions should be considered when using the plant. For example, some plants can potentially be harmful to the eyes and skin.

**Table 2**  
Ethnoveterinary plants used to control ticks in Africa.

Scientific name	Family	Plant part	Preparation methods, administration and dosage levels	Comments & precautions	References
<i>Aloe ferox</i> Mill.	Asphodelaceae	Leaves	Leaves are crushed, and the juice is applied to the skin	–	Sanhokwe et al. (2016)
<i>Elephantorrhiza elephantina</i> (Burch.) Skeels	Fabaceae	Roots	Grind the roots and boil in water for 30 min until the water turns red, spray the animal	–	Sanhokwe et al. (2016)
<i>Acockanthera oppositifolia</i> (Lam.) Codd	Apocynaceae	Leaves	Grind leaves, boil, cool and drench the animals. Dose with 1 L bottle of adults and 300 ml bottle for kids	–	Sanhokwe et al. (2016)
<i>Bulbine latifolia</i> (L.f.) Spreng	Asphodelaceae	Leaves	Grind leaves, boil and apply to skin or drench with 1L	–	Sanhokwe et al. (2016)
<i>Tagetes minuta</i> L.	Asteraceae	Whole plant	Crush and mix with water	Safe to use	Nyahangare et al. (2015)
<i>Terminalia sericea</i> Burch. ex DC	Combretaceae	Leaves	Crush and mix with water, spray the animal	Very effective	Nyahangare et al. (2015)
<i>Xeroderris stuhlmannii</i>	Papilionaceae	Barks	Crush stems and spread on infested sites	Very effective	Nyahangare et al. (2015)
<i>Zantedeschia albomaculata</i>	Araceae	Stem	Crush mix with water and drench the animal	Very effective	Nyahangare et al. (2015)
<i>Ptenocarpus angolensis</i>	Papilionoideae	Barks, branches	Mix with water	Safe to use	Nyahangare et al. (2015)
<i>Ricinus communis</i> .L	Euphorbiaceae	Leaves	Grind leaves and paste on tick infested site	Very effective	Nyahangare et al. (2015)
<i>Solanum ponduriforme</i> E.Mey	Solanaceae	Fruits	Crush fruits and mix with water	Handle with care	Nyahangare et al. (2015)
<i>Albizia amara</i> (Roxb.)Boiv.	Fabaceae	Leaves	Crush leaves mix with water and spray	Effective	Nyahangare et al. (2015)
<i>Bauhinia petersiana</i> Bolle.	Fabaceae	Leaves	Crush leaves, mix with water	Safe to use	Nyahangare et al. (2015)
<i>Cissus quadrangularis</i> .L.	Vitaceae	Stems	Crush and mix with water to spray	Handle with care, causes itching	Nyahangare et al. (2015)
<i>Capsicum annuum</i> L.	Solanaceae	Fruits	Crush the fruits and mix with soot in water and spray	Causes eye irritation	Nyahangare et al. (2015)
<i>Ornithogalum</i> sp	Alliaceae	Roots	Crush and mix with water	Very effective	Nyahangare et al. (2015)
<i>Rotheca eriophylla</i>	Lamiaceae	Leaves	Macerate, soak with water and spray	Very effective and safe to use	Nyahangare et al. (2015)
<i>Colophospermum mopane</i> (J. Kirk ex Benth.) J. Léonard	Fabaceae	Branches and twigs	Burn and apply ashes on animal skin	Safe to use	Nyahangare et al. (2015)
<i>Euphorbia hirta</i> .L.	Spurges	Herbs	The sap is extracted from the fresh plant and smeared in the infested site	–	Nyahangare et al. (2015)
<i>Solanecio mannii</i> (Hook.f.) C. Jeffrey	Asteraceae	Shrub	Leaves are crushed and put in water and decanted, spray directly on infested areas of the body	–	Nyahangare et al. (2015)
<i>Kigelia africana</i> (Lam), Benth	Bignonias	Bark and fruit	The fruit or bark of the plants are pounded using a mortar and the pounded powder is added to water and sprayed on affected areas	–	Nyahangare et al. (2015)
<i>Vernonia amygdalina</i> Delile	Compositae/ Asteraceae	Leaves	Animal made to drink crushed leaves, soot and water mixture	Very effective	Nyahangare et al. (2015)
<i>Lippia capensis</i> (Thunb.) Spreng	Verbenaceae	Leaves, twigs	Leaves, twigs and whole plant are crushed and mixed with water and sprayed to the infested site.	Safe to use	Nyahangare et al. (2015)

Regassa (2000) reported that *Ficus brachypoda* plant killed 72% of *Amblyomma cohaerens* ticks and *Ficus obovalifolia* was able to kill all of *Amblyomma variegatum* (Table 3). Magono, Nchu and Eloff (2011) reported a repellency index of 100% from hexane extracts of *Lippia javanica* (Burm.f.) Spreng on *Hyalomma* ticks. Similarly, Madzimure et al. (2011) reported that 10 and 20% w/v of leaf extracts of *Lippia javanica* (Burm.f.) Spreng was effective in controlling *Amblyomma* sp, *Boophilus*, *Hyalomma* and *Rhipicephalus* and was as good as acaricide tickburster

**Table 3**  
Mortality (%) of adult *Amblyomma cohaerens* and *Amblyomma variegatum* treated with different plant preparations.

Plant preparation	Percentage mortality in adult ticks	
	<i>A. cohaerens</i>	<i>A. variegatum</i>
<i>Ficus brachypoda</i> (Miq.) Miq.	72	No ticks
<i>Capsicum annuum</i> L	6	No ticks
<i>Ficus obovalifolia</i>	68	100
<i>Solanum incanum</i> L.	12	0
Control	0	0

Source: Regassa. (2000).

that is commercially used to control ticks. Schwabach et al. (2003) reported a decrease in tick numbers in goat kids treated with *Azadirachta indica*.

### 3.5.3. Plant parts and preparation methods used

During remedy preparation, farmers exploit different plant parts and preparation methods (Kuma et al., 2015). The most common plant parts used during preparations are roots, leaves, barks, fruits and young shoots and flowers (Kuma et al., 2015) though the use of leaves usually takes precedence (Sanhokwe et al., 2016). Infusions, concoctions, decoctions and crushing. Infusion is the process whereby the plant material is soaked in water and left for some time to allow the active ingredient to infuse to water and form a mixture.

Decoctions is a process whereby the plant materials are boiled with water, however, concoctions are whereby plant ingredients are mixed to form a mixture (Kuma et al., 2015). Decoction has been reported as the most widely used preparation method when controlling external parasites in goats (Sanhokwe et al., 2016). The study reported that approximately 60% of farmers used decoction, whereas 40% use infusion to prepare the plants. Crushing and squeezing are the main forms of preparation (Kuma et al., 2015). Mashed or crushed method entails that plant materials are stirred in water to make concoction.

Plant materials are also ground into powder while others are freshly mashed to form paste that will be pasted into infested site (Madzimure et al., 2011). Farmers infuse the plant extracts to obtain juices after squeezing freshly leaves, twigs or bark. These juices are obtained by pressing the sap of the plant part. Farmers use different parts of the plant depending on the plant or tree used. For example, *Aloe ferox* Mill and *Cissus quadrangularis* L. their active ingredients are found from leaves whereas plants like *Ornithogalum sp* roots are the main the source of the active ingredient.

### 3.5.4. Route of administration and dosage levels of plants

Medication is administered differently and under different dosage levels, common administration route includes oral, nasal and smoke bath treatments (Kuma et al., 2015). Usually the medication is administered using cups, and water or drink bottles. Farmers use 1–2 liters of oral solution (Kioko et al., 2015). These standards are based on experience and oral teachings from the elderly people. Other plants species, for example *Euphorbia hirta* L. involves extraction of the sap from the plant which is then smeared directly on tick infested site (Nyahangare et al., 2015). *Bulbine latifolia* are prepared and orally administered to the goats. In most cases the route of administration to control of ticks are oral, spraying and pasting the medication on the infested site (Table 2). Dosage levels vary, because some of the plants have a strong bitter taste and only administered in small dosages.

Whilst others are rendered too strong and only given in small quantities. Indigenous people adjust dosages according to the size of the goats (Gakuubi & Wanzala, 2017). Indigenous knowledge, therefore, play a huge role in veterinary care of goats. There is, however, not much information about IK and control of TBD's in goats. Farmers, however, use various EVM to treat for TBD's.

## 4. Discussion

Understanding the role of IK to mitigate tick challenges in goats is imperative to improve goat productivity and thus sustainable livelihoods. Studies on the use of IK to control ticks has attracted much interest recently due to high development of resistance to acaricides and the need close the gap that exist between IK and conventional knowledge (Mkwanazi et al., 2019). Therefore, to enhance sustainable livelihoods through ensuring consistent availability and supply of food both at a local and households envisages that the productivity of goats is improved. The observation that goats contributes to ensuring food security agrees with Mdletshe, Ndlela, Nsahlai and Chimonyo (2018). Chevron provides an acceptable source of protein and essential amino

acids to meet the dietary requirements of the average adult consumers (Webb, 2014). Goat milk possess good protein content in comparison with cow and sheep. Communal farmers should be encouraged to milk goats (Mpendulo, Chimonyo & Zindove, 2017). It is, thus necessary to develop awareness programmes that could enable farmers to realize the value of goat milk to ensure household food security.

Women use milk from goats for their children who are allergic to cow milk and lactose intolerant. Goat derived foods have high protein quality to promote growth and prevent stunting, underweight and chronic malnutrition to toddlers and children. Women participate extensively in various activities having complementary roles and sharing activities with their male counterparts, and their contribution is higher than that of men (Tefera, 2007). One may argue that for women, chickens are worth keeping than goats, however the low labour demand for goats makes them also attractive to empower women. Even though goats are ubiquitous, they are still not fully exploited enough to create opportunities and contribute to the gross domestic product (GDP) and national economy. In addition, their productivity is still low and its contribution largely informal compared to other species such as cattle and sheep. Thus, improving the productivity of goat could be of value to capacity building of unemployed youths. This include use of indigenous breeds that are adaptable to local conditions such as drought and water scarcity and require less anthelmintics. The market is locally available where youth can sell goats to the community for use slaughter during cultural ceremonies.

In conventional knowledge, ticks are described and identified through their festoons, scutum patterns, location and time of the year and others may also consider the capitulum (Walker et al., 2003). Ticks are traditionally recognized by their colour, size, on-host feeding sites and habitat preference (Wanzala, Takken, Mukabana, Pala & Hassanali, 2012). Kioko et al. (2015) observed that Local people use local names to describe and classify tick species. Farmers relate each tick species with the damage it causes. Wanzala et al. (2012) reported that local people were familiar with the locations of different ticks on goats. The naming of tick species using local vernacular could be challenging because the names can represent more than one tick species. For example, the brightly coloured bont tick was described as *kgofa e thamaqa* by the Setswana people in South Africa simply referring to a multi coloured tick, however the same people also refer to it as *kgofa e tala* referring to the bright yellowish green marking on its outer casing (Brown, Ainslie & Beinart, 2013). There is a distinction between how conventional knowledge and IK are used to describe ticks. These two knowledge systems, however, should complement each other for sustainable veterinary care, especially for the resource poor. For the objective assessment of economic losses caused by ticks in goats, there is a need to identify the ticks and determine their loads and prevalence. Information on tick loads and prevalence in goats is limited.

The findings that ticks result in extensive damage on goats through causing skin irritation, can allow bacteria to penetrate through the skin, leading to the development of local abscesses that damage the skin Jongejan et al. (2020). This finding also explains the importance of ticks in goats, which is mostly ignored. Goats are hardly dipped in rural communities (Mkwanazi et al., 2019). They damage the hide through piercing that leaves permanent markings. These markings compromise the value of the hide when being processed for leather manufacturing. Ticks with longer mouthparts such as *Amblyomma* and *Hyalomma* cause more extensive damage than those with shorter mouthparts such as *Boophilus* and *Rhipicephalus* (Jongejan et al., 2020). The observation that goats are continuously challenged by substantial numbers of *A. hebraeum* ticks throughout the year is a major obstacle preventing the upgrade of local goat breeds. Humans may be at risk of contracting tick-bite fever. In Southern Africa, several studies have been conducted to determine tick loads. Majority of such work has only been considered in cattle. The attempt to improve goat production in the developing countries envisages that such work should in cooperate goat. There is a lack of systematic work to assess the distribution of tick species infesting

goats. Knowledge on the distribution of ticks infesting goats and infections they carry is indispensable to acquire for the development of proper prevention and effective control of ticks.

*Acokanthera oppositifolia* (Lam.) Codd is rendered toxic because of the manifestation of cardiac glycoside it contains, hence during its preparations the plant extract is diluted to reduce the harmful toxicity (Sanhokwe et al., 2016). *Aloe ferox* Mill is widely used in Africa, its popularity arises from the laxative effect it has because of the presence of glycoside aloin Eloff and McGaw (2014). *Aloe ferox* Mill possesses insect repellent properties and may also treat anaplasmosis and heartwater (Masika & Afolayan, 2003). In contrast, Moyo and Masika (2009) reported no significant effects of *Aloe ferox* Mill on ticks. The use of *Aloe volkensii* subsp. *Volkensii* is due to its biologically active ingredients that produces a physiological action against anaplasmosis (Kioko et al., 2015). *Elephantorrhiza elephantina* (Burch.) Skeels is used to control ticks in goats and can also treat heartwater (Luseba & Van de Merwe, 2006), the plant possesses antibiotic properties and relieves inflammation and has purgative effects. This is important because babesiosis can lead to a multi system organ failure, including liver damage. Masika and Afolayan (2003) reported that *Heteromorpha arborescens* (Spreng.) Cham. & Schltdl contains two vital antimicrobial compounds falcariindiol and asaricin that enable the plant to have pharmacological and antimicrobial properties. *Rumex lanceolatus* Thunb that controls heartwater, contain glycosides of chrysophanol that has laxative effect in its roots (Masika & Afolayan, 2003).

Other plant species such as *Pelargonium reniforme* Curtis and *Eucomis punctata* L'Hér are used in combination and are mixed with other substances such as potassium permanganate and river salt to enhance the effectiveness of the extract. *Drimia delagoensis* (Baker) Jessop is phytochemically distinguished by the presence of the cardiac glycosides bufadienolides that upon enzymatic hydrolysis produces medicinally important bufadienolide proscillaridine. The antibacterial activity of the crude extract of *Drimia delagoensis* (Baker) Jessop is moderate to relatively low though the plant is still largely used in ethno - veterinary medicine (Mc Gaw and Eloff, 2008). The use of *Cissus quadrangularis* L. to control ticks is attributed to its inflammatory and antimicrobial effects (Mkwanazi et al., 2019). *Cissus quadrangularis* L. is reported to have fungicidal and anti-pyretic properties. *Lippia javanica* (Burm.f.) Spreng has successfully been used to control ticks and contains multiple classes of phytochemicals including alkaloid and flavoids. The plant possesses a wide range of pharmacological activities, which include anti-microbial and pesticidal effects (Maroyi, 2012). *Azadirachta indica* extract possess the ability to disrupts mating and oviposition of exposed insects and inhibits the hatching of their eggs and failure to moult (Schwalbach et al., 2003). The detrimental effects on growth performance, behaviour and meat quality of most herbal extracts are not yet clearly understood.

The observation that leaves are mostly preferred by farmers resonates with that of Kioko et al. (2015) where 30% of farmers preferred to use leaves than barks and roots. Similar findings were reported by Maroyi (2012) reported that most used plant part were leaves (51%), bark (16%), roots (13%) and fruits (10%). High preference of decoctions could be because since the process involves boiling, farmers would be trying to ensure that the plants do not become toxic to the body of the goat. Another plausible reasoning for high use of decoction could be due to that the process of decoction, extracts water soluble polar compounds and the high temperature applied during boiling reduces the toxicity of the thermolabile compounds in ethno-veterinary plants that can be poisonous to goats (Djoueche, Azebaze & Dongmo, 2011).

The use of different plant parts during preparations could be attributed to seasonal effect as plants growth vary with season and this variation can hinder the growth of some plants during the cold-dry season. Utilization of leaves is also abundant in most parts of the world due to the belief that leaf harvesting reduces loss of the plants from natural products and it does not destroy the whole plant (Wanzala et al., 2012). High use of leaves could be because leaves are usually the one containing the active compounds (Kioko et al., 2015). The use of

roots in herbal remedy preparation is not advisable as this possibly destroy the whole plant. Hence, it is of paramount importance to determine factors that contribute to the preferred method of preparations so that necessary recommendations can be made.

The preference of using oral administration could be due to ease of handling of goats. The method does not require sophisticated operation or machines. The rapid interest in the use of IK to mitigate challenges of resistance and high cost of acaricides necessitate that research should be further conducted to ascertain the dosage levels. It should also focus on how farmers correlate age, sex and body condition of goat with the disease itself and medication applied. Consequently, could also include the severity of the disease. Farmers usually define diseases using clinical signs and sometimes diseases exhibit differential diagnosis and that may affect the accuracy of dosages when administering medication and thus affecting the efficacy of the herbal remedy.

Overexploitation of natural resources due to overuse and destructive harvesting during collection of roots and barks has led to several plants facing extinction. Those in possession of the knowledge also rely on plant remedies for human health issues and that put pressure on many plants used in veterinary care. Due poverty and the increase in the number of people using plants, therefore plants are harvested and sold in the market, individuals often at times harvest the whole plant thereby affecting the growth of that plant species. Efforts, therefore, that promote plant conservation should be instigated, which are the product of in situ and ex situ conservation. Plants can be conserved by being planted in home gardens and schools. Policies pertaining plant harvesting can be implemented, permit authorizing plant harvest could be endorsed from authorities in the local areas and garden keepers. Programs that encourage farmers to preserve or conserve IK should be developed. Despite, the growing need of exploring IK use, however there are still uncertainties associated with their efficacy and safety. Consequently, institutionalized veterinary services endorses farmers to use acaricides. There are also no regulatory standards available regarding the use of these IK. Research should continue to identify active and toxic compounds from for credibility purposes. Herbal understanding of toxicities can reveal some of the potential dangers associated with the use of these EVM and thereupon harmful detrimental effects can be mitigated.

The use of non-plant materials involve knowledge about animal remains and minerals that have curative and palliative effects transmitted from one generation to another and it is the outcome of bold experimentation through trial and error method over centuries. Non-plant materials used to control ticks involve methods such as hand picking of ticks early in the morning before goat are headed to the pastures. Other common practices used include pasture burning and hand picking (Kioko et al., 2015). Pasture burning reduces the availability of feed for grazing of goat and other livestock species. Farmers may also combine plant extracts with non-plant materials (Sanhokwe et al., 2016). The mixing of non-plant substances with plant materials is thought to enhance the absorption of compounds contained in the plants (Wanzala et al., 2012) thereby improving its efficacy. Other communities the use indigenous non-plant materials more widely than EVM, however the extent of their use is still unknown. As a result, it is crucial to determine such information as it complement conventional knowledge.

Remedies of non-plant origin used involve the use of substances such as rancid lard, urine earthworms (produced on farm), cuttlefish bones, copper sulphate (bought) and ashes (produced on farm), rock salt (Sanhokwe et al., 2016). Substances such as olive oil are scrubbed on the infested site of the skin. Sometimes olive oil is mixed with copper sulphate (bought) for the treatment of wounds infested with maggots. Rock salt has emulsifying properties that assist with the formation of stable emulsions thereby increasing the solubilization of alkaline compounds in plant extracts. Detergents, grease oil, paraffin, millipede and Jeyes fluid are other traditional practices that are commonly practiced. Grease oil is administered as is to a lesser extent mixed with liquid tick and smeared on goats to repel ticks. Use of grease oil is attributed to its efficacy as an acaricidal, that has been identified to be about 38.1 (Dreyer,

Fourie & Kok, 1998).

The safety of grease oil on the quality of the skin goat has not been clearly defined, hence the need of in-depth research on its potential danger on the goat skin, otherwise care should be given when being in used. Substances such as grease oil contain aliphatic hydrocarbons, aromatic hydrocarbons, and polycyclic aromatic hydrocarbons. These substances are easily available, which can be the probable reasoning why most people use them. Subsequently, understanding the link between IK and CK will assist stakeholders and policy makers to stimulate and strengthen the contribution of IK to the social and economic development.

**5. Concluding remarks**

Goat are considered hardy; however, their productivity is hindered by diseases and parasites. Tick control is not usually practiced in goats. The use ethno-veterinary plants could be useful to achieving sustainable plant-based remedies or could otherwise be used in complimentarily with conventional knowledge to enhance veterinary care. The rapid environmental, social, economic and political changes occurring in many developing countries comes the danger that the IK will be overwhelmed and lost forever. Younger generations are acquiring different values and lifestyles as a result of exposure to global and national influences. Traditional communication networks are breaking down, meaning that elders are dying without passing their knowledge on to children. Henceforth, there need to document, conserve and preserve IK. The need to assess potential efficacy and safety of other ethno-

veterinary plants is also a subject of interest.

**Authors contributions**

MVM did the layout and writing of first draft of the manuscript. SZN and MC corrected and improved the manuscript

**Ethical considerations**

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).

**Declaration of Competing Interest**

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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**Appendix 1**

Quality assessment of included articles

Author, year	Method	Q 1	Q2	Q3	Q4	Q5	Q6	Q7	Rank
<b>2020</b>									
Jongejan et al., 2020	Participatory rural appraisal	Y	Y	Y	Y	Y	Y	Y	H
<b>2019</b>									
Mkwanazi et al., 2019	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Mseleku et al., 2019	Participatory rural appraisal	Y	Y	Y	Y	Y	Y	Y	H
<b>2018</b>									
Mdletshe et al. (2018)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Vilakazi, Zengeni & Mafongoya, 2019	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
<b>2017</b>									
Wanzala (2017)	Review	Y	Y	Y	CT	Y	Y	Y	H
Madibela (2017)	Review	Y	Y	Y	CT	CT	Y	CT	M
Durawo et al. (2017)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Mpendulo et al. (2017)	Experimental	Y	Y	Y	Y	Y	Y	Y	H
<b>2016</b>									
Sanhokwe et al. (2016)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Getaneh et al. (2016)	Review	Y	Y	Y	CT	Y	Y	Y	M
<b>2015</b>									
Nyahangare et al. (2015))	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Kioko et al. (2015))	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Kuma et al. (2015)	Report and opinion	Y	Y	Y	CT	Y	Y	Y	M
<b>2014</b>									
Slayi et al. (2014)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Webb (2014)	Review	Y	Y	CT	CT	Y	Y	CT	W
Eloff and Mc Gaw (2014)	Book chapter	Y	Y	Y	CT	Y	Y	Y	H
Magwede et al. (2014)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
<b>2013</b>									
Brown et al. (2013)	Interviews	Y	Y	Y	Y	Y	Y	Y	H
Ngambi et al. (2013)	Review	Y	Y	Y	CT	Y	Y	Y	M
<b>2012</b>									
Gakuubi and Wanzala (2012)	Participatory rural appraisal	Y	Y	Y	Y	Y	Y	Y	H
Wanzala et al. (2012)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Maroyi (2012)	Participatory rural appraisal	Y	Y	Y	Y	Y	Y	Y	H
<b>2011</b>									
Madzimure et al. (2011)	Experimental	Y	Y	Y	Y	Y	Y	Y	H
Djoueche et al. (2011)	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H

(continued on next page)



(continued)

Author, year	Method	Q 1	Q2	Q3	Q4	Q5	Q6	Q7	Rank
Magono et al. (2011) 2009	Experimental	Y	Y	Y	Y	Y	Y	Y	H
Moyo and Masika (2009) 2008	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Mc Gaw and Eloff (2008) 2007	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Nyangiwe and Horak (2007) Tefera (2007) 2006	Structured survey and Experimental Case study, Structured questionnaire	Y Y	Y Y	Y Y	Y CT	Y CT	Y Y	Y CT	H W
Mwaniki (2006) 2003	Report and opinion	Y	Y	Y	CT	CT	Y	Y	M
Schwalbach et al. (2003) Walker et al. (2003)) Masika and Afolayan (2003) 2000	Experimental Book chapter Participatory rural appraisal	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	H H H
Regassa (2000) 1998	Structured questionnaire	Y	Y	Y	Y	Y	Y	Y	H
Dreyer et al. (1998) 1996	Experimental	Y	Y	Y	Y	Y	Y	Y	H
Yunker (1996) 1990	Review	Y	Y	Y	CT	YY	Y	Y	H
Barry and Niekerk (1990)	Technical note	Y	Y	Y	Y	Y	Y	Y	H

## Note:

Q1 = Did the study address the clear focused issue?

Q2 = Did the authors use appropriate method to answer their questions?

Q3 = Was the data sufficient to warrant reporting?

Q4 = Did the study have enough experimental units to reduce biasness?

Q5 = Is there a clear statement of findings?

Q6 = Can the results be applied to a local population?

Q7 = How valuable is the research?

Y – Yes (Clearly described)

N – No (Not described)

CT – Cannot tell (described but with limited details)

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