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Commiphora swynnertonii (BURTT) as a potential new alternative for the management of tick infestation in Tanzania

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Abstract

The evolution of tick resistance to synthetic acaricides has given rise to the need for new scientific investigations on alternative ways to control tick infestation. In this esteems, various studies on plant extracts have been developed aiming to identify new compounds that are able to control ticks. In this context, *Commiphora swynnertonii* exudates may be a promising alternative in the management of ticks. *Commiphora swynnertonii* is the flowering plant in the family Burseraceae and it is popularly known as "Oltemwai" by Maasai people of Tanzania. In this review we highlight four major tick-borne diseases which are of economic importance in Tanzania. The use of synthetic acaricides and their challenges brought to the environment are also discussed in this review. *Commiphora swynnertonii* appears to be as a promising alternative in the control of tick infestation and other arthropods of economic importance.

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Introduction

Ticks are ectoparasites which are the main vectors for disease causing agents to humans, livestock and wild animals all over the world (Aydin *et al.*, 2015). After mosquitoes, ticks are considered the most prevalent group of ectoparasitic arthropods to transmit pathogens to humans and rank first in the transmission of pathogens that cause disease in animals (Jongejan and Uilenberg 2004; Ogrzewalska *et al.*, 2009). There are over 896 cataloged species of ticks that are divided into three families: Argasidae, Ixodidae and Nuttalliellidae (Simlinger, 2005; Iqbal *et al.*, 2006; Andreotti *et al.*, 2014; Guglielmone *et al.*, 2010). The family Ixodidae, hard ticks contains about 683 species while Argasidae family, soft ticks contains 185 species and family Nuttalliellidae has only one species (Jongejan and Uilenberg, 2004; Latif and Walker 2004). The species of ticks that parasitize domestic animals are usually the ones that are most studied, with their biology, vector capacity and forms of control being the subject of many studies in the country (Veronez *et al.*, 2010). Species of tick that infest cattle population in Tanzania are; *Boophilus decoloratus*, *Rhipicephalus appendiculatus*, *Amblyomma variegatum*, *Rhipicephalus evertsi*, *Rhipicephalus microplus*, *Amblyomma lepidum*, *Rhipicephalus pravus*, *Amblyomma gemma,* and *Hyalomma albiparmatum,* (Mamiro *et al.*, 2016). These species of ticks are ticks of economic important in Tanzania (Lynen *et al.*, 2007). They transmit pathogens which cause diseases (tick-borne diseases) to livestock resulted in hindering their production.

The control of these ectoparasites is still performed through the application of synthetic acaricides but their use has become less reliable due to unaffordability of the drugs to the farmers (livestock keepers) especially small holder farmers, development of tick resistance to synthetic acaricides and contamination of the environment or food with toxic residues (Akhtar *et al.*, 2000; Dellavalle *et al.,* 2011; Shai *et al.*, 2009;). The rise and assortment of tick strains that are resistant to these synthetic drugs remains a major inspiration to develop new anti-tick agents (Andreotti *et al.*, 2014).

Considering these reality, several studies with plant extracts have been developed with the aim of identifying new compounds that are able to control ticks. The use of phytotherapeutics obtained from the resinous exudates of *C. swynnertonii* is a promising alternative (Edwin *et al.,* 2017; Kalala *et al.,* 2014; Mkangara *et al.,* 2014). This plant species is readily available in the northern part of Tanzania (Ruffo *et al.*, 2002).

The tick-borne diseases discussed in this review are largely important for domestic and production animals and are enormously important to public health in Tanzania. Economic losses due to tick and tick-borne diseases are discussed in this review in order to draw attention to the livestock keepers on finding solutions to manage ticks which are the causative agents of diseases to animals. Challenges resulted from the use of synthetic acaricides are also discussed to encourage further research. The use of *C. swynnertonii* plant is highlighted in this review as a promising alternative for controlling tick infestation.

Tick-borne diseases

Tick-borne diseases (TBDs) are reported to be the major limitation to livestock production in Africa (Onono *et al.*, 2013). The incidence of TBDs and resulting economic losses vary widely within the country due to factors such as agro- ecological zones, cattle type, cattle production systems and socio-economic factors (Kivaria, 2006). Tick-borne diseases such as East Cost Fever, anaplasmosis, babesiosis and Cowdriosis account for 72% of all cattle mortality in Tanzania (Fyumagwa *et al.*, 2004; Leynen *et al.*, 2007). These diseases are considered as TBDs of economic important in Tanzania (Kivaria, 2006; Guglielmone *et al.*, 2006; Wesonga *et al.*, 2010).

East Coast fever

ECF is a cattle disease syndrome caused by the parasite *Theileria parva*, transmitted by *R. appendiculatus* and is one of the most important livestock diseases in Africa (Lessard *et al.*, 1988; Norval *et al.*, 1992; Muraguri *et al.*, 1999; Lounsbury, 1904; Neitz, 1955; Lawrence *et al.,* 1983).

Theileria parva depends on the *Rhipicephalus appendiculatus*, a three-host tick, which parasitizes mainly cattle, for its transmission and its distribution is directly related to the distribution of the ticks. The distribution range of East Cost Fever extends from southern Sudan to Africa and as far west as the Democratic Republic of Congo (DRC) (Olwoch *et al.*, 2008). Among all TBDs, East Coast fever (Theileriosis) is economically, the most important tick-borne disease in Tanzania (Mbassa *et al.*, 2009). This disease accounts for more than 70% of all cattle death annually in Tanzania (Kivaria *et al.*, 2007).

Anaplasmosis

Anaplasmosis is a haemoparasitic disease caused by *Anaplasma marginale* a rickettsia that infects the red blood cells of cattle and is transmitted by *Boophilus* spp, cattle ticks common in the warm moist environments (Dalgliesh *et al.*, 1990). Anaplasmosis is common tick-borne diseases in Africa, Australia, Russia, South America, and the United States, Mediterranean countries and Russia (Rafyi & Maghami, 1961). The disease is economically importance to livestock population in Tanzania and it is resulted to weakness, fever, constipation, inappetence, severe anaemia, dehydration, abortion and/or death and contributes to great economic loss to livestock productivity (Eriks *et al.*, 1994; de la Fuente *et al.*, 2005).

Babesiosis

Babesiosis is a tick-borne disease of cattle caused by the protozoan parasites of the genus *Babesia* (Ristic, 1981). Parasites of the genus *Babesia* infect a wide variety of domestic and wild mammals as well as human being (Penzhorn, 2006). These protozoa particularly *Babesia bovis* and *Babesia bigemina* are transmitted by *Rhipicephalus* spp which are widely distributed in tropical and subtropical countries (Smith *et al.*, 1893). *Babesia bovis*, *B. bigemina* together with *B. divergens* are the major inhibitors of the cattle industry and the species are distributed in Africa, Asia, Australia, and Central and South America (Bock *et al.*, 2004).

Cowdriosis

Cowdriosis is a tick-borne disease of cattle, sheep, goats and some wild ruminants. The disease is caused by a rickettsia, known as *Ehrlichia ruminantium* which is transmitted by genus *Amblyomma* (*A. variegatum* and *A. hebraeum*) (Provost & Bezuidenhout, 1987). The diseases occur throughout African continent, particularly in South Africa (Okoh *et al.*, 1987) and the infection causes a high fever, nervous signs, hydrothorax and oedema of the lungs and brain, and eventually death of the animals.

Economic losses caused by tick infestation and tick-borne diseases

Tick infestation and tick-borne diseases constrain cattle production and improvement, leading to considerable economic losses. In east Africa, the loss of cattle due to tick and tick borne diseases particularly ECF was estimated to be 168 million United States Dollar including a mortality of 1.1 million cattle (Mukhebi *et al.*, 1992). In Tanzania the analysis of livestock deaths recorded between 1981 and 1993 indicated that 72% of all mortalities were due to tick-borne diseases (Mtei and Msami 1996). Moreover the overall costs associated with tick and TBD control in 1997 amounted to 54.7 million US$ (Mcleod and Kristjanson 1999) and the total annual national loss inclusive of cattle mortality was estimated to be 364 million US$ (Kivaria 2006). In 2007 Kivaria and his coworkers have estimated that the total losses annually per cow due to ECF mortality, morbidity, control and prevention practices was amount to be US$ 205.40. Other African country like Uganda the cost incurred for the control of ticks and tick-borne diseases was estimated to be 308,144 USD (Ocaido *et al.*, 2009).

The use of synthetic acaricides to control tick infestation

The use of synthetic acaricides is the most common method used for decades by livestock keepers to control tick infestation (Opdebeeck *et al.*, 1988). Synthetic acaricides that has been employed for the management of ticks are organophosphates (OP), phyrethroid, amitraz, macrocyclic lactone (ML), arsenic, organochlorine, benzenehexachloride (BHC), polychloroterpine, dieldrin and aldrin, cyclodiene compounds and toxaphene just to mention a few. Despite the fact that synthetic acaricides has been effective in the management of ticks, their use has become less reliable, unacceptable and unsustainable due to several reasons, such as high cost of acaricides, tick resistance to synthetic acaricides and contamination of the environment or food with toxic residues (Bissinger *et al.*, 2010; Kalala *et al.*, 2014; Mkolo *et al.*, 2007).

Development of tick resistance to synthetic acaricides

Development of tick resistance to a successive acaricides has been a major problem in livestock farmers (Sindhu *et al.*, 2003; Kivaria *et al.*, 2007). The constant exposure of ticks to acaricides, which is accompanying with a lack of proper management, accelerates the selection pressure for resistant individuals in the population, inevitably worsening the resistance problem (Crampton *et al.*, 1999). *Boophilus decoloratus* and *Boophilus microplus* has developed resistance to arsenical, toxaphene, chlorinated cyclodiene and organophosphorus acaricides (Baker, 1965; FAO, 1984; George *et al.*, 2004). Fernandes, (2001) reported the resistance of *Boophilus microplus* to deltamethrin and cypermethrin, and showed the required level of mortality only to high concentrations of permethrin. The evolution of tick resistance to acaricides has been a major determinant of the need for new products (George, 2000). Due to these constraint caused by tick infestation in livestock productivity there is a need for the researchers to find an alternative way of controlling these species.

The use of plants as an alternative to synthetic acaricides

The use of plants and plant-based products to kill or repel parasitic arthropods has been widely used by many communities as an alternative to synthetic acaricides (Opiro *et al.*, 2013). Moreover, the use of these plants is recommended by the United Nations (UN), which identified that two-thirds of the world's population uses medicinal plants (Andreotti *et al.*, 2014). Several studies with plants extracts have been established with the aim of using plant extracts as an alternative method to synthetic drugs. *R. appendiculatus*, *Amblyomma variegatum* and other tick species have been the subject of many studies due to the emergence and selection of strains that are increasingly resistant to various chemicals worldwide (Barata, 2005).

Presence of different compounds with different mechanisms of action from plant make plant based products to have more advantages over synthetic drugs such as slower development of resistance (FAO, 2004; Balandrin *et al.*, 1985; Chagas *et al.*, 2003). Approximately 55 plant species belonging to 26 families have been tested for acaricidal activity against ticks (Olivo *et al.*, 2009; Wanzala *et al.*, 2014; Nyabayo *et al.*, 2015; Silva Lima *et al.*, 2016).

Commiphora swynnertonii

Commiphora is the genus of flowering plants in the frankincense and myrrh family, Burseraceae which encompasses approximately 190 species of shrubs and trees. The genus is distributed throughout the sub-tropical region of Africa, Western and Eastern Indian Ocean islands, Arabia (Paparozzi, 2005; Adam and Selim, 2013), China, Egypt, northern Namibia, Iran, Pakistan, Peninsula, Sri Lanka and Brazil (Soromessa, 2013). The genus name *Commiphora* originates from the Greek words Kommi meaning 'gum' and pheros meaning 'bearing' (Van der Walt, 1974). The Afrikaans name for *Commiphora* is 'kanniedood', means 'cannot die'. This is an indication of sustainability of the plant and also refers to the fact that the truncheons grow easily when planted. Several species of this genus have been investigated as possible sources of different biological activities such as antibacterial, antifungal, antiviral, antioxidant and anti-inflammatory (All *et al.*, 2007; Paraskeva *et al.*, 2008; Akor and Anjorin, 2009; Ezekiel *et al.*, 2010; Haffor, 2010; Kumari *et al.*, 2011). The activity is due to the presence of secondary metabolisms that produce compounds that are not distributed in all parts of the plants and are play an important role in the interaction between the plants and the environment (Kissmann, 1992).

Commiphora swynertonii is among the specie in genus *Commiphora* which has been claimed to be a potential plant in the treatment of sexually transmitted diseases, ulcers, wounds (cut and burn wounds), abscesses, swelling of legs, chesty cough, scabies and controlling ectoparasites, (Nagagi *et al.*, 2017).

This plant is widely distributed in the northern part of Tanzania and southern part of Kenya (Kalala *et al*., 2014), tropical and subtropical part of Asia and Southern America (Mkangara *et al*., 2014). It is characterized by small tree highly branched with spine reaching a height of about 3 meters (Kalala *et al*., 2014). The barks are pale grey that peels off in papery pieces. When damaged the bark release a watery, milky sap and later become reddish brown resinous exudates. Leaves vary between simple and compound leaves, shiny copper green and during wet season the leaves arise and detached during dry season.

The chemical constituents which has been investigated from *Commiphora* species, are Dammarine triterpenes, Ferulate, Furanosesquiterpenes, Guggultetrol, Lignans, Flavonones, Sesquiterpenes, esters, Cumunic aldehyde Euginol, Phenolic compounds, tannins, alkaloids, Steroids resin acids and Protein (Zhu *et al*., 2001; Fatope *et al*., 2003; Al-Harbi *et al*., 1997; Hanus *et al*., 2005; Aliyu *et al*., 2007). Phytochemical screening of *Commiphora swynnertonii* showed the presence of Saponins, Flavonoids, Cardiac glycosides, Terpenoids, Tannins and Steroids (Bakari *et al*., 2013). Leaves of *C. swynnertonii* were reported to contain essential oils which were five sesquiterpenoids and four sesquiterpenoid derivatives, copaene and isocaryophyllene (Kaoneka *et al*., 2007).

Commiphora swynnertonii is commonly known as Oltemwai by Maasai people of Tanzania. Its sap or resinous exudates are used for management of ticks, fleas and tsetse flies and treatment of worm infestation, wound, dental caries and cleansing bladder (Kalala *et al*., 2014). A number of investigations have focused on the validation of ethnoveterinary information of *C. swynnertonii*.

The study conducted by Kaoneka and Mollel (2012) tested the extracts of C. swynnertonii in the control of brown ear tick *R. appendiculatus*. In that study a concentration of 10% (w/v), the authors observed that, the hexane and ethyl acetate extracts of *C. swynertonii* induced mean mortalities of 71% and 54% respectively, in two week old nymphs and established that the hydro-distilled oil of *C. swynnertonii* stem bark was as effective as the commercial acaricides, Triatix against *R. appendiculatus*. Another study using *C. swynnertonii* by Mkangara *et al*. (2014) investigated the *in vitro* acaricidal potential of stem bark extracts of *C. swynnertonii* in the control of *R. appendiculatus* and *A. variegatum*. In that study the authors concluded that *C. swynnertonii* (Burtt) stem bark petroleum ether extract exhibited relatively high acaricidal activity at 50% lethal concentration value (LC50) of 72.31 and 71.67mg/mL which resulted a mortality of 100% against *A. variegatum* and 87% against *R. appendiculatus* respectively after 156hours of exposure to treatments.

Kalala and his coworkers 2014 investigated the acaricidal activity of stem bark exudates from *C. swynnertonii* against *R. appendiculatus* and *A. variegatum* using Larval Packet test (LPT) and Adult immersion test (AIT).

The authors investigated that the exudates obtained from *C. swynnertonii* stem bark were found to have strong acaricidal activity against the ticks with LC50 of 1.72mg/ml for *R. appendiculatus* and 1.91mg/ml for *A. variegatum*. The study further investigated that the exudate prevented or reduced oviposition and egg hatching capability of the ticks and concluded that the C. swynnertonii exudate is recommended to be used in protecting livestock and domesticate animals against ectoparasites.

Sambuta and Masola (2006) reported the anti-ectoparasitic effects of *Commiphora swynnertonii* against ticks, fleas and mites and observed satisfactory results. Recently study conducted by Edwin *et al*., 2017 tested the extracts obtained from *C. swynnertonii* exudates in the control of *Rhipicephalus appendiculatus* larvae.

The authors observed that chloroform and hexane extract of *C. swynnertonii* exudates are effective against *R. appendiculatus* larvae. The resin extract of *Commiphora swynnertonii* was also reported to have significance antibacterial, antifungal, antiviral, and anticoccidaial activity (Bakari *et al*., 2013).

Future perspective of Commiphora swynnertonii as potential plant in management of tick infestation

Tick infestation and tick-borne diseases are a constant threat to the economical production of livestock industry. Introduction of synthetic acaricides has been used to control these ectoparasites. Recognition of drug resistance associated with the use of synthetic acaricides motivated the scientific community toward finding an alternate source of acaricides in controlling ticks. In this perception, development of plant-derived acaricides emerged as a promising results.

Medicinal plants, already known as a natural source of a range of bioactive compounds, have received attention in research focusing on their utilization as a preferred source of acaricidal agents in treating ectoparasites. The demand of these plants for therapeutic purposes is increasing and will continue in the future mainly because of less toxicity and side effects of the products to the environment (Ramanan *et al.*, 2007). Since the demand of plants as new window in the management of ectoparasites is increasing in both developed and developing countries, public sectors and health care professional has also demanded evidences on the efficacy, safety, quality, availability and preservation of these plants (Ghani, 2013). Furthermore, conservation status of medicinal plant species should also be studied in order to open up challenges for the conservationists, policy makers and researchers.

With this cautionary note, it is evident that plants and plant based products as alternative to synthetic acaricides hold good future prospects and they may one day emerge as better alternatives for synthetic drugs.

Conclusion

Based on extensive literatures, *C. swynnertonii* plant is considered as useful plant in controlling ectoparasites. The biological effectiveness of this plant provide the most useful information for researchers to carry out further studies on the isolation and identification of all compounds and determine exactly which compound is contributing to the acaricidal activity.

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