International Journal of Advanced Multidisciplinary Research
ISSN: 2393-8870
www.ijarm.com
DOI: 10.22192/ijamr Volume 7, Issue 12 -2020

Review Article

DOI: http://dx.doi.org/10.22192/ijamr.2020.07.12.003

Review on ticks resistant breed of cattle in Africa and its practical importance for tick control

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Keywords

Acaricides,
Breed Resistance,
cattle,
Ectoprasites,
Ticks,
Africa

Abstract

Ticks have a negative effect on dairy and beef cattle production systems around the world with the concomitant risk they represent for the transmission of some important infectious diseases. Most tick control strategies currently advocated rely heavily on the use of anthelmintics and acaricides. However, the regular use of any chemical to control infective organisms poses the risk of developing resistant populations. World-wide reports of antiparasitics with resistance to one or more of the available broad-spectrum groups are therefore of great concern to all of those involved in advising on parasite control. To maintain the production benefits of livestock production systems the efficacy of available compounds must be maintained so that control measures remain effective. Among parasite problems the control of ectoparasites mainly ticks almost depends on the use of acaricides. Because of observed disadvantages of using acaricidal products, alternative methods may minimize such emerging problems associated with these chemicals. There is a need to develop new and improved methods of controlling ticks and monitoring of resistance in the field, and to link their use with improved control strategies aimed at slowing down the inevitable development of such resistance. One of the alternative methods is the use of host resistance mainly tick resistant breed of cattle. It is very idea to apply integrated approaches that should incorporate combination of classical and modern methods of tick control.

Introduction

Ticks are obligate, blood-feeding ectoparasites of vertebrates, particularly mammals and birds. It has been estimated that about 80% of the world population of cattle is infested with ticks. The lifecycle of ticks (both Ixodids and Argasids) undergo moulting stages in their development; eggs, 6-legged larva, 8-legged nymph and adult (Chartier et al., 2000). Ticks are most numerous, particularly in tropical and sub-tropical regions, and their impact on animal health and production is greatest in these regions (Kettle, 1995).

Ticks are considered as the most damaging livestock pests on a global scale. Ticks are responsible for a great diversity of livestock health problems. Approximately 80 % of the world's cattle population is at risk to tick infestation and tick-borne diseases (Pegram, et al., 1993). Their infestation alone can give rise to severe irritation and trauma, which results in substantial economic losses from reduced milk yield, skin and hide damage and reduced weight gain. As vectors of pathogens, ticks are second only to mosquitoes and are responsible for the transmission of protozoal, riskettsial, bacterial and viral deseases among domestic animals (Keating, 1983). According to Mc-Cosker (1989) it is estimated that the global costs of tick control and productivity losses account for some 700 million USD annually.

Ticks are responsible for severe economic losses in both dairy and beef cattle production in tropical countries and is one of the major problems that animal breeders face (Rony et al., 2010). It was reported by many researchers that tick infestation in cattle causes enormous financial losses in African countries and responsible for loses $160 million annually mainly due to cattle mortality (Matthewson and Blackmann, 1983; Dipeolu et al., 1992; Jonsson, 2006; Olwoch et al., 2008; Smith and Parker, 2010).

Application of acaricides in dips and sprays remains as the conventional means of tick control over the past many decades. This method has resulted in a profound influence on livestock productivity through dramatic reduction in the prevalence of tick infestation and tick-borne diseases. Acaricides, particularly the stable and persistent ones, have provided rapid and efficient means of combating livestock ticks in many parts of the world (Tatchell, 1987). This method has been and still practiced in Ethiopia and likely to remain as one of the most dependable weapon in the foreseeable future (Regassa and De-Castro, 1993).

In many African countries cattle tick control depends largely on the use of different chemicals such as application of acaricides in dips and sprays remains as the conventional means of tick control over the past many decades. This method has resulted in a profound influence on livestock productivity through dramatic reduction in the prevalence of tick infestation and tick-borne diseases. Acaricides, particularly the stable and persistent ones, have provided rapid and efficient means of combating livestock ticks in many parts of the world (Tatchell , 1987). This method has been and still practiced and likely to remain as one of the most dependable weapon in the foreseeable future (Regassa and De-Castro, 1993). However, their injudicious use represents the greatest threat to livestock industry of many countries. Over-reliance and misuse of most chemical acaricides have resulted in a rapid emergence of resistant tick populations and objectionable pesticide residues in the environment (Akhtar et al., 2011).

Routine use of acaracide treatments is unacceptable from an organic perspective. Strategies should be developed which focus on prevent the diseases and support the specific resistance of the animals to ticks and the tick borne diseases. High host resistance is the key to effective long-term tick control with total resistance the ultimate aim. While improvements to acaricides and vaccines are continuously pursued, improvements to the most important single factor controlling ticks, host resistance, have been neglected. Resistance is as heritable as milk yield or growth and in tropical breeds can be increased to very high levels by selection. Despite this there are no current examples of sustained selection for tick resistance (Frisch, 1999).

Common tick species in Africa

In Africa, climatic (temperature and humidity) as well as environmental conditions (vegetation) is so favorable for biological development of many tick species. According to Jongejan and Jongejan et al. (2004) 650 different tick species infest cattle in different agro-ecological sites. Out of seven reported genera in Africa, four of them cause severe economic losses economic infesting different breeds of cattle. These are: Rhipicephalus, Amblyomma, Hyalomma and the subgenus Rhipicephalus (formerly Boophilus) (Table 1).

Hyalomma marginatum is widely distributed across North Africa and Asia where it is reported from Algeria, Armenia, Azerbaijan, Egypt, Ethiopia, Georgia, Iran, Iraq, Israel, Morocco, Sudan, Syria, Tunisia and Turkey (Table 1).

Table 1. Species ticks and their distribution in Africa (Latif and Walker, 2004).

Tick Spp	Distribution
Hyalomma spp.	Northern Africa and the Sudan
R. appendiculatus	East, Central and Southern Africa
R. appendiculatus, R. evertsi, A. variegatum	South and East Africa
I. ricinus, I. presulcatus, B. microplus, B. calcaratus R. bursa, Boophilus spp.	Africa
B. annulatus, B. calcaratus, B. decoloratus,B. microplus, R. e. evertsi, R. bursa, R. appendiculatus, Haemaphysalispunctata	N & S Africa
B. calcaratus	N &W Africa
Boophilus spp. Amblyomma spp.	East central and southern parts of Africa

In Ethiopia several tick species of the genera *Amblyomma*, *Boophilus*, *Haemaphysalis*, *Hyalomma*and *Rhipicephalus* have been identified (Morel, 1980). Tick surveys have been carried out in different regions by different researchers (Pegram *et al*., 1993; De Castro, 1994; Solomon, 1994; Yilma *et al.*, 1995; Seyoum, 2001). Out of 60 species of ticks infesting both domestic and wild animals in the continent, 33 of them are known to be most common and are important parasites of cattle and other livestock species (Pegram *et al*., 1993).

Among dominating species, *R. microplus* has extended its range and is now present in all warm and humid areas of the continent. The bont tick (*A. hebraeum*) was reported to occur only in the warm, moist coastal areas of South Africa. But, it has recently been reported that *A. hebraeum*'s distribution is expanding to the inland semiarid areas of South Africa. This increase in the distribution of the bont tick in South Africa may be associated with more prolonged periods of drought as revealed by De La Fuente *et al*. (2008) for the bont tick in Zimbabwe.

African tick resistant cattle breeds

Cattle differ widely in their resistance to ticks and tick borne diseases. Wherever possible, tick-resistant cattle should be promoted through selective breeding to increase the resistance of cattle in a herd. This will result in lighter tick infestations and reduce the requirement for acaricide treatments. Continuously selecting those animals for breeding that consistently carry the smallest number of ticks is a good and cheap strategy. Local cattle breeds are well-known for being more resistant to tick borne diseases than exotic breeds, which never had been exposed and therefore also not naturally selected for resistance (Da Silva, 2007).

The earlier investigation results and conducted researches by Bonsma in 1940s and Bonsma (1981) in South Africa paved ways for studies on host-resistance to tick infestations demonstrating that African indigenous cattle carried far fewer ticks than British beef cattle and reported much lower mortality rate than the British cattle. This pioneer work by Bonsma was resurrected by researchers in Africa 40 years later. Assessment and quantification of host-resistance were carried out on several African indigenous breeds of cattle (Table 1). Most of these breeds maintained tick-resistance with high productivity trait (Jonsson, 2006).

Different researchers disclosed that many breeds of cattle differences in their response to tick infestations. *Bos indicus* pure breeds and cross breeds were reported to be more resistant than *Bos taurus* breeds (Da Silva, 2007). African cattle breed contain four groups: humpless Bos taurus, humped Bos indicus, Sanga (African humpless Bostaurus crossbred with humped Bos indicus), and Zenga, defined as Sanga, back crossed with Zebu. In addition to these four categories, other African cattle breeds have been recently derived through recent cross breeding with exotic (Nyamushamba et al., 2017)). Reports by Ali and De Castro (1993), showed that tick resistance might vary among breeds and the species of infesting ticks. Accordingly, Latif and Walker (2004) have characterized and listed major tick resistant zebu cattle in Africa (Table 2). It is known that in many subtropical and semi-arid environments in Africa, indigenous dual-purpose breeds are highly resistant to ticks, resulting in low infestation rates (Norval et al., 1991; Nyamushamba et al., 2017).

Table 2. Tick-resistant zebu cattle in Africa (Latif and Walker, 2004)

Breed	Country	Reference
Afrikander	South Africa	Bonsma (1940) in Bonsma (1981)
Brahman	South Africa	Rechav (1987), Rechav et al (1990)
Bonsmara	South Africa	Scholtz et al (1991)
Ngunis-Nkoni (Sanga)	South Africa	Scholtz et al (1992)
Boran	Kenya	de Castro (1991)
East African Zebu	Kenya	Latif et al (1991)
Kenana	Sudan	Latif (1984a)
Butana	Sudan	Latif (1984b)
Boran	Ethiopia	Ali (1989) in: de Castro (1991)

According to a number of authors, Zebu cattle (*Bos indicus*) demonstrated higher and remarkable resistance to ticks than European cattle, Bostaurus. (Porto Neto *et al*. 2011; Madale; Wambura et al., 1998; Latif and Walker, 2004; Jonsson, 2006; Da Silva et al. 2007).

Adey (2003) conducted a comparative study in the Ghibe Valley, Ethiopia, to obtain information on the resistance levels of four indigenous breeds of cattle (Abigar, Gurage, Horro and Sheko) to natural infestation with ticks. Resistance to ticks among breeds was evaluated based on the cumulative log transformed counts of total ticks, fully engorged females and adult ticks. Based on the given parameters, Horro and Gurage breeds were found to exhibit significantly higher resistance to ticks than Abigar and Sheko breeds (Table 4).

Numerous studies have been conducted to determine the resistance of Nguni cattle to ticks infestation (Muchenje et al., 2013; Marufu et al., 2010; Marufu et al., 2013; Mapholi et al., 2014). Among them, Mwai et al (2015) revealed that, the Tswana cattle from Botswana are also resistant to tick challenges. These findings were in agreement with Rege et al (2007) who also studied the same breed of cattle. Meanwhile, Khombe (2002) reported that Mashona cattle were more resistant to ticks and with productivity level. More recent reports by Marufu et al. (2011) indicated that the resistance to ticks of sanga breed has been attributed to coat characteristics such as colour, hair length and density and also their grooming behaviour and delayed cutaneous hypersensitivity reaction to tick infestation (Marufu et al., 2014). Nyamushamba et al., (2017) characterized the level of resistance by some African breeds of cattle (Table 3).

Table 3. Level of resistance to tick species by some cattle breed in Africa

Cattle breeds	Level of resistance	Tick species	References
Nguni compared to Hereford & Brahman	High	Rh. decoloratus	[Rechav et al., 1991]
Zimbabiansanga compared to Nguni and Brahman	High	A. variegatum, Rh. decoloratus	[Norval et al., 1996]
Boran compared to Tulis	High	Rh. microplus	[Frisch and O’Neill, 1998]
Nguni compared to Bonsmara and Angus steers	High	Rh. appendiculatus	[Muchenje et al., 2008]
Nguni breed compared to indigenous-exotic crosses (non-descript cattle)	High	Rh. appendiculatus, Hyalomma species	[Marufu et al., 2010]
Nguni cattle compared to Bonsmara	High	Rh. microplus	[Marufu et al., 2011]

In Ethiopia studies on indigenous breeds such as Boran and Horro (*Bos indicus*) and their crosses with none African breeds of cattle such as Simmental, Friesian and Jersy (*Bos taurus*) demonstrated that the pure Horro and Boran breeds had lowest tick burdens. The crosses of Horro with Simmental and Jersey showed also high resistance than all the other crosses and all crosses with Boran showed low resistance (Ali and de Castro, 1993). In a study done among Arsi, Boran and Boran Friesian cross breeds showed that Arsi breed had higher resistance than Boran and its cross (Solomon, 1994).

African Zebu (Bos indicus) is found to be more resistant to infestation by ticks compared to taurine animals (Piper et al., 2009; Roland et al., 2018). However, among African taurine cattle, the N'Dama and Ankole (humpless longhorns) have been reported to be resistant to tick infestation (Mattioli et al., 2000; Roland et al., 2018). In addition, Tswana cattle (South African Sanga), from Botswana, have very high tolerance to heavy tick challenges (Rege et al., 1999; Marufu et al., 2010). According to Roland et al. (2018), of African local cattle demonstrate comparatively high resistance to local ticks of the genera, Rhipicephalus, Boophilus and Hyalomma has received recent attention.

Mechanism of breed resistance against ticks

Resistance to tick infestation is not uniform among individuals and local breeds of cattle. It was reported that in many African countries, indigenous dual purpose breeds are highly resistant to ticks, resulting in low infestation level by ticks (Mattioli et al., 2000; Roland et al., 2018). As indicated by Porto Neto et al. (2011), different levels of resistance occur in all breeds, but this is manifested more strongly in zebu cattle and their crosses.

Host resistance to ticks is the ability of a host, once primed, to mount an immune response to components of the saliva of feeding ticks, debilitating or killing them. The methodology for studying the levels of host resistance to Ixodid ticks involves the assessment of several feeding and fertility parameters like reduced number of feeding ticks, engorgement weight, length of feeding period, egg production, percentage of egg hatching, and increased mortality of egg and larvae (Piper et al., 2009).

Indigenous cattle resistance to ticks could be innate or acquired. The defense mechanisms, may include tick avoidance, grooming, skin characteristics and more specific immunological responses, are involved in reducing the number of ticks parasitizing cattle. Avoidance was attributed to the sighting of the ticks (Latif and Walker, 2004; Piper et al., 2009).

African indigenous cattle breed (*Bos indicus*) naturally self-grooms and groom each other thoroughly and frequently. Quite fewer ticks were found on those animals that were able to groom (Latif and Walker, 2004; Roland et al., 2018).

Following infestations by ticks, cutaneous hypersensitivity reaction develops and followed by spontaneous or acquired resistance against invading ectopratasites. The mechanism responsible for acquired resistance to ticks has been suggested to be a mast cell-dependent eosinophil hypersensitivity (Minjauw and de Castro, 2000). Resistance can be passively transferred with viable lymph node cells but not with serum from resistant hosts. This passage method of tick resistance suggests a delayed hypersensitivity mechanism for the acquisition of resistance (Lodos et al., 2000; Latif and Walker, 2004) followed by increased blood histamine level resulting in increased of cutaneous basophils or mast cells which continuously degranulate in the region of ticks attachment to produce more and more histamine. The histamine has shown to stimulate detachment of tick larvae (Akhtar et al., 2011; Bowman *et al*., 1996).

Itching sensation results from immunological mediators induced by tick antigen which stimulates grooming. However, dislodging of ticks in the case of two–three host ticks by grooming may simply be a response to the irritation of ticks walking on the skin while seeking their predilection sites before attachment (Mooring et al., 1995).

Differences in serum concentration of some proteins (e.g. haptoglobulin and transferrin) were confirmed and these could potentially be used as biomarkers to monitor the level of tick infestation (Shyma et al., 2015). Regitano et al. (2008) reported that in naturally infected cross breed *B. taurus* X *B. indicus* s and also in pure *B. indicus*, genotypes for a microsatellite marker close to the interleukin-4 locus were associated with tick numbers.

Some findings also shows that tick immunosuppression of the host enhance the establishment of tick transmitted pathogens in the host. In laboratory animals and cattle that are resistant to tick infestations, tick-induced immunosuppression has not been observed and thus speculated that resistant hosts might have a mechanism of escaping the immunomodulatory act of feeding ticks that made such hosts capable of maintaining low burden of tick infestation (Wikel and Bergman, 1997). Knowledge of the mechanism is very essential for it helps in designing successful immunological strategies to control ticks in susceptible hosts.

Factors affecting the level of host resistance to ticks

According to Minjauw and De Castro (2000), the level of host resistance against tick infestation can be influenced by numerous factors such as physiological, environmental of and the degree to expression of host resistance to ticks or. Other factors such as nutrition, sex, pregnancy, lactation, age, exposure to ticks, breed and tick density play key roles (FAO, 2004). Pregnant cows also found to be more sensitive than non-pregnant and carried a higher number of ticks mainly during the late stages of the pregnancy (Gasparin et al., 2007).

According to Minjauw and De Castro (2003); Foster et al. (2007), skin thickness play an important role on host resistance to ticks, even though, contradictory results were reported on this issue, the coat type, hair density and skin secretions may have some roles. Contemporary group comparison reveals lighter colored animals are more resistant than dark colored ones (Fraga et al., 2003).

A wide range of acquired humoral and cell mediated immune responses have been observed in laboratory animals as well as in cattle. The scenario of humoral immunity starts from langerhans cells trapping tick salivary molecules in the epidermis and migrating to the nearby draining lymph nodes where they act as antigen-presenting cells for specifically reactive host lymphocytes, which results in production of circulating tick reactive antibodies (Wikel and Bergman, 1997).

Breed resistance against ticks and its implication

Knowledge and clear understanding of the breed resistance to ticks could improve breeding programs to get more improved breed of animals that are resistant to tick infestation and do have desired productive trait (Minjauw and De Castro, 2000; Mapholi et al., 2014). Wharton (1983) and Frisch (1999), indicated that breed resistance is heritable where breeding and selection for tick resistance are possible not only in African indigenous cattle (Zebu) but also within European breeds.

Genetic variation in resistance of livestock should be quantified within and across breeds so that appropriate strategies are adopted in breeding programs. The host and tick genomics and their proteomics, such as gene expression profiles, are likely to facilitate studies addressing the sequencing, annotation, and functional analysis of their entire genomes (Frisch, 1999; Mapholi et al., 2014).

Nyamushamba et al. (2017) and Piper et al., (2009), demonstrated alternative methods of tick control and concluded that the utilization of host resistance, while offering an attractive approach to tick control. Resistance is an acquired characteristic and each animal develops its own level of resistance in response to tick challenge compared with other breeds.

Conclusion and Recommendations

Ticks, due to their direct impact and the diseases they transmit, are one of the major constraints to the development of cattle breeding in Africa. In many African countries cattle tick control depends largely on the use of different chemicals such as application of acaricides in dips and sprays remains as the conventional means of tick control over the past many decades. However, their injudicious use represents the greatest threat to livestock industry of many countries. Over-reliance and misuse of most chemical acaricides have resulted in a rapid emergence of resistant tick populations and objectionable pesticide residues in the environment. Regular and routine use of acaracide treatments is unacceptable from an organic perspective. Strategies should be developed which focus on prevent the diseases and support the specific resistance of the animals to ticks and the tick borne diseases. High host resistance is the key to effective long-term tick control with total resistance the ultimate aim. Even though, difficult to get absolute resistance for ticks, breed resistance against ticks is an important trait to be used for tick control. The selection should be based on the values for resistance level and production traits in order to achieve the desired result. Selection for resistance should be based on tick numbers surviving on cattle exposed either naturally or artificially to tick challenge. Cattle breeds, which have been introduced into areas where ticks are endemic, may display a very low degree of natural resistance to ticks. Breeding for genetic resistance is one of the promising ways artificial challenges which may open a new insight for a noble tick control.

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DOI:10.22192/ijamr.2020.07.12.003	

How to cite this article:
Yacob Hailu Tolossa and Birhane Wakjira. (2020). Review on ticks resistant breed of cattle in Africa and its practical importance for tick control. Int. J. Adv. Multidiscip. Res. 7(12): 14-23.
DOI: http://dx.doi.org/10.22192/ijamr.2020.07.12.003