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Control and management of ticks

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Abstract
Ticks are well-known parasites that affect livestock productivity. This paper reviews the current knowledge regarding the spread of ticks with their impact in animal health and the limitations to achieve effective control measures. The forecasted trends in climate play an obvious role in promoting the spread of ticks in several regions. The reported increase in altitude of this tick species in the mountainous regions of Central and South America appears to be driven by such general trends in climate change. This factor, however, is not the only single contributor to the spread of ticks. The poor management of farms, uncontrolled movements of domestic animals, abundance of wild animals, and absence of an adequate framework to capture the ecological plasticity of certain ticks may explain the complexity of the control measures. Herein, we review the problems and opportunities for the integrated control of ticks of ruminants. Developments discussed in the review in the area of tick vaccines and other tick control measures should have an impact on the future livestock production.

Keywords: Tick, tick control, management and acaricide

Introduction

On a global basis, ticks are second to mosquitoes as vectors of infectious pathogens to humans, and they form the most important group of arthropods to transfer disease pathogens from one animal to another. Ticks and tick-borne diseases (TTBDs) affect 80% of the world cattle population and are widely distributed throughout the world, particularly in tropical and subtropical countries (de Castro 1997) [1], which cause significant production losses (Jongejan and Uilenberg 2004) [2]. De Castro (1997) [1] estimated the global costs of TTBDs in cattle between US$ 13.9 and US$ 18.7 billion annually. The use of acaricides as the principal mean for tick control results in the selection of chemical-resistant ticks along with contamination of the environment and animal products. These consequences, combined with public concerns over different environmental issues, have led to the search for alternative methods of control that are consistent with the principles of sustainable agriculture (Donald 1994) [3]. The integrated pest management (IPM), in which application of two or more technologies are integrated in an environmentally compatible and cost-effective manner to control target pest population, has been identified as the future option. Several authors have suggested that the most cost-effective approach of tick control is to combine vaccination with natural resistance, particularly in extensive pastoral systems (Willadsen *et al*., 1995) [5].

Livestock is an integral part of the agricultural production system in India and plays an important role in national economy as well as in socio-economic development of millions of rural households. Livestock is an important source of animal protein for farm families and also used for draught power in agriculture and transport, and their dung is used to increase soil fertility. Although India is ranking first in the total milk production, the livestock sector is suffering from a number of disease problems caused by bacteria, viruses, fungi and parasites. Among the parasitological problems, the damage caused by TTBDs is considered very high and the control of TTBDs has been given priority (Bansal 2005) [6]. The present review is focused on effect of TTBDs on sustainable livestock farming and future control programmes in India.

Distribution of tick species of India

As per the last compilation report on tick species of India, approximately 106 tick species belonging to two families of Ixodidae and Argasidae are reported to infest domestic, wild and game animals (Geevarghese *et al*., 1997) [7]. Among the reported species of ticks, *Amblyomma testudinarium*, *Dermacentor auratus*, *Haemaphysalis bispinosa*, *H. spinigera*, *H. intermedia*, *Hyalomma anatolicum anatolicum*, *H. marginatum isaaci*, *H. hussaini*, *H. detritum*, *H.*

kumari, *Boophilus microplus*, *Ixodes acutitarsus*, *I. ovatus*, *Nosomma monstrosum*, *Rhipicephalus haemaphysaloides* and *R. turanicus* have been considered the most widely distributed tick species infesting cattle, buffalo, sheep and goats. *H. a. anatolicum*, *H. m. isacci*, *B. microplus* and *R. haemaphysaloides* ticks are reported from almost all the states of India. Reports of *I. acutitarsus* and *I. ovatus* are mostly available from east and northeastern zones of India. Similarly, *D. auratus* infestation is not reported from the western zone and also from southern states except Karnataka. The tick species, *Nosomma monstrosum* is not reported from north eastern states, central zones, Rajasthan and southern states except Andhra Pradesh and Kerala. The tick, *A. testudinarium* is mainly reported from north eastern zones, states of West Bengal, Punjab, Madhya Pradesh, Orissa, Karnataka and Tamil Nadu. Of the three predominant *Haemaphysalis* species, *H. bispinosa* is prevalent throughout India except Uttar Pradesh, *while H. spinigera* is restricted in southern states, central zones, Orissa in eastern zone and Meghalaya in north eastern zone. The *H. spinigera* is the only tick species reported from the Andaman and Nicobar Islands. *H. intermedia* is reported in all the southern states except Kerala, central zones, eastern zones except West Bengal, northern zone except Uttar Pradesh and Haryana, however, reports are not available from western zones. Among the seven north eastern states, *H. intermedia* are reported from Assam only. In most of the southern states except Kerala all the predominant tick species are reported from cattle, buffaloes, sheep and goats. In Kerala, the following tick species are reported *viz*., *H. kumari, H. spinigera, H. bispinosa, H. turturis, R. haemaphysaloides* and *B. decoloratus* (Prakasan and Ramani 2003) [8].

Tick control methods in India

The most widely used method for the control of ticks is the direct application of acaricides to host animals (Table 1). In most of the cases, the application of acaricides is repeated after 21-30 days. A recent survey on tick resistance conducted through questionnaire reported a large scale tick resistance in India (FAO 2004b) [9]. Insecticides consumption in Indian agriculture has been increased more than 100% from 22, 013 to 61, 357 tons during 1971-1995 (http://www.indiastat.com). However, acaricides are expensive and detrimental to the environment and human beings as residues are present in milk and meat and so their use should be minimized and integrated with alternative approaches. Depending on the abundance and importance of the various tick species, strategies such as seasonal treatments at the peak of tick activity may be sufficient to avoid economic losses due to ticks and TBDs. Tick infestation of animal sheds can be avoided by plastering all surfaces with smooth cement to block cracks and crevices, but this is only true for the owners who have a separate shed for keeping their livestock. Although the control of ticks relies heavily on the use of chemicals, the selection of resistant tick strains to the available compounds is a serious threat to the sustainability of this approach. Designing an economical, integrated tick control strategy for a particular production system in a specific area is one of the most difficult challenges faced by the veterinary scientists of India since extension activities are not sufficiently strengthened to provide farmers with the information necessary to enable them to evaluate sustainable strategies suitable for the control of TTBDs.

Table 1: Commonly used acaricides and their efficacy in India

Acaricide type	Compounds	Method of application	Efficacy (%)	References
Pyrethroids	Cypermethrin	Wash	100	Khan (1996) [10]
	Deltamethrin	Spray, Dip	96-100	Pathan *et al*., (2003) [11]
				Gupta *et al*., (1998) [12]
Organophosphates	Coumaphos	Swab	95-100	Khan and Srivastava (1993) [13]
				Talukdar *et al*., (1998) [14]
Carbamates	Carbaryl	Spray	100	Basu and Haldar (1997) [15]
Macrocyclic lactones	Ivermectin	Injection	100	Maske *et al*., (1992) [16]

Vaccines

The work on immunization of animals against targeted tick species is initiated in India in the early nineties to develop immunoprophylactic measure that would be more effective against local tick strains (Manohar and Banerjee 1992a, b; Thakur *et al*., 1992) [17, 18]. But the results obtained in preliminary studies have not been confirmed in the natural hosts. Kumar and a group of scientists from Haryana Agriculture University, Hisar reported cross-protective efficacy of midgut extracts of *H. dromedarii* following immunization of rabbits (Kumar and Kumar 1995, 1996) [19]. However, the challenge dose (n = 10 pairs of ticks) used for the cross-protection study was not sufficient to establish the cross-protective potentiality of the antigen tested. Common cross-reactive proteins of 66 kDa were detected in the salivary gland extracts of *H. a. anatolicum* and in *B. microplus* (Parmar and Grewal 1996; Parmar *et al*., 1996) [20, 21]. Similarly, Ghosh *et al*., (1998) [22] reported six immunodominant proteins of 97.4, 85, 66, 47.3, 42 and 31 kDa in all the stages of *H. a. anatolicum*. Subsequently, Ghosh and Khan (2000) [23] reported common proteins of 68, 57.5, 50.8, 47.3, 43 and < 43 kDa in all the stages of *B. microplus* and *H. a. anatolicum*. However, further work using the identified common proteins for raising cross-protective immunogen has not been reported.

Banerjee *et al*., (1990) [24] prepared three extracts of salivary glands and tested in cattle and concluded that the protective antigens are present in the sediment collected after centrifugation. A comparatively higher level of immunity in calves immunized by whole extracts of salivary gland in combination with ascaris extract as immunomodulator was reported by Sran *et al*., (1996) [27]. Sangwan *et al*., (1998) [26] prepared whole nymphal extract, nymphal membrane antigen and nymphal soluble antigens of *H. a. anatolicum* and used these for immunization of cattle. They were of the opinion that whole nymphal extracts are more suitable than the soluble and membrane antigens but none of the above studies have been carried further to attain the ultimate goal.

Host resistance

Host resistance is stable, heritable, long lasting and the single most important factor affecting the economics of tick control. It is a low cost permanent solution requiring no extra resources and incurring no additional costs. High host resistance is advantageous in any tick control programme. However, its improvement has been almost entirely neglected in Asia (Frisch 1999) [27] including India. In India, cattle breeds of Ongole/Nellore, Sahiwal, Ponwar hill cattle and buffaloes are recorded in literature as resistance to tick infestation (Gaur *et al*., 2002) [28]. Most of the times, the tick resistance status of these animals was attributed to the physical characters and behaviour of these animals. The genetic or molecular basis of host resistance to tick and tick borne diseases is unknown.

Ongole/Nellore cattle breed

A dual-purpose, large sized breed with loosely knit frames. The breed tract from Andhra Pradesh State and is found to have high level of resistance against *Boophilus microplus*. The physical characteristic of the skin coat is highly unfavorable for the tick attachment and feeding (Joshi and Phillips 1953; Gaur *et al*., 2002) [29, 30]. The dense skin texture, reflecting and glistering skin coat and the presence of large number of sweat glands per unit area of skin made the skin coat hostile for the tick attachment. Flexible tail tip, having cartilage in place of last three or four vertebrae helps as a brush to repel vectors and the presence of well-developed subcutaneous panniculus carnosis muscle repels vectors by twitching. The skin being more vascular and with large number of sweat glands, more heat is dissipated through the skin surface which maintains the lower skin temperature, confers higher tick resistance (Schleger *et al*., 1981; O'Kelly and Spiers 1983) [31, 32]. The sebum secretion of the Nellore cattle was reported to have fly repellent activity and the tick repellent activity of the sebum is unknown.

Sahiwal cattle breed

The Sahiwal is a milk breed originated in the dry Punjab region which lies along the India-Pakistan border. It is noted for its high resistance to parasites, both internal and external and heat-tolerant.

Ponwar cattle breed

The Ponwar is a draught cattle breed and is native to the Pilibhit District of Uttar Pradesh. The body is small, compact and non-fleshy and the skin is tight. The tail is long and reaches to below the hock and it is highly helpful in removing the vector attachment (Gaur *et al*., 2004) [33]. This cattle breed was reported to be highly resistant to tick and tick borne diseases. Since these hill cattle were being maintained on grazing in the forest area, they might have acquired the resistance towards ticks and other diseases due to continuous natural challenge.

Buffalo

Indian buffaloes are notably resistant to the tick species of India. Healthy buffaloes are not commonly affected by tick borne diseases nor are the hides damaged by their bites. Though the buffaloes are equally susceptible to the tick borne diseases as cattle breeds, the fewer occurrences of tick borne diseases could be linked to the tick resistance nature. The thick skin coat and wallowing and rubbing habits of the buffaloes could be attributed to the tick resistance.

Selection of dual purpose Nellore breed and buffalo for breeding has tremendous scope in developing stock of animals having high level of tick resistance in India. Selection will be most efficient in improving productivity if a multi-trait index is developed by incorporating breeding values for both production and resistance traits. Since there is a zero correlation between tick resistance and growth (Jonsson *et al*., 2000) [35], simultaneous selection for both traits is expected to result in improvement of both traits (Mackinnon *et al*., 1991) [36]. Milk yield did not decrease under intense selection for tick resistance (Utech and Wharton 1982) [37], which suggests that both traits can be improved simultaneously.

Pasture management

Although pasture management is a sustainable method to control ticks, its application is difficult in India where many livestock farmers have only small land holdings. But still this method is a viable option that can be adapted in organized livestock farms (India has 257 government controlled livestock farms and many dairy cooperatives) or in cooperative farming where pasture land is available for animals. This approach only requires good fencing and management skills. In India, Stylosanthes is regarded as the most important range legume for the humid to semi-arid tropics. It is extensively utilized in pastoral, agro-pastoral and silvi-pastoral systems for animal production (Chandra *et al*., 2006) [38]. Apart from their tick-trapping properties, livestock nutrition will also be improved. Government policies favouring the cultivation of this type of grasses by providing seeds at lower cost and by motivating the farmers through extension education would have some positive impact on TTBDs control. Simply by pasture management *viz*., pasture spelling, rotational grazing and cultivation of tick-trapping gasses that incurs no additional costs to generate an environment with reduced tick population/tick free environment and by the additional effect of the reduced use of acaricides, a livestock farmer can produce milk and meat of high quality (without acaricide residues) with lower prices.

Botanical acaricides

The ethno-veterinary and medical knowledge offers a range of herbs to be evaluated for their insecticidal and acaricidal property. Certain plants and herbs are known to possess insecticidal, growth inhibiting, anti-moulting and repellent activities. Khudrathulla and Jagannath (2000) [39] studied the effect of methonolic extract of *Stylosanthes scabra* on Ixodid ticks. The leaves of tobacco (*Nicotiana tabacum*) were found effective against *R. haemophysaloides* (Choudhury *et al*., 2004) [40]. Methonolic extracts of neem (*Azadirachta indica*) leaves and bark, nochi (*Vitex negundo*) leaves, vashambu (*Acorus calamus*) rhizome and Pungu (*Pongamia glabra*) leaves were tested for the acaricidal effects. Neem bark proved to be the most effective followed by vashamu (Pathak *et al*., 2004) [41].

In our laboratory the alcoholic extract of sitaphal (*Annona squamosa*) seed is being evaluated for its acaricidal property against different life stages of *H. a. anatolicum* and *B. microplus* and the initial results are highly encouraging. The evaluation of botanical acaricides in crude extract form and subsequent isolation and characterization of the key active components, have a great scope for commercialization. India possesses 45, 000 plant species of which 15, 000-20, 000 have proven medicinal value and have lands not suitable for agriculture activities. The tested/yet to be tested locally available plant extracts prepared from the perennial plants can easily be grown in these unutilized lands. Once the active principle of the effective components is known the same can be commercially produced and marketed. Besides the cost effectiveness the environment friendly products will have low mammalian toxicity, less residual effect in animal products and have the potential to reduce or replace the chemical acaricide use. Besides, since botanical acaricides consist of number of active molecules against ticks, the chances of selection of resistance tick population is expected to be slower than commonly used acaricides where single point mutation is rendering an insecticide ineffective.

Broad spectrum anti-tick vaccines

Multiple tick species infestation on animals is impedance to the use of tick vaccines with a narrow spectrum, having antigens of a single tick species. The recombinant BM86 included in commercial vaccine formulations TickGARD (Hoechst Animal Health, Australia) and Gavac (Heber Biotec S. A., Havana, Cuba) confers partial protection against phylogenetically related *Hyalomma* and *Rhipicephalus* tick genera (de Vos *et al*., 2001) [42]. However, immunization with BM86 failed to protect against the more phylogenetically distant *Amblyomma* spp. (de Vos *et al*., 2001) [42]. Therefore, there remains a need to identify broad range vaccine candidates against tick infestations across phylogenetically distant species. Tick genes encoding for protective antigens have been discovered that are expressed across tick species and in some circumstances across genera, thus making the use of these cross-reactive antigens in broad range anti-tick vaccine formulations perhaps possible. These genes were cloned and associated polypeptides of *I. scapularis* were designated as 4D8 (also identified as subolesin), 4F8 and 4E6 (Almaza´n *et al*., 2003a, b, 2005a, b; de la Fuente and Kocan 2006) [43-47]. The sequence of 4D8 was shown to be conserved among different tick genera and the activity of subolesin protective antigen was demonstrated to extend to other tick species, including non-Ixodes tick species (Almaza´n *et al*., 2005a; de la Fuente and Kocan 2006) [45, 47]. The 4D8 molecule is expected to present in important tick species of India.

Conclusion

Due to high costs involved in treating animals with insecticides most of the small and marginal farmers are utilizing indigenous method of keeping their animals tick free (including hand-pick method). The multi-tick infestations pattern on animals are completely different in different agro-climatic regions of India (India has 15 agro-climatic regions) and so there is an urgent need to develop strategic region specific schedule of treatment of animals.

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