Bio Vet Innovator Magazine
(Fueling The Future of Science…)
Volume 3 (Issue 9) OCTOBER 2026
OPEN ACCESS World Animal Day – 04th October 2026 Popular Article

Integrated Tick Management: Challenges, Opportunities and Future Perspectives

Dr. Pratik G. Kokate[1*], Dr. Naina V. Singh[2], and Dr. Vishal B. Awate[3]
1M. V. Sc (Veterinary Parasitology), Veterinary Officer (Gr–A), Buldhana, Maharashtra, India
2M. V. Sc (Veterinary Pathology), Veterinary Officer (Gr–A), Buldhana, Maharashtra, India
3M. V. Sc (Veterinary Medicine), Veterinary Officer (Gr–A), Buldhana, Maharashtra, India
***Corresponding Author:** drpratikkokate@gmail.com
DOI: https://doi.org/10.5281/zenodo.23139259

Received: October 02, 2026
Published: October 05, 2026
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Abstract:

Ticks are important blood-feeding ectoparasites of livestock, companion animals and wildlife. In addition to causing direct damage and production losses, they transmit several pathogens responsible for important animal and zoonotic diseases. Chemical acaricides have traditionally been the principal method of tick control; however, their repeated use has resulted in the development of acaricide resistance and has raised concerns regarding environmental contamination, residues and toxicity. An integrated approach combining physical, chemical, biological and immunological methods can provide more sustainable tick management. Pasture management, entomopathogenic fungi, parasitoids, entomopathogenic nematodes, botanicals, host resistance and anti-tick vaccines are promising components of such an approach. Regular monitoring of acaricide resistance and rational use of chemicals, together with farmer awareness and adoption of alternative control measures, are essential for sustainable management of ticks and tick-borne diseases.

Keywords: ticks, integrated tick management, acaricide resistance, biological control, anti-tick vaccine, pasture management

Introduction:

Ticks are ubiquitous hematophagous arthropod ectoparasites of major veterinary and public-health importance. There are approximately 920 tick species worldwide and emphasizes their widespread occurrence in livestock. Ticks are also important vectors of pathogens affecting both animals and humans. Ticks are broadly divided into Ixodidae (hard ticks) and Argasidae (soft ticks). Important hard-tick genera include *Hyalomma*, *Rhipicephalus* and *Amblyomma*, while *Argas*, *Ornithodorus* and *Otobius* are among the soft ticks. Their development generally proceeds through egg, larva, nymph and adult stages. The veterinary significance of ticks is largely associated with their ability to transmit pathogens causing

babesiosis, theileriosis and ehrlichiosis, while several tick species are also involved in transmission of important human diseases.

Acaricides and Acaricide Resistance:

Chemical acaricides remain an important component of conventional tick control. Several groups have been used over the years, including organochlorines, organophosphates, carbamates, pyrethroids, formamidines and macrocyclic lactones. These compounds act on different physiological targets, particularly the tick nervous system. However, prolonged and inappropriate use of acaricides can lead to environmental contamination, residues in animal products, toxicity concerns and effects on non-target organisms. The emergence of resistant tick populations is one of the most important limitations of chemical control. Resistance to several acaricide groups has been documented in cattle ticks, particularly *Rhipicephalus (Boophilus) microplus*.

The development of acaricide resistance is influenced by several environmental, human and biological factors. Temperature and vegetation, inappropriate acaricide application, communal grazing, transboundary animal movement, tick biology and host-related factors can all influence resistance development (Foil *et al*., 2004). Genetic changes affecting target sites and detoxification mechanisms can further contribute to resistance (Corley *et al*., 2013). Therefore, regular resistance monitoring and rational selection of acaricides are essential components of effective tick-control programmes (Abbas *et al*., 2014).

Integrated Tick Management:

Integrated tick management involves combining several control measures rather than relying exclusively on chemical treatment. An integrated programme can include physical, chemical, biological and vaccine-based approaches and can be implemented both on the host and in the environment. The objective is not necessarily to eliminate every tick but to maintain tick populations below economically and epidemiologically important levels while reducing selection pressure for acaricide resistance.

1. Physical Management:

Pasture management can help reduce contact between ticks and susceptible hosts. Rotational grazing and pasture spelling can interfere with the tick life cycle by limiting host availability. The cultivation of tick-trapping grasses as a potential pasture-management approach.

Such measures are particularly relevant in organized livestock production systems where grazing patterns can be systematically managed.

2. Biological Control of Ticks:

Biological control offers several possibilities for reducing dependence on chemical acaricides. It includes entomopathogenic fungi, parasitoids, entomopathogenic nematodes, endosymbionts, botanicals, natural predators and breeding of tick-resistant animals.

- ***Entomopathogenic Fungi:*** Entomopathogenic fungi (EPF) are among the most extensively

investigated biological control agents for ticks. i.e. *Metarhizium anisopliae*, *Beauveria bassiana* and *Akanthomyces lecanii* (Fernandes *et al*., 2012). These fungi can infect ticks through the cuticle, followed by fungal growth and eventual death of the host. Their ability to act against different stages of ticks and their potential application both on animals and in the environment make them attractive candidates for integrated control (Rajula *et al*., 2020). Field studies by Webster et al. (2015) showed that, combining *M. anisopliae* with commercial acaricides such as cypermethrin and chlorpyriphos enhanced control of *R. microplus*, with reported efficacy of 97.9%.

- ***Parasitoids and Entomopathogenic Nematodes:*** Tick parasitoids, particularly *Ixodiphagus* species, represent another biological-control possibility because of their host specificity. The seminar lists several *Ixodiphagus* species associated with tick parasitism.

  Entomopathogenic nematodes belonging to Heterorhabditidae and Steinernematidae can locate ticks and introduce symbiotic bacteria that cause mortality. Their potential as biological agents have been investigated because of their ability to act rapidly against susceptible ticks (Glazer, 2001; Alekseev and Samish, 2001).

- ***Tick Endosymbionts: A Novel Target -*** Endosymbiotic microorganisms can influence tick nutrition, development, reproduction, stress responses and immunity (Duron *et al*., 2015). Reproductive-associated bacteria such as *Cardinium* and *Spiroplasma* have also been described in ticks (Perlman *et al*., 2006).

  These interactions create opportunities for novel tick-control strategies. It identifies both chemotherapeutic and immunological approaches targeting endosymbionts, although characterization of the relevant symbiotic organisms remains necessary before these approaches can be effectively developed.

3. Anti-Tick Vaccines and Vaccinomics:

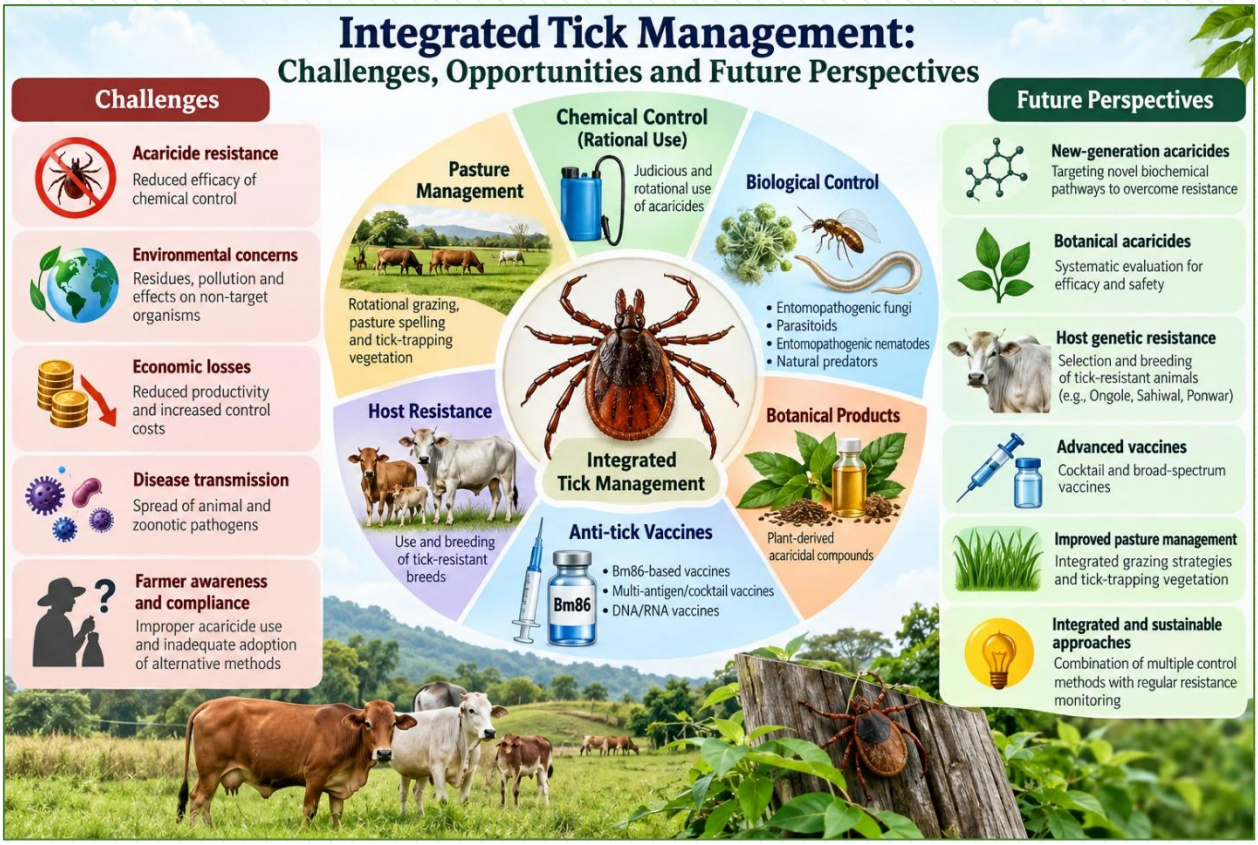
Vaccination provides an immunological alternative to conventional chemical control. Different vaccine approaches under investigation include recombinant, cocktail, anti-idiotype antibody, DNA-based and RNA-based vaccines.

The Bm86 antigen has been an important target in the development of anti-tick vaccines. Vaccines based on Bm86, including GAVAC and TickGARD, have demonstrated promising efficacy against *Rhipicephalus (Boophilus) microplus* and have provided an alternative approach to conventional chemical tick control (Jonsson *et al*., 2000). Such vaccines can reduce tick infestation and reproductive capacity, thereby contributing to integrated tick-management programmes.

Future Opportunities:

New-generation acaricides may target biochemical pathways that have not been extensively exploited by existing compounds. This could help provide alternatives where resistance to conventional

acaricides has developed. Botanical acaricides are another area of interest. Plants and plant-derived products have traditionally been investigated for parasitic control, and systematic evaluation of their efficacy and safety could provide additional tools for integrated tick management (Babar *et al*., 2012).



Host resistance offers a long-term approach through the selection and breeding of tick-resistant animals. Breeds such as Ongole, Sahiwal and Ponwar have been associated with greater resistance to tick infestation (Gaur *et al*., 2002). Similarly, development of cocktail vaccines and broad-spectrum anti-tick vaccines represents an important research opportunity.

Conclusion:

Integrated tick management, combining rational acaricide use with pasture management, biological control, botanicals, host resistance and anti-tick vaccination, offers a sustainable strategy for tick control. Regular monitoring of acaricide resistance and greater use of biological and immunological methods can help reduce dependence on chemical acaricides and improve long-term tick management.

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ISSN: 3048-8397

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