Journal of Communicable Diseases
Volume 53, Issue 3 - 2021, Pg. No. 167-172
Peer Reviewed & Open Access Journal

Review Article

Integrated Pest Management Programs with Special Emphasis on Livestock Production in India: A Review

Athira Kumichiyil Kumaran[1,2], Anis KV[2]

[1]Department of Zoology, Christ College, Irinjalakuda, Thrissur, Kerala, India.
[2]St. Joseph's College (Autonomous), Irinjalakuda, Thrissur, Kerala, India.
DOI: https://doi.org/10.24321/0019.5138.202153

I N F O

Corresponding Author:
Anis KV, St. Joseph's College (Autonomous), Irinjalakuda, Thrissur, Kerala, India.
E-mail Id:
srashachf@gmail.com
Orcid Id:
https://orcid.org/0000-0002-5238-7572
How to cite this article:
Kumaran AK, Anis KV. Integrated Pest Management Programs with Special Emphasis on Livestock Production in India: A Review. J Commun Dis. 2021;53(3):167-172.

Date of Submission: 2021-08-09
Date of Acceptance: 2021-09-17

A B S T R A C T

Ticks are blood-feeding ectoparasites considered as a great role in medical and veterinary science. However, they can transmit a wide variety of infectious agents that significantly impact animals' health and product performance, which negatively reflects the livelihood of resource-poor farming communities, especially in India because 80% of the human population depends on income from dairy farms. This review focused on the problems associated with TBDs and integrated tick control strategies, emphasizing livestock farming systems in India. Developments discussed in the review in the controlling measures such as the efficacy of acaricides, biological control, and recent advances in vaccine development.

Keywords: Ixodidae, Acaricides, Biological Control, Vaccines, Livestock Production

Introduction

The problem of tick-borne diseases and vector control in urban and rural areas has attracted investigation for several years, many recent studies concerning the occurrence of tick abundance and ratification of zoonosis. The dramatic increase of tick population in both zones are correlated with the existence of suitable environmental conditions provided by urban forests, private gardens, public woods, deciduous forest, and agricultural land. The successful survival of ticks depends on optimal temperature, humidity in their habitats, and availability of host, which is the foremost way to disperse tick-borne disease (TBD).[2] Therefore, domestic animal rearing plays a very significant role in the exaltation of economic status. Furthermore, it provides livelihood security through the provision of employment and sustainable household nutrition to poor and pro-poor rural masses of the countries and plentiful exporting of milk products to neighboring states.

In many countries, including India, the fundamental facts about the development of rural communities are entirely dependent on livestock production, which is drastically declined by the efficacy of various parasitic diseases such as lumpy skin disease, Rocky Mountain spotted fever, babesiosis, and anaplasmosis, lyme disease and rickettsial infections to the domestic animals and humans leads to large scale economic losses in India. Due to the unavailability of good quality vaccine from several states and inadequate preventive measures, the poor people from different parts of this continent exposing severe life threatening diseases. And also huge impact on livestock product marketing. That is particularly mediated by ectoparasites, including blood-sucking ticks, flies, mosquitoes and mites are

predominantly inhabited on mammals, birds and reptiles and also humans throughout the world[11] The largest family of hard ticks is Ixodidae contains 14 genera and some of them are medically and veterinary importance includes *Haemaphysalis, Hyalomma, Dermacentor, Rhipicephalus and Amblyomma*.[8] On the other hand, the most important soft ticks belong to the family Argasidae, which contains the genus *Ornithodoros, Argas and Otobius*.[18]

Researchers implemented several scientific approaches for decreasing the risk of parasitic infections including the use of chemicals with repellency and parasiticidal activity, habitat management and other personal and environment-based preventive and control measures,[32,33] genetic selection of hosts with higher resistance to ticks, vaccines and use of Ayurvedhic plant extracts.[5] For more years ago, AD Donald in 1994 demonstrated use of chemical compounds was effective in tick control[9] but the results of continues use development of chemical-resistant ticks along with contamination of the environment and animal products. After the effect of this possible development combined with public concerns over different environmental issues have led to the search for high-quality controlling strategies consistent with sustainable agriculture principles. The Integrated Pest Management (IPM) system established more technological strategies in an environmentally compatible and cost-effective manner to control the target tick population in preferred areas. Several authors forwarded the important point to combine the most cost-effective tick control methods with natural resistant vaccination, particularly in extensive pastoral systems.[31] This review is focused on tick control measures such as chemical, mechanical, biological and efficacy of vaccine and impacts of tick borne disease on domestic ruminants from India, which provide future research directions for the development and implementation of successful vaccine. These effective knowledge grasp from English language tick control papers published in Elsevier, Springer nature, Zootaxa and journal of medical microbiology etc. moreover, the references are added by using the software Endnote X9.

Economic Repercussions of Vector-borne Disease

Production animals play a significant role in the economy and food security of human population throughout the world; for the increase of economic status of poultry and cattle farming is needed to be an appropriate health condition which is negatively converted by pathogenic efficacy of ticks. The blood feeding behavior of ticks varies from species to species, it feed on creature for a long term provide an ample opportunity for transmission of microbes. The enormous rate of tick infestation can cause anemia, and also the invading pathogens can suppress the immunity of host animal there by decrease the productivity of livestock and they become unhealthy leads to death of an animal. Tick-borne diseases continue to be a major constraint on profitable livestock production and the health conditions of animals. In recent years TBDs were freshly ranked as most relevant.[19] The parasitic zoonosis has vastly occurred in tropical and subtropical countries[4] is responsible for severe economic losses both through the direct effects of blood-sucking and indirectly as the transmission of disease-causing microbes, including bacteria viruses, rickettsia and protozoa. Uncontrolled blood-feeding by large numbers of ticks causes a reduction in body weight and severe life-threatening disease to domestic animals.

The impact of ticks on livestock production and health includes tick-borne disease morbidity and mortality, huge loss of milk and meat production, eggs and leather, damage on the quality of the skin and also the cost associated with tick control and treatments. The economic losses due to ticks can be expressed either in body mass or milk production and the financial assessment of individual animals per year. Previous studies demonstrated that tick borne disease can reduce the international trade and exporting of live animals for the domestic ruminant management system, moreover during the maintenance and rearing humans are highly under the risk of TBDs such as rickettsial infection, Q fever, Crimean congo hemorrhagic fever etc. The cattle tick *Rhipicephalus (B) microplus* provides significant role in disease transmission due to their vectorial capacity and vast geographical distribution. Jaime Betancur in 2018 reported global economic loss caused by R. microplus is USD $ 13.9-18.7 billion per year. In order to reduce the possibility of epidemics generated by ticks to develop new strategies to control hard ticks.

Control Measures of Ixodidae

Innumerable successful studies implemented feasible tick control programs in extremely contaminated areas. One of the most useful way to control tick through the application of acaricides, in many industrial farm management centers breaks the life cycle of Ixodes through the use of appropriate chemical compounds. However, a few years ago, relevant studies conclusively proved the drawbacks of acaricides' functions. Ticks have developed an adequate resistance towards the chemical combination[26,30], which makes existing acaricides ineffective and thereby limiting the efficacy of existing tick control methods. Another remaining strategy to control and prevent ticks is manual elimination, which is difficult for a large number of infested animals because the farm employees were highly under the risk of infectious disease, use of highly profitable breeds resistant to ticks and release of sterile male ticks to the area were thoroughly contaminated with parasitic vectors. Sowing of medicinal plants that are unfavorable for ticks, rotation of pastures with forced breaks to intersperse the pest's life span.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.202153

Provide quality food nutrition to improve resistance against tick bite and pathogen transmission. Apply plant extracts and essential oils with acaricidal activity to prevent the attachment of ticks to the host animal. Biological control with nematodes, entomopathogenic fungi, ants, birds, and others carries through safety precautions because the microbes are harmful to humans.

Mechanical Control

Adult females normally lay huge amounts of eggs in cracks and interstice of hut of domestic animals, as a result, the productive critter is highly under the threat of TBDs. Fumigation, scrapping, and periodic burning of farm waste effectively reduce the tick burden on the animals. This practice should be periodically repeated before mixing newly purchased animals to the existing stock on the farm. Manual removal of ticks is another simple way in rural areas where the farmers pick out ticks by using forefingers without any discomfort to the animal, the grasped ticks are twisted by using footwear at the counterclockwise direction to kill them.

Chemical Control

The most probably used method for tick control is the application of acaricides, individual animals are effectively treated with chemical compounds either through washes, pour on, spot on spraying or by dipping. the selection of acaricides is depend on the kind of animal skin and hairy coat.[25] Some of the experimental studies reported the consumption of acaricides in Indian agriculture has been increased more than 100%, because large number of farmers utilized chemical repellents periodically.[14] Commercially available toxicants in India are Pyrethroids, Organophosphates and Carbamates Macrocyclic lactones. Organophosphates and pyrethroids are commercially available on the market in all over the country while formamidines like amitraz and macrocyclic lactones like ivermectin is comparatively recent and is rising due to the inefficiency of OP and SP acaricides to control tick infestations.[16] Previous studies frequently reported the resistivity of ticks in all over the world, in case of cattle tick R. (B). microplus developing resistance to organophosphates and synthetic pyrethroids. Since in India was not well documented the resistant activity of ticks even though possibility of widespread resistance was reported in a FAO questionnaire survey.

A comprehensive study revealed that resistant status of *Rhipicephalus (Boophilus) microplus* to OP and SP compounds at the level varied from low to high collected from different agro-climatic zones of India[27] otherwise in *H. anatolicum* detected less resistance against SP and OP compounds[28,29] and in the next year a relative study documented by Sharma and his colleagues deltamethrin and cypermethrin resistance in the same tick species.

As the base of rural community Ghosh H et al.[14] introduced a major problem in terms of usage of acaricides, which is costly and deleterious to the human beings and its territory and also much more complications in large scale poultry farm that is the residues of toxicants are present in meat and milk. So their use should be minimized to develop a new strategies to control the abundance of ticks.

Biological Control

This is the part of integrated pest management (IPM) system, it means the introduction of biological microorganisms (e.g. fungi, bacteria, nematodes, predators, parasitoids, birds and entomopathogenic) to the areas is highly under the risk of tick infestation. Thereby, it can declines the population growth of ticks.[1,13] Popularly used biological control agent parasitoids belongs to the order Hymenoptera, which is the successive bio controller in most of the cases.[7] Only a few species of hymenopteran include I. hookeri parasites are known to affect ticks.

Researchers delivered a matured new breed of wasps from France, I hookeri have unable to control tick population in Massachusetts USA[21] further workers repeated this experiment over 1 year finally researchers concluded that species can control *Amblyomma variegatum* on a field with 10 infested cattle in Kenya. They documented the survival rate of ticks declined from 44 to 2 per animal.[21] Rodents, birds, ants, spiders, lizards and beetles, nematodes and fungus are attack soil living stages of the ticks like larva and nymph and depending on climatic conditions, these predators can consume a large number of ticks Yet, having such effective importance in the development of a biological tick control methods has been forsake as compared to the control of plant pests or dipterous insects harmful to human population and animals.

Pasture Regulation

The combination of pasture rotation and use of chemical acaricides is one of the profitable method for preventing tick population in grazing land. Truthful conversion of ample vegetation and high rainfall into poor vegetation and inconsistent rainfall and moreover burning of pastures is the significant way to reduce the tick population.[20] Even though pasture management is a sustainable option to reduce ticks species abundance but it is infeasible in India, where many livestock farmers have only small landholdings.

However, this technique is a viable option that can be adapted in a well-organized animal rearing center; this strategy requires good fencing and management skills. Stylosanthes are the most important pasture legumes of tropical India for the humid to semi-arid regions. It can drastically improve the productivity of grazing land, which enhances the quality of animal products[3,6] through the conception of healthy herbs. Government policies oblige

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.202153

this kind of cropping by providing seeds at lower expense and making a medium for communication about animal rearing with experts would positively impact tick control. This kind of management can effectively reduce the use of acaricides; a livestock farmer can produce good quality animal products like milk and meat at a lower cost.

Tick Vaccine

As the base of drawbacks in mechanical and chemical control of ticks, the development of a vaccine against vector is considered as one of the important option. Most of the Vaccines is expensive but eco-friendly that allows controlling various vector-borne diseases. Tick vaccines can prevent the parasitic transmission of *B. bigemina* and reduced passage of *B. bovis* using the Bm86-based vaccine against *B. annulatus*.[24] A fundamental effort of research work developed two recombinant vaccines GavacTM and TickGARDPLUS, against *R. (B.) microplus* are available commercially.[16] These protective vaccines evolved on the basis of midgut protein Bm86. In forgoing experiment of Bm86 found that cross-protection against *R. (B.) annulatus* and *R. (B.) decoloratus* infestations and conferred restricted protection against *Hyalomma* and Rhipicephalus species.[10,23]

However, Bm 86 based vaccine provides incomplete results in several tick species, including *Amblyomma*[6] and against some geographical strains of *R. (B.) microplus*.[12] Earlier work in India has concentrated on immune responses against ticks by immunizing the animals with incompletely purified antigens.[15] On the sake of vaccine development, many research centers and institutions are actively involved, near to the Kerala Karnataka state government successfully made vaccine against Kyasanur forest disease, it is one of the major outbreak happened in southwest peninsular India, the genus successfully transmitted KFDV Haemaphysalis is a significant tick vector found all over the world. On the basis of the increasing death rate in shimoga district in Karnataka, developed formalin inactivated tissue culture vaccine[17] results in drastic decline in death rate.

Highly threatened species of tick extract provide effective resistance against tick infestation, Johnston et.al examined the crude extract of mature female Boophilus microplus. The crude vaccine containing either particulate or additionally with soluble components gives effective immunity. As a result of reaching the crude vaccine in hemocele of ticks some of the ticks die and evoking infertile females up to 70%.[22]

Conclusion

Tick-borne disease is a significant cause of economic losses to the dairy farms of resource-poor farming communities like India. The decreased outputs of animal products, by-products, and manure contribute to production and productivity losses and severe epidemic disease to the vertebrates. Long term applications of chemical acaricides leads to the development of resistance and detrimental effects on environment and human beings. Recently developed acaricides have tended to be more costly, so most small and marginal farmers are utilizing indigenous methods to get rid of tick infestations. Biological control and pasture management are efficacious for pest control but do not provide a complete cure for tick bites and vector-borne diseases. The introduction of wild aves to cattle management is a difficult technique to control ticks. The Indian government and NGO providing funds to investigate TTBDs and implement more accurate strategies to control tick vectors. Additional research initiatives are to be taken by the Indian Council of Medical Research and vector control research center to work on the development of tick vaccine against *H. spinigera, H. bispinosa, Rhipicephalus Boophilus microplus* and *R. appendiculatus* infestations on animals, which is expected to reduce the transmission of Kyasanur forest disease virus, Crimean congo haemorrhagic fever virus and Alkhurma hemorrhagic fever virus to animals. In the twenty first century several tick borne viral and bacterial diseases are re- emerged to cause great economic loss to the owners of livestock farm. Most of the zoonotic diseases affect the quality milk and meat production by reducing immunity and body mass of the host. The modern society majorly depend on meat product in daily life, so infested materials are atrocious for human being. That's why urgent need of implementation of vector control system to minimize the pandemic situations.

Conflict of Interest: None

References

1. Abdigoudarzi M, Esmaeilnia K, Shariat N. Laboratory study on biological control of ticks (Acari: Ixodidae) by entomopathogenic indigenous fungi (Beauveria bassiana). Iran J Arthropod Borne Dis. 2009;3(2):36-43. [PubMed] [Google Scholar]
2. Brites-Neto J, Duarte KMR, Martins TF. Tick-borne infections in human and animal population worldwide. Vet World. 2015 Mar;8(3):301-15. [PubMed] [Google Scholar]
3. Chandra A, Pathak P, Bhatt R. Stylosanthes research in India: prospects and challenges ahead. Current Science. 2006;90(7):915-21. [Google Scholar]
4. de Castro JJ. Sustainable tick and tickborne disease control in livestock improvement in developing countries. Vet Parasitol. 1997 Jul;71(2-3):77-97. [PubMed] [Google Scholar]
5. de la Fuente J. Controlling ticks and tick-borne diseases. looking forward. Ticks Tick Borne Dis. 2018 Jul;9(5):1354-7. [PubMed] [Google Scholar]
6. De Vos S, Zeinstra L, Taoufik A, Willadsen P, Jongejan

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.202153

F. Evidence for the utility of the Bm86 antigen from Boophilus microplus in vaccination against other tick species. Exp Appl Acarol. 2001;25(3):245-61. [PubMed] [Google Scholar]
7. DeBach P, Becher, Rosen D. Biological control by natural enemies. CUP Archive, 1991. [Google Scholar]
8. Gerem B, Eskezia B, Desta A. Review on the impact of ticks on livestock health and productivity. J Biol Agric Health. 2016;6(22):1-7. [Google Scholar]
9. Donald A. Parasites, animal production and sustainable development. Vet Parasitol. 1994 Aug;54(1-3):27-47. [PubMed] [Google Scholar]
10. Fragoso H, Rad PH, Ortiz M, Rodriguez M, Redondo M, Herrera L, De la Fuente J. Protection against Boophilus annulatus infestations in cattle vaccinated with the B. microplus Bm86-containing vaccine Gavac. Vaccine. 1998 Dec;16(20):1990-92. [PubMed] [Google Scholar]
11. Furman DP, Loomis EC. The ticks of California (Acari: Ixodida). University of California Press, 1984;25.
12. García-García JC, Gonzalez IL, González DM, Valdés M, Méndez L, Lamberti J, Ortiz M. Sequence variations in the Boophilus microplus Bm86 locus and implications for immunoprotection in cattle vaccinated with this antigen. Exp Appl Acarol. 1999 Nov;23(11):883-95. [PubMed] [Google Scholar]
13. George J, Pound J, Davey R. Acaricides for controlling ticks on cattle and the problem of acaricide resistance. Ticks: biology, disease and control, 2008;408-423. [Google Scholar]
14. Ghosh S, Azhahianambi P, de la Fuente J. Control of ticks of ruminants, with special emphasis on livestock farming systems in India: present and future possibilities for integrated control-a review. Exp Appl Acarol. 2006;40(1):49-66. [PubMed] [Google Scholar]
15. Ghosh S, Khan M. Studies on immunological control of ticks. II: Immunization of cattle against Boophilus microplus using tick extract supernatant antigen. J Vet Parasitol. 1996;10:33-7.
16. Ghosh S, Nagar G. Problem of ticks and tick-borne diseases in India with special emphasis on progress in tick control research: a review. J Vector Borne Dis. 2014 Dec;51(4):259-70. [PubMed] [Google Scholar]
17. Holbrook MR. Kyasanur forest disease. Antiviral research. 2012;96(3):353-362. [PubMed] [Google Scholar]
18. Hurtado OJB, Giraldo-Ríos C. Economic and health impact of the ticks in production animals. Ticks and Tick-Borne Pathogens. Books on Demand, 2019;1-19. [Google Scholar]
19. Minjauw B, McLeod A. Epidemiology and economics of tick-borne diseases: their effects on the livelihoods of the poor in East and Southern Africa and in India. Consultancy report to the Animal Health Programme (AHP) of the Department for International Development (DFID), Nairobi, Kenya. 2000;94.
20. Mondal D, Sarma K, Saravanan M. Upcoming of the integrated tick control program of ruminants with special emphasis on livestock farming system in India. Ticks Tick Borne Dis. 2013 Feb;4(1-2):1-10. [PubMed] [Google Scholar]
21. Mwangi EN, Hassan SM, Kaaya GP, Essuman S. The impact of Ixodiphagus hookeri, a tick parasitoid, on Ambl yomma variegatum (Acari: Ixodidae) in a field trial in Kenya. Exp Appl Acarol. 1997 Feb;21(2):117-26. [PubMed] [Google Scholar]
22. Nath S, Mandal S, Pal S, Jadhao S, Ottalwar N, Sanyal PK. Impact and management of acaricide resistance: pertaining to sustainable control of ticks. Int J Livest Res. 2018;8(10):46-60. [Google Scholar]
23. Perez-Perez D, Bechara GH, Machado RZ, Andrade GM, Del Vecchio RE, Pedroso MS, Hernández MV, Farnós O. Efficacy of the Bm86 antigen against immature instars and adults of the dog tick Rhipicephalus sanguineus (Latreille, 1806) (Acari: Ixodidae). Vet Parasitol. 2010 Feb;167(2-4):321-6. [PubMed] [Google Scholar]
24. Pipano E, Alekceev E, Galker F, Fish L, Samish M, Shkap V. Immunity against Boophilus annulatus induced by the Bm86 (Tick-GARD) vaccine. Exp Appl Acarol. 2003;29(1-2):141-9. [PubMed] [Google Scholar]
25. Radostits OM, Gay CC, Hinchcliff KW, Constable PD. Veterinary medicine e-book: a textbook of the diseases of cattle, horses, sheep, pigs and goats. Elsevier Health Sciences, 2006. [Google Scholar]
26. Rodríguez-Vivas RI, Rosado-Aguilar JA, Ojeda-Chi MM, Pérez-Cogollo LC, Trinidad-Martínez I, Bolio-González ME. Control integrado de garrapatas en la ganadería bovina. Ecosistemas y Recursos Agropecuarios. 2014;1(3):295-308. [Google Scholar]
27. Sharma AK, Kumar R, Kumar S, Nagar G, Singh NK, Rawat SS, Ghosh S. Deltamethrin and cypermethrin resistance status of Rhipicephalus (Boophilus) microplus collected from six agro-climatic regions of India. Vet Parasitol. 2012 Sep;188(3-4):337-45. [PubMed] [Google Scholar]
28. Shyma K, Kumar S, Sangwan A, Sharma AK, Nagar G, Ray D, Ghosh S. Acaricide resistance status of Rhipicephalus (Boophilus) microplus and *Hyalomma* anatolicum collected from Haryana and Rajasthan states of India. Exp Appl Acarol. 2016 Aug;69(4):487-500. [PubMed] [Google Scholar]
29. Shyma K, Kumar S, Sharma AK, Ray D, Ghosh S. Acaricide resistance status in Indian isolates of *Hyalomma* anatolicum. Exp Appl Acarol. 2012 Dec;58(4):471-81. [PubMed] [Google Scholar]
30. Karaağaç SU. Insecticide resistance. Insecticides - advances in integrated pest management. 1st ed. Croatia: In Tech. 2012;469-478.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.202153

31. Willadsen P, Bird P, Cobon G, Hungerford J. Commercialisation of a recombinant vaccine against Boophilus microplus. Parasitology. 1995;110(S1):S43-50. [PubMed] [Google Scholar]
32. Anoopkumar, A., Aneesh, E.M. A critical assessment of mosquito control and the influence of climate change on mosquito-borne disease epidemics. Environ Dev Sustain (2021). https://doi.org/10.1007/s10668-021-01792-4
33. Anoopkumar, A.N., Aneesh, E.M. Environmental epidemiology and neurological manifestations of dengue serotypes with special inference on molecular trends, virus detection, and pathogenicity. Environ Dev Sustain 23, 11217–11239 (2021). https://doi.org/10.1007/s10668-020-01161-7

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.202153