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Pheromone based tick control: A sustainable alternative to chemical control

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Abstract

Ticks are major vectors of pathogens affecting livestock and companion animals, and their control has traditionally depended on chemical acaricides. However, the emergence of acaricide resistance, concerns over chemical residues in animal products and environmental contamination have prompted the search for safer and more sustainable alternatives. Among the novel approaches being investigated, pheromone-based tick control has attracted considerable interest because it exploits the natural chemical communication of ticks to manipulate their behaviour. Tick pheromones, including assembly, attraction-aggregation-attachment and sex pheromones, have been successfully incorporated into innovative control strategies such as mating disruption, tick decoys, pheromone-baited traps and controlled-release formulations. Combining pheromones with biodegradable delivery systems, plant-derived acaricides and entomopathogenic fungi further enhance their potential as environmentally benign tools for integrated tick management. This article highlights the biology of tick pheromones, recent advances in pheromone-based technologies and their prospects as sustainable alternatives to conventional tick control.

Key words:- Semiochemicals, pheromones, tick control

Introduction

Ticks are important vectors of several haemoprotozoan and rickettsial pathogens affecting livestock and companion animals. For decades, tick control has relied mainly on the extensive use of chemical acaricides. However, indiscriminate and repeated application of these chemicals has resulted in the widespread development of acaricide resistance in many tick populations. In addition, concerns regarding chemical residues in animal products and environmental contamination have intensified the search for safer and more sustainable alternatives.

Several non-chemical and integrated approaches have been explored with varying levels of success. Among these, pheromone-based control has emerged as a promising strategy because of its target specificity, minimal environmental impact, and reduced reliance on chemical acaricides. Having proved highly successful in agricultural pest management, pheromone-based technologies are now attracting increasing attention as potential tools for integrated tick management.

Semiochemicals

Semiochemicals are chemical substances that mediate communication between arthropods and influence their behaviour. Based on the nature of the interaction and the organisms involved, semiochemicals are broadly classified into kairamones, allomones, and pheromones (Sonenshine, 1985). Kairamones are chemical signals produced by one species that elicit a response in another species, providing an advantage to the receiving organism. In contrast, allomones facilitate interspecific communication in a manner that benefits the emitting organism. Pheromones are chemical signals involved in communication among individuals of the same species and play a crucial role in regulating various behavioural and physiological activities.

Tick pheromones

Three major classes of pheromones have been identified in ticks: assembly pheromones (APs), attraction-aggregation-attachment pheromones (AAAPs), and sex pheromones (Sonenshine, 2004).

Assembly pheromones are non-volatile, water-soluble metabolites of the blood meal and consist mainly of purine derivatives such as adenine, guanine, xanthine and hematin. These compounds promote clustering of ticks, thereby enhancing survival in favourable microclimates and facilitating host location. The AAAP is a mixture of organic volatile compounds secreted by feeding male ticks that attract unfed males and females to aggregate on the host for feeding. Sex pheromones regulate mate recognition and mating behaviour, ensuring successful reproduction and include attractant sex pheromone, mounting sex pheromone and genital sex pheromone.

Pheromone-based tick control

The behavioural responses of ticks to pheromones have been exploited to develop innovative control strategies. In these approaches, pheromones are combined with small quantities of acaricides to lure ticks to treated sites where they acquire a lethal dose of the

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chemical. Since only minute quantities of acaricides are required, these methods reduce environmental contamination and may help delay the development of acaricide resistance.

One such strategy is mating disruption, in which synthetic sex pheromones are used as behavioural confusants. Sex pheromones such as 2,6-dichlorophenol (2,6-DCP), applied together with small amounts of acaricide on the host animal, stimulate mate-searching behaviour in male ticks. Unable to locate females, the males fail to mate, thereby reducing tick reproduction.

Another innovative approach for using pheromones in tick control was the development of tick decoys, which exploited the natural behaviour of ticks to improve control efficiency. In these systems, sex or AAAPs were combined with small quantities of acaricides in plastic tags attached to livestock. Attracted by the pheromone cues, ticks move towards the tags and are eliminated upon contact with the acaricide. This targeted approach reduces tick infestations while minimizing indiscriminate pesticide application.

A further advancement was the development of the patented LastCall™ device, in which assembly pheromone components were incorporated with acaricides into oil droplets and sprayed onto vegetation. By attracting host-seeking ticks in the environment, the system provided targeted suppression of free-living tick populations and showed encouraging results in field evaluations.

Controlled-release micro and nano formulations of pheromones have been developed to improve the longevity and effectiveness of pheromone-based interventions. Biodegradable materials such as calcium alginate and chitosan, as well as synthetic polymers including polycaprolactone, have been used to encapsulate pheromones with or without acaricides. These formulations ensure sustained release of pheromones over extended periods, maintaining attraction and improving efficacy under laboratory and field conditions. Tick control devices using AP or sex pheromone microparticles have shown high efficacy in controlling environmental stages of ticks in cattle sheds and kennels.

Recent advances in formulation and delivery technologies have broadened the potential of pheromone-based tick control. Researchers have developed pheromone-impregnated vapour patches for use in kennels, while eco-friendly approaches such as biodegradable microparticles carrying plant-derived acaricidal compounds and solar-powered pheromone traps are also being explored. Another promising innovation combines pheromones with entomopathogenic fungi. In these systems, pheromones attract ticks to baited traps, where they become infected with the fungi and eventually die. Although most of these technologies are still under

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experimental evaluation, they demonstrate the potential of pheromone-based approaches to become environmentally sustainable tools within integrated tick management programmes.

More recently, semiochemicals have also been investigated as natural tick repellents. Certain volatile compounds, including benzaldehyde and 2-hexanone, which occur naturally in the scent of some dog breeds such as beagles, have been found to deter ticks. Experimental formulations containing these compounds have shown encouraging repellent activity, opening new possibilities for the development of safe and environmentally friendly tick control products.

Conclusion

Pheromone-based tick control represents a promising shift from conventional chemical-dependent approaches towards more targeted and environmentally sustainable management strategies. By exploiting the natural behavioural responses of ticks, these technologies enable the use of substantially lower quantities of acaricides while maintaining effective control. Innovations such as mating disruption, pheromone-based decoys, controlled-release formulations and pheromone-assisted biological control have demonstrated encouraging results under experimental and field conditions. Although most of these approaches are yet to be commercialised on a large scale, they provide valuable components for integrated tick management programmes. Continued research and technological refinement are likely to improve their practicality, affordability and field performance, ultimately reducing the dependence on conventional acaricides.

Future Prospects

Future research on pheromone-based tick control should focus on developing cost-effective formulations suitable for field use. Advances in nanotechnology, biodegradable controlled-release systems and smart delivery devices are expected to improve pheromone stability and longevity under diverse environmental conditions. Combining pheromones with biological control agents such as entomopathogenic fungi, botanical acaricides or anti-tick vaccines could provide highly effective integrated management strategies with minimal environmental impact. The integration of pheromone-based technologies with precision livestock farming, sensor-based monitoring and automated trapping systems also offers exciting opportunities for early detection and targeted tick control. With continued interdisciplinary research and successful field validation, pheromone-based approaches have the potential to become an important component of sustainable tick management programmes, benefiting livestock production, companion animal health and public health.

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