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Entomopathogenic Fungi: Bioinsectcide For Tick Control

Dr. Abhisek Mishra[1*], Dr. Asha Yadav[1], Dr. Naitam Sneha Kanhaiya[2]
[1]*MVSc Scholar, Veterinary Medicine, ICAR- IVRI*
[2]*MVSc Scholar, Veterinary Microbiology, ICAR- IVRI*
***Corresponding Author:** abhisekmishrabunu1998@gmail.com
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Abstract:

Ticks pose significant health threats to humans and animals, transmitting diseases and causing direct harm through blood feeding. Traditional control methods face limitations due to safety, environmental concerns, and the growing tick populations influenced by climate change. Entomopathogenic fungi (EPFs), such as *Beauveria bassiana* and *Metarhizium anisopliae*, have emerged as promising alternatives to chemical pesticides, effectively targeting all life stages of ticks. These fungi exhibit direct and indirect effects on ticks, disrupting their reproductive capabilities and reducing disease spread. However, their efficacy can be hindered by environmental conditions, tick species variability, and defense mechanisms developed by hosts. Despite the challenges, EPFs represent a sustainable approach to pest management, necessitating further research to optimize their application in integrated tick control strategies while ensuring safety for non-target organisms.

Keywords: Entomopathogenic fungi, *Metarhizium anisopliae, Beauveria bassiana, Purpureocillium lilacinum*, Bioinsecticide, Tick control

Introduction:

Ticks are among the most troublesome parasitic pests in the world. Ticks extensively infest people, animals, and their pets. They spread serious veterinary and medical diseases and have a direct detrimental impact on their hosts by feeding on blood. Blood loss, alopecia, fatal paralysis (some ticks can inject toxins), and exsanguination are just a few of the additional direct effects that ticks have on the health and well-being of their hosts in addition to their role as biological and mechanical disease vectors. These effects can affect humans, livestock, and wild animals. Problems with product performance, availability, and environmental safety make it difficult to control ticks with traditional chemical methods, but tick management is essential, especially since populations of some species may be growing due to climate change. Ixodid and Argasid ticks are both linked to the spread of harmful pathogens. The Ixodid tick fauna is made up of more than 700 species worldwide and is separated into two groups: the Metastriata, which includes more than 200 species, and the Prostriata, which includes the *Ixodes* genus. In terms of abundance, distribution, and contribution to tick-borne diseases (TBDs), the most significant species worldwide are the brown dog tick (*Rhipicephalus sanguineus*), *I. ricinus* (which is most common in Europe), *Dermacentor reticulatus* and Ixodes persulcatus (which are found in Siberia and more widely in Asia), and the deer tick (*I. scapularis*), which is found in most parts of North America and is a major vector of Lyme disease. Several fungal species are well suited to arthropod control because they can cause epizootic infections, and the majority of them infect their hosts directly through the arthropod's tegument. The majority of the organisms are associated with biological pest control, but they have also been used to combat some livestock ectoparasites in recent years. *Metarhizium anisopliae* and *Beauveria bassiana* are the fungi that have been studied the most as tick control agents. Entomopathogenic fungi's potential as tick-control agents, however, is frequently underestimated because they are thought to be too limited by the environmental conditions found in tick habitats.

Mode of Action of Entomopathogenic Fungi and Its Effects:

Certain species, like *B. bassiana* and *M. anisopliae*, have emerged as "classic" examples of bioinsecticide candidates in specific geographic regions, providing alternatives to chemical pesticides where they are neither environmentally nor economically sustainable. Entomopathogenic fungi are already widely used in some areas of pest management. Additionally, they may have both direct and indirect effects on their hosts, such as ticks, which can be used to control pests. For instance, it has been demonstrated that *Metarhizium* species can influence ticks' feeding habits in the field, resulting in sub-lethal effects. EPFs have the ability to control ticks at all stages of their life cycle, including eggs, larvae, nymphs, adults, and engorged females, whether directly or indirectly. It should come as no surprise that this control also lowers the spread of tick-borne diseases. According to one study, *M. anisopliae* and *B. bassiana* both decreased egg hatchability (EH), increased egg incubation period (EIP), and increased egg hatchability period (EHP) when used against R. microplus ticks. Likewise, it was reported that exposure to *B. bassiana* and *M. anisopliae* decreased the egg hatchability of *Rhipicephalus appendiculatus* and *Amblyomma variegatum*; however, the effectiveness of both EPFs varied according to their formulation.

Using hydrophobic mechanisms, EPF conidia that are airborne settle on the host's cuticle surface. The adhesins and hydrophobins, two surface proteins that have been found in *B. bassiana* and show the presence of homologous proteins, are the main mediators of this adhesion process. Conidia enter a germination phase, which is aided by favorable environmental conditions, after they have firmly attached to a host. In order for EPFs to penetrate the tick's cuticle, a germination tube is created during this process, and then an appressorium or penetration peg is formed. Penetration is an active process that requires the physical force of the penetration peg or appressorium as well as the coordinated activity of hydrolytic cuticular enzymes such as lipases, chitinases and proteases. The EPF grows to produce both mycelium and spores after entering the host. These structures multiply throughout the tick's body, invading different tissues with the help of its circulatory system. This colonization process facilitates the establishment and absorption of nutrients within the host. Beauvericin, Beauverolides, Bassiannolide, and Destruxins are among the mycotoxins that are produced by different EPF species during their growth and are important toxic substances that target ticks. The tick's cellular processes, flaccid paralysis, Malpighian tubes, muscular tissues, and middle intestine are just a few of the structures and functions that these toxins can affect. The fungus penetrates the outer layer of the host, produces aerial mycelia, and starts the sporulation process on the cadaver to help spread the fungal biomass to infect a new host after the host completely passes away from the infection and the EPFs' nutrient resources are exhausted.

It is well known that entomopathogenic fungi can infect the eggs of different tick and insect species. *Purpureocillium lilacinum* is one such particular fungus that has been shown to infect tick eggs and prevent the emergence of larvae from them by generating enzymes that degrade the protective eggshell. Interestingly, *P. lilacinum* secretes serine protease enzymes, which are crucial in altering the tick eggshell's structure. EPFs parasitize tick eggs using a variety of different methods in addition to the enzymatic one. Fungal spores can adhere to the surface of tick eggs and pierce the eggshell, which could directly kill the developing embryos or cause the egg to develop abnormally, which would prevent tick embryos from developing normally. Tick population growth may be impacted by the emergence of aberrant or weaker larvae that have a lower chance of surviving, decreased hatchability, or delayed hatching from eggs.

Limitations of Entomopathogenic Fungi:

- EPFs may also be negatively impacted by contemporary tick control techniques, such as synthetic acaricides that alter tick physiology, reproduction, or survival. Since other acaricides have shown that traditional controls and EPFs are incompatible, caution must be exercised when incorporating EPFs into integrated tick management programs.
- The type of tick and its developmental stage can affect how effective EPFs are; some fungi are more effective against particular tick species than others, while others have little to no effect.
- Since these fungi are highly sensitive to heat, humidity, and ultraviolet light (UV-A and UV-B), the environment in which EPFs are used is crucial to their success. Suboptimal environmental conditions hinder fungal growth and lessen the ability of EPFs to effectively infect and kill ticks.
- Several arthropod hosts have developed defenses against EPF infestation, including the production of metabolites that reduce the effectiveness of EPFs.
- One more limitation on the use of EPFs is their availability and accessibility. The fact that there are relatively few fungal strains and formulations designed especially for tick control, despite the fact that there are many commercially available products containing EPF species, may be a reflection of the challenges in overcoming issues with EPFs' durability and persistence in the outdoor environment where they would need to function in order to target these pests.
- It's also important to take into account any possible safety risks associated with using EPFs. Certain precautions must be taken to minimize any possible cross-species hazards, particularly for other invertebrates, even though these fungi are generally believed to be safe for humans and other non-target organisms.

Conclusions:

EPFs are a unique class of microorganisms that have a great deal of promise as biological control agents for ticks and other vertebrates. There is a growing need for environmentally friendly and sustainable tick control methods as the drawbacks and detrimental effects of chemical acaricides become more apparent. In both laboratory and field settings, EPFs have proven effective in controlling a variety of tick species, including species from the genera *Beauveria*, *Metarhizium*, *Lecanicillium*, and *Isaria*. Researchers will be able to select strains that will provide safe, effective tick control that complements the local co-control techniques being used and reduces risks to non-target organisms and the larger community by improving their understanding of the mode of action of EPF. Understanding the ecological interactions between these fungi and their hosts—including the elements that affect successful colonization, like inoculation techniques and environmental sensitivity—has been the main focus of research efforts. Even though only a few fungal species are currently used commercially, continued research is opening the door for both the creation of new EPF species for commercial use and the more effective use of currently available products.

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