VETERINARY TODAY
ISSN: 2583-8288
Technical Article
Published on: 31.12.2024

Entomopathogenic Fungi in control of Ticks

Manaswini Dehuri
Assistant Professor,
Department of Veterinary Parasitology,
Odisha University of Agriculture and Technology, Bhubaneswar-751003, India

DOI:10.5281/Vettoday.14583109

Abstract: Since the advent of broad-spectrum parasiticides, they have been widely utilized by farmers to manage or eradicate ticks. Biological control methods like Entomopathogenic fungi can contribute to biodiversity conservation in natural ecosystems and can complement synthetic chemical products without leaving harmful residues in the environment. EPFs can be commercially developed for use as biopesticides, however the effectiveness, longevity, and infectivity of fungal spores under field conditions remain suboptimal. Genera such as *Beauveria*, *Metarhizium*, *Lecanicillium*, and *Isaria* are relatively easy to mass-produce. Gaining a deeper understanding of the fungus's biology can enhance its effective application under field conditions. The ovicidal properties of the fungi could aid in suppressing seed tick emergence, thereby contributing to overall tick population control.

Introduction

Tick control primarily relies on the use of chemical acaricides, which have significantly contributed to the sustainability of livestock production in recent decades. Recent global findings indicate that parasite control strategies relying solely on rigorous chemical applications are not sustainable with the emergence of resistant or multi-resistant parasites, as well as improper application methods, which can reduce their effectiveness as well as the negative effect on environment. The widespread prevalence of these issues affects various stakeholders, including the pharmaceutical industry, professionals, farmers, and public health sectors.

Entomopathogenic fungi (EPF) are a group of fungal pathogens targeting arthropods, are cosmopolitan saprophytic organisms inhabiting diverse ecosystems and climates, where they interact with arthropods. There is existence of about 1,000 EPF species, spanning over 100 genera which can play a critical role in regulating arthropod populations within natural ecosystems. The EPF interactions with arthropods hold significance for environmental microbiology, ecosystem balance, biodiversity, the evolution of eukaryotic organisms, and pest management

EPF exhibit evolutionary adaptability to enhance their biological cycles and are capable of colonizing arthropods for reproductive purposes. Using EPF as a biological control method presents a promising, sustainable approach to tick management and can be integrated into comprehensive pest management strategies. Moreover, they offer advantages over traditional acaricides, such as cost-effectiveness, minimal adverse effects on non-target organisms, reduced environmental and food contamination by chemical residues, and short fungal generation times, enabling high production.

EPFs initiate infection by recognizing their host and adhering to the host's cuticle, where conidia germinate and form hyphae and appressoria. These structures apply mechanical pressure and secrete enzymes to breach the cuticle, allowing the fungi to invade the host's body, ultimately leading to death. The fungal mycelium then colonizes the cadaver and emerges from the cuticle to perpetuate its vegetative cycle. The germination of conidia and the development of appressoria are critical interactions between EPFs and arthropod hosts. The lipid composition of a tick's epicuticle significantly influences the germination of fungal conidia, resulting in tick mortality.

It has been observed that combining *Metarhizium anisopliae* with commercial acaricides (cypermethrin and chlorpyrifos) achieved a high tick control efficacy against *Rhipicephalus microplus*. The most extensively studied EPF species for tick control include *Metarhizium anisopliae* , *Beauveria bassiana*, and *Akanthomyces lecanii*.

Mode of action

- The mode of infection of entomopathogenic fungi offers key advantages over traditional acaricides due to their diverse mechanisms for colonizing and eliminating ticks. These fungi utilize enzymatic, toxicological, and mechanical invasion strategies, which make it challenging for ticks to develop resistance against them.
- They can target nearly all life stages of arthropods, providing a significant advantage in pest management strategies.
- identification of a susceptible host
- conidial adhesion and germination on the host's cuticle;
- formation of specific structures like germ tubes and appressoria
- penetration through the cuticle- The penetration involving spore adhesion, germination, and enzymatic or physical penetration of the host cuticle—these processes are influenced by environmental factors such as temperature and humidity
- rapid fungal growth leading to the host's death- mycelial proliferation within the hemocoel; and production of toxic metabolites.
- conidial production as fungal hyphae emerge from the host- after the host's death, fungi reproduce on its cuticle, producing conidia that may infect other hosts under favorable environmental conditions.
- Among fungal toxins, destruxins, secondary metabolites produced by isolates like *M. anisopliae* are well-known. These compounds exhibit multiple bioactivities, including insecticidal, herbicidal, and antiviral properties. The virulence of EPF is largely determined by the genetic makeup of individual isolates. However, laboratory manipulation can enhance or diminish virulence levels depending on factors like inappropriate cultivation media, suboptimal pH or temperature, and frequent transfers in artificial culture can reduce virulence. Genetic manipulation, including the addition or deletion of genes, has also been employed to improve fungal efficacy . The virulence of a *M. anisopliae* isolate was enhanced by inserting additional copies of the Pr1 gene, responsible for encoding a cuticle-degrading protease, under an active *Aspergillus* promoter. This genetic modification resulted in continuous Pr1 expression, increasing mortality rates and reducing the time required to kill targets. Similarly, expressing scorpion toxin AaIT in *M. anisopliae* improved its effectiveness against multiple insect species

Application of fungi

- The field applications of EPF conidia have shown promise in tick control, especially when applied to hosts in protected environments that shield fungi from extreme conditions like UV radiation, heat, and desiccation.
- Aqueous suspensions of EPF conidia applied to pastures have also yielded good results .This approach is particularly effective for tick species with life cycles that involve significant time off the host, such as during ecdysis or host-seeking phases. However, due to the large grazing areas in tropical and subtropical regions, direct application to hosts might be more economically viable for controlling cattle ticks like *R. microplus* .
- Advanced formulations and technologies, such as photoprotective agents and oil-based formulations, have been developed to mitigate the effects of environmental factors like UV radiation. Nanotechnology offers promising solutions for enhancing fungal efficacy, with microencapsulation protecting conidia from adverse conditions and improving biocontrol performance.
- To invade their host, EPFs must first penetrate the epicuticle, the outermost layer of the cuticle, which primarily comprises esterified lipids that vary among host species. The adherence of conidia to the host is facilitated by various proteins and lipolytic enzymes. These enzymes not only assist in host recognition but also disrupt the lipid balance in ticks, impairing their survival and reducing their reproductive capabilities.
- In ticks, the invasion pattern of *Metarhizium anisopliae* differs from that seen in insects, exhibiting simultaneous internal and cuticular fungal growth. Ticks possess a lower chitin content and unique

protein arrangements in the female alloscutum, which allows rapid expansion during feeding. These structural differences make ticks particularly susceptible to fungal attack. The accelerated degradation of the tick cuticle due to fungal activity leads to increased water loss, hastening the death of the tick.

- To achieve the desired impact on tick mortality (knockdown effect), the concentration of conidia plays a crucial role, with higher doses resulting in greater mortality rates. *Metarhizium anisopliae* demonstrates limited effectiveness when applied to the skin surface due to elevated temperatures that diminish conidial efficacy. The performance of the fungus may also decline in environments with low water availability.
- However, a major limitation to their widespread application is their sensitivity to environmental factors, including temperature, ultraviolet radiation, and the necessity for sufficient moisture to support conidial germination. Nonetheless, EPFs present a minimal risk of resistance development, even with their extended persistence in the environment.

References

Alcalá-Gómez, J., Cruz-Vázquez, C., Fernández-Ruvalcaba, M., Ángel-Sahagún, C., Vitela-Mendoza, I., and Ramos-Parra, M. (2017). Virulence of Metarhizium anisopliae and Beauveria bassiana isolates and the effects of fungal infection on the reproduction potential of Rhiphicephalus microplus engorged females. Biocontrol. Sci. Techn. 27, 931–939.

Alonso-Díaz MA and Fernández-Salas A (2021) Entomopathogenic Fungi for Tick Control in Cattle Livestock From Mexico. Front. Fungal Biol. 2:657694.

Beys da Silva W. O. Santi L. Corrẽa A. P. F. Silva L. A. D. Bresciani F. R. and Schrank, A. . (2010a). The entomopathogen Metarhizium anisopliae can modulate the secretion of lipolytic enzymes in response to different substrates including components of arthropod cuticle. Fungal Biol. 114, 911–916.

Bram, R. A. (1994). Integrated control of ectoparasites. Rev. Off. Int. Epizoot. 13, 1357–1365.

De Alva, R. (1995). “Creating new products for animal health,” in Tercer Seminario Internacional de Parasitologia Animal, ed S. Rodríguez-Camarillo, and H. Fragoso-Sánchez (Acapulco), 86–87.

Dehuri, M., Panda, M., Sahoo, N., Mohanty, B., & Behera, B. (2022). Nested PCR assay for detection of Theileria annulata in Hyalomma anatolicum infesting cattle from coastal Odisha, India. Animal biotechnology, 33(6), 1229–1234.

Fernandes, É. K., Bittencourt, V. R., and Roberts, D. W. (2012). Perspectives on the potential of entomopathogenic fungi in biological control of ticks. Exp. Parasitol. 130, 300–305.

Kiss, T., Cadar, D., and Spînu, M. (2012). Tick prevention at a crossroad: new and renewed solutions. Vet. Parasitol. 187, 357–366.

Ojeda-Chi, M. M., Rodriguez-Vivas, R. I., Galindo-Velasco, E., and Lezama-Gutiérrrez, R. (2010). Laboratory and field evaluation of Metarhizium anisopliae (Deuteromycotina: Hyphomycetes) for the control of Rhipicephalus microplus (Acari: Ixodidae) in the Mexican tropics. Vet. Parasitol. 170, 348–354.

Rajula, J., Rahman, A., and Krutmuang, P. (2020). Entomopathogenic fungi in Southeast Asia and Africa and their possible adoption in biological control. Biol. Control. 151:104399.

Skinner, M., Parker, B. L., and Kim, J. S. (2014). Role of entomopathogenic fungi in integrated pest management. J. Integ. Pest. Manag. 10, 169–191.