



Unveiling Host Defense Networks: Worm Resistance Mechanisms and Mechanisms by Which Hosts Resist Worm Infections

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Abstract

Worm infections pose significant threats to human health, animal welfare, and agricultural productivity worldwide. Understanding the mechanisms underlying host resistance to worm infections is crucial for the development of effective control strategies. This research article provides an overview of the current knowledge on the mechanisms of worm resistance, drawing insights from immunology, genetics, and other relevant disciplines. We discuss the role of the host immune system in recognizing and eliminating worm infections, the genetic factors influencing host susceptibility, and the interplay between environmental factors and host-parasite interactions. Additionally, we explore emerging research areas such as vaccine development, nutritional interventions, and the impact of drug resistance on worm control strategies. By extracting the findings from diverse fields of study, this article aims to contribute to the advancement of our understanding of worm resistance mechanisms and may help to inform future research directions.

Keywords: Drug Resistance, Environmental Factors, Genetics; Host-Parasite Interactions, Immunology, Vaccine Development, Worm Resistance.

Introduction

Worm infections, caused by various parasitic helminths (Amin, 2021), represent a significant burden on global health, particularly in resource-limited settings (Bote *et al.*, 2023; Iredell, 2019; Knobler *et al.*, 2003; Riaz *et al.*, 2020; States & Nations, 2022; World Health Organization, 2021). Millar *et al.*, (2020) and Profile, (2019) indicated that worm infections can lead to chronic diseases, malnutrition, impaired cognitive development, and reduced productivity in humans, livestock, and crops. Despite ongoing efforts to control worm infections through anthelmintic drugs, preventive measures, and sanitation improvements, these parasites continue to pose challenges due to factors such as drug resistance, environmental changes, and socioeconomic disparities.

Understanding the mechanisms by which hosts resist worm infections is essential for developing sustainable and effective control strategies. Host resistance to worm infections can be multifaceted, involving immunological, genetic, physiological, and environmental factors. By elucidating these mechanisms, researchers aim to identify targets for intervention, improve diagnostics, and optimize treatment regimens.

Immunological Mechanisms of Worm Resistance

(Biomedicine, 2015; Charlier *et al.*, 2016; Profile, 2019; Riaz *et al.*, 2020; Saeed, 2023) revealed that the immune system also plays an important role in the host relationship in worms. After infection, the host's immune system usually mounts a response that destroys the parasite. This response involves the production of antibodies as well as the production of many immune cells, such as eosinophils, mast cells, dendritic cells, T cells, and B cells (Amin, 2021; Kassahun *et al.*, 2016; Profile, 2019; Riaz *et al.*, 2020).

According to (Of *et al.*, 2023), Effector mechanisms such as antibody-mediated cytotoxicity, cytokine production, and eosinophil activation contribute to parasite clearance and tissue repair.

However, helminths have developed many strategies to evade or modify the immune system, allowing them to establish and control infections (Idris *et al.*, 2019; Ghai *et al.*, 2019). An example is the ability of some worms to coat themselves with host proteins or to produce molecules that attack host molecules, thus avoiding recognition by the immune system.

Necator americanus is an example of resistance in the cases of hookworm (Jenkins *et al.*, 2021; Logan *et al.*, 2020; Orr *et al.*, 2019; Servián *et al.*, 2022). This parasite secretes molecules that suppress the host's immune system, allowing it to establish a long-term infection without being cleared by the host's immune system.

Overall, the interaction between parasites and its immune system is complex and involves balancing the host's efforts to destroy the parasite with the parasite's strategies to evade or alter the immune system.

Genetic Determinants of Worm Resistance

Profile, (2019) indicated that, the host genetics also influence susceptibility to worm infections, with evidence suggesting that genetic variations contribute to individual differences in resistance. Genome-wide association studies (GWAS) and candidate gene approaches have identified genetic loci associated with resistance to specific worm species in livestock, and crops. These genetic factors may affect various aspects of host physiology, including immune function, barrier integrity, and metabolism (Amin, 2021). Understanding the genetic basis of worm resistance can help in breeding programs aimed at developing resilient livestock and crops. Examples are below;

Animals

Cattle: According to Pal & Chakravarty, (2020), in order to protect cattle against intestinal worms, breeds such as Red Angus and Senepol cattle were selected, as well as species such as *Ostertagia ostertagi* and *Haemonchus contortus*, which can cause health problems in cattle and reduce productivity.

Poultry (Chickens): Breeds such as the Rhode Island Red and the Australorp are known for their resistance to common poultry worms such as *Ascaridia galli* (roundworm) and *Heterakis gallinarum* (cecal worm) (Zirintunda *et al.*, 2022).

Sheep: An article by Lalramhluna *et al.*, (2020) indicated that breeds such as the Barbados Blackbelly and the St. Croix have been bred to resist intestinal nematodes such as *Haemonchus contortus*, an important parasite that affects sheep worldwide.

Crops

Maize (corn) variety "GSS-33": According to Bekelja, (2022) and Miller, (2021), there are a variety of corn that had been bred to be resistant to corn rootworms (*Diabrotica spp.*) which is a type of pest that reduces the yield of corn by attacking its roots.

Soybean variety "PI 88788": Developed for resistance to soybean cyst nematode (*Heterodera glycines*), a parasitic worm that damages soybean roots, causing yield losses (GUTU, 2019).

Wheat variety "Tritipyrum line #28-28-6": This wheat variety is resistant to the grain cyst nematode (*Heterodera avenae*), an important pest of wheat crops (Bvenura & Kambizi, 2022).

Environmental and Behavioral Influences

Environmental factors can influence host behavior and therefore host resistance to helminths or other parasites.

Temperature and Host Activity: Temperature affects the level of host activity (Daagema *et al.*, 2020; Pedersen, 2018). Warmth can cause greater activity, making it more susceptible to helminth infections (Collins, 2007). For example, in the rainy season, livestock increases due to the abundance of feed, which can lead to gastrointestinal diseases as a result of animals being fed with fresh grass or legume which may have worms on it when not dry. Helminth infections are a big problem in sub-Saharan African countries such as Ghana.

Habitat Complexity and Host Exposure: The complexity of the habitat can influence the host's behavior and exposure to the worms (Weatherhead & Hotez, 2015). In more complex environments, hosts may have more opportunities to avoid contaminated areas or find refuge from infective stages. For example, rodents living in complex burrow systems may have lower exposure to soil-transmitted worms compared to those in simpler habitats.

Relationships and collective ownership: The social structure of owners has a significant impact on collective assets, resulting in increased lines of exposure (Collins, 2007). According to Riaz *et al.*, (2020) and Devagappanavar, (2023), hosts living in groups or clusters may be more contagious due to contact between individuals. This occurs in animals such as primates or ungulates, where close contact facilitates the transmission of parasitic infections.

Predator-Prey Interactions and Host Stress: Riaz *et al.*, (2020) and Weatherhead & Hotez, (2015) indicated that predation risk can cause stress in the host, affect the immune system, and affect helminths. For example, in mouse studies, predation risk is associated with immunosuppression and increased worm burden.

Availability of Resources and Food Ownership: Availability of resources such as food affects the nutrition of the host (Asunción *et al.*, 2022), which in turn affects the spread of helminth infection (Gitao *et al.*, 2017). Weatherhead & Hotez, (2015) indicated that the malnourished host's immune system will be weakened, making it more vulnerable to helminth infections. This has been seen in wild animals suffering from nutritional stress (MOH, 2017), causing susceptibility to parasitic diseases (Bharti *et al.*, 2018).

As a result, environmental factors can shape host behavior, which in turn influences their resistance against worms. Understanding these connections is crucial for designing effective parasite control strategies, whether in agricultural settings, wildlife conservation, or human health interventions.

Emerging Research Areas

Recent advances in vaccine development, nutritional interventions, and alternative control strategies offer promising avenues for enhancing worm resistance (Charlier *et al.*, 2016; Daagema *et al.*, 2020). Vaccines targeting specific worm antigens or inducing broad-spectrum immune responses are under development for human and veterinary use (Millar *et al.*, 2020; Profile, 2019; Weatherhead & Hotez, 2015; World Health, 2013). Nutritional interventions

aimed at boosting immune function and improving host resilience are being explored in both clinical and agricultural settings (Pareek *et al.*, 2023; (Riaz *et al.*, 2020). Ameen *et al.*, (2010) also indicated that the use of ethnoveterinary can aid in the eradication of worms in humans and animals. Ndiokubwayo *et al.*, (2013) revealed that the efforts to monitor and combat drug resistance in parasitic worms are critical for preserving the efficacy of anthelmintic treatments.

Conclusion

Research on the mechanisms of worm resistance spans multiple disciplines and continues to yield valuable insights into host-parasite interactions. By integrating findings from immunology, genetics, epidemiology, and other fields, researchers can develop holistic approaches to worm control that are effective, sustainable, and tailored to local contexts. Future studies should focus on elucidating the complex networks of host defense mechanisms, identifying novel targets for intervention, and translating research findings into practical solutions for parasitic disease prevention and management.

Contribution by Authors

Equal contribution. All authors declared that ‘written informed’ consent was obtained from the approved parties for the publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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