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# Vaccination: The Future of Helminth Parasite Control

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## Abstract
Helminth parasites constitute one of the greatest disease-causing agents with serious productivity implications in grazing livestock worldwide. Effective and sustainable control of these parasites is has become a serious concern due to development of resistance to chemotherapeutic agents by these parasites. This is largely as a result of an over-reliance on chemical agents for worm control. Vaccination offers a non-chemical method of parasite control which has shown the possibility of effectiveness as a helminth control strategy. A number of experimental helminth vaccines have been developed and tested with positive results. There is however, still a long way between helminth vaccine development and availability of these vaccines for commercial use. It is therefore recommended that further studies be carried out towards the development of more vaccines against economically important helminth parasites. Also, standard operating procedures for production and quality control of efficacious helminth vaccines need to be put in place to facilitate progress in this direction.

**Keywords:** Helminths, Vaccines, worm control, ruminants

## Introduction
Parasitic diseases are one of the major factors militating against profitable animal production around the world. Generally, parasites have been known to be responsible for severe economic losses in livestock production ventures, resulting from decreased productivity in affected animals, condemnation of viable organs during meat inspection, increased morbidity and mortality in the affected flock, as well as causing several zoonoses (Hansen and Perry, 1994). Till date, helminth parasite control has mostly been by the use of several anthelminthic drugs either for chemoprophylaxis or chemotherapy of affected animals. However, the development of resistance by most of these parasites to available drugs, high cost and limited availability of these synthetic drugs as well as food safety issues relating to deposition of drug residues have continued to threaten the future of the continued use of anthelmintics in parasite control (Mortensen et al., 2003). Hence, the continued search for alternative effective parasite control strategies by scientists. This paper reviews the potentials of vaccination approaches in helminth parasite control

## Overview of Current Parasite Control Strategies
**Chemical control:** Chemical control involves the use of drugs called anthelmintics for the control of helminth parasites (Conder and Campbell, 1995). This comprises the use of chemotherapy or chemoprophylaxis, both of which have long been in use as parasite control strategies employed all over the world. However, this method also has its attendant risks. As a matter of fact, every drug is a 'poison' of some sort. An anthelminthic is a 'poison' that is supposed to be more toxic to the parasite than to the host (Kebede et al., 2016). Chemoprophylaxis refers to pre-emptive anthelminthic treatment of susceptible animals at certain periods in order to inhibit establishment of infection or clinical disease by the parasite. Chemotherapy, on the other hand, is used to refer to the anthelmintic treatment of affected animals after the onset of clinical infection (Geary et al., 1999). The escalating issue of development of drug resistance by helminth parasites, food safety concerns from depositing drug residues, high cost and limited availability of these drugs are current issues militating against the continued use of anthelmintics as a parasite control strategy in the near future (Knox et al., 2001).

**Biological control:** This involves the introduction of one living organism into an environment to control the population of another target organism below a threshold where it causes minimal problems to susceptible hosts (Larsen, 1999). A classic example is the introduction of nematophagous fungi e.g *Duddingtonia spp* into pasture to reduce the population of pre-parasitic stages of nematode parasites. There are three main types of nematophagous fungi on the basis of ecological habit. Nematode-trapping fungi are those fungi which have evolved structural adaptations to trap or penetrate their prey. They produce mycelium external to the nematode body through which they attack the nematodes by various means e.g *Stylopage hadra*, *Arthrobotrys musiformis*. Endoparasitic fungi attack nematodes through many modifications brought about in conidia e.g *Cephalosporium spp*. Egg Parasites are a few saprophytic fungi which attack nematode eggs e.g *Paecilomyces lilacinus* (Nordbring-Hertz *et al.,* 2011). Introducing these fungi into infested pasture can reduce burdens of helminth larvae and consequently, infection rate of susceptible animals.

**Integrated parasite control:** This refers to the use of a combination of biological, biotechnological and chemical control measures in farming practices in order to reduce the use of chemical control agents to the barest minimum, and achieve a longer lasting protection for susceptible animals, for instance, the combination of grazing management and anthelminthic treatment (Uilenberg, 1996). A good knowledge of the epidemiology of target parasites is necessary for the effective use of this control strategy. This strategy has been highly advocated due to the benefits of its use. For instance, a single treatment of animals with anthelmintics in an infected environment proved to have a very transitory effect as the animals became re-infected within a short time after treatment. Also, prolonged repeated use of anthelmintics predisposes animals to the development of resistance (Knox and Sutherland, 2012). Hence the combination of management practices such as rotational grazing of pasture and sparing treatment with anthelmintics proved to achieve more lasting results in treated animals.

**The Potentials of Helminth Vaccines**

Immunization or vaccination is the most desirable means of combating infectious agents. The fact that vaccines are potentially safer, cheaper and more efficacious prophylactics than drugs cannot be over-emphasized. The possibility of immunoprotection against different parasite stages by their host has formed the basis for the belief and search for vaccines against helminth parasites (Keebaugh and Schlenke, 2014). In field conditions, it was observed that multiple exposures of adult cattle and sheep to free-living parasite stages in the environment resulted in the development of resistance to re-infection by these parasites (Maizels and Smith, 2012). It has however been discovered that development of this immunity depends on a number of factors such as breed, age, the genetic makeup of individual animal and health status of the affected animal. Management factors which include the provision of adequate nutrition and clean pasture also influence the development of immunity in affected animals (Francisco et al., 2009). All of these factors need to be considered when developing candidate vaccines against helminth parasites.

Recent research has revealed the possibility of stimulating protective immunity in animals against helminth parasites through vaccination. Vaccines with the ability to interrupt the life cycle of certain helminth parasites have been developed and their efficacy tested against varied animal species with positive results (Hewitson and Maizels, 2014). The prospect of vaccination against helminth parasites appears to be an exciting one, considering the current difficulty in achieving effective control against these parasites. Vaccination could either be geared towards protection of the most susceptible animals in the herd by preventing the establishment of infection post-exposure or towards minimizing the buildup of parasite larvae on pasture, thereby reducing the infection rate of susceptible animals by eliminating adult parasite stages in carriers (Anthony *et al.,* 2007). Recent advancements in molecular techniques have also proven to be a welcome advantage for the future of vaccine development. In an attempt to develop commercial vaccines against economically important parasites, researchers have so far focused on identifying their target antigens. Experimentally, it has been shown that irradiated ova of *Ascaridia galli* have been able to confer a degree of protection for chickens against the parasite (Khoo and Dell, 2001). Ultraviolet irradiated *Ascaris suum* eggs have also been reported to protect pigs from Ascariasis (Tsuji *et al.,* 2004).

McLeonard and van Dijk (2017) reported the development of an efficacious vaccine against verminous pneumonia caused by the lungworm *Dictyocaulus viviparous* in cattle and *Dictyocaulus filaria* in sheep in the 1950s. This vaccine was developed employing whole irradiated nematode larvae. Similarly, an experimental vaccine has been used to protect puppies against the dog hookworm, *Ancylostoma caninum* (Fujiwara et al., 2006). Here, irradiated larvae are administered three days after birth in order to provide immunity to puppies. Most experimental helminth vaccines have been produced using dead helminths or their extracts (Smith, 1999). Despite the numerous possibilities available, vaccines have not yet been widely used globally in helminth parasite control. At present, there are currently no commercially available vaccines for the control of most of the parasitic infections of animals.

**Current Challenges to Helminth Vaccine Development**

There have been a reported large number of unsuccessful attempts to develop vaccines against helminth parasites (Mutapi *et al.,* 2013). Despite the concerted efforts of many researchers all around the world, development of commercially available helminth vaccines has continued to experience many limiting constraints. The few successful vaccines which have currently been developed against certain helminths have been characterized by the use of widely contrasting technologies in their production, hence the difficulty in reproducing and commercializing them. Their results have also been quite varied when tested under different environmental conditions (Maizels *et al.,* 1999). Generally, there are several reasons why a vaccine may not be able to confer protective immunity in animals. It may as a result of vaccines containing the wrong strain of the organism or wrong antigens, or because the production process may have destroyed the protective epitopes. It could also be as a result of insufficient antigens in the vaccine formulation. More significantly is the failure of an effective vaccine to stimulate immunity, probably as a result of unsatisfactory administration. The vaccine may have been administered too late following the onset of the incubation phase of the disease. Vaccination at this time may not be able to stimulate protective immunity (Wiedermann *et al.,* 2016). In addition, a common occurrence is the failure of an animal to mount an immune response. This may occur in immunocompromised hosts under certain conditions of stress such as pregnancy, extremes of cold and heat, fatigue and malnourishment, which may decrease normal immune responses in the animal. Failure of vaccine efficacy may also be attributed to the inability of the host immune system to stimulate antigen presenting cells so they can effectively process antigens and release appropriate interleukins. Finally, helper and effector T cells must be generated to several isotopes in the vaccine so that variations in Major Histocompatibility Complex (MHC) Class II polymorphism and epitope properties are overcome (Hinman *et al.,* 1992; Ghiasi *et al.,* 1997).

**Conclusion and Recommendation**

In the near future, the use of vaccination against parasitic diseases of animals in veterinary health services is expected to contribute significantly to promoting livestock health and productivity. Research results have shown that several efficacious vaccines against helminths have been produced but not yet widely commercialized. It is therefore recommended that further studies be carried out towards the development of more vaccines against economically important helminth parasites. Standard operating procedures for production and quality control of efficacious vaccines should also be established. Also, management conditions which compromise the immune system of host animals should be reduced to the barest minimum before testing candidate vaccines to avoid data distortion.

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