***Review Article***

**CURRENT TRENDS IN VACCINES AGAINST PARASITE IN DOMESTIC ANIMALS**

**ABSTRACT**

Numerous parasites can cause illness, which have significant effects on productivity and health of animals causing significant economic losses worldwide. Traditional control approaches, such as anthelmintic medicines, are challenged by drug resistance and residues in food products. As a result, the development of effective and sustainable parasite vaccines has emerged as an important topic of research. Parasitic infestation can cause economic loss in the livestock sector and the best way to prevent this loss is by vaccination. The agents that cause parasitic diseases are protozoa, helminths, and ectoparasites, and each requires a unique strategy for prevention and management. This review overviews the present landscape of parasitic vaccine development, highlighting the key strategies, challenges, and upcoming future prospective. The ultimate objective is to create parasite vaccines that are safe, efficient, and profitable, enhancing animal welfare and promoting public health and global food security.

*Keywords:*Ectoparasites; endoparasites; helminth; parasite; protozoa; Vaccine.

1. **INTRODUCTION**

Parasitic illnesses are thought to be a significant barrier in reducing animal productivity and limiting health, resulting in significant economic losses in livestock. Animal production field suffers significant financial losses due to attack on the body surface by both endoparasites, which resides inside the body, and ectoparasites, which resides outside the body. Protozoa, helminths, and ectoparasites are the agents that cause parasitic disorders, and each one needs a different approach in prevention and control. In a recent study held in Nigeria, it was concluded that gastrointestinal helminth infections are the most common parasitic infestation among ruminant livestock (Sylvia et al., 2015).

Endoparasites include nematodes, trematodes, cestodes. Nematodes like ascarids, threadworm, hookworm, whipworm, heartworm, lung worm, subcutaneous worm and trematode are flukes, whereas cestodes are tapeworm. Ectoparasites include ticks, mites, lice, fleas, and flies (Kaminsky and Mäser, 2025). To evade host immune responses, parasites employ a variety of intricate strategies, such as antigenic variation, which can alter the immune system and can cause chronic, long-lasting infections. As a result, controlling parasitic illness is difficult and typically calls for sophisticated diagnostics as well as integrated control strategies that includes treatment, chemotherapy, and vaccinations (Strydom et al., 2023).

Although India has the largest population of cattle and buffalo, most livestock owners own fewer herds, making alternative strategies like grazing management, biological control, and host genetic resistance as impractical. Vaccinating animal is the most cost-effective and sustainable way to prevent parasitic infestations in our nation even though some of the vaccinations are expensive initially, the protection they provide lasts for a long time justifying the initial cost. Therefore, immunizing animals against a range of clinical, chronic, and sub clinical parasite diseases will be a more affordable and efficient way to reduce the disease burden over time and enhance animal productivity (Sharma et al., 2015).

Florin-Christensenet al*.* (2021) suggested that vaccinations are economically and environmentally beneficial way to protect animals from parasitic diseases and it decreases the susceptibility of humans from animal-borne infection. The live vaccines can be manufactured from animal host by harvesting or collecting the antigen, standardization, quality control, shelf-life studies and analysis of cost of manufacture (Morrison and Tomley, 2016). Vaccines should be safe, adequate and well-founded for control of the vectors or parasites and eliminate drugs used in endemic regions (Rios et al., 2019).

The purpose of this article is to collect information on the use of already available vaccinations (including their benefits and downsides) as well as potential future developments in the creation of vaccines against helminths, ectoparasites, and protozoa. Development of parasitic vaccines, epidemiological data for existing and upcoming vaccines, immune responses of parasites, antigenic variation, host/parasite interactions, and vectored vaccines are the topics covered (Stutzer et al*.,* 2018).

1. **CURRENT STATUS OF VACCINE AGAINST HELMINTH**

In animal models, helminth immuno-modulation has been investigated for a number of vaccines. According to the number of these researches, the existence of these illnesses before vaccination may compromise vaccine-specific immune responses.  Knowing how helminths affect, how animals react to vaccinations is a crucial subject that could affect global health policy (Natukunda et al*.,* 2022).

Parasitic vaccines against helminths are recently available in the market. Some of these vaccines are Bovilis and Huskvac for *Dictyocaulus viviparus* in cattle; Barbervax, Wormvax vaccine against *Haemonchus contortus*(barber’s pole worm) in sheep. Marketable two recombinant helminths vaccines are Providean, HidatilEG95, Tecnovax for *Echinococcus granulosus* in ruminants. The Indian Immunologicals Limited produced Cysvax against *Taenia solium* in pigs (Vercruysse et al*.*, 2018).

You et al., 2023 reviewed that innovative veterinary vaccines are accomplished by developing recombinant vaccines, some vaccines can attain up to 94% protection against *Taenia ovis*and more or less 100% against *Taenia saginata*and*Taenia solium*. EG95 is a successful vaccine against *Echinococcus granulosus* infection in sheep.

Dictyocaulus viviparus

Haemonchus contortus

Echinococcus granulosus

**Existing Parasitic**

**Vaccine Against**

*Taenia saginata*

*Taenia ovis*

*Taenia solium*

**Fig 1: Vaccine against Helminth**

* 1. ***Dictyocaulus viviparus*in cattle**

It is the first commercial anti-metazoan vaccine with live irradiated antigen. Route of administration is oral and vaccinations can be done within 4 weeks of age. Level of protection is claimed to be 95%–98% (worm burden) (Chamberset al*.,* 2016)

**Benefits**(Shite et al*.,*2015)

i. This vaccine focuses on season grazing animals and is more suited for pregnant cows.

ii.  This vaccine improves immunity of cattle.

**Downsides**

i. It may exacerbate the condition in calves with existing lung lesions due to viral pneumonia.

ii. The vaccine has a short shelf-life and less commercial availability.

iii.  Vaccination schemes are laborious during spring and in spring born beef calves.

**2.2*Haemonchus contortus* in sheep**

The vaccine uses protein antigens and the route of administration is subcutaneous. Three vaccinations have to be done at an interval of 3–4 week before *Haemonchus* season. Re-vaccination can be done at six-week intervals. Protection level is reported as 93%–95% (egg counts) and 72%–94% (worm burden) (Britton et al*.*, 2020; Adduci et al*.,* 2022)

**Benefits** (Ehsan et al*.,* 2020)

1. *Haemonchus* vaccine controls adult worms during early grazing season

ii.  Vaccine reduces infective larvae

iii.   This vaccine has relatively cheap production protocols.

**Downsides**

i. This vaccine is not fully effective.

**2.3 *Echinococcus granulosus*in sheep**

The vaccine uses EG95 antigen and the route of administration is subcutaneous or intramuscular. Vaccination schedule comprises of two vaccinations with one month interval with a level of protection95%–100% (Assanaand Zoli, 2024).

**Benefits** (Valizadeh et al., 2017)

i.  Vaccination is the best method to prevent echinococcosis

ii.  Vaccinated sheep shown high immunity against infection

iii. Reduced financial loss and increased sheep production

iv. The EG95 is a proven vaccine in its efficacy

**Downsides**

i. The EG95 is not available in many developing countries or is very expensive. Only in some of the leading countries use this vaccine to control the infestation.

**2.4 *Taenia* cestode**

Most recently, TSOL18 has shown to be quite successful in protecting pigs from naturally occurring *T. solium* infections. It has been demonstrated that TSOL18 application is quite successful in completely eradicating *T. solium* infestation in pigs. Pigs can be first immunized at two months of age, and the booster shot can be administered three months later. Giving oxfendazole prior to immunization, helps in removing any cysts that were already present in the pigs. It is observed that immunity develops two weeks after the booster dosage. The first license for the use of oxfendazole in accordance with Good Manufacturing Practice (GMP) standards to treat cysticercosis in pigs was granted in 2013, and the TSOL18 vaccine received license in India in 2016 (Ouma et al*.,* 2021).

Taenia saginata is a significant cestode for both cattle and economy. The beef meat sector suffers losses when cattle are infected with the cysticercus larval stage. Cloning of T. saginata oncosphere antigens can be done using recombinant DNA techniques. Many veterinary vaccine manufacturing techniques are based on the recombinant DNA technology (Kar et al., 2025). The vaccine with two antigen combination (TSA-9 and TSA-18) produce up to 99.8% protection against T. saginata infection. It will be necessary to specify the vaccine's operational features, such as the length of immunity in calves. Commercial application of the vaccine to prevent bovine cysticercosis is reported (Okello and Thomas, 2017).

In New Zealand, a recombinant vaccine against *Taenia ovis* has been produced that can give protection against tapeworm in sheep. A cloned oncosphere antigen (To45W) and an adjuvant based on saponins are both present in this vaccination. The gut wall cannot be penetrated by parasites because it triggers a reaction. It is very effective in reducing parasite levels by 98% (Pernthaner et al*.*, 2021).

Vaccine development passed through several generations *viz*. live, attenuated, inactivated or killed, biochemical fractions, sub unit, and DNA vaccine (Singhet al*.,*2019). Veterinary vaccines form about 23% worldwide market for animals. Further research is going on for developing new helminth vaccines for protecting animals (Tran, 2018).

1. **VACCINE AGAINST PROTOZOAN PARASITE**

At present, the only vaccine that can effectively prevent protozoan diseases in domestic animals are those for toxoplasmosis, babesiosis, and theileriosis. A form of premunity develops in acute babesiosis survivors where they show immunity to a subsequent clinical illness (Florin-Christensen et al., 2021).

Important parasitic infestation in poultry is coccidiosis which is caused by *Eimeria* spp and it leads to considerable financial losses globally. Anticoccidial vaccines are crucial for broiler production. Anticoccidial live vaccines are available on the market and live vaccines are needed for management and care of the poultry flocks. It is observed that recombinant vaccines improved immunity in poultry. The anti-coccidial vaccines for poultry, such as those against *Eimeria*in chicken and turkey, are the only class of vaccines that have undergone significant development. In theory, immunizing vulnerable animals with live parasites such as *Eimeria* oocysts from relevant species may control the infection (Hauck and Macklin, 2024).

Vaccines against Coccidia in poultry are Coccivac B, Coccivac D, Coccivac T, Nobilis COX ATM, Eimeriavax 4m, Immucox, Paracox-8, Livacox, and Cox Abic. Antigen is live attenuated and the administration is through s**pray application, drinking water, gel application, feed, in ovo vaccination, or subcutaneous/intramuscular injection.** Vaccine can be given **at a** very early stage of life in chicks, sometimes as young as one day (Joachim, 2016).

Parasitic protozoan *Eimeria* spp. causes coccidiosis in poultry which are highly immunogenic (Venkatas and Adeleke, 2019). DNA epitope vaccines protect the poultry against E. tenella, E. maxima, E. necatrix, and E. acervulina in chicken. Multivalent epitope DNA vaccines mainly increase body weight, and reduces oocyst expulsion from the infected birds (Song et al*.,* 2015).

A vaccine against *Toxoplasma* should ideally be able to protect animals, and in turn would lower the risk of transmission to humans. At present, only one vaccine against *Toxoplasma* is available in the market, called Toxovax. It is a live attenuated vaccine made especially to lower the rate of foetal miscarriage in sheep. More recently, it has been demonstrated that Toxovax helps pigs with tissue cysts. Antigen is live attenuated and route of administration are intramuscular. Vaccination is recommended at least four weeks before mating to protect against abortions. Vaccination for sheep can be done from 5 months of age, and at least 3 weeks before to mating (Warner et al*.*, 2021).

The haemoprotozoan disease caused by *Babesia* spp. affects both intermediate and final hosts. Subunit and whole-pathogen vaccines are two major vaccine types against *B. microti* (Jerzak et al., 2023). In endemic regions, live attenuated vaccines are used against acute bovine babesiosis. Attenuated *B. bovis* strain is cultured in well-defined *in vitro* method (Bastos et al*.*, 2023). Vaccine against canine babesiosis is Pirodog which is a live attenuated antigen containing vaccine. Route of administration of the vaccine is through intramuscular or subcutaneous injection. Vaccination can be given at 3-4 week of age (de Barros and Koutsodontis, 2023).

Leishmaniosis (Dum Dum dore or Oriental sore) is an infectious protozoan infection. Live *Leishmania major* organism are inoculated into the skin to prevents the reinfection and this is the first-generation vaccine strategy for preventing the *Leishmania*parasites with improved immune responses (Rooholamini et al., 2024) and the antigen is recombinant proteins. Administration is through subcutaneous route and the vaccination schedule involves inoculation of a single dose at 6 months of age. Repeated vaccinations may be needed to maintain immunity, especially in high-risk environments or for long-term protection.  Annual boosters are recommended to maintain protection.

Protozoan diseases can be prevented through vaccination. Some of the protozoan vaccines are 1. Anaplaz: Contain killed antigen and is administered through subcutaneous route. Vaccination schedule consists of giving the first vaccine at the age of 4 to 9 month old cattle.

2. GiardiaVax: A subunit vaccine against*Giardiasis* caused by *Giardia lamblia* in dogs. Vaccine is administered through subcutaneous route in dogs above 8 weeks of age or older and the second dose is given after 2-4 weeks later.

3. Pirodog/Nobivac Piro: Contain soluble parasite antigen from *Babesia canis* and *Babesia rossi*. First injection should be given subcutaneously at 6 months of age and second after 3-6 weeks. Then needs to be repeated every 6 months.

4. Bovilis Neoguard: Vaccine containing inactivated tachyzoites of *Neospora caninum* and this can be used in pregnant cows also. First dose can be given at 6 months of age followed by second dose 4 weeks later. Pregnant animals can be vaccinated at 6 months of pregnancy.

5. Toxovax: Live attenuated strain of *Toxoplasma gondii* mainly used in sheep through intramuscular injection. Only one injection can protect the animal lifelong.

6. Leish 111f: Recombinant polyprotein vaccine against visceral leishmaniasis. Three doses are given through subcutaneous route at three weeks interval.

7. EPM vaccine: Vaccine (under development) against Equine Protozoal Myeloencephalitis (EPM) caused by *Sarcocystis neurona*.

8. Beta-tubulin: The vaccine contains beta-tubulin gene of *Trypanosoma evansi* cloned and expressed in *E. coli*. It can protect against *Trypanosoma evansi*, *Trypanosoma brucei* and *Trypanosoma equiperdum*.

9. TrichGuard®: Vaccine with killed concentrated culture of *Tritrichomonas* *foetus* used against *Tritrichomonas foetus* in cattle, the causative agent of Trichomoniasis. Administered subcutaneously at least 6 weeks pre-breeding with a second dose 2-4 weeks later (Selzer and Epe, 2021).

10. Rakshavac T (contain schizonts grown in lymphoblast cell culture) given subcutaneously to 3 months of age and above with annual revaccination to protect against Theileriosis. SPAG1 (Sporozoite surface antigen of *Theileria* *annulata*), TAMS1 (contain merozoite surface antigen of *Theileria* *annulata*), p67 (sporozoite surface antigen of *Theileria* *parva*) (Patra *et al.*, 2017). The route of administration of the vaccine is oral, I/M, S/C, ocular, or intranasal. The route depends on the stage of infection and type of organisms (Aginaet al*.,*2020). The creation of vaccines in one location of the world sparked the innovation in other nations that were in need and who were suffering animal losses. For instance, in India, the vaccine was successfully developed in Haryana, Punjab, Tamil Nadu, Gujarat, and IVRI (Uttar Pradesh) following the successful generation of an attenuated schizont infected lymphoblast-based cell culture vaccine of *Theileria annulata* in Israel. Indian Immunologicals marketed the Rhakshavac T. After Dictol was successfully marketed in Europe, Dhar and Sharma also produced Difil in India in 1981. A number of vaccines, including that of Anaplasmosis, were taken off the market because of poor consumer acceptance rather than efficacy (Xue et al*.*, 2020).

**4. VACCINE AGAINST ECTOPARASITES:**

Vaccination is the cost effective and eco-friendly method which protect against infestations, and reduces parasitic burden in cattle. Ectoparasitic vaccines are mostly developed against *Haemaphysalis longicornis*, *I. ricinus, R. microplus*, *Amblyomma americanum*, and *I. scapularis* infections in animals*.* Some tick- borne vaccines have also been developed recently. The available vaccines for ectoparasites are:

1. Bovimune IxovacTM: Injectable cattle tick vaccine (recombinant) to control *Rhipicephalus* tick. This can be used in cattle from two months of age at the rate of 2 ml per animal on 0th, 4th and 7th weeks and booster has to be given every 6 months for better efficacy.

2. GavacTM (Bm86-based): Recombinant vaccine contains *Boophilus microplus* antigen (Bm86).

These vaccines are limited to some Latin American countries (Trujilloet al*.*, 2024).

3. rBmVDAC (*Rhipicephalus microplus* voltage-dependent anion channel) is an anti-tick vaccine and can able to prevent the babesiosis infection in cattle. rBmVDAC antibodies mainly identify the native protein from the midguts of *Rhipicephalus microplus*and the efficacy of this vaccine is 82% against *R. microplus.* Ortega-Sánchez et al*.* (2020) suggested that the most important, and widely spread tick in the world is *Rhipicephalus microplus*that causes high financial losses in farms, and livestock industry. *Rhipicephalus microplus*mainly attack hosts through feeding on blood and transmitting bovine babesiosis.

**5. UPCOMING PARASITIC VACCINE**

Studies are going on to develop recombinant or purified or recombinant expressed worm proteins-based vaccine for Cooperia oncophora and Ostertagia ostertagi in cattle, and Teladorsagia circumcincta and *Fasciola* hepatica in ruminants (Collett et al*.*, 2022). Experimental vaccines for helminth infestation in ruminants such as fascioliasis and echinococcosis, and Barbervax vaccine to prevent the sheep and goats getting infected from Barber’s pole worm have approval in South Africa, Australia, and United Kingdom (Daga et al*.*, 2022).

**Upcoming**

**Parasitic vaccine**

Fig 2: Upcoming Parasitic Vaccine

* 1. ***Ostertagia ostertagi***

Contain antigen like Activation-associated secreted proteins (ASPs) and somatic antigens. Routes of administration is intramuscular/subcutaneous/intraperitoneal/oral. The vaccination schedule consists of the following.

Pre-grazing season: -Vaccines are often given before the onset of the grazing season to help prevent the initial infection.

Multiple doses: - Most vaccine protocols involve multiple doses (*e.g*., three doses) at intervals (*e.g*., 3-week intervals) to establish and maintain immune systems (Claerebout and Geldhof, 2020)

* 1. ***Cooperia oncophora***

Contain antigen ddASP (double domain ASP) administered through intramuscular injection. The calves are often vaccinated three times several weeks apart, followed by a booster vaccination to maintain immunity.

* 1. ***Teladorsagia circumcincta***

Cocktail vaccines are produced by mixing more than two antigens with adjuvants which help to increase the immunity. The cocktail vaccine is the recombinant protein significantly used in *Teladorsagia*infection in sheep. It is a recombinant subunit vaccine. Route of administration is subcutaneous injection. The vaccination schedule typically involves a series of three doses, with the first dose followed by boosters at intervals, such as 21 days apart (Zafra et al*.*, 2021).

* 1. **Fasciola hepatica**

*Fasciola hepatica,* also known as liver fluke in ruminants, having a universal distribution which causes substantial economic loss in the animal production. In a recent study, host parasite interactions and their effect on *Fasciola hepatica* vaccine development is reviewed (Flores-Velázquez et al*.*, 2023; Rufino-Moya et al*.,* 2024). Antigen is **Kunitz-type molecule which functions as Glutathione S-transferase (GST).** Administration route is i**ntramuscular, subcutaneous, intranasal, intragastric, or intradermal.** The first two vaccines should be given three weeks apart, followed by a third after four weeks after the second.

**5.5 *Dermatophilus congolensis***

It causes lumpy wool in sheep whichspreads mainly through direct contact with the infected animal. Experimental vaccine contains part of *D. congolensis* proved to protect lumpy wool in sheep (Tellam et al*.*, 2021).

Selecting or producing parasite lines with reduced virulence (attenuation) is one of the best ways to develop conventional vaccines. Attenuation is the process of consistently producing

a parasite line with reduced virulence (Hajraet al*.*, 2020).

**5.6** ***Heamonchus contortus***

Commercially developed vaccines against parasites focused mainly on target antigens, and some antigen include secretory and excretory antigens, tick’s salivary gland and hidden antigens for *Heamonchus contortus.*After production of the vaccine,it iswell tested for its effectiveness that gives an impetus for its production and marketing (Kebede et al*.*, 2016).

Vargaset al*.* (2022) noted that even though research in development of parasitic vaccines give satisfactory results, their commercialization is still less. Vaccination should offer improved immunity, protect animal health, and increased animal production (Nisbetet al*.*, 2016).

**5.7** ***Trypanosoma evansi***

Trypanosomosis is a protozoan parasitic disease which is caused by *Trypanosoma evansi*and also known as ‘surra’ in animals. New vaccine for trypanosomiasis includes mRNA vaccine, vector-based vaccine, and CRISPR- attenuated vaccine (Pereira et al*.*, 2024).

**6. EFFECTS ON ANIMAL HEALTH**

Biological agents called vaccines are made to trigger immune reaction so that are particular to harmful microbes in an effort to stop or lessen infectious diseases. Veterinary vaccines are administered to animal in order to preserve their health and boost productivity. Vaccines to prevent zoonotic diseases in companion animals, food animals, and even wildlife have significantly decreased the prevalence of zoonotic diseases in humans. Food security, human health, animal health, or economic stability may all be threatened by infectious disease agents in some circumstances (Roth and Sandbulte, 2021).

Farm animals are benefitted from vaccinations because vaccination prevent or lessen sickness, which in turn reduce the pain and suffering. Providing farmers with the variety of vaccines they require to safeguard the health and well-being of their animals is the goal of the animal medicine industry. Strict regulatory requirements guarantee the safety, effectiveness, and quality of these vaccinations, which are approved and manufactured (Brun, 2016).

The development of an effective parasitic vaccine is challenging because of complex life cycles of parasites and poor understanding of how they evade the immune system of their host. Developing effective vaccines against parasites is essential in lowering their prevalence in both human and animal populations (Pinazoet al*.*, 2024).

Veterinary parasitic vaccines take part as an important act on animal health protection. Vaccines can prevent diseases caused by parasites, and improve the efficiency of animal husbandry, reduce the use of drugs, and protect the environment and the ecological balance. At the same time, vaccines reduce the incidence of zoonotic diseases and increase the potential of livestock, poultry, companion animals (Thomaset al., 2022).

Bhowmick and Han, (2020) reviewed that ticks are blood-feeding ectoparasites that can widely dissipate pathogens or organisms through animals to humans in many parts of the world. For prevention of zoonotic diseases tick control is important. Vaccination is safe, effective, feasible and eco-friendly. From recent ideas and knowledge tick-protective antigens have been identified to control tick-borne diseases.

Vaccination is the effective intervention strategy to control the parasitic illness in livestock animals. By analyzing the earlier vaccine development and their efforts, technologies, use of adjuvants and protective antigens control of parasitosis can be achieved. (Liu et al., 2023; Alzan et al*.*, 2024). The development of molecular technology is also a favorable circumstance for upcoming creation of novel vaccination. Current and reliable scientific data are necessary to understand and use vaccination to prevent parasitic infestation (Sander et al*.*, 2020).

**Protect animals**

Rr**Reduce larvae and egg**

**Prevent parasitic infection**

**Reduced contamination of parasites**

**Increased animal production**

**Improved animal health**

Fig 3: Effects on Animal Health

Most of the vaccines are working by addition of pathogen-specific proteins to the body systems. The types of veterinary vaccines mostly used are inactivated vaccines, live-attenuated vaccines, or toxoids. The vaccine has a plan of action to prevent or reduce parasitic infection and an improved beneficial immune boost to the animal body (Krauer and Bittar, 2024).

**7. CONCLUSION**

 The topic Current Trend in Vaccines Against Parasite in livestock animals can help to create awareness about novel parasitic vaccine techniques globally. Although vaccines against parasites are still infrequent and there are positive indications that their count may rise over course of time. According to the present paradigm, understanding parasitic genes would allow for the discovery of helpful vaccines that can subsequently use recombinant systems and biotechnology for further research and production. To advance science, research on the host-parasite interface must be prioritized which can pave the way for developing newer vaccines and promote a motivation to put results into practice.

**Disclaimer** (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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