***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 livestock sector and the best way to prevent this loss is 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:*Vaccine; parasite; helminth; protozoa; ectoparasites

1. **Introduction**

Parasitic illnesses are thought to be a significant barrier to reducing animal productivity and limiting health, resulting in significant financial losses for livestock. Animal production field suffers significant financial losses due to attacks on the body surface by both endoparasites, which reside inside the body, and ectoparasites, which reside on the body. Protozoa, helminths, and ectoparasites are the agents that cause parasitic disorders, and each one needs a different approach to prevention and control. Endoparasites include nematodes, trematodes, cestodes. Nematodes like ascarids, threadworm, hookworm, whipworm, heartworm, lung worm, subcutaneous worm and trematode are flukes, cestodes is 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 cause chronic, long-lasting infections. Because of this, controlling parasite illnesses is difficult and typically calls for sophisticated diagnostics as well as integrated control strategies that include 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 impractical. Vaccinating animals is the most cost-effective and sustainable way to prevent parasite infections in our nation; while vaccinations are more expensive initially, the protection they provide lasts for a long time. Therefore, immunizing animals against a range of clinical, chronic, and sub clinical parasite diseases will be a more affordable and efficient way to reduce parasitic infections over time and enhance animal productivity (Sharma et al., 2015).

Florin-Christensenet al. (2021) suggested that vaccines are economically and environmentally beneficial way to protect animals from parasitic diseases and it decreases the susceptibility of humans to animal-borne infection. The live vaccines can be manufactured from animal host by harvesting or collecting the antigen, standardisation, quality control, shelf-life studies and analysis of cost of manufacture (Morrison and Tomley, 2016). Vaccine should be safe, adequate and well-founded for control the vectors or parasites and eliminates drugs uses in endemic region (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 vaccinations. According to a 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 helmiths 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 helmiths 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 vaccine can attain up to 94% protection against *Taenia ovis* and more or less 100% against *Taenia saginata* and *Taenia solium*. EG95 is the succesful vaccine for *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

**2.1 Dictyocaulus viviparus in cattle:**- It is the first commercial anti-metazoan vaccine with live irradiated antigen. Route aadministration is oral and vaccinations can be done within 4 weeks. Level of protection is claimed to be 95%–98% (worm burden) (Chambers et al*.,* 2016)

**Benefits** (Shite et al*.,* 2015)

1. This vaccine focuses on first season grazing animals and more suited for pregnant cow.
2. This vaccine improved immunity of cattle.

**Downsides**

1. It may exacerbate the condition in calves with lung lesions due to viral pneumonia.
2. The vaccine has short shelf-life and it’s less commercial availability.
3. Vaccination scheme is laborious during spring and spring born beef calves.

**2.2 Haemonchus contortus**in sheep:**-** Using protein antigens. Route of administration is subcutaneous and 3 vaccinations are done with an interval of 3–4 week before Haemonchus season. Re-vaccination is 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
2. Vaccine reduces infective larvae
3. This vaccine has relatively cheap production protocols.

**Downsides**

1. This vaccine is not fully effective.

**2.3 Echinococcus granulosusin sheep**:- Antigen- EG95, Administration Route- Subcutaneous or intramuscular, Vaccination Schedule**-**2 vaccinations with 1-month interval, Level of Protection**-**95%–100% (Assana *and Zoli*, 2024).

**Benefits** (Valizadeh et al., 2017)

1. Vaccination is the best method to prevent echinococcosis
2. Vaccinated sheep shown high immunity against infection
3. Livestock can be protected by vaccination against Echinococcus
4. Reduced financial loss and increased sheep production
5. The EG95 is a proven vaccine in its efficacy

**Downsides**

1. The EG95 is not available in many developing countries or is very expensive. Only in some of the leading countries used to control the infection.

**2.4 *Taenia* cestode:-**

Most recently, TSOL18 has been 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* pig infections. Pigs who have received the first immunization are at least two months old, and the booster shot may be administered three months later. Prior to immunization, oxfendazole removes any cysts that were already present in the pigs and also works well against other internal parasites and worms. Pigs’ immunity develops two weeks after the booster dosage. The first license for the use of oxfendazole produced in accordance with Good Manufacturing Practice (GMP) standards to treat cysticercosis in pigs was granted in 2013, and the TSOL18 vaccine received its license in India in 2016 (Ouma et al*.,* 2021).

Taenia saginata is a significant cestode parasite for both medicine and the economy. The beef meat sector loses when cattle are infected with the cysticercus larval stage. Cloning of T. saginata oncosphere antigens 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 to 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 created that can give sheep protective protection against this tapeworm. 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 at reducing parasite levels by 98% (Pernthaner et al*.*, 2021).

Vaccination is the perfect way to minimize financial losses caused by parasites. Vaccine development passed through several generations viz. live, attenuated, inactivated or killed, biochemical fractions, sub unit, and DNA vaccine (Singhet al*.,* 2019). Veterinary vaccines forming about 23% worldwide market for animals. Further research is going on for developing helminth vaccines for protecting animals from helminth parasites (Tran, 2018).

**3. Vaccine against Protozoan Parasite**

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

Important parasitic infestation in poultry production is coccidiosis which is caused by Eimeria spp and it leads to considerable financial losses in global. Anitcoccidia vaccines is crucial for broiler production. Anitcoccidia live vaccines are available on the market and live vaccines is 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 vaccinations against parasites that have undergone significant development. In theory, immunizing vulnerable animals with live parasites—in this case, *Eimeria* oocysts from many pertinent species—represents a controlled infection (Hauck and Macklin, 2024).

 Vaccines against Coccidia: Coccivac B, Coccivac D, Coccivac T, Nobilis COX ATM, Eimeriavax 4m, Immucox, Paracox-8, Livacox, Cox Abic. Antigen- Live attenuated. Administration Routes: **Spray application, drinking water, Gel application, Feed, in ovo vaccination, Subcutaneous/Intramuscular injection.** Vaccination Schedule - **Early vaccination: -** Coccidiosis vaccination is often initiated very early in the life of chicks, sometimes as young as one day of age (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 of the infected birds (Song et al*.,* 2015).

 A vaccination against *Toxoplasma* should ideally be able to protect animals, as this would lower the risk of transmission to humans. There is now just one vaccine against *Toxoplasma* available on the market, called Toxovax. It is a live attenuated vaccine made especially to lower the rate of fetal miscarriage in sheep. More recently, it has been demonstrated that Toxovax helps pigs with tissue cysts. Antigen- Live attenuated, Administration Route- Intramuscular, Vaccination Schedule- vaccine 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 host. Subunit and whole-pathogen vaccines are two major vaccine types against *B. microti* (Jerzak et al., 2023). In endemic regions acute bovine babesiosis infection control is by live *in vivo* attenuated *Babesia bovis* vaccines. Attenuated *B. bovis* strains culture in well-defined invitro method which is most efficient and sustainable (Bastos etal*.*, 2023). Vaccine against canine babesiosis is Pirodog which is a l**ive attenuated antigen containing vaccine.** Route of administration of 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 the 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 prevent the *Leishmania* parasites with improved immune responses (Rooholamini et al., 2024) and the antigen is recombinant proteins. Administration is through subcutaneous route. Vaccination Schedule: A single dose at 6 months of age. Repeated vaccinations may be needed to maintain immunity, especially in high-risk environments or for longer-term protection.  Annual boosters are recommended to maintain protection.

Protozoan diseases can be prevented by vaccination and vaccination is the best, most effective, more efficient method to control protozoan infections. Some protozoan vaccines are Anaplaz which is the killed and live antigen vaccine for *anaplasma.* Administration of this vaccine is through subcutaneous and vaccination schedule consists of giving first vaccine at the age of 4-to 9-month-old cattle. Vaccines for *Giardia*: Giardiavax. Vaccines against Babesia: Pirodog/Nobivac Piro. Vaccines against *Neospora*: Bovilis Neoguard. Vaccines against *Toxoplasma*: Live attenuated vaccines-T263, S48 strain (Toxovax), TS-4. Vaccines against *Leishmania*: Leish111f. Vaccines against Sarcocystis: EPM vaccine. Vaccines for *Tryapnosoma*: Beta-tubulin, MAP p15, Trans-sialidase (TSA). Vaccine against cattle trichomoniosis in the USA (TrichGuard®) is commercially available (Selzer and Epe, 2021).

Vaccine against *Theileria*: Rhakshavac T, SPAG1, TAMS1, p67 (Patra et al., 2017). *Theileria* sub unit vaccine. The route of administration of vaccine is oral, I/M, S/C, ocular, or intranasal. The route depends on the stage of infection and type of organisms (Agina et al*.,* 2020).

The creation of vaccines in one location sparked innovation in other nations that were in need and suffered 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 Immunological marketed the Anand (Gujurat) vaccine under the trade name Rhakshavac T. After Dictol was successfully marketed in Europe, Dhar and Sharma also produced Difil in India in 1981. A number of vaccines, including 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 best way for control of ectoparasites, which is cost effective and eco-friendly that protect infestations, and reduced parasitic burden in cattle. Ectoparasites vaccine mainly made for *Haemaphysalis longicornis*, *I. ricinus, R. microplus*, *Amblyomma americanun*, *I. scapularis.* Some tick- borne and ticks orgamisms’ vaccines has been developed recently. The available vaccine for ectoparasites is the IxovacTM, GavacTM is Bm86-based and Bovimune are present in market. These vaccines are limited to some Latin American countries (Trujillo et al., 2024).

Ortega-Sánchez et al. (2020) suggested that the most important, widely spread tick in world is Rhipicephalus microplus that causes high financial losses in farms, and livestock industry. Rhipicephalus microplus mainly attack hosts through feeding on blood and piercing the skin and transmits bovine babesiosis. Babesia bigemina is the organism which causes bovine babesiosis. rBmVDAC is anti-tick vaccine and it can prevent the infection. rBmVDAC antibodies mainly identify the native protein from the midguts of Rhipicephalus microplus and the efficacy of this vaccine is 82% against R. microplus.

**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 for ruminants (Collett et al*.*, 2022). Experimental vaccines for helminth infection 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**

Fig2: Upcoming Parasitic Vaccine

1. **Ostertagia ostertagi**:- Antigen - **Activation-associated secreted proteins (ASPs), Somatic antigens.** Routes of administration is i**ntramuscular/subcutaneous/intraperitoneal/oral**

Vaccine Schedule: **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**:- Antigen - ddASP. **Administration route -** Intramuscular injection

**Vaccine Schedule -** Calves are often vaccinated three times, with the initial doses given 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 proteins significantly used in *Teladorsagia* infection in sheep and giving high level of prevention in sheep production. **Vaccine antigen is** 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 which is 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-**Kunitz-type molecule, Glutathione S-transferase (GST).** Administration Routes - **Intramuscular, Subcutaneous, Intranasal, Intragastric, Intradermal.** Vaccine schedule -The first two given three weeks apart, followed by infection four weeks after the second, and then additional vaccinations at four weeks post-infection and eight-week intervals.

*Dermatophilus congolensis* is the organism which causes lumpy wool in sheep and this organismspread among sheep by contact transmission. 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).

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

Vargas et 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 (Nisbet et al*.*, 2016).

Trypanosomosis is the 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 reactions that are particular to harmful microbes in an effort to stop or lessen infectious diseases. Veterinary vaccinations are administered to cattle 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, but producers lack the resources or sufficient incentives to pay for immunization (Roth and Sandbulte, 2021).

Farm animals benefit from vaccinations because they prevent or lessen sickness, which lessens the pain and suffering that comes with being sick. 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 to lowering their prevalence in both human and animal populations (Pinazo et al., 2024).

Vaccination is considered one of the options for parasite control. In the face of veterinary parasitic diseases, **BioVenic** promotes animal health and specializes in designing comprehensive solutions to the challenges of animal parasites. Veterinary parasitic vaccines take part 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 increased the potential of livestock, poultry, companion animals (Thomaset al., 2022).

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

Vaccination is the effective intervention strategy to control the parasitic illness in livestock animals. By analysing the earlier vaccine development and their efforts, technologies, use of adjuvants and protective antigens control of parasitoses can be achieved. (Liu et al., 2023; Alzan et al*.*, 2024).

Vaccination can be used to prevent vulnerable livestock  against parasitic infection and reduce the number of larvae or egg on pasture. The development of molecular technology is also a favourable 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**

**Improved animal health**

**Increased animal production**

 **Fig.3. Effects on Animal Health**

Most of the vaccine worked by adding pathogen-specific proteins to the body systems. Type of veterinary vaccines mostly used are inactivated vaccines, live-attenuated vaccines, or toxoids. The vaccine has their plan of action to prevent or reduce parasitic infection and 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 gene 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 vaccine and promote a motivation to put results into practice.

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