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Strategic approaches to parasitic threats mitigation in animal health: An overview

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Abstract

Parasitic management is vital in veterinary medicine, affecting livestock health, productivity, and economic sustainability. Effective control integrates multiple strategies, including chemotherapy, bioactive crops, biological control, pasture management, phytotherapy, and immunoprophylaxis. Chemotherapy remains a primary method using targeted drugs, while bioactive crops and nutrition help combat parasites sustainably. Pasture management reduces parasite burdens through rotational grazing. Biological control relies on natural predators, and phytotherapy utilizes medicinal plants with antiparasitic properties. Immunoprophylaxis, through vaccines, offers a long-term solution, though challenges in formulation persist.

Keywords: Anthelmintic, parasites, IPM, pasture management, predators

Introduction

Life on Earth is constantly exposed to parasites and re infected in a chain response mode. Parasitic management is a critical aspect of veterinary medicine, especially when it comes to controlling parasites that affect livestock, companion animals, and wildlife. Parasitic infections pose a significant challenge to livestock health, productivity, and economic sustainability. These parasites, including helminths, protozoa, and arthropods, cause diseases that lead to weight loss, reduced milk and meat production, impaired reproduction, and even mortality. Effective parasite control is essential to maintaining livestock welfare and ensuring food security. Mitigating parasitic threats involves an integrated approach that includes chemotherapy, bioactive crops and nutrition, biological control methods, pasture management, phytotherapy and immunoprophylaxis. Overreliance on chemical dewormers has led to widespread resistance, necessitating sustainable alternatives such as rotational grazing, the use of natural predators, and bioactive forages with antiparasitic properties. Advancements in genomics and biotechnology are also opening new avenues for targeted parasite management. This comprehensive approach to parasite control not only improves animal health but also enhances farm profitability and reduces the environmental impact of chemical treatments. By combining traditional and modern strategies, livestock producers can develop sustainable parasite management programs that ensure long-term productivity and resilience.

1. Chemotherapy

It is necessary to mitigate and/or eliminate specific pathogens at the local, national and universal levels (that play a significant role) to reduce the threat of infections (Bahk *et al.*, 2018) [4]. A multifaceted strategy, including medication-assisted chemotherapy, is necessary for the effective management of parasitic diseases. Treatment of parasitic diseases with chemical substances is known as chemotherapy and the chemical substances used for this purpose are called chemotherapeutic agents or drugs (Horn and Duraisingh, 2014) [9]. Chemotherapy has revolutionized medicine in the modern era.

Anthelmintics, a class of chemotherapeutic agents, target helminth infections (trematodes, nematodes, and cestodes) in humans, livestock, and crops, preventing poor growth and economic loss. These drugs act as vermifuges, which expel live worms, or vermicides, which kill them (Hall, 1998) [8]. Antifascioliasis drugs like *Bithionol* are effective against sheep liver fluke and paragonimiasis. Antinematodal drugs include *Benzimidazoles*, which are broad-

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spectrum anthelmintics, while *Closantel* targets *H. contortus*. *Ivermectin*, a macrocyclic lactone, acts as an endoectocide, and *Piperazine* is effective against *Ascaris* species. *Diethylcarbamazine* treats filarial infections, and *Emodepside* is used against parasites resistant to benzimidazoles, ivermectin, and levamisole. Anticestodal drugs like *Niclosamide* and *Praziquantel* combat cestode infections, with *Praziquantel* also being effective against *Schistosoma*. Antimalarial medications include *Tafenoquine/Chloroquine* for *Plasmodium vivax*, *Lumefantrine* for *P. falciparum*, and *Amodiaquine*, antifolates, *Quinine*, *Mefloquine*, and *Primaquine*, which target both *P. falciparum* and *P. vivax*. *Atovaquone* and *Doxycycline* are also used for malaria treatment. Antibabesial treatments include *Diminazene diacetate* for *B. caballi*, *B. bigemina*, and *B. equi*, along with *Imidocarb dipropionate*, a *Clindamycin-quinine* combination, and an *Atovaquone-azithromycin* combination. Trypanocidal drugs such as *Benzimidazoles* treat *Chagas disease*, while *Melarsoprol*, *Pentamidine*, and *Suramin* are used for African sleeping sickness. Finally, Antileishmanial treatments involve *Antimonials*, *Sodium stibogluconate*, *Amphotericin B*, and *Buparvaquone*.

2. Bioactive Crops and Nutrition

The use of bioactive plants to control parasites has increased in popularity to their reduced negative human, animal and environmental impacts compared with traditional pest control methods (Zeineldin *et al.*, 2020) [22]. This method focuses on leveraging naturally occurring plant compounds, functional feed additives, and nutritionally optimized diets to control or reduce parasitic burdens. These strategies can serve as an alternative or complement to conventional chemical treatments (anthelmintics and acaricides), especially in the face of rising drug resistance.

Use of bioactive crops against helminths

Bioactive substances such as ascaridole from *Chenopodium ambrosioides* and thiosulfates (allicin) from *Allium sativum* (garlic bulb) (wormseeds), terpenoids or phenolic compounds, coumarins extracted from *Cichorium intybus* (chicory forage), and naphthoquinone extracted from *Juglans regia* (walnut leaves and peels) are known to have inhibitory effects against various helminth infections in terms of lowering the number of eggs and hatchability. Similarly, proanthocyanins, phenolic acids, luteolin, sulphated and/or methylated flavonoids, flavonoid glycosides, galloylquinic acid isomers, cafeoylquinic and dicafeoylquinic acids, and quercetin glycosides that were isolated from salt-tolerant plants from southern Portugal's coastal regions were found to be effective *in vitro* in terms of reported reduction in larval exsheathment inhibition assay (LEIA) and egg hatching inhibition assay (EHIA) against *Haemonchus contortus* and *Trichostrongylus colubriformis* third stage larvae (L3) and eggs (Oliveira *et al.*, 2021) [15].

Use of bioactive crops against Arthropods

Plants, such as neem (*Azadirachta indica*), contain bioactive chemicals like azadirachtin that inhibit arthropods, including mosquitoes, flies, triatomines, cockroaches, fleas and lice. Certain essential oils also show acaricidal effects, with terpenes, especially monoterpenes and sesquiterpenes, being the most active components. A study by Camilo *et al.* (2017) [5] reviewed the acaricidal properties of 121 essential oil species across 25 families. Recent studies highlight carvacrol and limonene as key monoterpenes. However, challenges

such as high cost, short residual life, lack of field research and difficulties in developing commercial products hinder the widespread use of essential oils for arthropod control (Salman *et al.*, 2020) [19].

Use of bioactive crops against protozoa

A number of plants have been found to have bioactive metabolites with anticoccidial properties, such as allicin, tannins, polyphenolic compounds, saponins, maslinic acid, proanthocyanidin, diferuloylmethane, flavonoids, acemannan, sugars, and anthraquinones. According to a review by Mgbeahurike *et al.* (2017) [13], secondary metabolites from a variety of Piper species are recognized to have traditional and therapeutic uses, particularly in India. These uses include inhibitory effects on important protozoans like *Plasmodium sp.*, *Trypanosoma sp.*, and *Leishmania sp.*

3. Pasture Management

Effective parasite control through pasture management is a holistic approach that reduces the dependency on chemical treatments, which may have long-term negative effects on the environment and animal health. By implementing these strategies, livestock producers can create healthier pastures and animals, ultimately improving productivity and reducing the impact of parasitic diseases. Various ways of pasture management are discussed below.

A. Rotational Grazing

Here the entire grazing land is divided into small paddocks. Rotational grazing involves moving animals between paddocks to prevent overgrazing, maintaining soil health and to allow pastures to rest and regrow to its maximum potential (Wang *et al.*, 2020) [20]. Effective management requires timing rotations based on forage growth to ensure optimal pasture utilization (Pereira *et al.*, 2020) [16]. This method also aids in parasite control by reducing larvae build up in the pasture and disrupting their life cycle, as animals avoid repeatedly grazing on contaminated areas.

B. Pasture Rest Periods

Resting pastures allows parasite larvae time to die off. The larvae of many parasites require specific environmental conditions (moisture, warmth) to survive and develop. By resting pastures, particularly during peak parasite development times (e.g., wet seasons), results in the reduction of the parasitic load in the pasture.

C. Cross Grazing with Different Species

Different livestock species harbour different types of parasites. For example, sheep and cattle tend to carry different parasite species, and certain species are host-specific. By rotating different animal species (e.g., cattle, sheep, goats etc.) on the same pasture, one can reduce the number of parasites specific to one species, as they won't survive when the host species is removed.

D. Use of Fodder Crops and Forage Species

Effective pasture management requires selecting the right forages for conservation, hay, or grazing. Depending on the season in a given location, a variety of legumes and grasses can be used individually or in combination. Forbs like chicory and brassicas can be added to enhance productivity (Baker & Mohler, 2015) [3]. The choice of plant species depends on several factors, including soil pH, nutrient levels, moisture, rainfall, temperature, and the intended purpose, such as

livestock nutrition or parasite control. Some plants, like *Datura stramonium* (jimson weed), *Calotropis procera* (milkweed), and *Peganum harmala* (harmal), are valued not only for their nutritional benefits but also for their natural antiparasitic properties.

E. Manure Management

Manure is a primary source of parasite eggs and larvae. Managing manure properly is essential for controlling parasites. Strategies include regularly removing manure from pastures can help reduce the spread of parasitic eggs. Composting manure can kill parasite eggs by raising the temperature, reducing the likelihood of contamination.

F. Integrated Parasite Management (IPM)

Integrated Parasite Management (IPM) in veterinary parasitology represents a holistic and sustainable approach to managing parasitic diseases in animals. It involves combining multiple strategies, including pasture management, surveillance, environmental management, biological control, and resistance management to control parasitic infections. IPM aims to control parasite populations effectively while reducing the long-term risks associated with overuse of drugs and other control measures. The adoption of IPM principles can lead to healthier animals, improved productivity, and reduced environmental impact, making it a key component of modern veterinary parasitology.

4. Biological Control

Biological control is defined as the activities carried out by a species to control other species in order to reduce its adverse effects (Alston, 2011) ^[1]. It is a natural, eco-friendly alternative to chemical treatments. These methods involve the use of natural predators, parasitoids, or pathogens to reduce parasite populations in livestock or on pastureland. Biological control aims to disrupt the life cycle of parasites without harming the environment or contributing to chemical resistance. Different ways of biological control discussed below

A. Predators

The biological control of parasites is accomplished by two different kinds of predators: invertebrate and vertebrate. Spiders and insect herbivores, mites, ants, beetles, dragonflies and water bugs are the invertebrates that are used for the biological control of parasites (Greathead and Greathead, 1992) ^[7]. Mites may prey on nematode ova and on the eggs and larvae of flies. *Macrocheles muscaedomesticae* is a mite that can prey on 10 house fly eggs a day (Azevedo *et al.*, 2018) ^[2]. Dragonflies and water bugs (*Diplonychus indicus*) are used to control the mosquito population; dragonfly larvae prey on mosquito larvae and dragonfly adults prey on adult mosquitoes (Karunaratne and Surendran, 2022) ^[10]. Vertebrate predators such as fish, amphibians, reptiles, birds, rodents, and mammals are employed in the biological control of parasites. Several fish species, including *Poecilia reticulata*, *Gambusia affinis*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Labeo rohita*, *Tilapia spp.*, carp fish, *Mylopharyngodon piceus* (black carp fish), as well as *Pelomedusa subrufa* (the water tortoise) feed on the mosquito population in water sources. Lizards prey on ticks and it has been reported that 2.5 to 15 ticks may be found in lizard stomachs (Pirali-Kheirabadi, 2012) ^[17].

B. Parasitoids

Parasitoids are parasites that attack, parasitize and harm other

parasites. Examples include ichneumon, braconid, and chalcid wasps, cabbage caterpillars, scale insects, and tachinid flies. Tachinid flies lay eggs on host insects like *Haematobia irritans* (horn fly), and their larvae kill the host. These flies are studied for controlling cattle flies. *Spalangia* wasps parasitize pupal stages of flies like *Musca domestica* (housefly) and *Stomoxys calcitrans* (stable fly), and are used in commercial livestock fly control. *Nasonia* wasps target filth fly pupae, aiding in fly control at poultry houses and livestock facilities.

C. Pathogens

Various pathogens, including fungi, bacteria, viruses, protozoa, nematodes, and earthworms, are used for parasite control. Entomopathogenic fungi (EPF), mainly from *Ascomycota* phylum, targets ticks, mites, and insects. *Zygomycota* phylum have a lesser contribution as EPF. Key EPF include *Beauveria bassiana*, *Metarhizium anisopliae*, *Lagenidium giganteum*, and *Verticillium lecanii*, *Entomophthora muscae*, *Coelomomyces spp.*, *Leptoglenia spp* with *B. bassiana* and *M. anisopliae* being commercially available for insect control. These fungi can persist in soil, offering long-term control (Quesada-Moraga *et al.* ^[18], 2006; Leger, 2008 ^[11]). *M. anisopliae* is particularly effective against *Rhipicephalus* ticks, vectors of babesiosis and anaplasmosis. Nematopathogenic fungi (NPF), such as *Arthrobotrys oligospora*, *Drechmeria coniospora*, and *Duddingtonia flagrans*, specifically target and kill nematodes.

D. Bacteria

Bacillus, *Paenibacillus* and *Streptomyces* are the genera of bacteria that are used for the biological control of insects or arachnids. Various species eg. *Bacillus thuringiensis* var. *israelensis*, *B. thuringiensis* var. *kurstaki*, *B. thuringiensis* var. *aizawai*, *B. thuringiensis* var. *tenebrionis* and *B. thuringiensis* var. *japonensis* strain buibui used for Bio control of parasites. Other than *Bacillus*, *Paenibacillus glabrata* infects and causes death of snails. *Streptomyces* (*S. avermitilis* and *S. griseolus*) is another genus of bacteria used for the biological control of parasites. Avermectins are toxins produced by *S. avermitilis* that kill a variety of parasites, such as arachnids, insects and nematodes.

E. Nematodes

Some species of nematodes eg. *Steinernema* and *Heterorhabditis* are effective against insect pests, including tick larvae and pupae. They are being investigated for their role in controlling Ixodes ticks (which transmit Lyme disease) and other ectoparasites in livestock and companion animals. *Heterorhabditis bacteriophora* has been used experimentally to control larvae of parasitic flies, particularly blowflies that infest livestock, including sheep and cattle.

5. Phytotherapy

Phytotherapy is a cost-effective and efficient alternative for controlling parasitic worms. Key phytochemicals include terpenoids, phenolic compounds, and alkaloids, with many medicinal plants showing anti-helminthic activity (Yellassubaiyah *et al.*, 2015) ^[21]. *Bursera grandifolia*, *Passiflora mexicana*, *B. copallifera*, *Lippia graveolens*, *Urtica dioica*, *Prosopis laevigata* and *Randia echinocarpa* are effective against *Haemonchus contortus* larvae, while extracts of *Achillea millefolium*, *Artemisia absinthium*, *Artemisia campestris*, *Artemisia vulgaris* and *Cichorium intybus* target *Toxocara vitulorum*, *H. contortus*, and *Trichostrongylus*

colubriformis infections.

A. Phytotherapy in Protozoans

Alocasia indica and *Salvia* species exhibit anti-giardia and anti-amoebic properties may be due to potent terpenoids. *Artemisia annua* inhibits sporulation of *Eimeria tenella* via oxidative stress, while tannins from *Pinus radiata* affect *E. tenella*, *E. acervulina*, and *E. maxima* (Molan *et al.*, 2009)^[14]. *Peristrophe bicalyculata* shows efficacy against trypanosomiasis, though its mechanism remains unclear. Among bisbenzylisoquinoline alkaloids, 13 are effective against *Leishmania donovani*, with *Drypetes gerrardii*, *Embllica officinalis*, and *Azadirachta indica* also exhibiting anti-leishmanial activity.

B. Phytotherapy in Arthropod Infestation

In poultry, the control of lice with pawpaw leaves has been reported, used as a topical agent after burning into ashes. In rabbits infected with psoroptic mange, salt and shea butter in a ratio of 1:100 showed 90% efficacy by the 14th day (Fajimi *et al.*, 2002)^[6]. Ethanol extract of *Dahlstedtia pentaphyla* was found to be effective against adult *Boophilus microplus* ticks and *Copaifera reticulata* extract was found to be effective against the larval stage. The larvicidal activity of the ethanol extract of *Magonia pubescens* is also reported in the case of *R. sanguineus*. Methanolic extract of *Tephrosia vogelii* and *Hypericum polyanthum* showed efficacy against hard ticks (Matovu and Olila, 2007)^[12].

6. Immunoprophylaxis

Immunoprophylaxis offers a long term, sustainable approach to controlling parasitic infections in animals. Despite challenges in vaccine development due to parasite complexity, progress is ongoing. Combining vaccines with other control measures will enhance parasite management in livestock and pets. Several vaccines have been developed for parasitic control in livestock and pets, targeting various pathogens. For helminths, *Echinococcus granulosus* (cattle) is addressed with the recombinant subunit vaccine, *Providean Hydatil EG95*, while *Cysticercus cellulosae* (pigs) is targeted with *Cysvax*, also a recombinant subunit vaccine. *Haemonchus contortus* in sheep and goats is controlled with the purified native antigen vaccine *Barbervax*, and *Dictyocaulus viviparus* (cattle) is managed using the live attenuated vaccines *Bovilis* and *Huskvac*. *Ancylostoma caninum* (dogs) is controlled with the gamma-irradiated infective vaccine *Canine hookworm vaccine*. For protozoa and rickettsia, *Babesia canis* and *B. rossi* in dogs are addressed with the subunit culture supernatant vaccine *Nobivac Piro*, while *Eimeria* sp. in chickens is prevented with either subunit vaccines such as *CoxAbic* or live attenuated vaccines like *Paracox*, *Livacox*, and *Eimeriavax*. *Leishmania donovani* in dogs is controlled with recombinant subunit vaccines like *Leish-Tec* and *Leishmune*, and *Theileria annulata* in cattle is managed with live attenuated vaccines such as *Rakshavaac T* and *Teylovac*. *Toxoplasma gondii* in sheep is prevented with the live attenuated vaccine *Toxovax*, while *Trichomonas foetus* in cattle is controlled with the inactivated *TrichGuard*. *Anaplasma marginale* in cattle is managed with both killed virulent vaccines like *Anaplaz* and *Plazvax*, and live attenuated vaccines like *Anaviv*. For ticks, *Rhipicephalus (Boophilus microplus)* in cattle is controlled using recombinant subunit vaccines like *Gavac Plus* and *Vacuna Hebertick*, as well as *Go-Tick* and *Tick-Vac*.

Conclusion

Mitigating parasitic threats in livestock requires a multifaceted approach that integrates various strategies to ensure long-term effectiveness. The use of chemotherapeutic agents, biological control, immunoprophylaxis, and integrated parasite management systems has proven essential in controlling parasitic diseases. Additionally, research into plant-based treatments, as well as the use of natural predators and parasitoids, offers promising alternatives to chemical interventions.

However, it is essential to combine these strategies to prevent resistance and promote animal welfare. By adopting a holistic approach, farmers can reduce the economic burden of parasitic diseases, improve livestock productivity, and ensure the sustainability of farming systems. Ultimately, a balance of traditional methods, cutting-edge innovations, and ecological awareness will provide the most effective and sustainable solutions for managing parasitic threats in livestock.

Conflict of Interest

Not available

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