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Popular Article

Nutritional approaches for prevention and control of gastrointestinal parasites in livestock

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Gastrointestinal parasitism has been long considered as a major challenge for the health and the welfare of animals. Parasitism, especially by helminth parasites, impairs health by causing inappetence, diarrhoea, anaemia and, in severe cases, death. In addition to compromising health and welfare, parasitism impairs productivity and results in poor growth and reproductive performance. Livestock are constantly exposed to gastrointestinal parasites through grazing. They eventually acquire immunity to the parasites and successfully regulate them, although their immunity may break down during certain stages of their lives. For the times when animals are susceptible to gastrointestinal parasites, control of parasitism has traditionally depended on the use of anthelmintic drugs. However, occurrence of resistance to anthelmintics is now a worldwide problem. Anthelmintic resistance in gastrointestinal parasites of cattle is an increasing problem, but remains less prevalent than in small ruminants. In addition, there is increased awareness about drug residues that potentially enter the food chain and are detrimental for the environment. Thus, there is an urgent requirement to minimize the regular, preventive use of anthelmintics and combine it with non-chemical means to control the parasitic infection.

The need for a reduction in the regular use of anthelmintics and particularly the urge to conserve the efficacy of the existing ones, has led to the establishment of protocols that enable a more targeted use of the drugs. One example of such targeted, selective treatment is via

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monitoring and treating individual animals with anthelmintic drugs. This should contribute towards slowing the speed of the development of anthelmintic resistance by reducing the selection pressure on the resistant parasites and maintaining a proportion of non-resistant parasites (refugia) in the population. The most well-known example of such targeted treatment is FAMACHA, a system that uses anaemia as morbidity marker for treatment, in sheep infected with the abomasal nematode *Haemonchus contortus*. Instead of drenching all the animals in a flock, only the ones that are considered at risk, due to low FAMACHA scores are treated.

Another example of selective anthelmintic treatment, this time targeted against specific parasite species, is the use of copper oxide wire particles (COWP). The use of COWP is targeted against a specific nematode species, *H. contortus*, whereas it has little effect against *T. circumcinta* or *Trichostrongylus columbriformis*. Experimental evidence has shown that the slow release of copper can act as an efficient anthelmintic by reducing worm burdens and fecal egg counts within 7 days of administration as well as improve the indicators of anaemia in infected flocks. The COWP indirectly act on adult nematodes through the increased copper status of the host, or directly due to increased copper in the abomasum, which could potentially damage and penetrate the cuticle of *H. contortus*. Doses of COWP as low as 0.5 g administered to lambs or kids were effective in reducing FEC by 90% and the lower doses reduced the risk of copper toxicity. However, in naturally-infected grazing lambs, anthelmintic activity did not last more than 28 days. The effectiveness of COWP may be greater in combination with feeding or grazing *Sericea lespedeza*, a forage rich in condensed tannins. It is suggested that if small ruminants are determined to be heavily infected, i.e., FAMACHA score of 4 or 5, then COWP should be coupled with an anthelmintics (albendazole or levamisole) to increase its efficacy.

Host nutrition can affect gastrointestinal nematodes through its influence on host resistance, which refers to the host ability to regulate gastrointestinal nematode establishment, development, fecundity and survival. Medicinal plants or plants with secondary plant compounds (bioactive plants) have been used as anthelmintics for centuries. Secondary plant compounds with anthelmintic activity include tannins, lactones, alkaloids, saponins, terpines, glycosides and phenolic compounds. These compounds are thought to protect the plant from pests, drought, excess moisture, and grazing animals. When used in moderation or when restricted to high-risk exposure to parasites, a few secondary plant compounds have shown potential for controlling gastrointestinal parasites in livestock, with the most widely studied being condensed tannins.

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Grazing or feeding condensed tannin-containing plants like *Sericea lespedeza*, *Lysiloma latisiliquum* or *Acacia mearnsii* can be used in an integrated management system to control gastrointestinal parasites. *Sericea lespedeza*, either grazed or fed as hay or pellets, reduced FEC of primarily *H. contortus*. The plant may reduce worm burdens, negatively affect larval development, survival in the feces and an increase in mucosal mast cells on the gastric mucosa of animals. Condensed tannins have the ability to bind to dietary protein, protect it from rumen degradation and make it available in the lower gastrointestinal tract for absorption. As a consequence, protein losses in the rumen are reduced and thus the resistance observed. Also, the forages like Lotus spp., Hedysarum spp., Onobrychis spp. and *Cichorium intybus*, are usually of high nutritive value and the majority of these forages are rich in condensed tannins or other PSM. If their consumption can be combined with high performance and anthelmintic effects, they could be considered the ideal candidate for alternatives to parasite control in ruminant production systems. However, there is little reported on the anthelmintic effects of condensed tannin plants on GIP in cattle, but extracts of tannins from sainfoin (*Onobrychis viciifolia*), birdsfoot trefoil (*Lotus corniculatus*), sulla (*Hedysarum coronarium*) and big trefoil reduced *in vitro* activity of cattle parasites *Cooperia oncophora* and *Ostertagia ostertagi.* Hydrolyzable tannins such as those found in *Epilobium angustifolium*, *Quercus robur*, *Rubus idaeus*, and *Rosa rugosa* demonstrated *in vitro* anthelmintic activity against *H. contortus*. *In vitro* contact with plant solutions led to changes in the surface of the cuticle, the cephalic region of L1 and L2 stages, and the unhatched eggs along with aggregates located at the buccal capsule and the anterior amphidial channels.

Additionally, lactones such as santonine isolated from *Artemisia* spp., have shown a strong anthelmintic activity towards *Ascaris* spp. of livestock. Alkaloids have demonstrated strong nematocidal activity towards *Strongyloides ratti* and *S. venezuelensis*, two human nematodes. The nematocidal activity of polyphenolic extracts from rasberry plants has been reported as early as the 1960s. The PSM may affect resistance to the parasitic infection through two main mechanisms. Firstly, improvement in the resistance of the parasitized animals may be immunologically mediated. Recent evidence suggested that grazing on chicory (*Cichorium intybus*), a plant rich in terpenes, such as sesqueterpene lactones, reduced the parasite burden of growing sheep. This was accompanied with an increase in mucosal inflammatory cells specific to the immune response, such as globule leucocytes. In addition, chicory does not contain high concentration of condensed tannins and its protein content is similar to conventional grass/clover grazing. However, chicory contains high amount of minerals and

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could potentially improve the resistance of parasitized hosts, through mineral supplementation. For example, selenium, copper, phosphorus and molybdenum have all been implicated in enhancing resistance against nematodes. Therefore, particularly at mineral deficient environments, chicory could contribute towards the improvement of resistance through mineral supplementation.

A number of plants with denoted anthelmintic properties have also been included in the British pharmacopoeia. For example, oil of chenopodium that derives from *Chenopodium ambrosioides*, was used for many years in the UK to treat nematode parasite infections (*Strongylus*, *Parascaris* and *Ascaris* spp.) in monogastric animals including humans. The leaves and dried flowers, have been used as an anthelmintic since the early 1900s. Chenopodium is still used to treat worm infections in Latin America. In addition, male fern *Dryopteris filix-mas* and *Artemisia* spp. plants have been used against cestodes such as *Moniezia* spp., and nematodes, such as *Ascaridia* spp., in ruminants and poultry respectively. Also, garlic contains a sulphuric compound, which has been considered responsible for the anthelmintic effect, whereas the walnut contains naphthoquinone, the active compound against worms. *Mallotus philippinensis* contains glycosides, which have been shown to be the active compounds against cestodes in goats. Recent studies have confirmed and extended these reports, demonstrating anti-parasitic activity from bioactive forages such as acacia (*Acacia cyanophylla*) foliage, *Ziziphus nummularia* bark and *Acacia nilotica* fruit, *Chenopodium album* and *Caesalpinia crista*, falcon's claw acacia (*Acacia polacantha*), *Coriandrum sativum* and ginger (*Zingiber officinale*)

Optimal nutrition is an important factor in tolerance to GIP. Increased dietary protein (soybean meal, fishmeal, cottonseed meal and urea) is associated with reduced FEC and reduced worm burdens, modulates inappetence related to GIP infection and improved expression of immunity. Increased protein enhances immune function which regulate the establishment, fecundity and survival of parasites. In general, protein supplementation results in an increased concentration of circulating and local inflammatory cells, mast cell proteases and circulating antibodies, especially during the phase of expression of immunity. In addition, protein supplementation also increased the proportion of thymus-derived cells that are associated with expression of cellular immunity in the local immune response. Likewise, protein feed ingredients like peas, beans and lupins contain a wide range of PSM with known or unknown anti-parasitic activities. Increased energy in the diet often led to increased body weight, but did not always influence GIP infection measures. Effects of higher protein levels in the diet may be more important for susceptible than parasite resistant breeds. Increased protein can be sourced from supplements or high-quality forages.

Nematode-trapping fungi, also known as predatory or nematophagous fungi, have potential as a biological control agent against the free-living larval stages of gastrointestinal nematodes (GIN) in livestock feces. These fungi are found worldwide and act by trapping and destroying the developing parasitic larvae in feces, by producing a variety of trapping structures such as constricting rings, non-constricting rings, adhesive knobs, adhesive hyphae, adhesive branches, and adhesive networks on the mycelium (bundle of hyphae). Of the various species of fungi tested, *Duddingtonia flagrans* spores have the best ability to survive passage through the gastrointestinal tract of ruminants This is important because active spores of the fungi must be present in the feces when deposited to have activity against the developing larvae. These fungi have rapid growth rates and high affinity for trapping and digesting larvae. After the animal defecates, the spores germinate and grow in the feces to form the sticky, sophisticated traps/loops which trap the developing larval stages of GIN in the fecal environment. Once trapped, larvae are unable to migrate out of the fecal mass and onto forage, thus, fewer larvae are available for consumption by a grazing ruminant host. This form of control has been successfully applied under field conditions and is an environmentally safe biological approach for forage-based feeding systems.

Non-chemical approaches for the control of parasitism currently under investigation include long-term solutions, such as breeding livestock for parasite resistance or developing vaccines against GIP. Taking advantage of host genetics for resistance and resilience to infection represent a promising and sustainable means to minimize GIP infection in a herd or flock. Breeds of tropical or African origin (e.g., St. Croix, Barbados Blackbelly, Gulf Coast Native, Santa Ines) generally show greater resistance as measured by FEC than breeds of temperate origins. Any parasite control strategy should also aim to reduce pasture infectivity. Grazing management can also influence GIP infection of livestock. Utilization of browse for goats to minimize grazing will decrease the numbers of infective larvae that are ingested, and use of plant species with more complex leaf structure and higher protein forages or legumes will help reduce GIP infection. Multi-species grazing and/or alternate grazing of cattle or horses with sheep or goats, offers important benefits to GIP control as parasite species differ between host species. Rotational grazing is another strategy that can reduce exposure to GIN larvae on pasture. Rotation of animals to new grass plots every 3 to 7 days, with return to the original grass plots 28 to 35 days later, led to a reduced incidence of deworming and lower worm

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infections as compared to continuously grazed grass plots. Diatomaceous earth (DE) is a natural siliceous substance that is formed from the skeletal remains of unicellular organisms. When DE is ingested by livestock, the microscopic shards are thought to use mechanical movements within the gut to cause injury to the cuticle of parasite and ultimately lead to the dehydration then death of the adult parasites.

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