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Recent Technologies Applying for Helminth Parasite Control in Ruminant Animals

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ABSTRACT

Parasitic diseases are one of the most common problems that confront the health and product-ivity of animals worldwide. They are responsible for organ condemnation, zoonoses and huge economic losses in animals' product. Various control methods have been advised and implemented to minimize losses caused by parasitic disease. Control generally implies the suppression of parasite burdens in the host below that level at which economic loss occurs. In the past chemotherapy and chemoprophylaxis are the most widely used control approaches all over the world. However, development of drug resistance, high price of drugs, unavailability and concern drug residues hinder the success of this approach. In recent years, the accent has shifted to more flexible approach, namely integrated parasite control, which refers to a system of multiple control approaches (chemical, non-chemical) are utilized, following the consideration of economic factors, epidemiology, resistance status, production system and management structure in place.

Key words: Anthelminthics, Biological control, Helminthes and Integrated control.

INTRODUCTION

One of the most serious problems facing scientists today is provision of adequate supplies of food to an ever-increasing human population. Animals have great role in production of that food and the disease is an important constraint to increase production of animal food for human consumption. Efforts to increase the world production of animal food for human consumption, therefore, must involve improvement in the productivity of livestock through intensified research activity in disease control as well as in nutrition and genetics. In the absence of effective control of parasitic disease, an expanded population of non- productive animal is created which cannot fulfill its genetic potential in the utilization of feed for growth and reproduction (Vanwyk, 2002). Helminthes (Nematodes, Cestodes and Trematodes) are extremely numerous and cosmopolitan parasites of human and animals and they are responsible for a considerable clinical and sub clinical disease and tremendous economic loss. They inflict harm to animals due to their pathogenicity, sharing of nutrient and by predisposing to other disease**.** Parasitic diseases of animals have known to cause a wide range of pathologic conditions in their host. For example, the developmental stages of gastric parasites cause a reduction in the functional gastric gland mass. Some parasites also known to cause organ damage due to either mechanical effect or inflammatory reactions (Schistosoma, Lungworm, Ascarida, etc.) (Chadrawathani and Waller, 2005).

In Ethiopia where farm animals are kept on pasture through the year and climatic conditions are favourable for the development of survival of infective stages, helminthes are recognized as a major cause of economic losses. Review of the available literature in Ethiopia strongly suggests that helminthosis has nationwide distribution and is considered as one of the major setbacks to live stock productivity incurring huge direct and indirect losses in the country, which is estimated to be an annual loss of 400 million US dollar to the meat industry and the export of livestock to foreign markets (Tilahun, 1998). In the past control of parasitic disease of livestock has long been based on the use of drugs and pesticides. In recent years, there has been a change in approach because of development of resistance of the parasites against the compound used; increasing cost of new products for the user; and problems associated with toxicity, environmental pollution and residues in animal product. It is just that, because of the various reasons mentioned the parasite control approach at present follows more multi disciplinary approach, namely integrated helminth control (Waller, 1999).

Therefore, the objectives of this critical review manuscript were to review and compile information on the possible methods of helminthes control particularly integrated parasite control.

PRINCIPLES OF CONTROL MEASURES AGAINST HELMINTHS IN RUMINANTS

Control generally implies the suppression of parasite burdens in the host below that level at which economic loss occurs. To do this effectively requires a comprehensive knowledge of the epidemiologic and ecologic factors that govern pasture larval populations and the role of host immunity to infection. The goals of control are, to prevent heavy exposure in susceptible hosts (recovery from heavy infection is always slow), to reduce overall levels of pasture contamination, to minimize the effects of parasite burdens, and to encourage the development of immunity in the animals. This objective is achieved by integrating grazing management, use of anthelminthics, utilization of the natural or artificial induced immunity, and improving nutritional management (Thamsborg *et al.*, 1999; Siege, 2010).

Considerations during control of helminthes

Epidemiology: The most important requirement for the successful implementation of rational and sustainable helminth parasite control programmes in grazing animals is a sound knowledge of the epidemiology of the parasite as it interacts with the host in a specific climatic, management and production environment. This knowledge base has been established through extensive studies and field trials. Strategically timed anthelminthics treatment and plans for safe pasture consideration must be based on precise epidemiological data obtained in a given area. The objective is to remove large worm burdens before and during climatic periods that are favorable for the development and survival of free-living stages and to prevent accumulation of larval contamination on pasture (Barger, 1999).

The new discoveries made relating to the epidemiology of ruminant parasitism have led to new concepts regarding patterns of infection, the life span of worms, the survival of infective larvae on pasture, the number of worm generations per year, hypobiosis, peri-parturient rise in egg counts, and the prophylactic use of anthelmithes. A key aspect is the integration of treatment and grazing management to prevent post treatment re-infection. Otherwise , treatment only remove worms with short life span normally destined to be lost in a few days, and provided only with transient protection before the process of re-infection returns worm burdens to pre treatment (Averbeck and Stromberg, 1999). There are important factors, which influence epidemiology of helminthes, among these Husbandries:-changes in husbandry, including intensive grazing increases the hazards of parasitic diseases .among aspects of animal husbandry affecting epizoology are the problems raised by cross transmission of parasites (Kunert, 1992).

Nutrition: it is well established that poorly fed animals are more susceptible to the effect of internal parasites and are more inclined to carry heavy worm burdens because of their failure to throw off infestations quickly (Drudge *et al.,* 2009). Seasonal patterns:-regular seasonal pattern changes permit prediction and prevention of parasitic infestation. The renewal and re infection come through two chief agencies namely, the arrival in the flock or herd of highly susceptible young animals as they born and the influence of meteorologic conditions on the free living stages of the parasite. If season of birth coincides with meteorologic conditions favorable for the development and survival of free-living stages, one expects rapid increase in the worm burdens (Besier and Duns, 1993).

Hypobiosis: numerous examples of temporary cessation of vital physiological processes are known to occur at various stages in the life of parasitic worm. Cases of cessation of activity must be regarded as phenomena of adaptation that allow the egg or larvae to perform the stage transformation without disturbance, or the adult to survive in unfavorable environmental conditions. There for hypobiosis has important practical implication because it enables the parasite to survive in a dormant state in the host during adverse periods when there is a hostile immunogenic environment. In contrast to the turnover of normally developed worms, arrested larvae tend to accumulate and may reach large numbers, apparently unaffected by host immune response. If a sudden resumption of development to adult worms occurs, it may produce a dramatic in pasture contamination and large worm burdens in the host at a time when pasture infectivity might be quite low (Averbeck and Stromberg, 1999).

Life cycle: The life cycle presents strong points in relation to control, whether the examination is epidemiologic or ecologic. Its understanding has always been the basis for devising control measures against helminthoses. A somewhat closer analysis of the life cycle and its division into stages and phases appeared to offer a better approach by emphasizing the need for seeking multiple points for attack, especially in those areas where there is no one particularly vulnerable points (Gordon, 2008).

POSSIBLE METHODS OF HELMINTHE CONTROL: INTEGRATED CONTROL

Total dependence on a single method of control has proved to be non-sustainable and cost in effective in the long term. In the past chemotherapy and chemoprophylaxis are the most widely used control approaches all over the world. However, development of drug resistance, high price of drugs, unavailability and concern drug residues hinder the success of this approach. In recent years, the accent has shifted to more flexiable approach, namely integrated parasite control. Integrated control means making optimal use of all available methods of control in a flexible way, adapted to local circumstances to economic reality. These may include biological, Immunological, mechanical, genetic and chemical measures, while sanitary and surveillance procedures remain available. The fundamental aims of integrated parasitic controls are: to reduce parasite population and maintain them at levels below hose causing injury, to steer chemical uses away from intensive, broad spectrum use towards optimized selective use to recognize that environmental damage may be an un intentional cost of parasite control and to reduce producers cost as well as lower chemical residue (FAO, 2000). The principles of integrated parasite control is to limit the contact between the hosts and the infective larvae in the field through grazing management method and improving the host response against parasite infections relying on the genetic selection between or within breeds, crossbreeding of resistant and susceptible breeds and/or the manipulation of nutrition. These approaches may benefit from a better understanding of the potential underlying mechanisms, in particular in regard of the host immune response against the worms (Smith *et al*., 1994).

Chemotherapeutic approaches

The chemical technology relies entirely on treatment with different formulations of anthelminthics used in different control strategies according to whether epidemiological knowledge is absent or available. An anthelminthics is a compound, which destroys or removes helminthes from the gastro-intestinal tract and other tissues and organs they may occupy in their hosts. Currently a good selection of safe anthelminthics is available, some with broad-spectrum activity and others with activity against specific helminthes infections. Many modern anthelminthics are effective against both adults and larval stages and an increasing number are efficacious against arrested or dormant larvae. Due to their cost and their tendency to delay or interfere with natural host immunity mechanisms, anthelminthics may not be the most desirable method of managing helminthes problems (Van wyk, 2002). Generally, they are used either to treat clinically sick animals (curative) or to prevent animals from serious attacks by parasites (prophylactic). Prophylactic treatment is given with the purpose of preventing the animal from serious attacks). The different approaches of prophylactic treatment are (Hansen and Nari, 1999).

Strategic treatment: Clinical parasitic disease in ruminants usually occurs at or shortly after times of peak larval availability. The timing of peak larval availability on pasture is of crucial importance in understanding the population dynamics of the parasite population, because this is when the largest worm burdens are acquired. In order to prevent these seasonal peaks from developing that strategically timed control measures are implemented. Thus, treatments are often administered at times when the larval challenge on pasture is low and the majority of the parasite, population is in the host. This reduces the pool of susceptible parasites and may increase selection pressure for resistance. Due to the effect of the climate and weather on development, survival and transmission of free living stages, weather conditions play a dominant role in determining the timing of strategic treatments (Barger *et al., 1999*). Geographical differences in the seasonal availability of infective larvae from the pastures have similarly been a key factor for determining the timing of strategic treatments. In temperate climatic zones, sequential treatments at the beginning of the grazing season, using intervals similar to the pre-patent period or pre-patent period plus the length of the residual effect of the drugs, have been used. Similar sequential treatments have been applied at the beginning of the rainy season in tropical zones, with one treatment added during the dry season when pastures would be almost sterile. Strategic treatments are administered, not only for therapeutic purposes to get rid of worms, but also as a prophylactic measure to prevent future contamination of pasture and reduce the risk of future re infection (Barger *et al., 1999*). Based on the epidemiology of the nematode, the most practiced approaches in implementing strategic control approaches are:-Protecting the young:- treatments with anthelminthics are commonly allowed to young animals until weaning and at weaning when they are supposed to suffer from nutritional stress. The second approach in implementing strategic control approach is treating of older animals, which is given with the objective of preventing pasture contamination and clinical helminthosis. The third approach is treating of pregnant animals to prevent contamination and to avoid risk to incoming new susceptible generation. Generally, strategic treatment is given 2-4 times per year depending up on climate, management practices as well as the prevalence of nematodes in area (Bowman, 1999).

Tactical treatment: Prophylactic treatment is given based on abnormal changes such as a climatic changes and nutritional changes; these changes include heavy rainfall, mild temperature, poor nutrition or when worm free animal introduced into endemic area. Even though different anthelmintic drug formulations are available in the market for curative and prophylactic purposes; frequent and haphazard use, over-reliance on chemicals causes for the development of drug resistance. As resistance to newer anthelminthics develops, there is a need for control measures alternative to chemotherapy. Chemical residues in foods are now a major concern and a strong driving force for reduced chemical inputs in agriculture. Consumers increasingly demand that food supply should be free from contaminants of all kinds use of anthelminthics leads to drug resistance by the helminthes (Tembely, 1998).

Non- chemotherapeutic approaches

With the increasingly wide spread problem of resistance to anthelminthics and the increase in consumer pressure or quality animal products without residues, the demand for alternative, nonchemical parasite control interventions will increase. Few of these methods have, however, been sufficiently validated to the point where they can be recommended for general use. It is also likely that they will have to be used in combination with other interventions in order to obtain the desired effect. Among the non-chemical tools available immediately for implementation are pasture management, breeding management and improved nutrition. Others, namely utilization of herbal remedies, and biological control, still require research, development and validation in different geo-climatic regions under a variety of production systems. They may, however, already be incorporated in integrated control strategies (Bowman, 1999).

Improved husbandry practice: Grazing management strategies have been demonstrated to be useful to alleviate the impact of helminthes in livestock. Unfortunately, these strategies have not been adopted fully due to the ease for the farmer to use drugs and the increased demand for land, which makes this proposition less likely in many intensive livestock systems. Grazing behavior, either naturally selective or imposed by husbandry may influence acquisition of infection as well as nutritional status. There is a described observation on the significance of bovine grazing behavior in relation to acquisition of *D. viviparous* infection. Overcrowding by grazing animals is one of the several indications for a tactical attack on a parasite enemy which is about to be reinforced. Young animals are very selective; twin lambs often acquire heavier infections than singles (Gordon, 2008). When pasture is lightly stocked, the animal will not graze so close to the ground and therefore will not pick up so many worms as when the pasture is heavily stocked and they must nip off every bite of green. It is possible to manage pastures so that animals are raised virtually free of worms but this is seldom practically. The trend in recent years has been to more intensive agriculture with large number of animals set stocked on pasture. While set stocking is potentially more dangerous, it works well if combined with anthelminthics treatments given at times suggested by epidemiological studies and aimed at maintaining a low level of pasture contamination. Pastures which is short in length, besides being poor nutritionally, encourages infestation because larval contamination concentration will be at a maximum (the distance they have to travel to get on to pasture is less and larvae which are concentrated in pasture litter, will be taken in with roots and soils) (Paraud *et al.,* 2005).

Rotational grazing is the first control measure, which must practice to minimize these effects. This is a grazing management technique involving subdivision of pastures in which each paddock is grazed for a short time and then rested for a relatively much longer time. Based on the parasites epidemiology, rotation of animals from heavily contaminated pasture to the clean pasture usually in weekly basis. Recently there has been increased interest in using rotational grazing of pastures for the optimization of pasture growth and productivity. This is an excellent tool, from the productivity point of view, as animals will consume a higher proportion of the available forage, which stimulates pasture re-growth. The major requirement for parasite control would be sufficient resting time for most of the infective larvae originating from the previous grazing to have died off. This is probably not achievable in temperate climates, given that substantial declines in pasture infectivity may take from 3 to 9 months, depending on the climate and time of the year. It may, however be useful on wet tropical pastures where larval survival times are short. This makes it possible to design a practicable rotation that is short enough to prevent re infection within a single grazing period, because development from egg to infective larva can take as little as 4 or 5 days. This strategy must combine with an anthelmintic treatment at the time of introducing the rotational system (Barger, 1999).

The second control measure used to minimize these effects is using alternate grazing. This parasite control is based on different age groups of the same species, or different species grazing the pastures in sequence. In cases where different age groups are used it is common practice to graze calves followed by older cattle, taking advantage of higher resistance in the older animals. If the system is based on alternating between species (sheep and cattle) it utilizes the fact that many parasites show little cross-infectivity between adult cattle and sheep and/or the reduced susceptibility of different host species. It should be kept in mind that cool moist weather prolongs larval survival, and it is likely that alternate grazing systems will be less efficient in controlling parasites in temperate climates compared to tropical and subtropical regions. This can be combined with anthelmintic treatment at the time of introducing another species or age group (Drudge *et al*., 2009). Early weaning is another approach to reduce the effect worm burdens .In flocks where nematodiosis is the major problem, to insure that most susceptible part of the flock (kids and lambs) separate from their mothers as early as possible and graze on clean pasture (paddock) useful method (Radostits, 2001). Controlling the density of livestock (stocking rate) is also used to minimize the effect of worm burden this is because overstocking forces the animals to graze closer to faecal material and closer to the ground, and may result in the consumption of a higher number of infective larvae (Barger *et al.,* 1999).

Nutritional Management: Gastro-intestinal parasitism of ruminants is a production-related phenomenon, enhanced by chronic malnutrition and under nutrition, which is particularly common in the developing world. Research has shown that improved nutrition reduces production losses and mortality rates due to worm parasites of livestock. Strategic feed supplementation, particularly to susceptible classes of stock such as young and peri-parturient animals, can have long-term benefits. Low-cost mineral and non-protein nitrogen supplements dramatically change the physiology of the rumen. These lead to greater feed intake and increased microbial protein production, resulting in increased protein for digestion and absorption in the small intestine. The ability of animals to cope with parasites may result in lower egg output by the worms and a subsequent reduction in pasture infectivity levels. The main effect of protein supplementation is to increase the rate of acquisition of immunity and increase resistance to re infection and this has been associated with an enhanced cellular immune response in the gastro-intestinal mucosa. Studies on the influence of nutrition on the expression of genotype have shown that the benefits of a superior genotype are not lost on a low protein diet where as a high protein diet can partially ameliorate the disadvantages of an inferior genotype (Coop and Holmes, 1996).

Biological control and their agents: Biological control is defined as the use of one living organism introduced into the environment to obtain control of target parasite, and thereby reducing the population growth of the latter below a threshold, where it causes minimal clinical and/or economic losses. Almost all strategies for the control of gastro-intestinal nematodes target the parasitic stages within the animal. In contrast, the biological control of nematode parasites is targeted at the free-living stages on pasture. Therefore, the aim of biological control is not to eliminate a given parasite organism but to lower the density of pest population below the clinical level and perhaps below the economic threshold above which production losses are obvious owing to a high parasitic population density. To successfully develop a product for use in an integrated biological control strategy, a number of criteria have to be met, such as survival through GI tract, able to grow and be active in dung, cheap to produce, and safe to handle (Faedo and Waller, 1996). When helminthes population growth rate is under control together with other methods, there are great prospects for long-term reduction of the parasite. For instance, nematophagus fungi were shown to reduce populations of pre - parasitic stages of nematodes significantly. These fungi are relatively easy to culture and can be released into the environment of the target organism in a controlled fashion. The fungus *Duddingtonia flagrans* is very efficient in controlling most of the economically important GI nematodes of grazing livestock by reducing pasture infectivity. This method is one of the promising methods to overcome the drug resistance problem. The fungi could be given with feed, feed supplement, feed blocks or controlled device system to the animals, and then the fungi resist ruminant gut passage, germinate and spread in dung and capture large numbers of infective larvae before it migrates to the pasture (Larsen, 2000). All nematode parasites of livestock have a life cycle, which involve not only the parasitic phase within the animal host, but also a free-living stage on pasture. All stages are potentially vulnerable to attack by biological control agents, but intuitively it would seem that the free-living components of the parasites life cycle offer the most promise. Therefore, for the near future, the greatest research effort in the quest for biological control (BC) agents of animal nematode parasites is likely to be focused on those organisms in the external or free living, environment. This is because a large range of organisms can exert their effects indirectly, by habitat (dung) destruction, or directly by using the free-living stages as a food source**.** Most of these BC agents are found within the groups of fungi, bacteria, virus, earthworms, and nematodes itself etc. (Van Wyk, 2001).

Fungi as biological control of nematode

Biological control using nematophagus fungi as a prophylactic measure reducing the infectivity level of pastures. It has no effect on parasites once the grazing animals have acquired them. It is anticipated that this will be inexpensive, sustainable non-chemical control method particularly suited to the practice of housing animals at night. It would be better where animals are provided with feed supplementation when housed, so that fungal material could either be co-administered or grown directly on the supplement if it consists of plant by-product material. The introduction of micro-fungi as a biological control in an integrated control programme of gastrointestinal nematodes could be as part of a feed supplement, or incorporated into various kinds of feed blocks presented to animals. This technology is currently under development and research. These nematophagus fungi are divided into three major groups based on their morphology and types of nematode destroying apparatus with more than 150-recorded species (Larsen, 2000; Waller, 1999).

Predacious fungi: which produce trapping organs such as a constricting (active) or non constricting (passive) rings, sticky structures like hyphae, knobs, branches or sticky net work along the vegetative hyphal system. The anchoring of nematode to the trap is followed by hyphal penetration of the nematode cuticle. Inside the nematode victim, atrophic hyphae grow out, fill the body of the nematode, and digest it. A group of Danish researchers, testing the effect of fungus *A. oligospora* primarily against parasitic nematodes in cattle and in other livestock species at different doses of spores mixed into faces, 250 and 2500 conidia per gm of faces was found to significantly lower the number (70 and 99 percent reduction, respectively) of developing *C. onchophora* larvae in faecal cultures . The trapping activity of the fungus was influenced by the motility of the infective larvae and there is no specificity for the parasitic species (Nansen *et al.* 1996). Unfortunately, various trials performed to test *A. oligospora* mycelium and conidia failed due to the destruction of these structures in the GI tract of the host animals. High dose (between 470 and 680 gram of fungal material on millet) of one of the three different fungal species (*A. musiformis, A. tortur* and *Dactylariacandida*) was fed for housed lambs, harboring a mono infection of either *H. contortus* or *O. circumcincta*. This subsequently led to survival of *A. tortur* through the GI tract at a level high enough to significantly reduce the number of *H. contortus* in faecal cultures. The other line of research is with *Duddingtonia flagrans*. This predacious fungus produces many resistant, thick-walled resting spores, Chlamydospores, which have the ability to successfully pass through the gastrointestinal tract and survive in the faecal material. Upon stimulation, they rapidly germinate and spread on and in fresh dung, and capture the infective larvae of most gastrointestinal worm species including *Cooperia, Ostertagia, Haemonchus, Nematodirus* and *Trichostrongylus* before they can migrate to the pasture (Fernandez *et al.,* 1999) and sheep (Peloille, 1991). These field trials have shown that daily feeding of fungal spores to grazing animals for 3-4 months prevents build-up of dangerous levels of infective larvae on the pasture((Gronvold *et al*.,1993). In an Australian study, found that sheep feed supplement containing *D. flagrans* chlamydospores had lower egg counts and improved live weight gains compared to untreated animals (Faedo and Knox, 2001).

Endoparasitic fungi: producing sticky drops on very small conidia, which adhere to the cuticle of the nematode, penetrate the cuticle and destroy the victim. These invade nematodes by penetration from sticky spores, which lodge in the gut. Inside the nematode victim, they develop an infection thallus, which absorbs the body content. This type of fungi is obligate parasite of nematodes, with very limited capacity to develop outside the prey and density dependent (Faedo and Waller, 1996). When a very high dose of *Drechmeria coniospora* (108 conidia per gm of feces) apply to faecal cultures found that only infective third stage parasite larvae stripped of the protective extra (second stage) cuticle, became infected by the fungus. Another Endoparasitic fungus, *Harposporium anguillulae* produce very small, half moon shaped conidia which lodge in the digestive tract of the feeding nematode and after germination totally digest the victim before finally breaking through the cuticle to produce new conidia on the short conidiophores. In a laboratory, study it was found that at a dose of 3 x10^5 conidia/ gm faces, the number of *H. contortus* larvae recovered was significantly reduced (Charles and Santos, 1995).

Egg parasite fungi: the fungi grow hyphal branches that attach to eggs, penetrate the shell enzymatic ally, and absorb the contents. These fungi have the ability to attack the egg stage, especially the cyst and root knot nematodes. They have an important role in the control of animal parasites, which have a long development and/or survival time in the egg stage in the environment outside host, for example, Ascaris, *Fasciola* spp., *amphistomes* etc. (Barron, 1997; Gronvold *et al*., 1996).

Table 1. Fungal species and Nematode parasites controlled by them.

Fungal species	*Parasites*
Endoparasitic fungi *Drechmeria coniospora* *Harposporium anguillucal*	*Haemonchus species* *Trichostrongylus colubriformis*
Predacious fungi *Arthrobotry soligospora* *Arthrobotry s misinforms* *Arthrobotrys robusta* *Monacrosporium endermatum*	*Ostertagia species* *Dictioyocaulus villilpar* *Haemonchus contortus* *Oesophagostomium species* *Cooperia species*
	Oesophagostomium circumcinta
	Haemonchus placei *Haemonchus contort us*
	Haemonchus contortus
Egg parasitic fungi *Verticillium chlamydosporium*	*Ascaris suum*

Source: Larsen, 2000

Bacteria as biological control of nematodes

Bacteria spores adhere by adhesive micro fibers to the cuticle of immature nematode. Later the spores germinate and penetrate the cuticle. Inside the victim, the filamentous micro colonies are created which destroy the reproductive capacity of the infected female host. *Bacillus thurnigienesis* (BT) is a complex spore forming aerobic bacteria, which form insect toxic crystals during sporulation, and it has been specifically referred to as a potential Bc agents for nematode parasites (Faedo and Waller, 1996).

Viruses as biological control of nematodes

Viruses has been implicated in causing abnormal behavior in plant parasitic nematode Meloidogyne and Tylenchrohynchus species, but it is exceedingly difficult to recognize viral infection in microscopic nematodes or differentiate them from those that are diseased or immobile for some other reason. Consequently, although important viral pathogens against free-living stages of animal parasitic nematodes are likely to exist, formidable hurdles are strong disincentives in the pursuits of this form of biological control (Larsen and Waller, 1996).

Biological control of Cestodes: Natural biological control of Cestodes by destruction of Cestodes eggs when various animals ingest them may occur in nature. In this way, vertebrates, which are not suitable hosts, may destroy Cestodes eggs and it is possible that invertebrates like ants, earthworms and beetles will destroy eggs or take them down in to the soil. No practical or successful cases of Bc of Cestodes are known and continuous research is important (Waller, 2006).

Biological control of Trematodes: Biological control of Shistosomes has concentrated on control of the intermediate snail host. Potential candidates for biological control of snails may be found among:-Predators such as fishes, birds, beetles and leeches, Parasites: such as nematodes, leeches and trematodes themselves (Faedo and Waller, 1996).

Immunological control

Vaccine*:* Considerable resources have been and still are being allocated to research into the effectors mechanisms of naturally acquired immunity to helminth infections with the aim of facilitating the development of vaccines. However, the situation is complex, involving a combination of local hypersensitivity, in addition to cell mediated, antibody and inflammatory responses, and is complicated further by the natural unresponsiveness (Sutherland *et al*., 1999). Using the successful development of the irradiated larval vaccine against the bovine lungworm, *Dictyocaulus viviparus* as a model, attempts have been made to produce vaccines against gut parasites in ruminants, but they have been less satisfactory likewise, this seemed to be the case with the vaccines based on antigenic fractions of parasitic material. Early attempts to immunize ruminants against gastrointestinal helminth, either with crude worm homogenate antigen or by ectopic infection, met with little or no success. Currently, attempts are being made to direct high titer antibody responses towards potentially susceptible targets on or secreted by the parasite. In the case of blood-feeding species, several target molecules have been identified on the surface of the intestine of the parasites. Because the host does not normally recognize molecules on the luminal surface of the parasite's intestinal cells during infection, these antigens are classified as hidden. Several vaccines using hidden antigens were developed for *Haemonchus contortus* in sheep, and these provided 94 percent protection and their efficacy reached 90 percent when worm burdens were studied (Newton *et al*., 1995). Another way to induce protection has been to use homologous antigen; that is an antigen first shown to be protective against another helminth species. An example is the glutathione-Strans ferases (GST) of *Fasciola hepatica,* which were chosen as candidate vaccine antigens because homologousprotein from *Schistosoma mansoni* and *S japonicum* had been shown to be protective in laboratory animal models of infection. Sheep and cattle immunized with native GSTs isolated from *F. hepatica* have been protected on average by 49 and 29 percent respectively, although the results from individual trials have been quite variable (Morrison *et al.,* 1996).

Selection for host resistance: With the widespread development of resistance to anthelminthics and the high cost of developing new drugs, the interest in exploiting and developing animals that are genetically resistant to helminths parasites has increased considerably. Studies have shown that resistance is heritable in cattle, sheep and goats. The immune response of some individual animal to infestation by a given parasite is better than that of others within the same population. In addition, certain populations and breeds tolerate a given parasitosis better than others do. Genetical resistance to *Haemonchus contort us* is demonstrated in different breeds of sheep. The *Red Masai*, the *Barbados Black belly* and the *St. Croix* are examples of breeds, which have demonstrated resistance traits. The Kenyan indigenous red Masai sheep was found to be the most resistant breed, which is related to the relative ability to elicit an immune response. The selection for resistance can be combined with any of the other strategies as required during the process of creating resistant herds and flocks (Gray, 1997).

CONCLUSION AND RECOMMENDATIONS

The knowledge of epidemiology of the helminthes existing in a defined region is crucial to implement control measures in that area as it enables to predict the time when to implement control measures before the animals fall at the grip of the helminthes. The threats of increasing parasite resistance to drugs in combination with increasing cost of developing new chemical products and problems associated with toxicity, environmental pollution and residue in animal products have led to some to believe that the sun is know setting on the chemotherapeutic era so integration of properly timed anthelminthics treatment with sound pasture management (hygiene) and husbandry can be effective in both reducing the number of drug treatment required and the larval contamination of pasture.

Based on the aforementioned scientific information gathered, the following points could be recommended:

- Any approach related to the current parasite control options should be studied in detail taking in to considerations of the specific economics and agro ecological situations of each country.
- Frequent, continuous and indiscriminate utilizations of anthelminthics should be avoided to prevent drug resistance.
- Implementation of non-chemotherapeutic approaches, such as worm vaccine, biological control, selection of resistant animal against parasites should get due attention.
- Immunity to helminthes is important aspect of helminthes control, and there remains much to be investigated from this field, therefore research need to be conducted.

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