Introduction

Parasites of goats are often shared with sheep even though the two species are different in their dietary selection and ability to extract nutrients from forages. There is no one answer as to how to control parasites of goats. However, there are several approaches that may be taken when one has an idea of when and where parasites are being acquired and how parasites survive in the environment.

Losses caused by parasitic disease varies considerably from death to that of a minor annoyance. The differences may be due to geographic, genetic, or husbandry variability. Genetic differences between breeds and among individuals within breeds may greatly determine the effect the parasites have on their hosts. More important is the system of management which will lead to a greater or lesser exposure to potentially damaging parasites. The management of rearing young varies depending on whether the animals are being raised for production of meat, milk or fiber and therefore disease is reflected by these differences.

Not all worms that are equally virulent and until one understands that there are regional and some local differences in the epidemiology and magnitude of the worm burden, rational control programs cannot be developed. However, without a doubt *Haemonchus contortus*, the barber pole worm, is the most important parasite of small ruminants in the southern United States. Locally, the bankrupt or blacks scour worm, *Trichostrongylus colubriformis* can be devastating and coccidiosis in recently weaned kids can be a major impediment to production.

Gastrointestinal nematodes have the same basic life cycle. Eggs are passed in the feces. A larva develops within the egg which then hatches. Larva feed on fecal bacteria and molts to the infective stage. The infective larvae leave the fecal pellet only when the feces are moist; as they only can move on to the forage in a film of moisture, such as dew. The larvae then become available to the grazing host. Within the host larvae molt, and become egg producing adults, approximately three weeks following ingestion.

Desiccation, or extremes of heat or cold are detrimental to the development and survival of eggs and larvae in the environment. The egg and the first two larval stages are especially vulnerable to desiccation and will not develop or survive if the fecal pellet dries too quickly. The infective larva is much more resistant to drying. The infective larva cannot feed and must utilize energy obtained while
feeding on fecal bacteria, it will live only as long as it has energy reserves. Energy is depleted in direct relationship to ambient temperature, so survival of the infective stage is short during the summer (30 to 60 days) and prolonged during the winter (4 to 8 months). Cold does not kill worms, as infective larvae survive the winter but will not live long once the temperature has increased in the spring. However, *Haemonchus* larvae are inactive during cool conditions and are not available on vegetation for transmission. In arid areas, drying of the fecal pellet will prevent infective larvae from leaving so the pellet becomes a repository for larvae which will be released when later moistened.

In moist environments larvae are picked up from pasture daily. In drier areas rains following periods of drought result in tremendous numbers of larvae being acquired in a short time. The numbers of larvae thus acquired is also increased because the animals are grazing closer to fecal pats and the ground.

A goat must be exposed to large numbers of larvae to suffer from parasitic disease, but not all parasites are able to establish. Factors which determine if a larval nematode is able to survive within the host are both host and worm related. It appears that there are several host factors which limit the numbers of parasites able to establish in the individual host. The mechanism(s) of natural resistance are unknown but appear to be heritable. Most hosts will also develop acquired immunity. The level of immunity is also heritable and requires exposure to worms before it functions. It is usually impossible to differentiate natural and acquired immunity, and both may be functioning at the same time. The immune system may prevent the establishment of worms, or cause the expulsion of worm already established within a host.

Hypobiosis, cessation of development of the worm within the host. Larvae in the early parasitic stages cease development; they do not feed but remain within the host in an inactive state until more favorable conditions occur for their development. The stimuli which induce hypobiosis are not well defined. Kids which have been infected by a species of worm may have hypobiotic larvae, whereas in naive kids the parasites develop at the normal rate.

Larvae in a state of hypobiosis evade unfavorable environmental conditions, and the host’s immunological surveillance system by being metabolically inert. When environmental conditions are more favorable for larval transmission, hypobiotic larvae resume development. This usually coincides with rapid pasture growth, although larvae may resume development even when the host is not on pasture. Larval development from hypobiosis often occurs near parturition. Thus, the worm has an adaptive mechanism to ensure there are sufficient numbers of its offspring to infect the next generation of hosts.

Resistance to infection is abrogated at the time of parturition and during early lactation. This periparturient relaxation of resistance results in the dams’ inability to expel adult worms. As a result, there is a rise in fecal egg counts which leads to serious pasture contamination. The use of an anthelmintic at or near the time of parturition has proven to be of value in neutralizing the periparturient rise. If an anthelmintic which has an effect against arrested larvae is used during the winter before they resume development, pasture contamination will be lowered.
Control Programs

Prevention, rather than cure, is the philosophy used in developing control programs against gastrointestinal nematodes. It must be assumed that worms cannot be eradicated but may be limited to the extent that they will not cause serious economic loss to the producer. A combination of treatment and management are necessary to achieve control. Several approaches to the use of anthelmintics are considered.

Strategic

The strategic approach is the use of an anthelmintic at a time when most of the total worm population is within the host and not on the pasture. This approach can be used when goats are moved from a contaminated pasture to a nearly parasite free pasture. Pastures become parasite safe when they have been tilled, given prolonged rest at a suitable time of year, or have been grazed by animals which are not satisfactory hosts for the target parasite species. Pastures grazed by adult cattle or used for hay production during the previous year may be nearly parasite free, as are small grain pastures and the gleanings of harvested crops.

Strategic treatments aimed at hypobiotic larvae are effective in aiding in the control of worm burdens during the subsequent transmission season. In dry climates; West Texas in most years, a single deworming may be sufficient to keep the level of parasitism below the economic threshold for the entire season. Treating in the winter, before parturition, will not only kill larvae that would emerge later but circumvents the effects of the periparturient rise of nematode egg production. However, strategic treatments select for anthelmintic resistance as the offspring of surviving worms will have only other survivors to mate with. Treatment before parturition and again at weaning, and moving to a clean pasture, along with yearly anthelmintic rotation, will serve the rancher well. Treating meat kids as they are weaned and moving them to clean pastures is a strategic approach.

Tactical

When weather conditions have been favorable for the transmission of parasites (Haemonchus requires 2 inches of rainfall in a month with a mean temperature of 60°F or higher), eliminating worms from the gastrointestinal tract before they have the opportunity to reproduce and further contaminate the environment is a tactical approach. The timing of tactical deworming may be based on recent rain or it may be based on increasing fecal egg counts. There is a, more or less, linear relationship between the number of important adult nematodes and fecal worm egg counts in small ruminants. If the mean egg count of 10-12 animals in a flock is above 1000 to 2000 eggs per gram of feces, the flock should be dewormed even though there are no signs of disease. Treatment, especially when accompanied by movement to pastures with few parasites, or at the onset of dry weather may prevent an outbreak of disease. The time of year and species of parasite are important in determining when the egg count is critical. With Haemonchus a count of >1000 in May or June in lactating dams would be reason to treat, however, in September or October >2000 would be the cut off point in dry animals.
Opportunistic

Treatment may also be given when livestock are gathered for reasons such as shearing, or as a part of the flushing process. This treatment may be strategic or tactical but is usually just opportunistic. These treatments give the host a temporary reprieve from the deleterious effects of parasites and this may be sufficient to protect from disease. However, opportunistic treatment seldom affects the population of parasites in the environment so the effects are usually short lived and give the owner a false sense of security.

Individual

Treatment of wormy individuals may prove to be a worthwhile endeavor especially where resistance to anthelmintics is widespread. Individuals in a flock will have a higher egg excretion count than the average. This over-distribution of the parasite population can be lessened by the selective treatment of wormy individuals or by the removal of these individuals from the flock. This is a very time consuming approach and requires individual evaluation so it is probably not economical except in very small flocks. This approach does not put any selection pressure against the anthelmintic(s) used as many of the larvae ingested will come from untreated hosts. Conversely, identifying animals with low egg counts may be a way of identifying resistant animals in a flock. With the failure of many anthelmintics in small ruminants, this may become an important selection criterion.

Suppressive

Suppressive anthelmintic treatments are given at regular intervals. To be completely effective, this must be done before the worms which are acquired since the last deworming become reproducing adults themselves. This interval is approximately 3 weeks. However, this method of parasite control is expensive and fails to utilize the host’s defences where they are applicable. Suppressive deworming is probably the most effective means of keeping parasite numbers lowered for a short period of time. However, this method will invariably lead to anthelmintic resistance by the parasite faster than when other approaches are utilized. Where large numbers of animals are confined to limited grazing, and either pasture rest, alternate grazing by other species, or tillage is impossible, suppressive deworming may have to be used.

Salvage

Salvage (treatment to save lives, not control parasites) is why anthelmintics are frequently used in small ruminants. This is treatment in the face of disease; the animals are frequently anemic, have bottle jaw or diarrhea due to the effects of worms. Whatever the case, animals may be in desperate straits and even if they have the genetic ability to resist worms, they will be overwhelmed. Although anthelmintics may remove thousands of worms from each of the treated animals, the pastures from which they came have billions of larvae awaiting ingestion. Under these circumstances, treatments at 2 to 3 week intervals may have to be practiced until weather conditions are no longer favorable for transmission.
Pasture Rotation

Over the years there have been advocates of pasture rotation schemes to aid in the control of parasitic disease. For the most part, pasture rotation schemes on improved pastures allow increased stocking density and increased populations of parasites. The improved nutritional status of the host on these pastures may overcome the deleterious effects of greater parasite exposure, but this is unlikely where Haemonchus is the primary parasite.

Pasture rotation may decrease parasite numbers in deferred grazing systems where a pasture is rested for at least 6 months during the cool or 3 months during the warm part of the year. Anything less than this is unlikely to effectively reduce larval populations in temperate climates. However, if the pasture were tilled and replanted, by the time regrowth had occurred, most of the infective larvae will have succumbed to the effects of solar radiation and desiccation. Studies comparing various deferred grazing systems in west Texas range lands have not shown significant differences among various management systems in the levels of most parasites acquired by lambs. The exception is Nematodirus, which was found in increased numbers in lambs grazing high-density low-frequency grazing systems at stocking rates higher than those in other management schemes. These studies were done during the “typical” dry summers which are the norm in west Texas. In wet tropics, due to the rapid depletion of energy reserves by infective larvae, short pasture rest periods (as few as 60 days) appear to be adequate to control internal parasites in goats but looses the advantage of improved pasture nutrition as the vegetation has over matured.

Alternate grazing of different species of ruminants may be of value in controlling some species of parasites. When the range is shared by several foraging species, the competition for nutrition is usually intraspecific. Interspecific competition for preferred forage is of lesser importance because of feeding behavior. When sheep and goats are cohabiting brushy country such as in the Edwards Plateau of Texas or forested areas in the Southeast, sheep tend to graze and goats browse bushy herbage. In these circumstances, sheep may suffer from severe parasitic disease while the goats are relatively unscathed. On the other hand, when goats are forced to graze the same pastures as sheep and have little opportunity to browse, the same parasites devastate the goat population while the sheep are minimally affected.

Anthelmintic Resistance

When maximum small ruminant production is desired, parasitic disease is an important limiting factor. The judicious use of anthelmintics is essential, although drought, good nutrition, tilling soil, alternative species grazing, dung destroying insects etc. may all contribute to the demise of parasites. Because of the lack of effective approved anthelmintics in the United States, producers are by necessity going to have to evaluate drugs which are approved in other countries for use in small ruminants. The effectiveness of these drugs is going to be variable and may differ from farm to farm. Populations of Haemonchus resistant to thiabendazole were reported within a few years of its introduction in the United States in the early 1960's and these populations are still resistant to thiabendazole as well as to other benzimidazoles (white drenches).
Anthelmintics which may be effective against benzimidazole resistant *Haemonchus* include levamisole which appears to be effective on approximately 60% of ranches evaluated in Texas. However, resistance to this compound is increasing. Ivermectin resistance has been documented in the United States and there is evidence that the resistance may be widespread, however, it is still less common than benzimidazole or levamisole resistance.

Anthelmintics with different activity than those to which the worms have become resistant should be used when resistance is encountered. Because of anthelmintic resistance, it is imperative that anthelmintics are evaluated to determine if they are truly effective on a specific farm. The simplest method to measure efficacy is to determine fecal egg counts before and after (7 to 10 days) the use of an anthelmintic. If possible, some animals should remain as untreated controls to determine if other factors may be contributing to parasite loss. Evaluation of anthelmintics should be done yearly on goat farms.

A larval development assay has been developed in which worm eggs are placed in varying concentrations of anthelmintics. The concentrations of drug required to prevent the hatching of the eggs and/or development to the infective stage is correlated with the results seen in fecal egg reduction tests. The larval development assay determines which species of parasites are resistant or susceptible at a farm and evaluates benzimidazoles, levamisole, combinations, and macrolides in a single test. This test is more sensitive than the fecal egg resistance in determining if a resistant subpopulation is present. When compared to the fecal egg reduction test it may also indicate if underdosing or the failure of individual animals to metabolize or present the drug to the worm is present.

There are differences as to how anthelmintics are metabolized among host species. With presently available anthelmintics, a rule of thumb should be to dose a goat at a level 1.5 to 2 times higher than a sheep unless a goat dosage has been established for the product. Levamisole at 12 mg/kg (1.5 ×) is approaching the toxicity level for goats. None of the cattle injectable anthelmintics should be injected into sheep or goats. It is very likely that the use of subcutaneously administered ivermectin significantly increased the selection of resistant worms. In Great Britain, New Zealand and Texas anthelmintic resistance was first noted in goats and, if they were grazed with sheep, the resistant worms then infected the sheep.

Holding animals without feed overnight before drenching and then administering in a low volume dose over the tongue will increase the efficacy of benzimidazole anthelmintics. Dividing the dose of benzimidazoles by administering two or three drenches at 12 hour intervals will increase efficacy. Using two anthelmintics of different drug families concurrently such as fenbendazole and levamisole has been effective in controlling worms even when each of the drugs used separately are ineffective.

The selection for resistant worms is accomplished by removing susceptible worms. There is a direct relationship between the number of treatments and the onset of anthelmintic resistance. Owners buy resistant worms, then select for them. By not effectively treating and quarantining infected animals, they allow the establishment of resistance on their property. They further select by deworming too
often. If they are not 100% effective in controlling parasites, the surviving worms have only other survivors with which to mate with and a small resistant population can increase rapidly as each female *Haemonchus* produces 5,000 to 6,000 eggs per day. Fewer dewormings means that some susceptible worms will be present to mate with and the advent of observable resistance takes longer. Another factor that will speed up the onset of resistance is underdosing by administering anthelmintics to the flock with the dose based on mean weights rather than on the heaviest animals in the flock. Underdosing per se will not select for resistance when a single, dominant gene is responsible for resistance but it may where several genes are involved or where heterozygote worms have a level of resistance that is dose dependent. With the safety margins of available anthelmintics, adequate dosage is essential in preventing the onset of resistance.

Repeated treatment at or near the prepatent period selects for resistance as the population is constantly culled. Suppressive deworming has been very successful in selecting for anthelmintic resistance. Suppressive deworming also may prevent the development of immunological resistance and further increase dependency on anthelmintic treatment.

*Anthelmintic Rotation*

A strategy intended to prevent anthelmintic resistance from occurring is by switching anthelmintics each time used. The rationale for doing this is that the worms will be exposed to a different drug than they had previously encountered and will not become resistant to the new drug. This is a very persuasive theory but unfortunately false. Researchers have demonstrated that rapid (within a grazing season) rotation of anthelmintics leads to resistance to all the compounds used in the rotation faster than if a product is used until no longer effective, then another drug is substituted. Slow rotation (use for a grazing season then switch the next year) is more likely to retard the development of resistance.

*Summary*

Present recommendations are to: 1) Make certain that the anthelmintic or combination used on a farm actually works (kills at least 90% of the available worms). 2) Deworm the flock during the period the worms are in hypobiosis and are being transmitted at low levels, i.e., the winter. 3) Utilize clean or safe pastures when possible; the aftermath of crops, annual forages, rotational or co-grazing with cattle or horses. 4) Rotate anthelmintics yearly, if effective drugs are available. 5) Deworm new animals, place them in a non-pasture environment such as a dry lot or barn after treatment and only allow them to forage after they are examined for the presence of worm eggs and none are found 7 to 14 days after treatment.

Other recommendations may be made depending on the management, climate, and forage the flock are subjected to. Selection of individuals resistant to worms, zero grazing systems or other suggestions may be ideal for some flocks but not at all practical for others. The interactions among parasites, hosts and environment are complex so there are no simple answers to everyone’s problems.
Coccidiostats for use in small ruminants. Not all of the products listed are approved for use in the United States but have been used and are approved in other countries.

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Trade Name</th>
<th>Feed Dose</th>
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<tbody>
<tr>
<td>*Amprolium</td>
<td>Corid</td>
<td>42 g/100 gal H₂O</td>
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<tr>
<td>Monensin¹</td>
<td>Rumensin</td>
<td>15 g/ton</td>
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<tr>
<td>Lasalocid²</td>
<td>Bovatec</td>
<td>25 g/ton</td>
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<tr>
<td>Decoquinate</td>
<td>Deccox</td>
<td>27 g/ton</td>
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<tr>
<td>Sulfa methiazine</td>
<td>Sulmet</td>
<td>50 g/ton</td>
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</tbody>
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The above are levels of coccidiostats for the prevention of coccidiosis during times of exposure to oocysts. Treatment times vary as will level needed for treating sick animals.

* Do not use for more than 28 days.

¹Appears to be more effective in goats than sheep.
²Appears to be more effective in sheep than goats.
Suggested Readings


The proper citation for this article is: