# Internal Parasite Control in Grazing Ruminants

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## Introduction

Throughout the world, internal parasites pose one of the major health limitations for grazing animals. Although there are numerous internal parasites, only a few of them account for the majority of problems for grazing livestock. The focus of this paper addresses the most significant group of these parasites, i.e. gastrointestinal nematodes and coccidia. The paper will concentrate on nematodes in domestic grazing ruminants in the northeastern and Mid-Atlantic regions of the United States. The principle ruminants covered will be sheep and goats, with some references to cattle.

## Outline

Although there are numerous internal parasites of grazing livestock, nematodes (roundworms) are the principal internal parasites that plague grazing ruminants and horses. According to location in the host, the principal nematodes of ruminants include:

- Abomasum
    - *Haemonchus* spp
        - *H. contortus* (sheep, goat, young calves)
        - *H. placei* (cattle)
    - *Ostertagia* spp
        - *O. ostertagi* (cattle)
        - *O. circumcincta* (sheep, goat)
    - *Trichostrongylus axei* (ruminants and horses)
- Small intestine
    - *Trichostrongylus* spp
    - *Cooperia* spp
    - *Nematodirus* spp
- Lung
    - *Dictyocaulus* spp
        - *D. viviparus* (cattle)
        - *D. filaris* (sheep, goat)

Other common internal parasites of ruminants would include:

- protozoa (coccidia)
- trematodes (flukes)
- cestodes (tapeworms)

In addition to common internal parasites, there are numerous exotic or occasional parasites. Some of these can occur as serious problems at a localized level. For example, the deer brain worm can fatally infect small ruminants, but rarely does on a large scale.

## Coccidia Epidemiology and Control

Coccidia, the major protozoan parasite, can debilitate barn reared sheep, goats and calves. Coccidia live in the mucosa of the small intestine, and under favorable conditions can multiply very rapidly. A rapid asexual development may occur prior to the release of large numbers of oocysts (commonly called eggs) in the feces. This rapid development, combined with a heavy level of infection means that the quantity of oocysts in the feces is not indicative of the severity of the disease. Coccidiosis is generally associated with young animals because their immune system has not developed the ability to combat heavy infections. These infections most commonly occur when animals are closely confined, particularly under conditions of poor sanitation and ventilation. They are less common in grazing animals, although they can occur in warm, moist conditions. In winter lambing (and kidding) systems, coccidia outbreaks are common in 3 – 4 week old lambs and kids. The early birthing and barn-rearing practices that are a part of many intensive management systems are conducive to the spread of coccidia. Young animals are most susceptible to coccidia. It is a common problem in all raised in confinement systems.

There are a number of factors that are can help producers realizes when coccidia outbreaks are likely to occur. It is predominantly a problem of young, growing animals, and regularly occurs as early as 3 – 4 weeks of age. Coccidia transmission occurs from oral ingestion of the embryonated oocysts. Thus when animals are raised in close conditions (barns, feedlots) with build up of fecal material, cocciadial outbreaks are most likely and usually more severe. Coccidia thrive in warm, moist environments, which also favor pneumonia, so these two diseases often parallel each other. Outbreaks on pasture are sometimes associated with seasonal rainfall. Factors which increase animal stress, such as shipping or weaning can be associated with outbreaks. From a management point of view, stress reduction and sanitation are essential coccidia control practices. Proper sanitation, which reduces fecal contamination and reduces moisture buildup, can reduce coccidia infection rate and disease outbreak.

In addition to stress reduction and sanitation, administration of anticoccidial drugs can significantly reduce coccidiosis. There are five anticoccidial drugs – lasalocid, monensin, decoquinate, amprolium and sulfaquinoxaline. Two types of drug protocols exist: treatment (amprolium and sulfaquinoxaline) and prevention (lasalocid, monensin, and decoquinate). Treatment generally involves 5 – 10 days and drugs are administered in water, in individual drench, or in feed form. Drugs used for treatment kill the coccidia, but animals can become reinfected once treatment stops. In contrast, most of the preventatives are as feed additives. Preventatives work by lower the shedding of oocysts into the environment, and they have about a 3 week time lag prior to lower the shedding. In nursing lambs and kids, their mothers can be a significant source of oocysts so a comprehensive preventative program would begin by treating ewes and does 3 weeks prior to birthing. It is often difficult to use the preventatives in nursing lambs or kids, since their creep feed consumption can be very erratic. In this case animals may need to be treated, sometimes individual. A critical part of coccidia control is reducing the treat of disease, through stress and environmental management. After exposure animals develop some immunity fairly quickly but may continue to shed oocysts even in adulthood which out signs of clinical disease.

## Nematode Pasture Epidemiology and Control

The gastrointestinal nematodes of ruminants and the small strongyles of horses all have a simple direct life cycle. This is illustrated in figure 1 by the nematode life cycle in sheep.

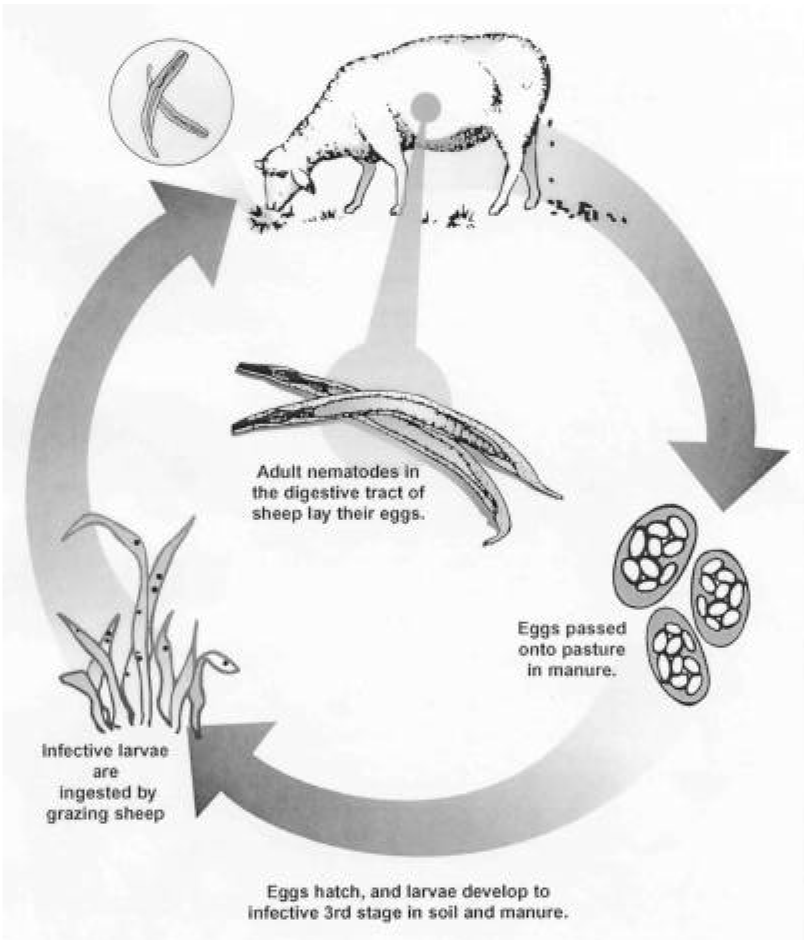
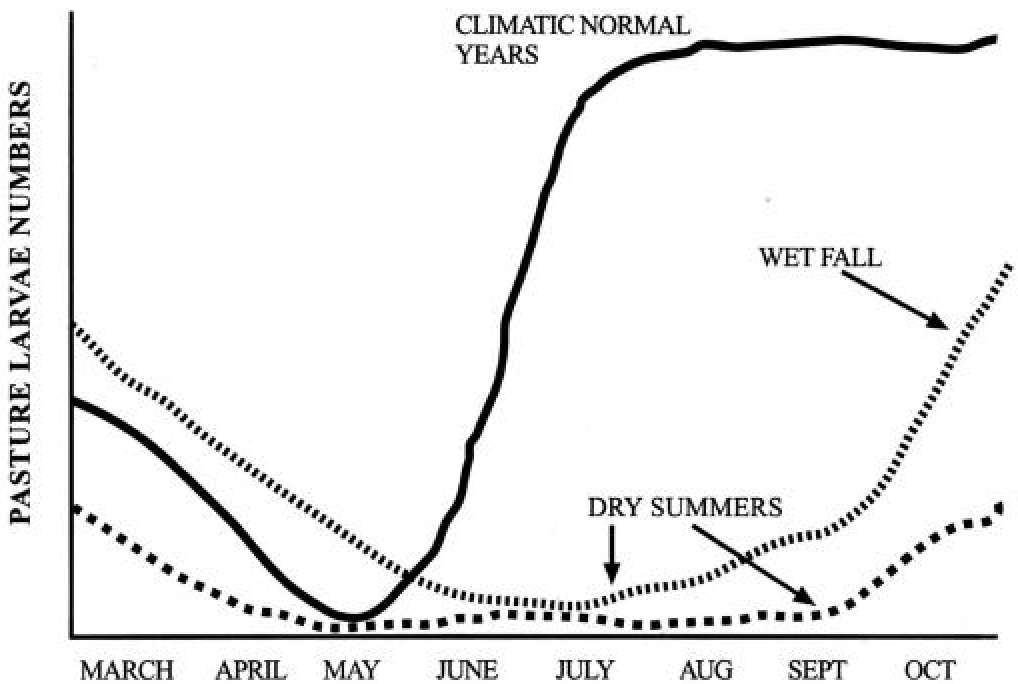



Figure 1. Direct life cycle of gastrointestinal nematodes in the sheep.
(Source MA & VA Cooperative Extension Parasite Control Fact Sheet)

In a direct cycle infective larvae are picked up from the pasture by the host. The larvae develop into egg laying adult nematodes. With some minor exceptions, the eggs are shed in the feces, embryonate, hatch into larvae on the pasture, some of which are consumed, continuing the cycle. A key point of the direct life cycle is that the nematodes do not multiply in the host. Multiplication is due to the quantity of eggs passed in the feces. Ultimately, the worm burden in the animal is directly related to the density of infective larvae on pasture.

The actual density of infective larvae on pasture is related to the stocking density or animals, the effectiveness of the worming program, and the environment. Environment can be a big factor, as is illustrated in figure 2 showing pasture larval numbers. The previous few years (2001-02) had been drought years in the Mid-Atlantic region; so many producers had relatively few parasite problems. However, this past year (2003) has been extremely wet and ideal for nematodes. Consequently parasite losses have been serious.

**Figure 2. Relative numbers of infective worm larvae on pastures during the grazing season for years with normal rainfall and for dry summers.**




(Source from VA Cooperative Extension Parasite Control Fact Sheet)

## Control Strategies

Anthelmintic resistant worms are probably selected from very small numbers of worms that are naturally tolerant to the drug being used. These may be present in occasional flocks, but before anthelmintics are used, these tolerant worms will be very rare. When possible, anthelmintic use should try to slow the development of resistance and prevent these worms becoming important. Strategies to prevent or delay the development of anthelmintic resistance fall into three groups: management strategies, grazing strategies and anthelmintic strategies.

## Management Strategies

### Controlling hypobiotic larvae

Nematodes overwinter either on pasture or in the host. Those that overwinter in the host stop their development (hypobiosis) when they are picked up from pasture in the fall. The most pathogenic nematodes of small ruminants, particularly *Haemonchus contortus*, overwinter principally in the host. Thus one of the most important times to worm animals is during the overwintering period. (Note that immature larvae do not shed eggs, so fecal analysis would likely give low values.) This treatment can be anytime from when they come off pasture in fall until they begin grazing next spring (usually it is after a killing frost and before giving birth). Most modern anthelmintics are effective against arrested (hypobiotic) larvae, but care should be taken to insure that the product of choice is both efficacious and that resistance has not developed to it. Data from New England have shown this overwintering treatment to be the most critical in reducing pasture levels of the most pathogenic nematode, *Haemonchus contortus.*

While the term overwintering implies freezing, nematodes in hot, dry climates also show hypobiosis to survive periods of heat stress. Similarly, control of arrested larvae in these climates would simply involve a different calendar. Data from west Texas have shown that effectively treating Angora goats during summer hypobiosis is the most critical worming in this environment.

An alternative or additional way to control hypobiotic larvae is to graze youngstock separately from their mothers. Since nematodes are not picked up in the barn, nursing animals will not be infected when they begin grazing. Under many management systems these early born small ruminants are large enough to be weaned near the beginning of grazing season. These weanlings should graze pastures with low parasite levels (clean/safe pastures), thus reducing the need to worm regularly.

**Immunity to parasitic infections**

There are breeds of animals (e.g., St. Croix, Gulf Coast Native and Katahdin sheep, West African Dwarf or Pygmy goats) that are known for their ability to tolerate parasites. This is one of the reasons for the increasing interest in hair sheep. Unfortunately, these breeds often don't fit into productions systems that are looking for large carcasses, nor is there an available quantity of high quality breeding stock for these breeds. Alternatively, researchers (mostly in Australia and New Zealand) have been working to select herds, within existing highly productive breeds, for comparable tolerance to parasites. Unfortunately, the progress has been slow and there is no commercially available seedstock selected for parasite tolerance. In spite of these limitations, systems are being developed to help producers take advantage of host immunity. One noted system would be a selective worming and culling system (see reduced worming section).

Another side of immunity is that as animals mature, under conditions of some exposed to parasites, they develop some immunity to parasitic infections. Once small ruminants are 3 to 4 years of age they have developed a strong immunity, whereas youngstock in their first grazing season are very susceptible to parasitic infections. Thus whenever one has the option to separate onto clean or safe pasture versus a pasture with a heavy parasite load, the cleaner pasture should be used for the younger animals. This is most commonly done when animals are weaned. Try to plan so that a clean or safe pasture is available at weaning. The extreme example of this strategy would be to raise youngstock only in confinement. This minimizes exposure to nematodes but increases the problems with coccidia.

## Grazing Strategies and Pasture Systems

### New pasture systems

The difference between a clean and safe pasture is simply a matter of degree. Clean land would be new grazing land or land after years without grazing, while safe would land reduced by haying or grazing for a season with an unrelated species. The other side of the issue the potential worm burden being introduced to the pasture. Animals pickup infective larvae by grazing pastures, so winter and spring born animals will not have nematodes at the beginning of the grazing season. Remember that their mothers are a potential source of larvae, which will develop to adulthood and contaminate the pasture.

Studies have showed that if mature animals are effectively treated for hypobiotic larvae prior to being placed on clean (or safe) pastures that parasite loads will only develop slowly. It's not possible to make a blanket statement about how long clean pasture will remain safe, but in many cases strategic hypobiotic treatment, followed by a grazing season on clean or safe pasture, may be the only treatment needed until the next winter hypobiotic treatment. For example, when researchers have placed wormed ewes (eggs counts at zero) on new pasture in the spring, they do not have to worm them doing the grazing season. Furthermore, in warmer climates where ewes are on pasture throughout the year, worm burdens stayed low throughout most of the next winter. So as a rule of thumb, wormfree pasture may remain safe for about a year. The actual time will vary a lot with the management and climatic conditions, and it would be wise to check animals following changes in weather conditions that encourage parasite growth (warm and moist). Note the other side of the clean pasture logic: the following year clean pastures will NO LONGER be safe after a year (or season) of grazing even when the animals had zero fecal counts at the beginning of the previous grazing.

### Pasture 'rotation' systems

It is commonly misconceived that rotating pastures helps to control parasites. In the classic definition of pasture rotation, THIS IS FALSE. I consider the classic definition as one proposed for optimal forage nutrition and improved stocking density. In such a system, animals would graze a pasture for a period of time (grazing period) then the pasture would rest for regrowth (rest period). The length of the grazing period depends on initial pasture condition, forage quantity and stocking density. It is commonly recommended that pastures are grazed from a couple days to a couple weeks. The length of the rest period depends on the time needed to regrow specific forages, the weather and pasture quality and management. It is commonly recommended that pastures rest from 2 to 7 weeks. It should be noted that these forage management recommendations are generally excellent for improving nutrition, but they will NOT improve parasite control. Research often shows that such pasture rotation results in a worsening the parasite situation. Please do not take this to mean that one should abandon good pasture rotation practices. Quite the contrary, nutrition is the most costly component of ruminant production, and pasture rotation will improve you herd performance. One major advantage of pasture rotation systems related to parasite control is that animals and pastures can be more readily managed, given producers the capability to have some control.

Are there rotation systems that will help control nematodes? Yes and a qualified maybe. Certainly very long rest periods work. Sheep grazing western range lands have relative few nematode problems, but they don't regraze the same land for several years. Certainly there would be systems that could be developed with relatively long rest periods. However, we don't recommend these long rest periods for parasite control, because certainly they would be too long for optimal forage quality.

One other comment on safe pastures would be related to browse utilization. Often it is noted that goats browsing in woodlands or managing brush land don't seem to have problems with parasites. Since infective larvae are generally associated with the moisture on the lower parts of the forage, animals consuming browse or woody plants would not pick up as many parasites. In some systems this may be viewed as a type of safe pasture.

**Worm and move and clean/safe pasture**

There are ways to work pasture rotation into parasite control strategies. This would combine the optimal nutrition with strategic parasite control. In moist temperate and southern areas, well managed pastures need to be utilized (grazed, hayed) regularly to maintain forage quality. Grazing strategies, including rotation, can be combined with other management strategies to reduce the use of anthelmintics. One of these strategies is to combine rotation and haying, so that as animals are rotated, they move to regrowth following a hay crop. In such a system, any one field would have a sequence like:

1) Grazing period
2) Rest period
3) Hay harvest
4) Rest period
1) Start over with grazing period

In theory, adding haying to the grazing rotation should enable systems in which animals do not have to be wormed when moved, but it would be wise to monitor animals for parasite loads. Another variable would be how far into the season haying can be maintained as a part of the system. Typically forage production is greatest in the spring then decreases over the summer, which means there is often an abundance of grass available for hay early in the season followed by a shortage later.

A variation of this system would be to move animals at weaning to regrowth from a hay field. Research has shown this strategy to greatly reduce fall parasite burdens in spring (or winter) born lambs. In the studies lambs were generally wormed at the time of moving. In theory, the few nematodes that survive worming may lead more rapidly to the development of resistance. This is because the animals are moved to an environment with few nematodes, so the survivors make up a greater portion of the nematode population. To get around this, people have suggested that when worming and moving animals that the animals are housed for several days after worming before moving to pasture. However, even moving without the holding period would be preferred to more frequent worming (the likely alternative), which is proven to rapidly select for resistance.

Under certain conditions, even animals moved to hay lands (or other safe pastures) might need wormed late in the grazing season. One can also use fecal analysis as a means of determining when pasture infectivity has increased. Under normal grazing systems, fecal egg counts will often rise dramatically in mid to late summer, but the actual time varies from year to year. Using regular fecal analysis, one can monitor more accurately when it is necessary to worm and move or how long a clean/safe pasture remains relatively uncontaminated.

**Alternate animal species**

The nematodes of sheep and goats are similar, but the nematodes of other animals differ significantly. Pastures, that were not been grazed by sheep or goats in the previous year, will safe or clean for grazing. A small number of producers raise two or more different animals in enough quantity that they can alternate from year to year which animals graze which pastures. If horses or cattle graze a pasture one year, then the following year that pasture would be considered safe for small ruminants. Goats and sheep have very similar nematode parasites, so alternating between them is not effective.

**Organic Agriculture Systems**

The biggest limitation in raising organic lamb or goat meat is the need to control internal parasites. Interesting organic agriculture may also offer a partial solution to parasite control. In organic agriculture, crop rotation mandates that land not be used for the same crop year after year. In organic systems, land rotation may typical involve 4 – 5 years with a particular parcel being in cereal grass, a legume, a hay crop, a cover crop, and an animal rotation. Often the animal used in rotation is hogs, but small ruminants would also work in such a system. In an organic system the pastures will be fairly clean because they haven't been grazed for several years. (A side note is that swine have ascarid nematodes that actually will persist in the soil for years. This is not true for ruminants.) From an organic point of view, the difficult will be to control hypobiotic larvae in the adult animals being put onto the clean pastures, otherwise systems for lambs and kids could be designed without worming. One option might be for organic producers to combine organic crops with natural lamb or goat meat production using very limited worming. (This is what most organic systems do with their hogs. The hogs are wormed for ascarids (so they aren't organic), but the land is still organic for crop production.) Even if a farm isn't organic the use of animals and crops in rotation systems increases the options for controlling internal parasites.

## Anthelmintic Management Strategies

### Reduce your use of anthelmintics

Studies in Australia have clearly shown that the more frequently an anthelmintic is used the faster resistance develops. If possible, anthelmintic use should be restricted to 2 or 3 times per year by combining anthelmintic use with the epidemiology of nematode infection. Regular monthly (or more frequent) dosing, as practiced on some farms, cannot be recommended.

In any herd, there is a large variation in animals in their ability to tolerate parasite loads. The emphasis on worming is shifting towards less frequent worming and treating only those animals that need to be wormed. There are a number of ways that producers could decide which animals are less parasite tolerant (need treatment). These would include fecal analysis of individuals, clinical evaluation of anemia (FAMACHA eyelid system) or general animal condition (large operations). Basically any of these systems would identify a portion of the herd as being more susceptible to parasites or specifically to *Haemonchus contortus*. There are several important concepts here. One is that the idea is to treat less frequently and less animals. These systems are not being used to decide when the whole herd should be treated, rather just the individuals. Another is that tolerance is a genetic trait, so that animals identified as less tolerant should be culled. This will slowly improve the average herd tolerance to parasites. Finally to some degree these systems emphasize selection on the basis of tolerance to *Haemonchus contortus*, the most pathological sheep and goat nematode. This is why veterinary parasitologists are encouraging producers to be trained in using fecal analysis or FAMACHA systems. One runs the risk of not properly analyzing fecal egg counts or eyelid anemia. In addition while *Haemonchus contortus* is the major parasite problem, other nematodes can also be devastating. These other nematodes will not cause severe anemia or as high fecal counts.

### Use the full dose of an anthelmintic

Use of a sub-therapeutic dose of anthelmintic may permit survival of some worms showing partial resistance to that drug. When these partially resistant worms interbreed they may produce offspring that are more resistant to the anthelmintic. Use of reduced doses mostly results from underestimating the weight of the animals. All animals should be weighed prior to treatment and recommended dose (or higher) should be used. As it is often not feasible to weigh all animals, weigh a few heavier ones and dose all according to these heavier weights. Surveys in Australia suggest that farmers very frequently underestimate the weight of sheep.

### Alternate the type of anthelmintic used

The optimal frequency for changing anthelmintic type to reduce the development or resistance has not been determined. To do so would be a very expensive experiment lasting many years. However, the generally accepted view is that anthelmintics should be alternated on an ***annual*** basis. Alternating anthelmintics at every worming is ***not*** recommended. This more frequent change may enhance the chances of developing resistance to both types of anthelmintics.

## Anthelmintic Efficacy and Availability

Modern broad-spectrum anthelmintics are active in three classes of compounds. These are:

- the benzimidazoles,
- levamisole and related compounds
- the macrocyclic lactones

The benzimidazoles are a relatively old group and include numerous anthelmintics. The oldest of these is thiabendazole, which has been replaced by newer, more modern benzimidazoles. Several of these modern benzimidazoles are labeled for use in cattle, sheep and horses. The more available of these products include:

- albendazole (Valbazen) for cattle and sheep
- fenbendazole (Safe-Guard, Panacur) for cattle, sheep, goats and horses
- oxfendazole (Benzelmin, Synanthic) for cattle and horses

At the time of their initial introduction, the benzimidazoles were a major improvement in anthelmintic treatment over the narrow-spectrum products previously available. One advantage of this group of modern benzimidazoles is that they are the anthelmintic class that is effective against the common tapeworms of livestock. Given the level of drug resistance, the widespread availability of benzimidazoles may appear misleading. This is due to their continued use in the cattle market where anthelmintic resistance has not dramatically reduced their effectiveness.

The group of levamisole and related compounds includes three common products:

- levamisole (Tramisol, Prohibit, Levasole) for cattle and sheep (and goats)
- morantel tartrate (Rumantel) for goats
- pyrantel tartrate (Strongid) for horses

**WARNING:** WHILE MOST ANTHELMINTICS CAN BE USED WITH CAUTION IN CLOSELY RELATED ANIMALS, **LEVAMISOLE** IS HIGHLY TOXIC TO HORSES. This is why pyrantel is still available to the horse market where it has been replaced by newer compounds, notably levamisole, for other livestock. In our current survey of producers, we've found that this class of compounds is the least commonly used by small ruminant producers in the Mid-Atlantic region.

The newest group of compounds is the macrocyclic lactones, of which ivermectin is the oldest and most widely used anthelmintic. This class includes:

- ivermectin (Ivomec, Zimectrin) for cattle, sheep and horses
- moxidectin (Cydectin, Quest) for cattle and horses
- doramectin (Dectomax) for cattle

Ivermectin became available on the market about twenty years ago. It rapidly became the most widely used anthelmintic for ruminants and horses. It has recently become available in numerous products, probably due to the removal of patent control. There are several newer macrocyclic lactones, only a couple of which are widely available on the market. Together this class of compounds is easily the most widely used group.

## Efficacy in Goats

Goat metabolism is physiologically different from cattle and sheep. Generally, it takes higher dose of anthelmintics to reach the same pharmacological dose in goats. This is important because most anthelmintics are not labeled for use in goats (or maybe mislabeled at lower than desired doses). It should be noted that these higher dose recommendations are not always based on actual controlled tests in goats, but the controlled tests that are available are consistent with a general increase. Another problem using field experience to determine recommend dosing levels for goats is that anthelmintic resistance has reduced the efficacy of many products, which could account for a need for higher doses. The general rule of thumb is that goats need twice the anthelmintic dosage (concentration on a body weight basis) as sheep or cattle. One exception to this rule is levamisole where an actual controlled study indicates that 1.5 times the sheep dose is efficacious in goats (or about 12 mg per kg body weight).

## Anthelmintic Resistance

Benzimidazoles, specifically thiabendazole, had only been on the US for three years until anthelmintic resistance was reported in 1964. Since that time, numerous scientific studies have indicated that widespread resistance to benzimidazoles occurs worldwide for small ruminants and horses. Interestingly, these products still have good efficacy against cattle nematodes. Also the modern benzimidazoles are effective against tapeworms in ruminants, which are not effectively controlled by most other anthelmintics. Current estimates suggest that 90 – 100% of small ruminants and horses farms have benzimidazole resistance nematodes. Additional data suggest that resistance to any benzimidazole is long lasting and will rapidly result in resistance to most (if not all) other benzimidazoles. For all practical purposes, benzimidazoles are no longer effective for controlling nematodes in horses or small ruminants. They can still be used for control in cattle and selective tapeworm control. In addition, albendazole is effective against liver flukes.

With the loss of the benzimidazoles, levamisole and related compounds became the mainstay of the sheep industries of Australia, New Zealand and most other countries where sheep were more common than cattle. Anthelmintic resistance followed fairly rapidly, and by the time ivermectin reach the market was fairly widespread. In the United States, current estimates are that levamisole resistance occurs on 20 – 40% of small ruminant farms. Some of our survey work suggests that levamisole resistance may not be less widespread on goat farms. Again it is not a significant problem in cattle, nor is it widely used. This group only occupies a very small portion of the equine market (e.g., pyrantel tartrate), as levamisole is highly toxic to horses.

Macrocyclic lactones have dominated the anthelmintic market, since ivermectin was released. Resistance in this group is more complex. In our current survey, ivermectin is the most commonly used anthelmintic in small ruminants. Nevertheless, the estimates are that significant ivermectin resistance occurs on 90 – 100% of small ruminant farms in the United States. Although ivermectin resistance has been suggested for horses, it is not currently a significant or widespread problem. So far resistance has not been reported to the newer macrocyclic lactones, moxidectin and doramectin. The question becomes whether these products work differently enough from ivermectin or if cross-resistance is rapidly developing?

## Fecal Analysis and Related Issues

Doing fecal analysis is great as a part of an overall management program, but they are of limited value in determining when to worm. Many producers are under the opinion that fecal analysis is a good indication of when you should worm your animals. This isn't entirely accurate.

As we see it, there are three real values to fecal analysis: first they tell you how infected your pastures are. Note that I said pastures (not animals). This is great in a management program where you monitor fecal egg counts for pasture loads. The main thing that a fecal tells you is how contaminated your pastures are with parasite larvae (or more specifically how bad they were three weeks earlier). If you're doing fecal analysis at regular intervals, then you can use this knowledge to design management strategies that keep pasture worm burden manageable. This is the real goal of parasite control.

Second, fecal analysis can be used as part of a culling program. If you run fecal analysis on your breeding herd, you can select for animals that are more tolerant to parasites. The idea would be to cull animals that have high fecal egg counts. The higher the percentage that you cull, the more rapid your selection will progress.

Third, fecal analysis can be used as part of a drug test program to see if your wormer works. Basically, if a wormer works, fecal egg counts should drop to zero and not return for at least a couple weeks. The actual test is called a fecal egg count reduction test (FECRT). In a FECRT, the efficacy of an anthelmintic is tested in an on-farm situation, so that there has to be good cooperation between farmers and testers. The test works like this. Animals are weighed and wormed with the anthelmintic(s) to which resistance is suspected. Animals should be wormed as close to the actual dose per body weight as practical. (When we test, we treat each animal based on individual weights.) Another critical part of the test is that fecal egg counts need to quantitative. Parasitologists general determine fecal egg counts in terms of eggs per gram of feces (EPG).

When actually conducting a FECRT, fecal samples are collected twice. First at the time of worming and then a second fecal is collected 7 – 14 days later. The reduction in EPG estimates the efficacy of the anthelmintic tested. For an effective test, initial fecal analysis should average 200 EPG or higher and there should be six or more animals tested. (I actually recommend testing ten in case a number of fecal EPGs are too low).

The actual calculation would be:

$$\text{FECR\%} = \left(1 - \frac{\underline{\text{Initial EPG} - \text{Final EPG}}}{\text{Initial EPG}}\right) \text{ times } 100$$

The 'times 100' simply makes this a percentage. If the final EPG were zero, then the FECR would be 100%. I prefer that individual FECR be calculated for each animal tested, and then an average of these values is used to determine the overall effectiveness. For an anthelmintic to be highly effective it should reduce the FEC by 90% or more. This is actually conservative, as for a product to reach the market it would have an efficacy approaching 100%. Be careful interpreting results! For example, if a treatment worked in all the animals but one, that one probably didn't get a full dose.

*Fecal Levels to Worm by*

There are two sides to using fecal analysis to determine when animals need wormed. Traditionally fecal analysis was conducted on a representative sample of the herd to determine when the herd needed treatment. Now we suggest that animals need to be treated as individuals in terms of worming, so that less worming occurs and that herds are selected for more tolerance to parasites. In such a system, the fecal value (or other measurement like anemia) is part of a scale relative to the rest of the herd used for selection. It will not be an absolute value of EPGs above which culling occurs, but rather animals with the highest 10 -15% would be culled for improving the herd. The percentage culled will depend on the rate of improvement and what other characteristic are being considered in the selection program.

On the other hand, even though we don't generally recommend using fecal EPGs to determine when to worm, animals with very high EPGs do need to be treated. In addition to EPGs, animals that show severe signs of anemia (or bottle jaw edema) are likely in need of treatment. Although the actual EPG value varies considerably, values between 500 – 1000 EPG are indicative of moderate to heavy parasite burdens for small ruminants. Grazing calves (and cows) would have problems at much lower levels. The point is that while EPGs can be indicative of a need for treatment, generally they are only part of the equation. Although these values indicate high internal nematode burdens, they are directly related to the pasture levels, which led to these burdens. In this case, treatment is for animal salvage, the cure requires removing animals from the sources of infection (or heavily infected pastures). The long term solution is developing systems that lower parasite burden, through animal selection, strategic treatment and pasture management.

*Fecal Examination Methods*

Animals grazing pasture pick up nematode larvae, thus the parasite burden is related to the pasture infectivity. The eggs of most nematodes can't be distinguished from each other in a fecal examination. Since fecal counts only estimate the parasite load, there is no clear-cut level at which worming is indicated.

A few key points about meaningful fecal examination: Fecal material needs to be relatively fresh and labeled with an animal's individual identification. For livestock, the optimum way of doing this is to collect each sample from the animal's rectum into a labeled plastic bag or glove. Samples should be kept cool or refrigerated, as nematodes eggs begin to embryonate after a few hours. Fresh samples can be preserved under refrigeration for several days.

For meaningful comparisons, samples need to be representative. This means that there is a need to have some idea why the fecal analysis is being conducted. For resistance testing, we suggest about ten animals for each anthelmintic / dose group. For an estimate of relative pasture infective, one could use a composite of six to ten animals. From week to week efforts should be made to not change the composite group drastically. For aid in culling, individual samples of potential culls would be needed.

Of course, fecal results need to be quantified. The simple presence or absence of a nematode egg means nothing. Low-level EPG are to be expected and not suggestive of any treatment need. Generally modified methods that estimate total counts by a factor of 50 or 100 are adequate for quantifying livestock. In contrast, flotation methods that actually count total EPGs require excessive counting labor for most livestock applications.

*A Modified Fecal Technique*

- Weigh out 2g of feces
- Add sample to 28 ml flotation solution in a plastic cup
- Homogenize thoroughly using a tongue depressor or stirring stick
- Strain through a cheesecloth or teas strainer into a second cup
- Using a Pasteur pipette or medicine dropper, fill both chambers of a McMaster counting slide
- Allow flotation process to occur for 5 minutes
- Using the 10x objective with the 10x eyepiece (for a total of 100x) on the microscope, count all Strongyloides eggs in both chambers and multiply this number by 50
- Count Coccidia oocysts (eggs) in only one lane of each chamber and multiply this number by 300

Notes related to fecal analysis:

- If you don't have a scale, consistence in measurement is most important. I suggest using a constant volume like a teaspoon. This way you will be able to make your own comparisons. Sometime you may be able to determine what your measured amount weighs, so that all your numbers could be mathematically converted to compare with other data. The point in that being constant is more important than knowing the exact weight. As a rough estimate a level teaspoon full might weigh 1 gm, so you can use two teaspoons with the about example or double your math answer to have an estimated EPGs.

- Flotation solutions are available through you veterinarian or you can simply make a solution that works great. A flotation solution is simply a saturated salt or sugar solution. Saturated means that you've added so much salt or sugar to water that it won't continue to dissolve. The easiest way to do this is put a quart or two of water on low heat (leave plenty of room in the pan) with regular stirring, slowly add salt or sugar (do not add both), until it won't dissolve any more. You can store leftover solution for later use in a sealed container or refrigerated (warm back to room temperature before using). The volume of 28 ml is about one liquid ounce.
- McMaster chambered counting slides can be purchased from: Advanced Equine Products, 5004-228th Avenue S.E., Issaquah, Washington 98029 Ph 425-391-1169 Fax 425-391-6669 Email info@advancedequine.com (I believe that this is the only place in the US that such slides can be purchased). My suggestions would be that if you plan on doing a lot of fecal analysis, you may wish to buy a number of slides, and make sure that you clean out your slides well when finished, as saturated solution will slowly destroy them.
- It may take some practice to figure out what is a nematode egg and (or) a coccidia oocyst. There is a lot of material and pictures available on the internet for help. I suggest www.sheepandgoat.com as a place to start.

## Summary

The area of parasite control for livestock is overall complex. This makes it difficult to make general recommendations from even one farm to another. The purpose of this material is to illustrate the complexity and to suggest some potential parasite control options. Given the serious problem with widespread anthelmintic resistance, one can be assured that parasite control will be one of the limiting issues raising small ruminants for the foreseeable future.

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