

Integrated Management of Internal Parasites in Goats

WORKSHOP PROCEEDINGS

LIVESTOCK PRODUCTION





PREFACE

Gastrointestinal parasites, especially the barber pole worm, is causing a major health problem in goats in the southern USA. Conventional method of controlling this parasite by just using chemical dewormer is ineffective. For several reasons, this parasite is developing resistance against most of the chemical dewormers available in the market. This program aims at educating and training county agents and goat producers in applying an integrated approach to manage gastrointestinal parasites and help avoid a huge loss in goat industry. A comprehensive training program ‘Integrated management of internal parasites in goats’ was developed in 2010 and being conducted annually since then. Main training topics are major internal parasites and their life-cycles, nutrition for enhancing the immune system of animals, animal selection and breeding for developing parasite-hardy goats, pasture improvement and grazing management for better nutrition and parasite control, use of FAMACHA to monitor anemic goats, and smart drenching strategies to manage the barber pole worm. Also, hands-on activities on collecting and examining fecal samples for identifying and quantifying parasite eggs to monitor the severity of parasite infection, use of FAMACHA card to assess the anemic condition, scoring body condition to scrutinize the health status of goats, examining and trimming overgrown hoofs, and drenching are the indispensable part of the training program.



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MAJOR INTERNAL PARASITES OF GOATS AND THEIR LIFE CYCLES

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Introduction

If your goats are sick, please observe and take note of their clinical signs before you seek the advice of your county agents. They may visit and also consult with the specialists in case laboratory work and veterinary advice is needed. The latter may be done because different species of parasites, their eggs, and larvae are difficult for an untrained eye to identify. Only a pathologist can accurately identify both common and unusual parasites. According to Christensen (2005), the relationship of internal parasites to the host is often complex. This is because most parasites that infest goats may require different species of animals or insects to complete their life cycles. A good understanding of the life cycles of many of these parasites may aid the goat owner in adopting best management practices that will prevent outbreaks of parasitic diseases. We will place more emphasis on these parasites such as barber-pole worm (*Haemonchus contortus*), which is very problematic in Southeastern States.

What is a Parasite?

The word parasite comes from the Greek language meaning “one who eats off the table of another, or any living thing that lives in another” (Zajac 2006). According to Miller (2004), parasitism and gastrointestinal worms are the most serious constraints affecting small ruminant production worldwide. A parasite by definition is a smaller organism that lives on or in and at the expense of a larger organism called the host. Parasite can also be described as a living organism, which receives nourishment and shelter from another organism where it thrives. For example, a louse found living off human head or cloth is a parasite (external parasite), worms inside the intestine of kids that do not allow them to grow well by sucking their nutrients are parasites (internal parasites). Just as we have parasites in humans so do we have them in domestic animals such as cows, horses, sheep, and goats. Our focus for this workshop will be on some of those major internal parasites found in goats. However, it must be noted that external parasites such as ticks, lice, mite, and fleas are also important.

Why Do We Have to Know About Parasites?

Generally, parasites do not let the animal host grow well. They feed on the foods needed for the animal to gain weight and reach marketable size. In addition, parasites can weaken its host in such a way that the host succumbs to the effect of other diseases. Some parasites may not immediately kill their hosts but they could cause long chronic illnesses that may lead to infertility. Furthermore, many internal parasites produce a lot of eggs that are passed in the host's feces. The eggs contaminate the ground from where other goats could pick them up and become infected.

How Does a Farmer Suspect Internal Parasite in Goats?

A farmer must always observe his/her herd everyday to look out for clinical signs of internal parasite infection. Generally, internal parasites cause persistent loss of weight and rough skin coats in goats despite adequate nutrition. It must be noted that many other diseases can also cause goats to lose weight. Some clinical infection of internal parasite can be manifested when the goats have diarrhea. Most parasite infections that involve loss of blood will cause the animal to show clear evidence of anemia, when the eyes and the lower eye-lids (lower membrane) are pale or “whitish”. The severity of infection would be judged by the different degrees of “whiteness” using the FAMACHA® eye color chart.

Types of Internal Parasites

There are many types of worms that can infect goats. For ease of description they are named after their structure and the organ in which they are found. Some of such names are round worm, wire-worm, thread-worm, lung-worm, tape-worm, and brain-worm. In the US as well as most parts of the world, the most important worm parasites are the gastrointestinal Trichostrongyles family. The most important one in the family is the barber pole worm (*Haemonchus contortus*), which causes many goat deaths every year.

Life Cycle, Clinical Signs, and Treatments of Internal Parasites

According to Strait (2009), the best way to determine what parasites are infecting your goats is to have your veterinarian, livestock specialist, or county agent check a fecal sample. He or she can then tell which parasites are infecting your goats as well as at what level, and what product to use to treat your goats. While certain clinical signs in goats are typical of certain internal parasites, it is not a good farming practice to generalize, and make a conclusion. A farmer can easily recognize sick animals that are not performing well without knowing the cause or causes. Farmers can also easily recognize animals with typical indicative signs such as diarrhea, rough coats, anemia, swollen jaws, and whitish eye that are associated with certain intestinal worm infestations. All these signs may not be due to internal parasites alone, especially after a farmer has treated the herd with an appropriate dewormer but failed to stop the disease progression.

As indicated by Zajac (2006), all of the available “modern” dewormers fall into three major groups of drugs. You need to recognize which ones are in each group because once worms become resistant to one member of the group, they will be resistant to the other members of the group. The best practice for a farmer is to take note of clinical signs of his herds and report to his nearest county agent as soon as possible.

1. The Barber Pole Worm (*Haemonchus contortus*)

Adult barber pole worm is about 0.8 to 1.2 inches long; eggs are thin-shelled with 24 cells (Leite-Browning 2006). The worm lives in the fourth stomach (abomasum) of goats. The male worm is bright red and the female worm is striped red and white which is why it is called barber pole worm. The red and white striping results from the white genital organs twisting around the blood-filled intestine. This parasite is more common in tropical or subtropical areas which have summer rainfall. Barber pole worm is found in both the intestine and stomach of goats where it is attached by its suckers. It has lancet that cuts the host's gut for blood sucking. It causes anemia but usually not scouring. Barber pole worm infection is the most common cause of anemia among all worms that cause loss of blood in heavily infected goats (Mobley 2008).

Life Cycle

General life cycle of nematodes (round worms) including barber pole worm is presented in Figure 1.1. Female barber pole worm is a prolific egg layer, frequently producing 5,000 to 10,000 eggs per day Christensen (2005). The eggs are already in the early stages of cell division when laid. Once they pass out with the feces, the larvae develop to the infective stage in four to five days at the optimal temperature of 75° to 85°F. The pre-infective larvae do not survive long if they dry out but can withstand freezing temperatures for long periods. Once the larvae reach the infective stage, they are much more resistant to dry conditions, surviving if not in direct sunlight for weeks. The infective larvae crawl up blades of grass that is wet with dew in the morning then go back down as the leaf blade dries out. In rainy weather they remain on the grass all day as the leaf blade remain wet, increasing the risk of infection. The goat becomes

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infected when they swallow grass containing larvae. The larvae undergo few molts in the abomasum to become mature in about 18 days and then begin laying eggs in three more days (i.e., in 21 days).

The barber pole worm pierces the mucous lining of the stomach where they actively suck blood. Severe infestations can cause death of the animal within a week of heavy infection without showing any clinical signs. Animals with chronic infections become anemic and lose weight. The barber pole worm tends to infect mostly young animals; however, older animals can develop heavy infections especially during early lactation which may prove fatal. In the late stages of infections, the animal develops a swelling beneath the lower jaw, called bottle jaw.

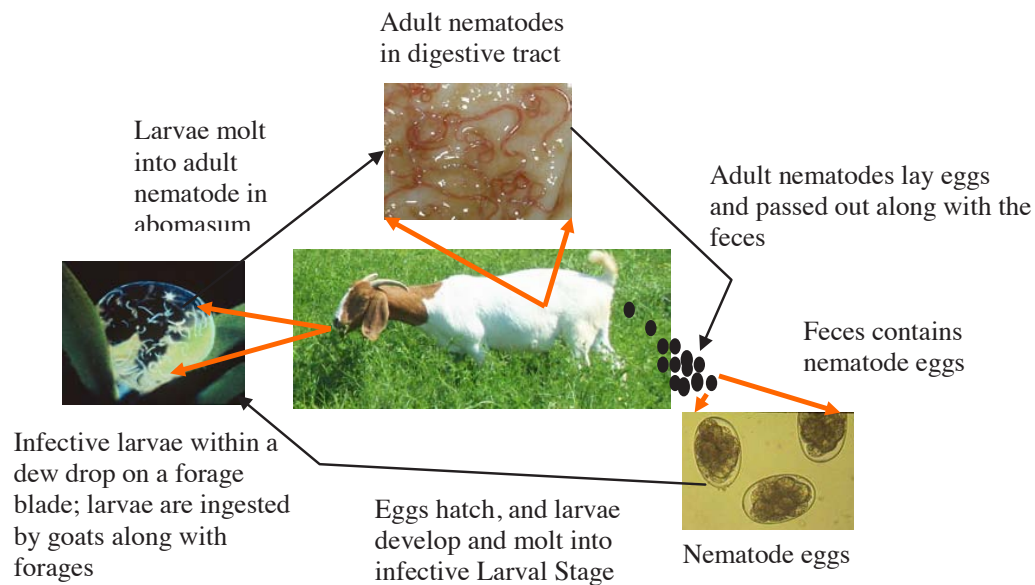


Figure1.1 General Life Cycle of Gastrointestinal Nematodes.

Because the female worm lays such a large number of eggs, the eggs are easily seen using a simple direct smear. To do that, take a small amount of feces, about the size of a match stick tip, smear it on a microscope slide breaking it down with a few drops of water, place a cover slip over and observe under low power. Under adverse climatic condition such as cold winter, barber pole larvae undergoes a process called “*arrested development*” where they sit quietly in the stomach following infection and do not molt into adults until several months later. This is an important adaptation for keeping the worm around through cold winters when eggs and larvae do not survive well on pastures. The worms that became arrested in the fall resume development in the spring and reproduce.

Clinical Signs

Affected goats become weak due to loss of iron from the blood. They show signs of anemia with pale mucus membrane (eye, gum, and vulva). Severe anemia may be accompanied by rough coat and weight loss. Some pregnant goats can abort while many, especially the kids may die. Many goats may also show diarrhea, and when fecal samples are looked under microscope, a lot of eggs would be seen to confirm worm infection of the herd.

Treatment

This is effective when appropriate anti-worm drug is used to de-worm the animals. See Table 1.1 below for details as to the weights of the animal to be treated and which drug to use. It must also be noted that almost all these drugs require “withdrawal periods” (that is the number of days the food products from treated animals must be avoided from human consumption).

Table 1.1. Commonly Used Dewormers in Goats (Oral Route of Administration Only) for all Worms Discussed in this Article

Dewormer	Approval	Dosage/ 100 lbs	Withdrawal period	
			Meat	Milk
Fenbendazole (Safeguard/Panacur)	Approved	2.3 ml	14 days	4 days
Morantel tartrate (Rumantel)	Approved	1/10 lb	30 days	0 days
Albendazole (Valbazen)	Extra-label	8 ml	7 days	5 days
Levamisole (Levasol, Tramisol)	Extra-label	12 ml	10 days	4 days
Ivermectin (Ivomec for Sheep)	Extra-label	24 ml	14 days	9 days
Moxidectin (Cydectin)	Extra-label	4 ml	23 days	56 days

Source: Zajac, 2006.

In addition to deworming, it is essential to feed some trace minerals to goats. Example of such minerals is copper oxide. Copper sulfate in water could also be fed to the goats to support the drugs used. The producer should also feed the treated animals with adequate feed to improve their immunity level. After de-worming, one should not allow crowding of the animals. Adequate space should be given to the animals to prevent re-infection from larva. If possible, animals should be moved from infested pasture for a period of time after de-worming. Solaiman (2007) recommended that 100 mg of copper per day (less than ¼ teaspoonful/day) fed as copper sulfate in water solution would improve the immune responses of goats.

2. Brown Stomach Worm (*Ostertagia circumcincta*)

This worm also lives in the fourth stomach but is much smaller than the barber pole worm. *Ostertagia circumcincta* is only about 0.4 inch long and is brown in color (Christensen 2005). It is commonly found in temperate climates with winter rainfall and drier summers; eggs can hatch at temperatures below 45°F. This makes infections of *Ostertagia* much more likely during the winter especially during rainfall.

Life Cycle

The life cycle of the brown stomach worm is similar to the barber pole worm (Christensen 2005; Georgi et al. 1985). Once the eggs pass out with the feces, the larva hatch and reach the infective stage in five to six days during the warm summer months. When ingested, the larvae make their way to the wall of the abomasum and become coiled in nodules on the mucous membrane. After about a week, the larvae leave the nodules and continue to develop into adult worms. Female worms are mature in 15 days after initial infection, and their eggs are found in the feces just about six days later. In other words, it takes about 21 days for the worm to mature and start laying eggs.

Clinical Signs

See Clinical Signs of most worms above.

Treatment

Treatment for this worm is effective when appropriate dewormer is used. See Table 1.1 for details.

3. Small Stomach (Bankrupt) and Intestinal Worms (*Trichostrongylus* spp.)

Most of the species of the genus *Trichostrongylus* actually live in the small intestine. Only one *T. axei* lives in the abomasum. These are very small worms, less than 0.3 inch long with thin bodies and are pale pink in color which makes them practically invisible on post-mortem examination. *Trichostrongylus*, like *Ostertagia* are more common in areas with winter rainfall.

Life Cycle

According to Christensen (2005), when laid, the eggs are in the early stages of cell division (4 to 8 cells). They may also have already developed to the sixteen or thirty-two cell stages. They develop rapidly, hatching in less than twenty hours in summer temperatures (70°F - 80°F.) If the eggs dry out before they hatch they become dormant and can survive for as long as 15 months. In the infective stage, larvae are also very resistant to dry conditions. Goats or sheep are infected when they graze on grass where the larvae have migrated. The larvae travel to the wall of the abomasum or the small intestine where they go through a molt. They then leave the wall to live freely in the lumen of the intestine or stomach. There they develop into adults and start laying eggs within 21 days after infection.

Clinical Signs

See Clinical Signs of most worms above.

Treatment

Treatment is effective when appropriate dewormer is used. See Table 1.1 above.

4. Tapeworm

Many producers are concerned about tapeworms (*Moniezia* spp.) which are seen as moving segments (white “rice grain-like” worms) in freshly deposited feces of infected goats. The adult tapeworm body may consist of as many as 40 segments called Strobila. Goats, sheep, and other ruminants also serve as intermediate hosts for carnivores such as foxes and dogs for tapeworms. So, most cattle, sheep, and goat keepers that have dogs, should also examine dogs for tapeworms and treat as required (Georgi et.al. 1985).

Life Cycle

The life cycle of *Moniezia* involves an Oribatid mite which is also known as field mite. Eggs are contained in the rice-like segments of the adult worm voided out along with feces of infected goats. The field mites eat up the eggs. Infection cycle is completed when goats eat up the mites from forages. The eggs develop into larvae in the intestine of the goats and the larvae matured into adult tapeworms in the goats or sheep. The pre-patent period of this parasite is 6-7 weeks.

Clinical Signs

See Clinical Signs of most worms above.

Treatment

An appropriate dewormer is used to treat the animals infected with *Moniezia* tape-worm. See Table 1.1.

5. Coccidiosis

According to Zajac (2006), two other parasites to control are coccidia and meningeal worms. Coccidiosis is somewhat different from most parasites because infection is direct from an egg-like stage called an oocyst. It is also picked up during grazing or in the barn. Coccidiosis is a major cause of poor feed efficiency and poor growth. The parasite is normally present in all ages of goats, but affects younger animals the most. It often shows clinical symptoms when the animals have been stressed in some way, including changes in the weather.

Coccidiosis is a disease that results from the invasion and destruction of the mucous lining of the small intestine by 10 to 12 different species of one-celled organisms (protozoa) of the genus *Eimeria* and one species of the genus *Cryptosporidium* of the taxonomic order Coccidiomorpha. *Eimeria* infections can result in serious clinical signs of fluid diarrhea, which may or may not contain mucous or blood, dehydration, emaciation, weakness, loss of appetite, and death. Some goats may instead be constipated and suddenly die without diarrhea. The small oocysts of *Eimeria* can be found in thousands in fecal flotation samples. However, diarrhea can appear one to two days before eggs appear and can continue after the oocyst discharge has returned to low levels. According to Mobley (2008), most coccidia are host specific, which means each type can only affect one species of animal.

Life Cycle

The life cycle of *Eimeria* species is somewhat complicated (Christensen 2005). The oocysts discharged with the feces are not infective at first. Under the right conditions of moisture and temperature the protoplasm of the oocysts organizes into four secondary cysts (sporocysts), each of which contains two sporozoites. It takes about two days for the infective sporulated oocyst to develop. When ingested by goats the sporozoites escape from the oocyst and invade the mucous lining and cells of the intestine. Once inside the cell the sporozoites develop into a mass of nuclei, each of which develops into more sporozoites that enter new cells to repeat the process. It is this constant invasion and destruction of intestinal cells that cause the symptoms of the disease. At some stage, some of the sporozoites form sexual cells which, once fertilized, become the oocytes that are released in the feces.

Cryptosporidium cause less severe symptoms than *Eimeria*. Young animals one to three weeks of age are most susceptible. Symptoms include weight loss, loss of appetite, and diarrhea or tenesmus (frequent, futile attempts to empty the bladder or rectum). The disease is seldom fatal. The eggs of *Cryptosporidium* are immediately infective when shed in the feces. Once ingested, the incubation period is about four days. Some species that infect calves can also infect man. The eggs of *Cryptosporidium* are very tiny and transparent - only one-tenth the size of an *Eimeria* oocyst, so are difficult to see without special staining techniques. The disease is self limiting, meaning that with supportive therapy, usually rehydration, the animal recovers on its own.

Clinical Signs

See clinical signs of most worms above.

Treatment

The most commonly used coccidiostats are by trade names: Monensin, Rumensin, Lasalocid Bovatec, Decoquate, Deccox, Amprolium, Corid, and Sulfadimethoxine Albon (Mobley 2008). See each drug's manufacturer's instructions for administering to animals.

6. Thread- or Thin-Necked Intestinal Worm (*Nematodirus* spp.)

These parasites, so named because the anterior part of the female worm is narrow and coiled, are about 0.4 to 0.8 inch long, and are creamy to bright pink in color. They live in the small intestine (Christensen 2005).

Life Cycle

When laid, the large eggs are in the early stages of cell division (4 to 8 cells). After passing out with the feces, the embryo develops very slowly often taking 14 days in optimum conditions. The larva goes through several molts before they hatch out of the egg. The eggs are very resistant to dry weather and low temperatures, surviving many months. Goats are infected when they ingest infectious larvae that have crawled up onto grass. The worm matures into an egg-laying adult after about four weeks.

Clinical Signs

See Clinical Signs of most worms above.

Treatment

An appropriate dewormer is used to treat the animals infected with this worm. See Table 1.1

7. Meningeal or Brain Worm (*Parelaphostrongylus tenuis*)

Brain worm of deer is a problem where there is high population of deer. White tail deer are the primary and natural host of brain worms (Miller 2004). This parasite is carried by deer in the lining of their brain. It has no effect on the deer, but can greatly affect goats. Brain worm affect llamas, alpacas, and only sometimes goats, and it can be deadly in goats (Miller 2004). Goats become infected when they eat the snails or slugs (infected with meningeal worm) found on blades of grass in the pasture.

Life Cycle

Eggs are voided along with feces by infected deer. The slugs and small snails ingest the eggs along with feces. Eggs hatch into larvae inside the slugs or snail that serve as the intermediate hosts. Goats become infected when they eat the snails or slugs found on blades of grass in the pasture. The larvae migrate to places where they do not normally reside in deer. The larvae migrate to the spinal cord of goats and the brain. The migrations cause damage to the central nervous systems of goats which may be severe enough to cause their death (Miller 2004).

Clinical Signs

See Clinical Signs of most worms above.

Treatment

Treatment of goat's brain worm is "frustrating" according to Zajac (2006) because the disease crops up with no warning and it is difficult to prevent. Treatment may be effective when appropriate dewormer is used to de-worm the animals. See Table 1.1 above. Though ivermectin is not approved by the FDA, it may help if the farmer consults a veterinarian. Irrespective of treatment protocol, some animals will get better and some will not.

8. Liver Flukes (*Fasciola* spp.)

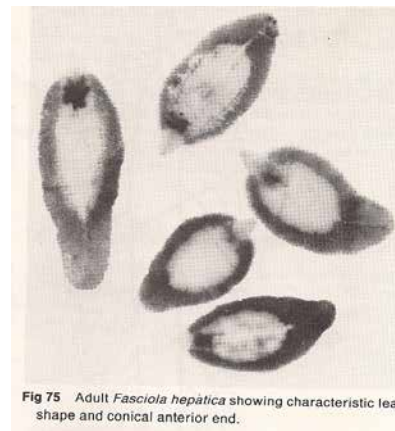
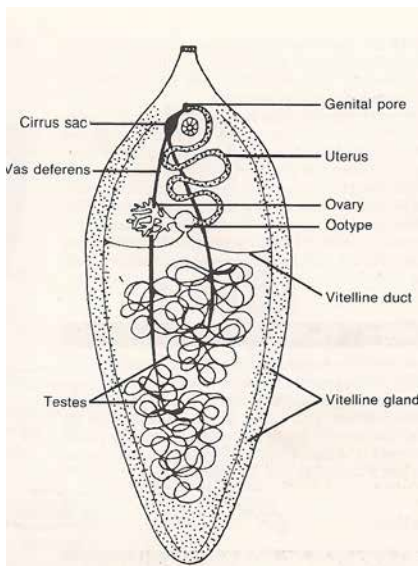


Fig 75 Adult *Fasciola hepatica* showing characteristic leaf shape and conical anterior end.

Figure 1.2. Different Body Parts (left), Adult Stage (upper right), and an Egg (lower right) of liver fluke.

Source: Urquhart et al., 1988.

An adult fluke (Figure 1.2) can cause a serious condition in the liver of goats and sheep. In cattle, the liver damaged by *Fasciola* is called *pipe-stem* liver. *Fasciola hepatica*, the sheep liver fluke, is somewhat misleading since this parasite is also found in animals other than sheep (including cattle and humans), and the parasite resides in the bile ducts inside the liver rather than the liver tissues. This species is a common parasite of sheep and cattle.

Life Cycle

Adult parasites reside in the intrahepatic bile ducts, produce eggs, and the eggs are passed in the host's feces. After passing through the first intermediate host (a snail), cercaria encyst on vegetation. The definitive host (sheep or goat) is infected when it eats the contaminated vegetation. The metacercaria excyst and make its way into the definitive host's small intestine, the immature worm penetrates the small intestine, and migrates through the abdominal cavity to the host's liver. The juvenile worm penetrates and migrates through the host's liver and finally ends up in the bile ducts. The migration of the worms through the host's liver and the presence of the worms in the bile ducts are responsible for the pathology associated with fascioliasis.

Clinical Signs

See Clinical Signs of most worms above.

Treatment

Liver fluke worm is controlled and treated by killing off the snail host. The farmer can use copper sulfate in water or stream to kill the intermediate host - snails. An appropriate dewormer should also be used to de-worm the animals infected with this worm. See Table 1.1

9. The Large Lung Worm (*Dictyocaulus filaria*)

These are long (up to 4 inch), white, thread-like worms that live in the air passages of the lungs (Christensen 2005). The female worm lays eggs in the air passages which are coughed up into the pharynx then swallowed. By the time they reach the intestines, the first stage larvae have already hatched. Some eggs may be coughed out in mucous onto the pastures.

Life Cycle

These larvae are stout, with a blunt tail and a round knob at the head end which closes the mouth so that the larvae cannot feed. After one or two days, the larvae undergo the first molt, but the skin is not shed and encloses the second-stage larva. The larva will undergo another molt in three or four more days again retaining the skin. These larvae can survive for up to nine months in shallow water, where they are swallowed by grazing animals. After they are swallowed the larva bore into the wall of the small intestine and travel to the lungs through the lymph vessels. After a third molt, the larvae make another trip through the lymph system to the heart and then back to the lungs through blood stream. By then they are fourth stage larva, which will be found in bronchi after eight days. Adults develop in lungs 18 days after infection and they will produce eggs in three to five weeks. (Christensen 2005).

Clinical Signs

See Clinical Signs of most worms above.

Treatment

Treatment is effective when an appropriate dewormer is used to de-worm the animals. See Table 1.1 above.

Summary and Conclusions

In conclusion, one should ask three main questions as listed below about life cycle of goat internal parasites. First, when are parasites most likely to infect goats in pastures? The answer is, the highest numbers of larvae are present in the pasture when the climate is most suitable for survival. If the weather has been warm and damp, the larvae numbers are likely to be high. However, if the weather has been hot and dry for a number of days, then the numbers are going to be low. Second, do the larvae survive through winter? The answer is yes. It has been found that the larvae sometimes survive over winter, especially where the winter is not severe. Thus, when the pasture starts to become green and you are ready to let the goats out to that lush pasture, you may be turning them into a field of new larvae. This is why you should be on a good de-worming program that would be specific to your farm. In addition, larvae may survive “over-winter” in goats in a dormant stage if parasites are not eliminated in the late fall with a broad spectrum de-worming product. Third, taking into consideration questions one and two above, how is parasite detection done? The answer is, the best way to determine what parasites are infecting your goats is to have your county agents, specialists, or veterinarian check fecal samples. They can then tell what parasites are infecting your goats, at what level, and what product to use to treat your goats. You can also check your goats for anemia by looking at their gums and the conjunctiva around the eyes. Both places should be bright pink to red in color. If the gums or conjunctiva are pale pink or whitish, then the goat is showing signs of anemia, which is an indication that you may need to de-worm.

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Newborn kids need to consume enough colostrum beginning soon after birth, then frequently for 24 hours of birth to remain healthy.

PASTURE AND GRAZING MANAGEMENT FOR PARASITE CONTROL

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How Goats Get Parasite Infection from Pasture?

Pastures contaminated with parasite eggs serve as a reservoir as well as provide an environment to hatch these eggs to larvae. The larvae undergo few development stages (molting) and become infective. Under favorable conditions, infective larvae travel to the tip of forages and enter into grazing animals' digestive tract along with the forages that these animals eat. This is the case of parasites that have direct life cycle (parasites that require only one host to complete their life cycle) such as most of the roundworms of veterinary importance (Figure 2.1). For the parasites that have indirect life cycles (parasites that require more than one host to complete the life cycle) such as liver flukes (snails are the intermediate host) and ruminant tapeworms (pasture mites are the intermediate hosts) (Urquhart et al. 1988), pastures provide the environment for the survival and development of parasite eggs, larvae, as well as the intermediate hosts. Larvae of parasites that have indirect life cycles infect suitable intermediate hosts and complete certain developmental stages within the intermediate hosts. These larvae are either liberated into the pasture and then they infect the grazing animals (Figure 2.2) such as in the case of liver flukes, or grazing animals get infected after ingesting the intermediate host infected with parasite larvae (Figure 2.3) such as in the case of ruminant tapeworms, where animals get infected after ingesting pasture mites with tapeworm larvae. Therefore, it is very important to properly manage the pasture and adopt suitable grazing practices to minimize the parasitic problems.



Goats must have access to a good quality, tall forages to minimize the chances of ingesting parasite larvae; grazing should be stopped when the stubble height is four to five inches.

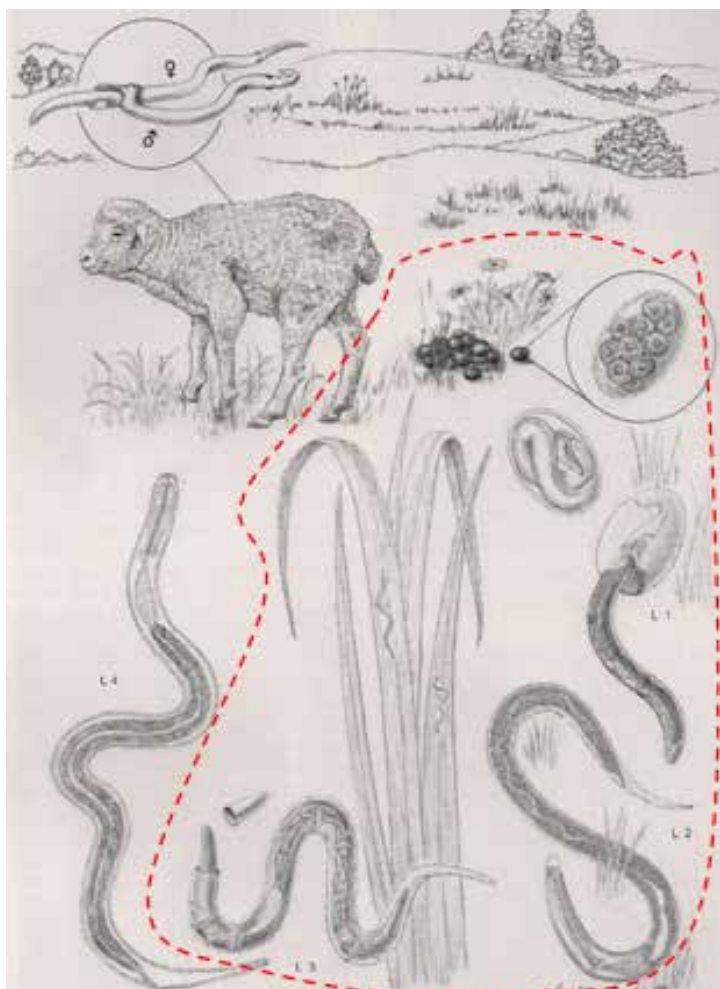


Figure 2.1. Typical roundworm life cycle. Steps inside the dotted line takes place in pastures.

Source: Adopted from (Bowman and Lynn 1995).

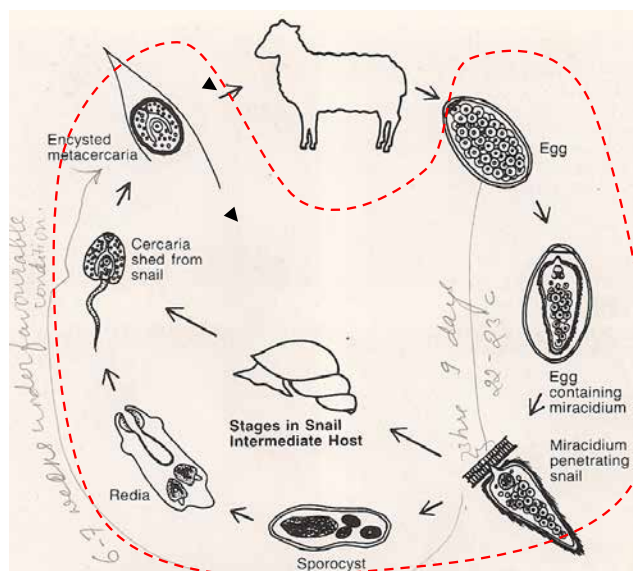


Figure 2.2. Liver Fluke Life Cycle and the Stages that Occur in Pasture.

Source: Adopted from Urquhart et al. (1988).

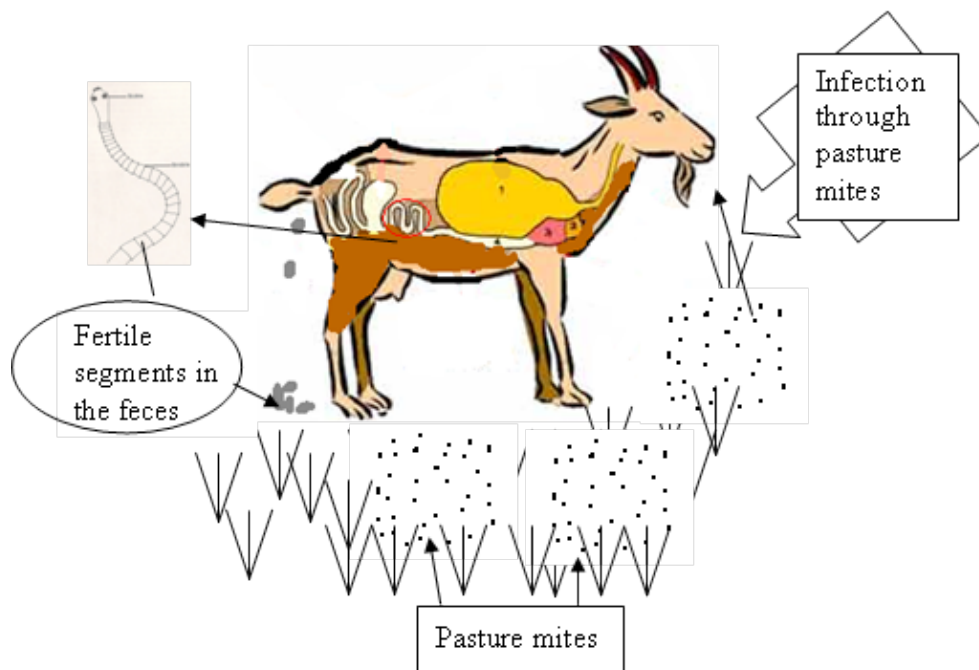


Figure 2.3: Typical Ruminant Tapeworm Life Cycle.

What Pasture Situation is Favorable for Parasite Survival and Development?

Wet and warm (65°F – 85°F) environment is favorable for the survival and development of parasite larvae in the pasture (Miller 2004). Parasite larvae remain close to the ground up to a level where there is enough moisture for their survival. Moisture also serves as a medium for the travel of larvae. When there is a lot of moisture, larvae travel towards the tip of the forage so that they can reach to the grazing animals through the forages that animals eat. When it is dry, larvae go back close to the ground surface and remain there until environment becomes favorable for them to travel up the forage again. Generally, the moisture available under the forage canopy is adequate for larvae survival. How long larvae remain alive in a pasture if they do not have chance to infect animals depends on how quickly they finish their energy reserves as they do not feed. Normally, the density of larvae remains high within 12-24 inch from the feces and 2-3 inches up on the forage plants. However, parasite larvae can reach beyond 2-3-inch height on the forage plant when it is warm and wet. Therefore, it is recommended that goats should not be allowed to graze forages lower than five inches. Moreover, parasite density remains high in certain areas of pasture where fecal material is accumulated such as around water source, under the tree shade (during hot days), and around feeding areas. Also, parasite larvae population will usually be high in overstocked pasture than in normally stocked or under-stocked pastures. Liver fluke prevalence will be high where there are water bodies (swamp areas) and snails.

What Can Be Done To Lower The Parasite Problem?

There are several things producers can do to lower the problem of internal parasites such as those listed below.

1. Include Condensed Tannin Containing Forages

Tannin is a compound present in various forages like sericea lespedeza, chicory, mimosa, and birdsfoot trefoil (suitable for the northern parts of the Southeast). Several studies have shown that condensed tannin has detrimental effects on internal parasites of goats, sheep, and deer. Sericea lespedeza is a perennial warm-season legume and widely adapted in the Southeast (Ball et al. 2007). It is well suited in well-drained loam to clay soil from southern Ohio to central

Alabama and from eastern Oklahoma to Atlantic coast. It is tolerant to drought condition and low fertility as well as acidic conditions. Its nutritive value is better than most perennial grasses. This forage can be planted for hay production as well as grazing, but continuous close grazing is not suitable for most of the varieties. ‘Au Grazer’ variety is most suitable under grazing condition (Ball and Mosjidis 2003). However, rotational or controlled grazing is recommended for its persistence. Seed of this variety is available from Sims Seed Company, Union Springs, AL.

Chicory is a short-lived (2-4 years, or 5-7 years with proper management) forb (neither grass nor legume). It is recommended for all parts of Southeast for pasture, but not suitable for hay production for its high water content. It can be grown together with tall fescue or bermudagrass when properly managed with rotational stocking. It is very tolerant of drought and acidic condition, but requires highly fertile soils. It is very palatable and nutritious forage, and goats like it. Mimosa trees can be introduced into the pasture or silvopasture setting. These trees are leguminous, so will provide quality fodder to goats along with tannin. Information on mimosa trees can be found from the local forest service office.

2. Include Browse and Tall Forages into the Grazing System

Goats are browsers. When they are exposed to multispecies pasture that include browse, grass, and forbs, goats derive 60 percent of their diet from browse (Walker 1994). Since parasite larvae are concentrated under the pasture canopy, parasite infection of goats can be significantly lowered keeping the goats’ head up such as when browsing. Like browse species, tall forages like sericea lespedeza, johnsongrass, and switchgrass help keep the goats’ head up and minimize the parasite problem than when grazing short grasses such as bahiagrass and common bermudagrass. Goats will utilize brush and shrubs under woodland. However, allowing goats to graze short forages under trees already contaminated with parasites will worsen the parasite problem. It is because understory forage canopy will have more moisture due to tree shade, so provides favorable conditions for parasite larvae survival.

3. Apply Mixed-Species Grazing

Cattle and goats complement each other by minimizing the parasitic larva of the other species as they do not share most of the gastrointestinal parasites with major pathogenic importance (Miller 2004, Urquhart et al. 1988). When grazed together, each species dilute the parasite larvae of the other species, and thereby, minimize the chance of infection. If co-grazing of cattle and goats is not possible or preferred, each species can be allowed to graze the pasture alternatively. However, one must be careful if there are young calves, which can be infected with *Haemonchus contortus* larvae, although the risk of parasite problem in calves is much less than in goats. Other than benefits of parasite control, mixed species grazing also offers higher forage utilization.

Co-grazing of cattle and goats can maximize forage utilization and reduce weed problem because each species has different forage preferences (Abaye et al. 2008, Coffey 2001). Cattle prefer to graze grasses while goats select from a wide range of grasses, brush and weeds, and browse. Many weed species found on the pasture grazed by cattle alone can be minimized by introducing goats into the grazing system. Also, quantity of meat produced per unit of pasture may be increased in mixed-species grazing than when either species are grazed alone because of higher forage utilization, reduction in weed problem, and minimization of the gastrointestinal parasitic problem.

4. Rotate Pasture and Hay Field, Crop Field and Pasture

Pastureland can be tilled and used for crop production while crop field can be developed into pasture. All these conversion

and tilling operation kill parasite eggs and larvae thereby greatly lowering the parasite burden. But one has to consider economics and practical aspects of all these conversions. Also, if there are different portions of land for hay production and grazing; one can reverse the land use pattern to minimize the parasite concentration. At the reasonable growth of forages after the first hay cutting, goats can be transferred to hay plots, and forages in conventional grazing plots can be allowed to grow for hay cutting. Switching between the hay and grazing plots can be done twice or thrice in a grazing season.

5. Isolate and Treat Areas where there are Snails

In areas where there is liver fluke problem, it is better to identify and isolate the pasture areas where there are snails. Draining the stagnant water reduces the snail habitat. One can use chemicals to minimize the snail population.



6. Improve Pasture for Better Nutrition

Well-fed goats have better immunity to withstand the parasite infection. While developing a pasture, producers need to consider making the pasture productive throughout or most of the year as much as possible. It can be done by incorporating the combination of warm-season and cool-season forage species (grasses, forbs, and legumes). Inclusion of legumes into the grazing system increases the quality of forages (Karki et al. 2009) and eventually the quality of animal diet. It is because legumes contain higher concentration of nitrogen and lower concentration of fiber than most grass species. Nitrogen content is directly related to protein concentration and fiber content related to forage digestibility. High nitrogen content and low fiber content is desirable for quality forage and animal feed.

7. Do not Overstock

Overstocking is a three-edged sword as it leads to high parasite load, unsustainable pasture because of damages to pasture plants and soil deterioration, and poor animal performance. Animal performance remains low when they are overstocked because of high parasite problem, low forage availability, and environmental stress. Stocking rate has to be determined based on available forage and requirement of grazing animals. Always, it is better to maintain low stocking rate to manage the parasites.

8. Apply Control Grazing when there is Multi-Species Pasture

Under continuous grazing system, animals are left on the whole pasture throughout the grazing season (Karki and Gurung 2009). Animals select and graze most palatable plants and plant parts first and less palatable later on. When there are multiple species in a pasture, some species may be more palatable than others. So, the more palatable species will be grazed repeatedly as long as animals can get them. Also, when goats congregate around the more palatable species, they drop feces there and make these places densely populated with the parasite eggs and larvae. So, goats have higher chance of getting parasite infection as they graze lower than five inches stubble of the palatable species. Moreover, overgrazing of the palatable species cause its low availability or extinction in the uncontrolled grazing.

Therefore, pastures that have multiple species should be managed applying controlled or rotational grazing.

Under control grazing, producers have control over where, when, and how long goats should graze. Control grazing can be practiced by adopting rotational grazing system or some other specialized grazing systems. Different control-grazing systems are briefly discussed below.

- a) Rotational grazing: In this system, whole pasture is divided into two or more subdivisions (paddocks) through appropriate fencing, and animals are allowed to graze one paddock at a time and moved to another paddock in a sequence or rotation based on forage availability.
- b) Specialized grazing:
 - I. Strip grazing: A strip of a pasture is fenced temporarily with a movable fence and animals are allowed to graze the strip for a short time, which may vary from few hours to a day depending on the strip size and forage availability. When the strip is grazed to a desirable level, the fence is moved to allow animals to another fresh strip.
 - II. Creep grazing: Smaller animals are allowed to go (creep) to a certain portion of pasture having higher forage quality through openings in fence that allows smaller animals but prevent larger animals from entering. Creep grazing is practiced to fulfill the nutritional requirements of young, growing animals grazing with their mothers and other mature animals. Creep grazing can be practiced to protect young kids from infection.
 - III. Forward creep: Kids are allowed to creep through a creep gate to a fresh pasture first, and then does are allowed to graze the same paddock. This will also lower the chance of kids getting infected with the internal parasites.
 - IV. Limit grazing: Animals are allowed to graze high quality pasture such as legumes or winter annuals for a limited time, e.g., for few hours everyday. Growing high quality forage on a separate piece of pasture and allowing animals to this piece for few hours everyday is useful to fulfill the nutrient requirements of livestock grazing low-quality pastures. This concept can be applied with the tannin-containing forages as well.
 - V. First and last grazer: When there are different classes of livestock in terms of parasite problem, those highly vulnerable to the parasite can be grazed first followed by the less vulnerable species. For example, when there are goats and cattle, goats can be allowed to graze first followed by cattle.

9. Maintain Soil Health to Minimize Parasite Eggs and Larvae

Healthy soil has abundant beneficial organisms such as earthworms, dung beetles, and nematodes trapping fungi. It has been suggested that earthworms kill parasite eggs and larvae either by ingesting them or taking them far below the ground surface into burrows. Similarly, dung beetles are shown to disperse the feces thereby facilitating it to dry and reducing the moisture content. Also, these beetles either ingest or carry the feces down to their burrows, so minimizes the parasite density in the pasture. Nematode trapping fungi are known to trap soil nematodes including parasite nematode larvae and eat them as their food. Depleted soil environment will be detrimental to these beneficial organisms.

10. Place Waterers and Feeders High Enough to Avoid Contamination with Feces

Since parasite eggs comes with feces from the infected goats and contaminate the environment, one should be careful while placing waterers and feeders, either for hay or concentrates, in the pasture. These feeders and waterers should be placed high enough from the ground surface such that water and feed are not contaminated with the fecal material.

How high these waterers and feeders should be placed depends on the height of the goats. One can try placing waterers and feeders at different heights and select one that gives the best result. Separate waterers and feeders can be provided to young kids using a creep.

Summary and Conclusions

- Pastures serve as reservoirs and provide suitable environment for the survival and development of internal parasites of goats and other animals.
- Warm and moist pasture environment is very conducive for the survival and development of parasite larvae as well as infection by these larvae to goats.
- The following points should be considered to minimize the internal parasitic problem in goats:
 - a. Include condensed tannin-containing forages
 - b. Include browse and tall forages into the grazing system
 - c. Apply mixed-species grazing
 - d. Rotate pasture and hay field, crop field and pasture
 - e. Isolate and treat areas where there are snails
 - f. Improve pasture for better nutrition
 - g. Do not overstock
 - h. Apply control grazing
 - i. Maintain pasture soil health
 - j. Minimize the fecal contamination to waterers and feeders



Inclusion of sericea lespedeza into goats' grazing system help reduce the internal parasite problem.

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NUTRITION, FEEDING, AND IMMUNITY AGAINST PARASITES

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Introduction

Southeastern states have witnessed a tremendous increase in meat goat numbers in the recent years, mainly, due to a growing demand by ethnic populations and niche markets. However, the goat meat market still relies heavily on imports, mainly from Australia, to meet the domestic demand (USDA 2009).

Goat production could become a very attractive enterprise to small landholders and limited-resource farmers because inputs required are comparatively modest and the goat life cycle is short. The cash flow is relatively quick compared to other livestock species. They can also be productive in a range of environments. The proximity to the major east coast ethnic markets adds a comparative advantage for the Southeastern region (Pinkerton et al. 1994). The region has an additional advantage in that goats can be grazed on a year-round basis due to mild and humid conditions which are favorable for forage production. However, this condition also favors the production of a menacing gastrointestinal parasite namely “barber pole worm”. Besides, most goats are also simply being raised in pastures like cattle, resulting less than optimal production environment thereby making them more prone to Barber pole worm. Given the choice, goats prefer browsing over grazing. Considerable economic losses are caused by decreased production, cost of prevention, and the death of infected goats (Miller 2005). The parasite of particular economic concern in the Southeast is the barber pole worm (*Haemonchus contortus*). This is a blood sucking worm which can cause anemia, loss of appetite, depression, loss of condition, and eventual death if not treated on time.

Integrated Approach for Parasite Control

The goat producers in the Southeast are facing the resistance problem of *H. contortus* to essentially all of the available dewormers due to its repeated use including use of many under-doses (Miller 2005). As a consequence, several approaches are being employed to control this nematode. They include smart drenching, rotational grazing, mixed/alternate livestock species grazing, developing parasite resistant goat breeds, copper oxide wire particles, use of condensed tanning containing forages, nematode-trapping fungi, vaccines, etc., with varying degree of success.

Nutritional management is an important part of an integrated management approach for parasite control because the ability of the host animal to tolerate increasing parasite infection depends on the nutritional status of the animals. Generally, well-fed animals are able to defend themselves better. The reduced feed intake is the first response when parasites or diseases overpower the host animal’s ability to function. When feed intake is reduced, animals utilize their reserves to meet the nutritional demand. Animals infected with gastrointestinal worms have damaged mucosal membranes thereby reducing the ability to absorb nutrients, thus, animals become less productive.

Animals require energy, protein (amino acids), fatty acids, fat soluble vitamins (A, D, E, K), water soluble vitamins (B-vitamins) and vitamin C, macro minerals, and trace elements for optimum health and growth. When availability of any of these nutrients is limited, animal productivity does down including depressed immunity. The

immune system is the line of defense against disease or parasite infections but it is very complex so it is extremely difficult to assess the effects of diet on immune function. However, research results have identified some dietary factors that affect the animal immune response.

What is the Relationship between Nutrition and Immune System?

Animals prioritize immune system for nutrients over growth. As a result, these nutrients devoted to the immune system are not available for growth and improving feed efficiency. Ideally, the immune response should be short with the lowest intensity while successfully eliminating the pathogen. An extreme immune response not only wastes resources but may cause local cell damage and depress productivity.

When animals become sick or are infected with parasites, often the dry matter intake rates go down. Providing key nutrients can reduce stress-induced weight loss and immunosuppression, improve weight gain and reduce morbidity and mortality. Nutrients enhance or depress immune function depending on the nutrient and level of its intake. Several nutrients play significant roles in the maintenance of healthy immune system.

Energy: Energy intake seems to have an important influence on immune activity.

Stressed animals undergo an altered eating pattern and have reduced ability to utilize certain feeds and nutrients because of changes in rumen function. To alleviate this problem, often the energy density of the diet is increased with supplemental fat when feed intake declines. But the use of fat as the energy source of choice in such instances may not be the best decision. Carbohydrate calories may be the best choice since immunological stress is known to impair triglyceride clearance from the blood, thus decreasing fat use (Butcher and Miles 2009).

Protein: Several studies with domestic animals have shown that when a diet is deficient in protein or amino acids, the concentration of circulating antibodies to a specific challenge organism is low because proteins must be synthesized for the immune response and repair of cell and tissue damage. When dietary supplementation of proteins are inadequate, body proteins are broken down to provide energy and amino acids for the immune system.

Vitamins A and D: Vitamin A plays roles in infection and maintenance of mucosal surfaces that are important in regulating immunity. Vitamin A deficiency reduces resistance to all types of disease, including parasites. Vitamin D is required to activate immune defense especially the killer cells of the immune system. The T-cells are unable to react to and fight off serious infections if vitamin D is deficient.

Antioxidants: They protect immune cells and surrounding tissue from damage. The antioxidant status of the animal is determined by the amount of antioxidant nutrients in the diet. The key nutrients that include dietary antioxidants are carotenes, vitamin E, and vitamin A, and trace minerals such as selenium, zinc, copper, and manganese which are used to synthesize antioxidant enzymes. Antioxidants are particularly important for the effectiveness of phagocytes, which are the front line of defense against invading pathogens. If phagocytes are deficient in antioxidants, they cannot effectively kill invading microorganism.

Vitamin E: It is currently the most important antioxidant for growth and increased resistance to stress and disease. According to Secrist et al. (1997), supplementation with vitamin E improves growth, feed efficiency and morbidity of feedlot cattle. Whether or not an economic benefit is achieved by supplementation is difficult to predict because there are many additional factors which affect economic efficiency.

Table 1. Effect of Supplemental Dietary Vitamin E on Morbidity and Performance of Transport-Stressed Calves (weighted means from 5 trials; Secrist et al. 1997).

Item	Control	Vitamin E ¹
Daily gain, kg	0.8	0.92
Dry matter intake, kg	7.48	7.49
Feed/gain ratio	12.42	9
Morbidity	55.1	47.9

¹Vitamin E levels were 400 to 1,000 IU/head/day.

Magnesium and phosphorus: These are the most important macro minerals associated with the immune response. Although there is a lack of goat and cattle data, their supplementation levels have influenced mortality in other animal species.

Trace mineral supplementation: Several micronutrients such as copper, zinc, manganese and selenium are required for the production of antioxidant enzymes. Studies have shown that the bovine phagocytes are unable to kill invading microorganisms if copper and selenium are deficient in the diets. Similarly, supplementation with zinc or with high levels of trace minerals has improved recovery from respiratory disease in several studies. Zinc is especially important in wound healing, thymic function, and proliferation of lymphocytes.

Copper-containing ceruloplasmin has been reported as a protective antioxidant and is a necessary component of the acute phase response. A copper deficiency reduces the amount of ceruloplasmin which is released during an inflammatory stress (DeSilvestro and Marten 1990).

When animals are fighting off diseases or parasitic infections, iron is removed from the circulation and sequestered into compartments which are nutritionally unavailable to bacteria and parasites. According to Weinberg (1974), this process of iron sequestering is called “nutritional immunity.” However, if the iron lost from circulation is replenished by injections or very high dietary supplementation, increase in mortality and morbidity will occur in a variety of diseases (Beisel 1977).

Manganese serves as a cofactor of superoxide dismutase and alleviates damage induced by the immune response itself. There is, however, very little change in the circulating manganese levels in the plasma during stress (Klasing et al. 1991).

B-vitamins and vitamin C: *Adequately fed ruminants do not need dietary supplementation of the most B-vitamins and vitamin C* because they are supplied by microbial synthesis in the rumen, rather than the diet. The combination of stress and low intake can result in low availability of B-vitamins and vitamin C which may affect rumen microbes and/or the animal itself.

Summary and Conclusions

Reduced feed intake is the foremost nutritional problem for highly stressed animals. Therefore, efforts must be made to ensure enough feed intake by animals so that it can stop breaking down its own tissues for fuel and begin to eliminate nutrient deficits. Under stressed situations, the central nervous system still requires blood glucose and red blood cells for maintenance by the infected animals which they supply by breaking down their body proteins in liver, kidney, intestine, and skeletal tissue to provide glucose precursors. Similarly, when animals are deficient in energy, body fat is broken down to provide fatty acids, the primary energy source for most other tissues. Over production of these fatty acids lead to production of ketone bodies, primarily β -hydroxybutyric acid and acetoacetic acid, this can cause metabolic acidosis.

When animals are fed adequately, they can tolerate increasing parasitic infection levels, but eventually a point will be reached, depending on the worms and the conditions involved, where parasites overwhelm the animals' ability to function properly. Parasite infected animals lose their ability to utilize nutrients efficiently. Managing goats on a proper nutritional status will allow the goats to express its full genetic potential for growth, feed conversion and mount a successful immune response. Therefore, the interrelationship between nutrition and immunity must be kept in mind, and goats must be supplied with sufficient amounts of essential nutrients for maintaining a strong immune system to minimize the loss from parasites and diseases.

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FAMACHA AND SMART DRENCHING FOR MANAGING BARBER POLE WORM

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Barber Pole Worm

Barber pole worm (*Haemonchus contortus*) is the number one problem to goat producers in the Southeast. This worm causes most of the low performance and death of goats under pasture-based production system. This worm inhabits the abomasum (the true stomach of ruminants) and sucks blood causing anemia and low blood protein. Anemia can be monitored by checking mucus membrane of eye. When there are numerous worms in the abomasum of goats (acute cases), severe anemia will develop within a very short time and animal may die without showing other symptoms of parasite infection. In acute cases, anemia becomes apparent about two weeks after infection. In less severe infection, it will take some time for the development of anemia. But animal performance will decrease day by day until the problem is corrected. Each worm removes about 0.05 ml blood per day by ingestion and seepage from the lesions. So, a goat with 5,000 barber pole worm may lose about 250 ml blood daily.

Why Barber Pole Worm is a Big Problem in the Southeast?

- These worms have a very short life cycle. Within about three weeks of infection, a female worm starts producing eggs, which come out in the feces and contaminate the environment.
- Females are very prolific meaning that they produce thousands of eggs on a single day. One adult female can produce around 5,000 eggs per day.
- Worms suck lot of blood and cause anemia, from which animals may die or debilitate.
- Warm and wet climate in the Southeast provides conducive environment for the survival and development of parasite eggs and larva. Wet environment also promotes parasite larvae movement onto the tip of forage plants. This movement facilitates parasite infection to the grazing animals.
- Worms mostly attack young, weak, pregnant, and lactating animals because these animals are less resistant and less resilient to the parasite infection.
- Goats evolved in dry climates, so they have not developed mechanism to fight against the problems that are prevalent in humid climates.
- Goats do not develop resistance against this worm even after numerous exposures.
- Worms are developing resistance to most chemical dewormers available in the market.
- Integrated parasite management strategies are not in common practice.
- Many producers are still depending on the traditional approach of parasite treatment.

Traditional Approach for Parasite Management and Necessary Improvement

- Treat the entire herd – **This is a wrong** practice. It eliminates the ‘Refugia’ (worm population susceptible to the drugs that are used to treat the goat herd) and accelerates resistant development in worm population against dewormers (Figure 4.1). It will also waste money because only around 30 percent of the goat herd harbors around 80 percent of the worm population. Therefore, treating the 30 percent of the goat herd that is harboring 80 percent of the worm population will be enough to manage parasite. This treatment strategy will also provide ‘refugia’.
- De-worm by the calendar – **This is wrong**. Goats should be de-wormed when it is needed based on the evidence and severity of infection. Evidence can be gathered by monitoring anemic condition (using FAMACHA card) and assessing parasite egg numbers in fecal samples.
- Rotate dewormers regularly – **This is wrong**. Dewormers should be rotated only when there is an evidence of parasite resistant to the dewormers. Parasite resistance to a dewormer can be monitored by analyzing fecal samples and counting parasite eggs before using a dewormer and two weeks or so after using the dewormer. When to do the after-dewormer-use fecal examination varies depending on which dewormer has been used: levamisole, 3-7 days, benzimidazoles, 8-10 days, and ivermectins, 14-18 days. This test is called fecal egg count reduction test (FECRT). Fecal egg count reduction less than 90 percent after using dewormer is an indication of parasite resistance. In this situation, producers need to switch to another class of dewormer. Another option is to find out dewormer resistance through larval development assay (DrechRite) presently being conducted by Dr. Ray M. Kaplan and his co-workers at The University of Georgia. But this test is expensive. Interested producers can contact the lab (phone: 706-542-0742; email: showell@vet.uga.edu) for further information and service detail.

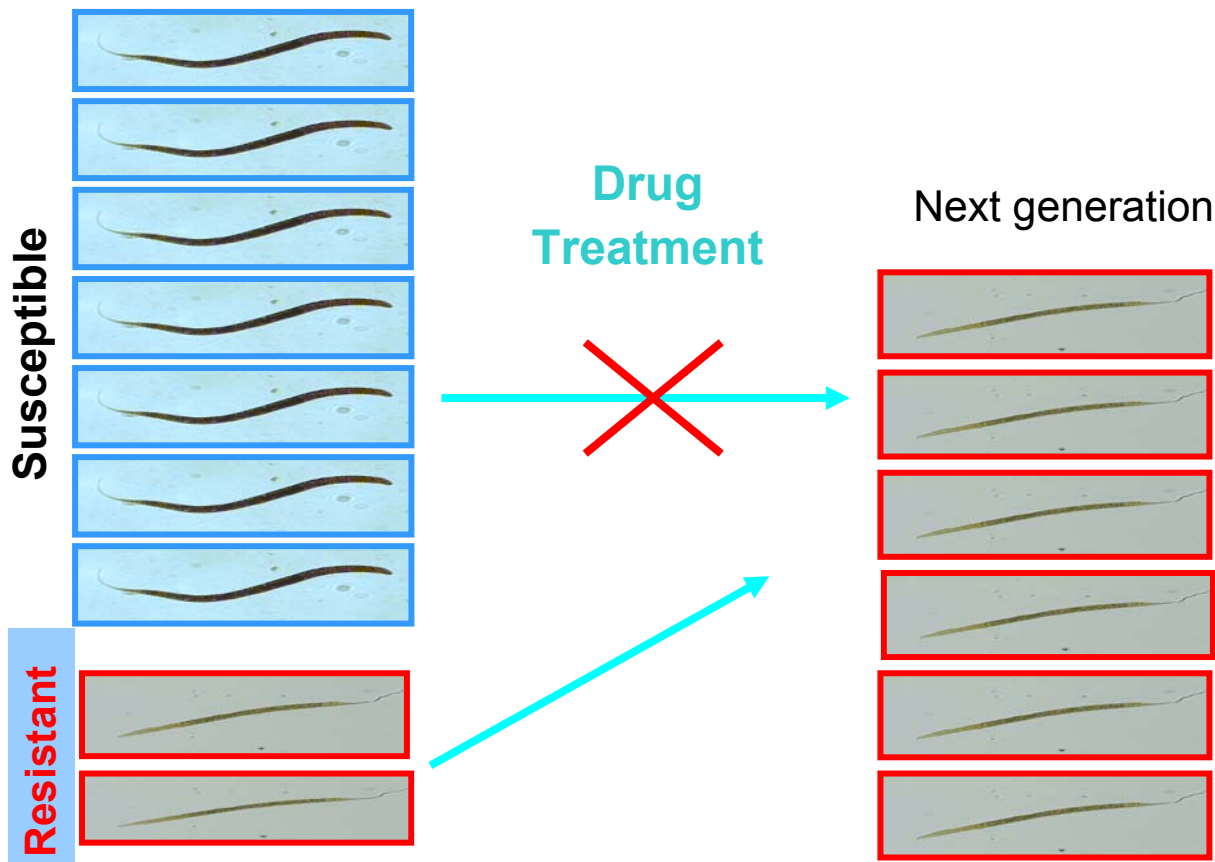


Figure 4.1. Resistant worms get chance to reproduce and produce numerous resistant worms in the next generation.
Source: SCSRPC, 2004.

Note: When whole herd is treated, susceptible worms will be killed and only a few worms that are resistant to the dewormer used will survive. In the next generation, resistant worms will multiply, which will continue generation after generation resulting in whole worm population being resistant to the dewormer being used.

- One Pasture – If there is only one pasture, de-wormed goats will be reinfected from the existing larvae in the pasture. When there are multiple pastures, moving recently de-wormed goats to a fresh pasture will prevent immediate re-infection. Similarly, weaned kids can be put in a fresh pasture and minimize the parasite problem.
- Overcrowding/overgrazing – It worsens the situation. Overcrowding/overgrazing increases the parasite (egg and larvae) density in the pasture as each infected goat adds parasite egg into the pasture. It will also force goats to graze lower than five inches of pasture stubble thereby exposing them to more parasite infection. Overcrowding also increases stress and minimizes the forage availability; both of these situations promote susceptibility of goats to parasites.
- If multiple pastures, de-worm and move animals to new pasture – Moving goats to a fresh pasture immediately after administering dewormers will contaminate the fresh pasture also. It is because infected goats will still be passing out parasite eggs (already produced) for few days after treatment. It is necessary to keep goats in a holding area for 48-72 hours after treatment and before they are moved to the fresh pasture.
- Unknowingly purchasing resistant worms – While purchasing breeding animals, one must make sure that the animals are not introducing resistant worms into the herd. For this, producers need to follow few things:
 - Only buy animals from trusted sources that are properly managing the parasite problem.
 - Quarantine the animals, test and treat for parasite, and test for parasite resistance.
 - Introduce the new animals to the herd only when there is evidence that newly brought animals are healthy and do not contribute to the parasite problem in the herd.

Use of FAMACHA to Identify Goats That Require Deworming

FAMACHA is a card containing five color categories to monitor the anemic condition in small ruminants (Figure 4.2). This card is named after the scientist who invented it - **Fafa Malan's Chart** – FaMaCha. This card has five color categories serially placed from 1 to 5, with 1 designated for no anemic and 5 for severely anemic conditions. Color categories 1 and 2 are considered normal meaning that animals in these categories do not require deworming. Animals under categories 4 and 5 require deworming. Whether to deworm animals in category 3 depends on different situations.

When to treat animals in Category 3?

Treat animals in category 3 if

- More than 10 percent of herd scores in categories 4 or 5
- Young kids are in # 3
- Pregnant or lactating does score #3
- # 3 goats are in poor body conditions, and
- There are concerns about goats' general health and well being that score #3



Figure 4.2: FAMACHA Card.

Source: SCSRPC, 2004.

How to Use the FAMACHA Card?

Eye color can be matched to the color categories of FAMACHA card as illustrated in Figures 4.3 and 4.4.

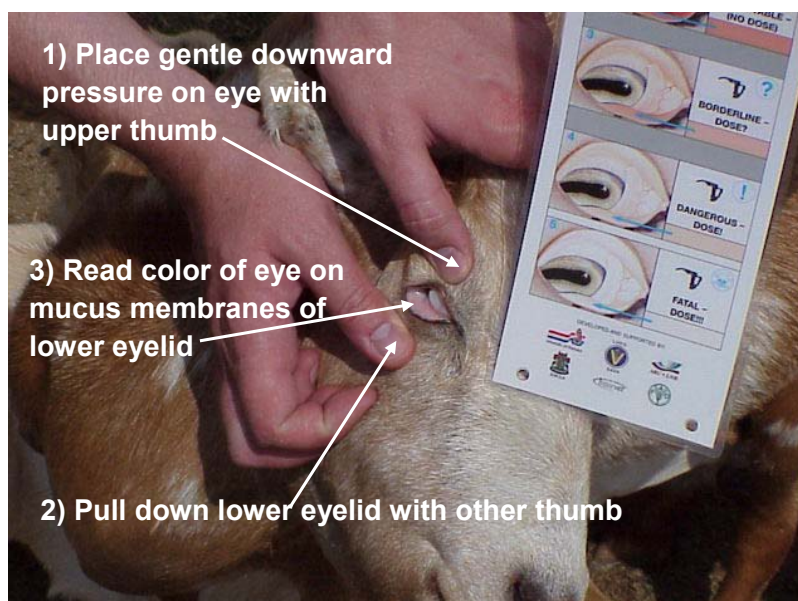


Figure 4.3: Method of Examining Mucus Membrane of Goat Eye to Monitor Anemia.

Source: SCSRPC, 2004.

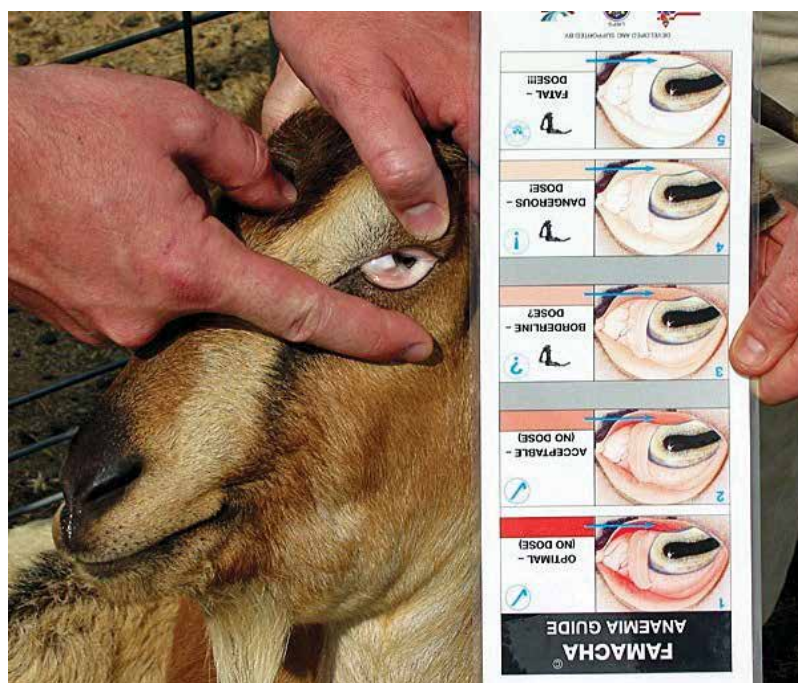


Figure 4.4: Use of FAMACHA Card to Match Eye Color of a Goat.

Source: SCSRPC, 2004.

FAMACHA AND SMART DRENCHING FOR MANAGING BARBER POLE WORM

FAMACHA card should be used in bright sunlight, and color of both eyes should be read. If color of two eyes does not match, one should score the higher category. Reading should be taken very quickly. Once read, it should be recorded on the record form that comes with the FAMACHA package (Figure 4.5). As mentioned earlier, animals in categories that require treatment should be dewormed and recorded. When reading is finished, FAMACHA card should be placed in a light-protected place. Reading should be taken every week during the peak season and every 2-3 weeks during non-peak seasons. The card should be replaced with a new card after 12 months.

FAMACHA ANEMIA RECORD

Group ID: _____

						Totals				
Category	1	2	3	4	5	1	2	3	4	5
Date: 5/1 Treatment:						15	27	12	1	0
Date: 5/15 Treatment:						5	22	20	8	0
Date: 6/1 Treatment:						0	18	25	11	1
Date: Treatment:										
Date: Treatment:										

● Counted

✓ Counted and Treated

✗ Bottle Jaw - Treated

Ray M. Kaplan, DVM, PhD

FAMACHA Anemia Record

5/30/03

Figure 4.5: Record Keeping Form for FAMACHA Reading and Deworming.

Source: SCSRPC, 2004.

Precaution with the FAMACHA Technique

- This technique is developed only for barber pole worm infection, so it is not appropriate to monitor the infection with other worms.

- Anemic condition can also be developed from parasites other than the barber pole worm, diseases, and nutritional causes. So, producers need to rule out other possibilities of anemia before treating for barber pole worm. The following are of some the conditions that can cause anemia:
 - Hookworm – not common in the U.S.;
 - Liver fluke – most likely in Gulf Coast and Northwestern States;
 - External parasites;
 - Blood parasites – not common in the U.S.;
 - Bacterial and viral diseases; and
 - Nutritional deficiencies.
- Some conditions as listed below can mask the anemic condition:
 - Hot and/or dusty condition that cause eye irritation;
 - Transportation of animals for a long time without proper rest afterwards;
 - Fever;
 - Eye infections;
 - Any diseases associated with circulatory failure, and
 - Eye injury.

Smart Drenching to Minimize Barber-Pole-Worm Problem

Smart drenching involves various strategies to minimize the worm problem as listed below.

- **Know the Resistance Status of the Herd/Flock:** As already mentioned, resistance status can be assessed by fecal egg count reduction test (FECRT) or larval development assay (DrechRite). Based on test results, ineffective dewormers should be replaced with effective dewormers.
- **Sound Pasture Management:** Pasture should be properly managed to minimize parasite problem. This has been discussed already under Pasture and Grazing Management for Parasite Control.
- **Keep Resistant Worms off the Farm:** Do not buy or bring any animals that have resistant worm.
- **Administer the Proper Dose:** Under-dosing promotes parasite resistance. Dose is normally based on animal's weight and the type of target parasite (Table 4.1). Therefore, it is of utmost importance to find out the body weight of animals and the target parasite. Meat goat should be weighed before administering dewormer and dosed as necessary. Body weight of meat goats is underestimated if tape method is used. Parasite type can be found out by doing fecal examination. If benzimidazoles are used, then it is suggested to repeat the dose in 12 hours to increase the efficacy.
- **Know Host Physiology:** Dewormers work better when they can stay in animals' body for a long time. For this, it is suggested to fast animals (only withhold food, but not water) for 24 hours before benzimidazoles are administered. When animals are fasted and dewormed, dewormers have longer time to remain in the gastrointestinal track than when animals are fed normally. Also, animals in late pregnancy pass out gastrointestinal contents much faster than dry animals or those in early pregnancy. So, efficacy of dewormers will be lowered if administered to animals at late pregnancy.
- **Selective Treatment:** As already mentioned, it is not wise to treat the whole herd. Since the barber pole worm causes anemia, the anemic condition of goats can be monitored using FAMACHA card and treat only those which are in categories that need treatment.

FAMACHA AND SMART DRENCHING FOR MANAGING BARBER POLE WORM

Table 4.1. Common Drugs to Treat Major Internal Parasites of Goats.

Parasite class	Drug* dose and route	Precaution	Remarks
Roundworms	<u>Benzimidazoles</u> Albendazole, Febantel, Fenbendazole, Oxfendazole: 7.5-10mg/kg orally Mebendazole 22.5mg/kg orally <u>Levamisole</u> : 12mg/kg orally <u>Avermectins</u> Ivermectin, Moxidectin (Cydectin) 0.4 mg/kg orally	Do not use albendazole in the first 3 weeks of pregnancy -Do not overdose, it is toxic -Do not use injectable preparations -Do not use during the last 3 weeks of pregnancy or in debilitated animals	Withhold food for 24 hours before treatment Repeat the treatment within 12 hours
Tapeworms	Albendazole 10-15mg/kg Fenbendazole 20-25mg/kg Praziquantel 10-15mg/kg (Route: All orally)		
Liver fluke	Albendazole 15-20mg/kg orally Clorsulon 7mg/kg orally		In the southern U.S., infected animals should be treated in the late summer or early fall
Coccidia	<u>For treatment</u> Trimethoprim sulfa 15mg/kg orally – once a day for five days Decoquinate 0.5mg/kg daily for 5-7 days <u>For prevention</u> Monensis 10-30 g per ton of feed		All animals in herd should be treated when there is an outbreak. Preventive dose should be used only when there are stressful situations (transportation, weaning, parturition). Unnecessary use develop parasite resistance

*For each drug, one must follow the withdrawal time labeled on the package of drug for meat and milk consumption and sale.
 Source: Matthews 2009, Plumb 2008, Pugh 2002.

Summary and Conclusions

- The barber pole worm is the number one problem in goats in Alabama and other states in the Southeast. This worm sucks blood and causes anemia.
- FAMACHA is an eye-color chart containing five color categories, and is developed to monitor anemic condition in small ruminants caused by barber pole worm.
- Smart drenching program involves various strategies to identify heavily infected animals and effective dewormers, and to administer appropriate dose in a proper manner only to those animals. This program also includes various ways to minimize parasite infection.
- The problem of barber pole worm can be managed by following the integrated parasite management program including the use of FAMACHA and smart drenching.

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ANTHELMINTIC RESISTANCE AND NOVEL APPROACHES OF PARASITE CONTROL IN SHEEP AND GOATS

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Introduction

Anthelmintic (dewormer) resistance in gastrointestinal parasites is a rapidly emerging health problem in small ruminants (sheep and goats). This phenomenon has led to an increasing number of anthelmintic treatment failures, ultimately resulting in increased morbidity and mortality in susceptible animals. In particular, the trichostrongyle parasites *Haemonchus contortus* and *Trichostrongylus colubriformis* are especially capable of rapidly acquiring resistance to anthelmintics. These parasites are common inhabitants of small ruminants in the southeastern United States. However, life-threatening haemonchosis has been reported in many Northern States and Canada, indicating that these parasites are not as geographically restricted as once believed.

Anthelmintic resistant parasites are now the rule instead of the exception. Dealing with these parasites requires good animal husbandry as well as clever strategies that take advantage of the parasite's biology. These strategies coupled with “novel” techniques for parasite management are necessary for the small ruminant farmer to survive in the era of anthelmintic resistance.

Anthelmintic Resistance

Anthelmintic resistance is defined as the ability of certain worms in a population to survive drug treatments that are generally effective against the same worm species and stage of infection. Resistance is caused by changes in the “resistant” genes carried by the worms in a population. The changes in the resistant genes occurs as the result of drug treatment producing genetic selection of resistant worms in a population – when you treat an animal with an anthelmintic, you are culling the susceptible worms. Over time and repeated culling, you produce a worm population that is resistant to that dewormer.

The emergence of multi-anthelmintic resistant *Haemonchus contortus* is currently one of the major health issues in small ruminants living in endemic areas. A recent report on anthelmintic resistance patterns on 45 sheep and goat farms in the southeastern United States indicated that *Haemonchus contortus* isolates were resistant to benzimidazoles, levamisole, and ivermectin on 98%, 54%, and 24% of the farms, respectively (Howell et al. 2008). Resistance to all three anthelmintics (hence, all 3 major anthelmintic classes) was evident on 48% of the farms. Total anthelmintic failure (i.e., resistance to benzimidazoles, levamisole, ivermectin, and moxidectin) was identified in *H. contortus* isolates from 17% of the small ruminant farms.

Haemonchus contortus is a virulent, blood feeding nematode that damages the abomasum and abomasal mucosa in sheep and goats. Heavy infections cause profound anemia, hypoproteinemia, loss of fecal consistency, and weight loss. Severely affected animals die from exsanguinations (blood loss). Periparturient females, kids in their first grazing season, and animals debilitated from another disease are most at risk. Mandibular edema (“bottlejaw”) is often observed in severe small ruminant cases, but is not a common feature of haemonchosis. A recent study conducted on Southeastern sheep and goat farms demonstrated that *Haemonchus contortus* is the most common nematode parasite

in small ruminant fecal cultures. *Trichostrongylus colubriformis* was the second most common isolate. This nematode is less virulent than *H. contortus*, and causes morbidity primarily through irritation of the small intestinal mucosa. In contrast to *H. contortus*, *T. colubriformis* infections are not associated with anemia.

Ivermectin resistance sets the stage for moxidectin resistance due to the molecular similarities between the two drugs. Resistance to moxidectin rapidly develops in ivermectin resistant *H. contortus* populations when it is used non-selectively in small ruminant herds (Kaplan et al. 2007). Recently, sequential larval developmental assays conducted over a two- year period on several farms in the southeastern United States documented conversion of the resident *H. contortus* population from moxidectin-sensitive to moxidectin-resistant (Williamson unpublished data). Whether the change in anthelmintic sensitivity arose from introduction of resistant *H. contortus* through new additions, or through the extreme selection pressure imposed by whole herd moxidectin treatment, is speculative at this point. However, these examples highlight why biosecurity and selective use of anthelmintics are crucial elements to a sustainable parasite control plan.

Selective Treatment

Selective treatment of only the animals in need of treatment exploits the natural distribution of parasites across a herd or flock is an important concept that can be used to the producers' advantage. In healthy sheep and goat herds, 20 to 30% of the animals harbour 80% of the gastrointestinal parasites. This "over dispersion" of parasites among hosts justifies selective rather than whole-herd anthelmintic treatment. The untreated animals in the herd provide minimal pasture contamination, but are a major source of refugia (worms that are not under selection pressure from exposure to an anthelmintic). Refugia plays an important role in how quickly a given worm population will become resistant to an anthelmintic. Without refugia, only resistant worms are left to reproduce with each other, which rapidly amplify resistant genes in the worm population. Accurate identification of animals that require anthelmintic treatment to maintain health and productivity is the cornerstone of the selective treatment paradigm. Low-level parasitism is well tolerated by healthy hosts, and it stimulates natural immunity. Further, total elimination of parasites from grazing animals is an impractical and unsustainable goal.

Discriminating between animals that need anthelmintic treatment and those that do not takes a combination of hands-on husbandry and fecal examinations. This approach is more labor-intensive than traditional calendar-based "whole herd" programs, because owners have to handle their animals on regular intervals, and maintain records. Body condition score (BCS) is a useful parameter to monitor in small ruminant herds. Generally speaking, the healthy-appearing, active animals that have optimal to high body condition scores are the least likely to be harbouring health-threatening worm burdens. The BCS is also influenced by increased energy demands, nutritional status, and presence of other diseases, but it is a good barometer of overall health. In particular, a declining body condition score in the absence of dietary changes or normal physiologic changes such as lactation warrants closer evaluation of the animal, including a fecal egg count. Body condition scoring subjectively grades the amount of subcutaneous body fat over bony protuberances, and categorizes them on a scale of 1 to 5, with 1 being emaciated and 5 being obese (Van Saun 2009). Half scores can be assigned to animals that score in the middle between two scores. A body condition score of 3 out of 5 is considered ideal although some healthy individuals naturally maintain condition at a slightly higher or lower score. Small ruminants should be palpated from the withers to the loin, and in the brisket area to determine the score. It is important to notice changes in body condition scores among individuals and the overall herd, especially if the scores are declining. Increased parasitism and inadequate nutrition are common reasons for decline in body condition scores in multiple animals in a herd.



Goats' access to free-choice mineral mix is necessary to keep them healthy and minimize the internal parasite problem.

Another criterion of evaluating animals for selective treatment is by monitoring anemic status with FAMACHA card. Since anemia is a prominent feature of haemonchosis, pallor of the conjunctiva and mucous membranes is an excellent indicator of the severity of *H. contortus* infections. This association was used by Dr. Francois (“Fafa”) Malan to develop the FAMACHA system in sheep and goat production systems in Africa (Malan et al. 2001). The FAMACHA score is highly correlated with the packed cell

volume and the fecal egg count in small ruminants and camelids with haemonchosis. The FAMACHA system was recently validated for small ruminants in the United States in 2004 (Kaplan et al. 2004) and camelids (Williamson et al. 2009). More information about FAMACHA and its use has been presented earlier (Page 23-30) in this proceedings.

The other criterion of evaluating animals for necessary treatment is by assessing quantity of parasite eggs present in animal feces. Quantitative fecal egg counts are extremely useful for determining the kind of internal parasites present in the herd and assessing the severity of infection. In particular, *H. contortus* and *T. colubriformis* are consistently high egg shedders, so the quantitative count is a good indicator of the magnitude of infection. In contrast, *Nematodirus* spp., *Trichuris* spp., and *Monezia* spp. shed oocytes intermittently, and often at low levels. Consequently, oocyte counts do not necessarily correlate as well with severity of infection. Many coccidian parasite loads are also difficult to assess based solely on the oocyst count.

Several excellent methods for fecal egg quantitation include the McMasters fecal egg count and the modified Stolls egg count. These methods differ in their sensitivity end points as well as the likelihood of detecting certain types of parasites. For instance, the McMaster’s fecal egg count is an easy, rapid, and accurate way to quantitate oocytes. Centrifugation techniques such as the modified Stolls test offer some advantages when detecting *Trichuris* spp., *Nematodirus* spp. oocytes and large coccidian oocysts, but offer no advantage when quantitating trichostrongyle oocytes. *T. colubriformis* and *H. contortus* oocysts look identical, and are reported as “trichostrongyles” by many laboratories. They are differentiated by using a peanut lectin stain, or by identification of larvae on coproculture.

The fecal egg count (FEC) provides extremely useful information with regards to the severity of the trichostrongyle burden, but this parameter should not be used as a sole indicator of whether or not to administer an anthelmintic. However, in the author’s experience, FECs less than 900 eggs per gram trichostrongyles were generally not associated with anemia or ill thrift in most healthy immunocompetent adult llamas and alpacas, where *H. contortus* was the predominant trichostrongyle. If the animal is showing signs of haemonchosis although the fecal egg count is low, treatment with an effective anthelmintic should not be delayed. Prepatent *H. contortus* infections can cause serious morbidity. Further, fecal egg counts are only as accurate as the methodology used to generate them, and “set points” for when therapeutic intervention is deemed necessary will differ accordingly.

The anthelmintic sensitivity pattern of the resident *H. contortus* population should be determined every two years, or more frequently, if treatment failures are suspected. This information saves money, time, and animals. A semi-quantitative fecal egg count reduction test can be performed on the farm to test efficacy of anthelmintics. This testing is best suited to large herds. Ideally, there should be six to ten animals in each anthelmintic treatment group and the untreated control group. Animals with FAMACHA scores of 3, 4, and 5 are the best test candidates as they are most likely to be shedding sufficient oocysts. Test groups should be balanced according to FAMACHA score. Animals that is extremely pale (FAMACHA 5/5) should not be left in a control group, and should receive immediate treatment with an effective anthelmintic. Individual fecal samples are collected for quantitative fecal egg counts at 10 to 14 days after anthelmintic treatment. Fresh fecal samples should be collected from the rectum, and stored in ziplock bags. All the air should be pushed out of the bag prior to sealing, or evacuated using a Reynolds handi-vac system. This step delays larvation, as does refrigeration of the samples. Properly stored samples can remain in diagnostic condition for a week. Fecal egg counts (FEC) are performed on each individual sample, and then the mean FEC for each treatment group are determined. The mean of the treatment group is compared with the mean of the control (untreated) group using the formula: $1 \text{ minus post-treatment FEC/control FEC} \times 100 = \% \text{ reduction FEC}$. An efficacious treatment will result in a reduction of 90-100%. Varying clinical benefit will be perceived in the gray zone between 50 and 89% reduction, but treatment does not bring about much improvement by the time efficacy slips below 50%.

The second test used to determine anthelmintic efficacy is the larval developmental (DrenchRite) assay. It is currently being performed by Dr. Ray Kaplan's Laboratory in the Department of Infectious Diseases at the University of Georgia, College of Veterinary Medicine. Laboratory personnel harvest ovocytes from composite fecal samples, and place them in wells that contain varying concentrations of anthelmintics such as ivermectin, levamisole, and a benzimidazole. Moxidectin sensitivity is extrapolated from behavior of larvae in the higher concentrations of the ivermectin wells. This assay predicts sensitivity and resistance of the nematodes to these anthelmintics. The DrenchRite test is currently approximately \$450, so it is not a tool that is affordable for all production situations.

Guidelines for Anthelmintic Use

Guidelines for anthelmintic use need to be determined on a farm by farm basis – one size does not fit all in this day and age. An effective anthelmintic should be utilized on a selective basis until its efficacy has declined to the point it is no longer of clinical benefit. Rotation of anthelmintics is discouraged as this practice promotes creation of multi-resistant worms. Several classes of anthelmintics can be used simultaneously, however, to take advantage of synergistic activity.

The three classes of anthelmintics commonly used in camelids are benzimidazoles, the imidothiazole/tetrahydropyrimidines, and the macrocyclic lactones. Recently, a fourth class of anthelmintics, referred to as the amino-acetonitrile derivatives, was developed, and marketed in New Zealand as monepental (Zolvix®). It is marketed for use in sheep; efficacy against camelid nematodes has not been studied. The majority of anthelmintics available to the small ruminant farmer are labeled for sheep at best; therefore, anthelmintic usage in goats is considered “off label use”. The dosing recommendations for goats have been extrapolated from sheep. The general rule of thumb for treating goats with an anthelmintic is to dose at 2X (two times) the labeled sheep dose, with the exception of levamisole. Due to levamisole's narrow margin of safety, it should be used in goats at a maximum of 1.5X (1.5 times) the labeled sheep dose. The most potent member of the macrocyclic lactone class, moxidectin, is still efficacious against many *Haemonchus contortus* isolates in sheep and goats, but resistance has already been documented and is increasing at an alarming rate. Oral moxidectin administration is preferred over subcutaneous dosing of moxidectin.

Benzimidazoles such as fenbendazole (Panacur®, Safe-Guard®), and albendazole (Valbazen®) currently have limited efficacy against nematodes such as *H. contortus* and *T. colubriformis*. However, they are still effective against other common camelid parasites. The efficacy of the benzimidazoles is increased by withholding food for 12 hours prior to treatment because fasting slows gastrointestinal transit time thereby allowing more contact time with the medication. A unique feature of benzimidazoles is that the duration of exposure has a marked effect on efficacy. As a result, multiple day dosing increases its killing capacity. Fenbendazole is safe enough to be used for consecutive day dosing in small ruminants. However, we can take note that administering albendazole over consecutive days in camelids has fatal consequences, particularly in crias (baby camelids) (Gruntman et al. 2009). Albendazole is associated with teratogenic effects (malformation of embryo of fetus) in some species, so it is not recommended for use in small ruminants in early pregnancy (first trimester).

Levamisole usage has increased in small ruminants and camelids as safer anthelmintics have lost efficacy against *H. contortus*. Levamisole is an imidazothiazole anthelmintic that acts as a cholinergic agonist in mammals, which is why it has a narrow therapeutic index. Animals need to be weighed and dosed carefully. The oral route is safer than the injectable route. Toxicity manifests as hyper-excitability, salivation, trembling, ataxia, urination, defecation, collapse, and in extreme cases, death from respiratory failure. Atropine sulfate (0.6-1.0 mg/kg SQ) can alleviate side effects if given promptly. Levamisole has been used safely and effectively at 0.8 mg/kg orally for sheep and 12 mg/kg orally for goats to treat *H. contortus* populations sensitive to the medication. Morantel tartrate and pyrantel pamoate are tetrahydropyrimidine anthelmintics that are less potent than levamisole, but they have a wider margin of safety. Morantel tartrate appears to be more effective in ruminants than pyrantel pamoate. Morantel tartrate (Rumatel®88) is sold in an alfalfa base, which is palatable to small ruminants but less palatable to camelids. Morantel tartrate (10 mg/kg orally) has variable efficacy against levamisole sensitive *H. contortus* isolates.

As anthelmintic failure progresses, there are strategies that can be used to prolong utility of available anthelmintics. Treatment of animals with two anthelmintics from different classes can be advantageous in some instances. Synergism between the drugs can enhance the overall killing effect on parasites. This strategy is particularly useful when no or only low-level resistance is present to the anthelmintics being used. The concurrent use of albendazole and ivermectin has shown efficacy in cases where parasites exhibited resistance to both drugs. (Le Jambre et al. 2010). This strategy does not promote anthelmintic resistance. Currently, use of three anthelmintics (one from each class) simultaneously (but not mixed in same syringe) is recommended for new additions prior to introduction onto pasture with the rest of the herd.

Management Strategies to Minimize Parasite Problems

Pasture Management

One of the most common management mistakes made by producers of grazing animals is to allow the pasture to become over-populated with animals by retaining offspring or continuing to acquire new animals. When too many animals are placed on a pasture, the level of egg contamination can become so high that even animals with acquired immunity can develop clinical signs of parasitism. Young animals (< 1 year of age), pregnant and lactating animals, and animals stressed by another disease process or shipping are particularly vulnerable to parasitism because immune function is impaired, or not yet fully developed. There are stocking guidelines for most species, and the current recommendation is for 5-7 sheep or goats per acre of productive land. Co-grazing or alternate grazing with cattle or horses is beneficial,

as these species do not share internal parasites, and utilize forage differently. Co-gazing or alternate grazing with small ruminants is detrimental, since small ruminants harboring *H. contortus* and *T. colubriformis* will disperse oocysts over the entire grazing area.

Moving sheep or goats to a grazing area that has not been grazed by small ruminants for a while is a highly beneficial way to break the parasitic life cycle. Free-living larvae have a finite lifespan, and most will die off a pasture in three months under hot conditions, and within six months in cooler conditions. Movement should occur several days after the herd has been evaluated and the most parasitized herd members treated with an effective anthelmintic. The untreated animals will shed refugia so the new pasture does not become populated only by the offspring from anthelmintic resistant parasites. More information on pasture and grazing management is presented on pages 17 to 26 of these proceedings.

Do Not Buy Resistant Worms!

The most efficient way to introduce resistant worms onto a farm is through new additions from other farms. Newly acquired animals or visitors coming for breeding purposes should be quarantined to a stall or a dry lot so that feces can be removed and disposed off away from the herd. In the case of a temporary visitor, the animal should not be comingled with the herd on pasture at all. New additions will ultimately need to be integrated into the herd, but several precautions need to be taken first. A quantitative fecal egg count should be performed, and if trichostrongyles are identified, the animals should receive a combination of anthelmintics. Oral moxidectin drench, a benzimidazole such as fenbendazole or albendazole, and a membrane depolarizing anthelmintic such as morantel tartrate or levamisole should be administered. Fourteen days after treatment, the fecal egg count should be determined. If the feces are free of trichostrongyle oocysts, the animal can be integrated into the herd once the quarantine time is over.

Good Nutrition is a Key!

Research into the link between nutrition and parasite resistance in small ruminants has established how vital the intake of high quality protein is for coping with parasitism (Sykes and Coop 2001). Gastrointestinal parasitic infections are costly to their hosts because they decrease appetite, stimulate protein synthesis necessary for immune function, and compensating protein rich fluids lost in the gastrointestinal tract. Ruminants on a nutritional plane that meets or exceeds recommendations for metabolizable dietary protein are better able to withstand parasite challenge than their undernourished counterparts. Nutritional guidelines are available for both sheep and goats. When addressing parasitic problems in sheep and goats, the nutrition should be carefully scrutinized through feed and forage analyses, and inadequacies corrected by supplementation. More pieces of information on nutrition and its role on parasite control are presented on pages 19 to 22.

Copper Oxide Wire Particles

Recent research has shown promise for the use of copper oxide wire particles (COWP) to control internal parasites of sheep and goats. Studies show that COWP boluses (2g) administered orally decrease parasite loads for up to two months (Burke et al. 2004 & 2005).

Summary and Conclusions

Gastrointestinal parasites in sheep and goats are a fact of life. Also, in this day and age, anthelmintic resistance is a fact of life. Neither parasites nor anthelmintic resistance is going to go away. The key to successfully raising sheep and goats is through an integrated, “holistic” approach to parasite management. The days of the magic bullet (drugs that work) are over; however, through careful herd management, the utilization of parasite biology along with selective treatment, and the incorporation of other novel techniques, successful parasite management in your herd or flock can be achieved.

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FECAL SAMPLE COLLECTION, PROCESSING, AND EVALUATION

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Introduction

Quantitative fecal egg counts (FECs) are extremely useful for determining the severity of internal parasite infection in the herd. The FEC can also be able to help determine the effectiveness of various dewormers for a given worm population. The FEC is a laboratory procedure that can be easily performed on a farm. The only special equipment required is a simple microscope capable of 100X (100 times) magnification (10X ocular lens and 10X objective lens) and a McMaster counting chamber. Other items needed are common items from a grocery store or Walmart.

Collecting and Handling the Fecal Sample

The first step in a fecal egg count is the collection of fecal samples. The optimal way to collect a fecal sample is to obtain it directly from the rectum of the animal. Direct collection prevents contamination from free living nematodes, eliminates any ambiguity as to which animal a fecal pellet belongs too, and insures that the sample is fresh. The direct collection is performed by inserting a gloved, lubricated finger into a animal's rectum. By using a "come here" motion with the inserted finger, fecal pellets can be "rolled back" to a position where the hooked finger can extract them from the rectum. Depending on the animal's size, you will need about 10 to 12 pellets for FECs. The second best method for collecting a fecal sample is to watch your animals closely. When you see one defecating, keep your eyes on the fresh pellets on the ground as you walk over to them. Collect about 10 to 12 pellets (you only want the fresh soft and warm ones). Regardless of the method utilized for collecting the feces, immediately place the feces in an air tight container, such as a zip lock bag. Be sure to express all of the air out of the bag prior to sealing it. Write the animals name on the bag. If you are going to perform the FEC immediately, or the same day, keep the bags out of the sun, and in a cool place. Should you not be able to perform the FEC on day of collection, then the samples may be sealed in a plastic bag and placed in the refrigerator for up to one week without significant deterioration of the gastrointestinal nematode eggs.

The Fecal Egg Count

The McMaster's fecal egg count is an easy, rapid, and accurate way to determine the quantity of parasite eggs passed in the feces. The resulting egg count provides extremely useful information with regards to the severity of the trichostrongyle burden. The FEC is also a good way to monitor the effectiveness of your dewormer. Sampling an animal at the time of deworming and performing a FEC will give you the pre-treatment egg count. Sample the animal again in 10 to 14 days and perform the post treatment FEC. If your dewormer is working, the post treatment FEC should be zero, or at least significantly lower than your pre treatment FEC. If not, then either there was a dosing problem with treatment or the dewormer used for treatment is no longer effective. The procedure for performing the McMaster FEC follows.

Procedure for Performing a McMaster Fecal Egg Count (50 epg Sensitivity)

- Collect fecal samples as previously described. Samples for egg counts can be stored in refrigerator for a week in a tightly sealed baggie.

- Mix fecal sample thoroughly and break up the fecal pellets as completely as possible.
- Weigh out two grams of feces by adding it to a small beaker that was zeroed out on the digital scale. Leave the beaker on the scale. Add sodium nitrate solution (or other flotation solution) until the final weight is 30 grams.
- Mix the feces and solution thoroughly with a tongue depressor. Strain the fecal mixture through a tea strainer or cheese cloth into a second beaker. Really work to force fluid through the tea strainer or cheese cloth by pressing with (gloved) fingers. This step really contributes to getting an accurate egg count.
- Fill the two counting chambers with fecal solution (Stir solution well, then fill one chamber, then stir solution again before filling second chamber). Try not to create visible (with the naked eye) air bubbles. Place the slide under the microscope. Use 4X magnification, and focus so that any tiny air bubbles are easy to see. The eggs will float in the same plane as the tiny air bubbles. The garbage sinks to a lower focal point.
- Do your actual egg counting using the 10X objective (total magnification will be 100X because eyepiece has 10X magnification). Be systematic in how you read the slides. Start in far left chamber at the lower corner of grid. Count the number of eggs in each of the six areas on each side of the slide by following a serpentine pattern (scan up the first column, then move over to the second column, scan down the second column, then move over to the third column, scan up the third column, and so on). Count both chambers of the slide. Do not count tapeworm eggs. Count whipworm, nematodirus, and trichostrongyle eggs separately. Add the number of eggs counted on both counting chambers on the slide (for each type of egg counted), and multiply by 50 to obtain the “eggs per gram” of each type. Two egg identification charts appear at the end of this guide (Figures 6.1 and 6.2).

Note: Some inquiring minds want to know where the multiplying by 50 comes from. Each counting chamber (2 per slide) holds 0.15 ml of solution from a 30 ml dilution of 2 grams of feces, so the total volume examined is 0.3 ml, or 1/100 of total volume. We started with 2 grams of feces so we just counted the eggs from .02 grams of feces (2 grams/100). To realize eggs per gram, multiply by 50 giving our results in eggs per gram ((2 grams / 100) X 50 = 1 gram).

Slide care: After doing counts, immediately rinse McMasters slide in soapy water. Dawn dishwashing soap works well. Use clean water for the final rinse. Let slides air dry on their side. Do not let the floatation solution dry in the slides.

So what does it mean? You have properly collected your samples and carefully performed your fecal egg counts. What do you do with the number(s). *H. contortus* and *T. colubriformis* are consistent egg shedders. So the quantitative egg count is a good indicator of the magnitude of infection for these two parasites. This author chooses to use the guidelines given by David M. Pugh in his book “Goat Medicine” when utilizing a fecal egg count to determine whether to treat an animal or not. Dr. Pugh’s guidelines are as follows:

Goat Kids, FEC > 500, treat.

Pregnant and lactating does, FEC >1000, treat.

Non pregnant and non lactating does, FEC > 2000 in warm season, treat.

Bucks, FEC > 2000, treat.

Note: These are guidelines and should not be used as an absolute! If you are using FAMACHA, and under the FAMACHA guidelines an animal should be treated, then by all means treat. If an animal exhibits the clinical signs of parasitism, or if you are directed by your veterinarian, then treat.

Materials:

Compound microscope

Scale

Saturated sodium chloride (table salt)*

50 ml centrifuge tube with screw cap. Note: tube should be marked with ml increments.

Tongue depressor

Pipet (1 ml syringe or eye dropper works well)

McMasters egg counting slide**

Paper towels

A fresh fecal sample should be collected and kept refrigerated until tested

***Saturated Sodium Chloride:**

Table salt 1 pound box

Tap water 3 quarts

Heat in pan with stirring until boiling, then let cool at room temp. The solution will look cloudy and some material will precipitate - this is OK. Pour clear part of solution into a dispensing container of some kind.

Store at room temperature. Do not refrigerate as additional solute will precipitate.

Note: Fecal floatation solutions are also commercially available, but are significantly more expensive than using this recipe (although not high dollar).



Browsing helps lower the internal parasite infestation in goats.

Parasites of Cattle, Sheep, and Goats

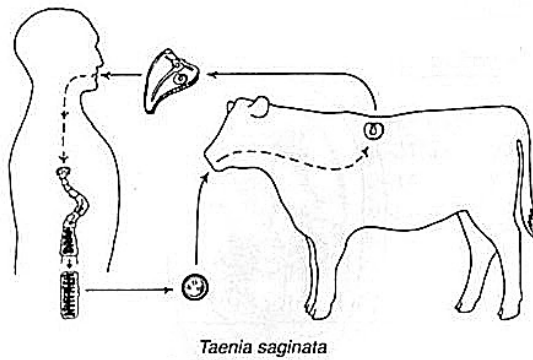


Fig. 72a. Life cycle of *Taenia saginata*.

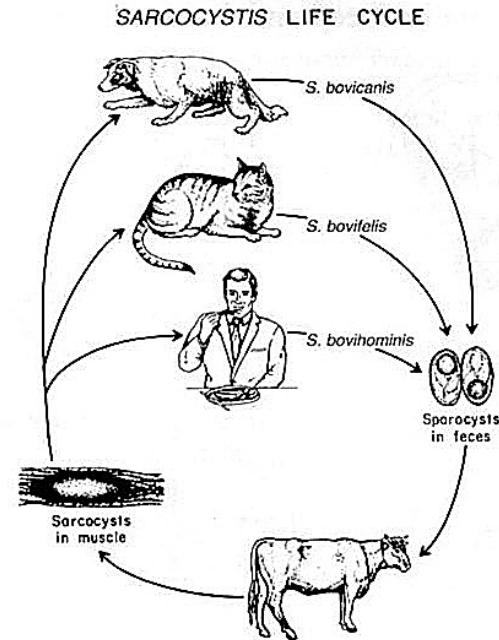


Fig. 72b. Life cycle of *Sarcocystis hominis*.
S. bovicanis is *S. cruzi*
S. bovisfelis is *S. hirsuta*
S. bovihominis is *S. hominis*

Fecal Eggs and Oocysts in Sheep and Goats

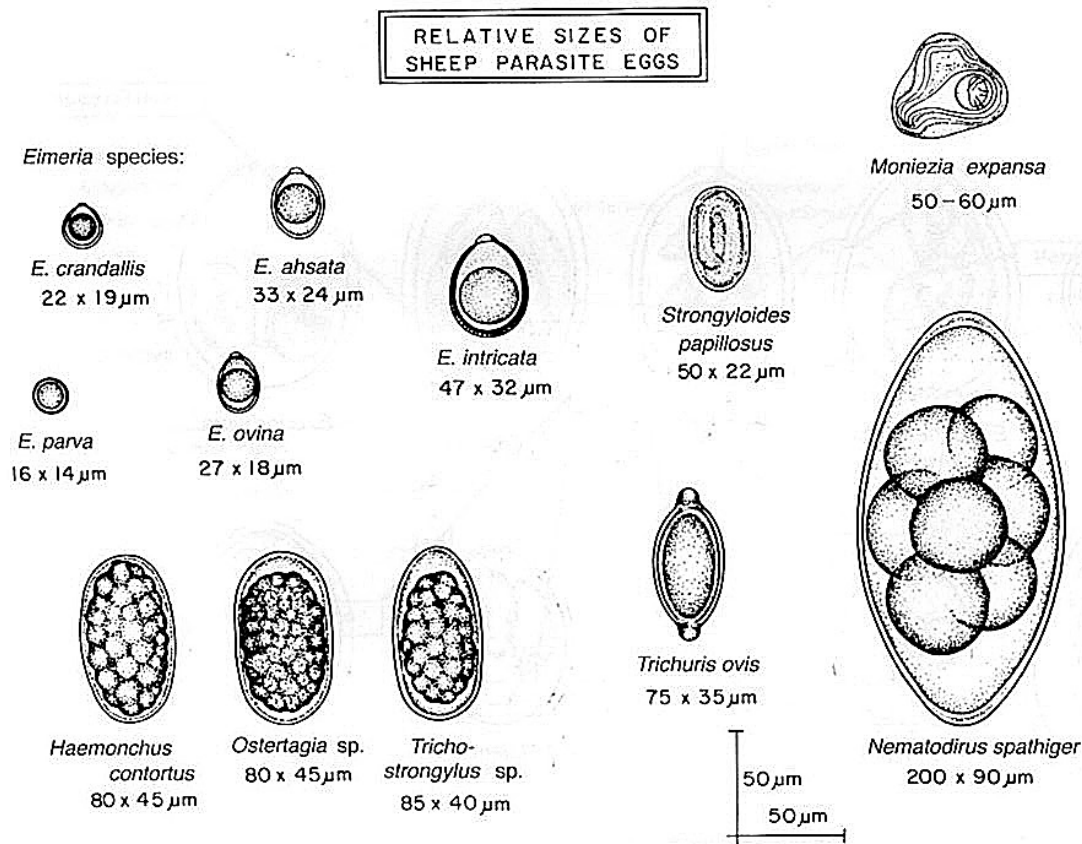
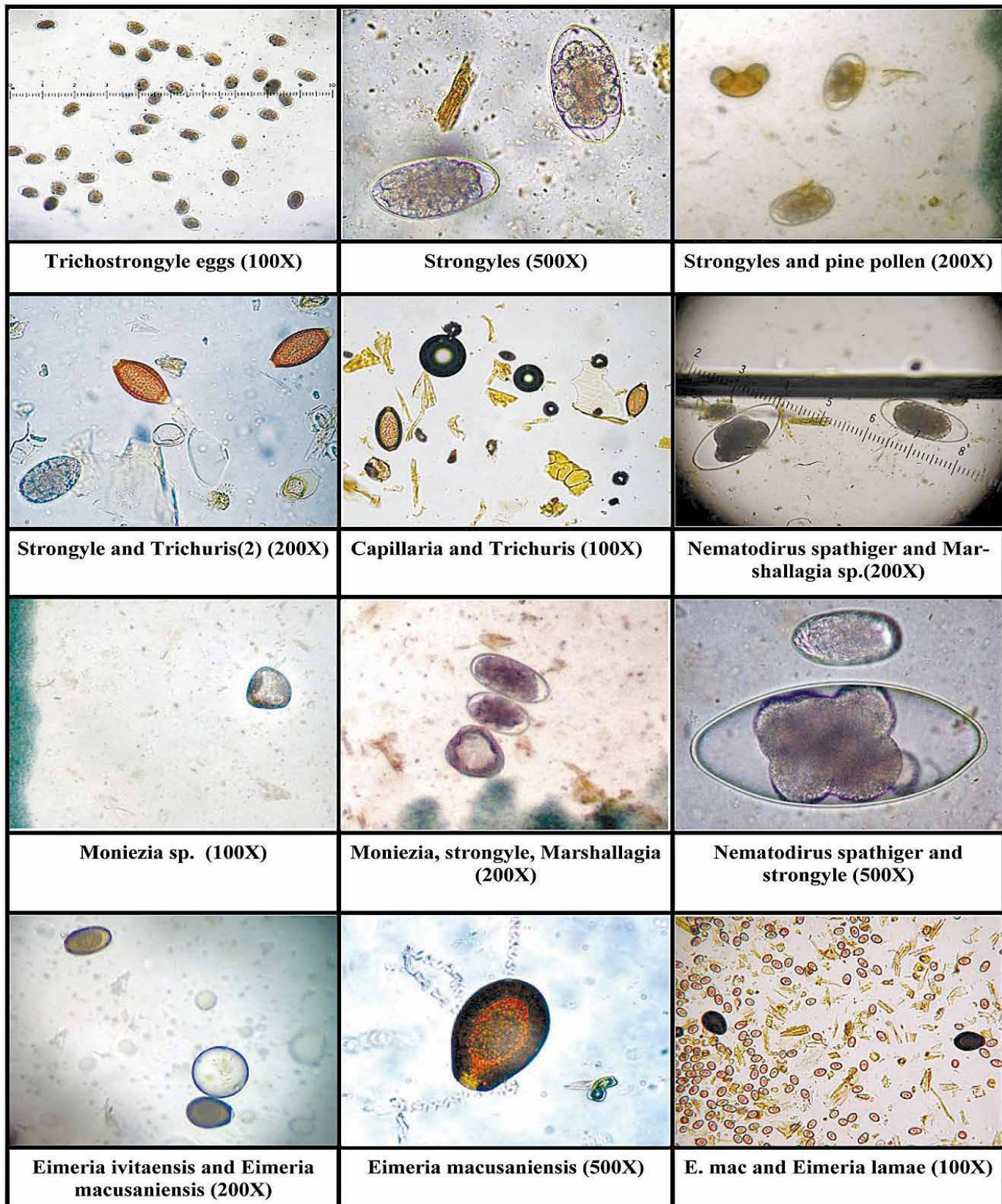


Fig. 73. Common parasite eggs and oocysts found in sheep feces.

Figure 6.1. Parasite Eggs and Oocysts from Sheep and Goats.

Source: Veterinary Parasitology Reference Manual, 5th Edition, Foreyt, 2001.

Eggs and Oocysts of Camelids and Small Ruminants



Photos by Bob Storey, Laboratory of Dr. Ray M. Kaplan, Dept. of Infectious Diseases, University of Georgia College of Veterinary Medicine ©2010

Figure 6.2. Eggs and Oocyst of Camelids and Small Ruminants.



Workshop Participants and Presenters



COOPERATIVE EXTENSION PROGRAM

College of Agriculture, Environment, and Nutrition Sciences



Workshop Coordinating Team

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April 26, 2011

Camden, AL

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