Smart Drenching and FAMACHA© Integrated Training for Sustainable Control of Gastrointestinal Nematodes in Small Ruminants

Southern Consortium for Small Ruminant Parasite Control

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SECTION 1
Small Ruminant Parasites

SECTION 2
FAMACHA© Training Module

SECTION 3

SECTION 4

Small Ruminant Parasite Control

Small Ruminant Parasites

Adapted with permission from Meat Goat Production Handbook, E (Kika) de la Garza American Institute for Goat Research, Langston University, Langston, OK

Effects on herd production

Parasitism, and gastrointestinal nematode parasitism in particular, is arguably the most serious constraint affecting small ruminant production world-wide. Economic losses are caused by decreased production, cost of prevention, cost of treatment, and the death of infected animals. It is difficult by any form of major survey or other estimation to establish precise figures on losses incurred in production from infection and disease. Even minimal accuracy of loss estimates is difficult because production diseases or disorders may result from interaction with nutritional and environmental stresses, management methods, concurrent diseases, genetic predispositions, or other factors. Periodic reports on such losses from governmental agencies and others, always range into millions of dollars per year and include all phases of production. Problems with nematode parasitism are often classified as production disease (i.e. chronic subclinical condition affecting productivity such as weight loss, reduced weight gain, reproductive inefficiency, etc.). A summary of diagnostic laboratory necropsies in Kentucky showed that worms accounted for 90% of the deaths in 428 goats submitted. Since goats and sheep share the same parasites, a recent publication of the USDA-APHIS-VS provided some data on the magnitude of the problem. Sixty-two percent of 5,174 sheep producers surveyed in the United States identified stomach/intestinal nematodes as a major concern. These losses were compounded in the southeastern region (Alabama, Arkansas, Georgia, Florida, Kentucky, Louisiana, Mississippi, Maryland, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia) of the U.S. because climatic conditions are generally more conducive to the growth and establishment of large nematode parasite populations. Seventy-five percent of 467 sheep producers surveyed in this region identified stomach/intestinal nematodes as a major concern. There is no similar data for goats, but it can be expected to be relatively the same. However, it should be noted here that is more so the case when goats are managed as grazers. When goats are managed as browsers, exposure to nematode parasites is reduced and subsequently the effects are not as severe. The nematode of particular concern is the Barber-pole worm (*Haemonchus contortus*). The tremendous egg-laying capacity of *H. contortus* is maintained by feeding on blood by both immature and mature stages. Severe blood loss can occur, resulting in anemia, loss of appetite, depression, loss of condition, and eventual death. Other worms contribute to 'production disease' as they usually do not kill, but affect the animal's ability to increase and/or maintain production (i.e. weight, reproduction, etc.).

External parasites, for the most part, are a nuisance and can cause reduced weight gain and weight loss simply because the animal spends more time and energy combating them than feeding. Physical injury occurs when irritation and scratching result in open wounds that then can become infected or subject to infestation with fly larvae.

Nutrition interaction

The effects of parasitic infection can be influenced by the nutritional status of the host. It is well known that well-fed animals can better withstand parasite infection than animals on an inadequate diet. It is also true that parasites interfere with the ability of the host to utilize nutrients efficiently. Therefore, it is important to understand this see-saw effect. The better an animal is fed the better it is able to tolerate increasing infection levels, but eventually a point may be reached, depending on the worms and conditions involved, where parasitism overwhelms the host's ability to function properly. To satisfy body demands, most nutrients are absorbed from the gut during digestion and additional nutrients are available as needed from body reserves. The term nutrient partitioning refers to the process of directing the flow of nutrients to where they are most needed at the current time. Depending on the host's age and sex, season of the year and exposure to various potential infectious (parasitic and otherwise) agents, nutrients are partitioned for growth, breeding, pregnancy, lactation, immunity, etc. The ability of the host to maintain a proper balance of this partitioning ensures that nutrients are used appropriately. For example, as gastrointestinal worm infection increases, more damage is done to the mucosa which will result in reduced absorption of nutrients, thus making the host utilize more stored body reserves. In addition, proteins are the building blocks of the host's immune system. So, as proteins are made less available, the host's immune function is compromised and it becomes more susceptible to subsequent infection. Overall, the net result of inadequate feeding, for the conditions encountered, will be loss of productivity unless the balance is restored.

Internal parasites

Gastrointestinal nematodes (worms)

Although there are a number of worms found in small ruminants, only the predominant and usually the most pathogenic ones will be discussed.

General life cycle

Before control measures can be considered, it is important to understand some aspects of the life cycle of these worms. The life cycle consists of part of their life being spent inside the animal and part of their life on the pasture (Figure 1).

Worms mate in the host and females lay eggs that pass out in the feces. The eggs hatch and develop to infective larvae while remaining in the feces. The infective larvae then move out of the feces onto the surrounding forage where they can be consumed during grazing thus completing the cycle (Figure 2). The time from ingestion of infective larvae to egg laying adults, called the prepatent period, is about three weeks and the time for development from egg to infective larvae can be as short as 7-10 days (especially during the summer months), therefore, transmission (reinfection) and continual pasture contamination can be quite rapid. During the colder months, however, larval development on pasture is delayed and may take up to a month or two to reach the infective larvae stage, thus pasture contamination and reinfection is minimized. The infective larvae have a protective sheath making them relatively resistant to adverse environmental conditions and can survive for months, thus extending transmission potential. As long as the temperature and moisture conditions remain warm and wet (especially following periods of substantial rainfall), development and survival continues and pasture contamination accumulates, but if the temperature gets too hot/cold and/or the moisture conditions become dry, development and survival are threatened and pasture contamination dissipates. Transmission of parasites can be reduced by implementing control measures to eliminate the worms from the animal (deworming) and/or reducing the chances that infective larvae have to reinfect the animal(management). Depending on the worm species, the time of the year that is most favorable for transmission varies. This will be addressed below.

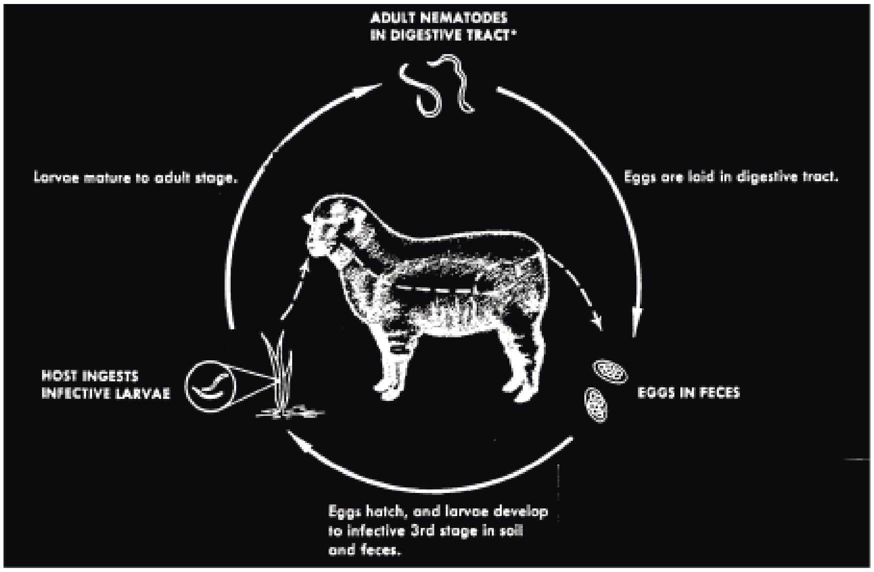


Figure 1. Typical nematode life cycle

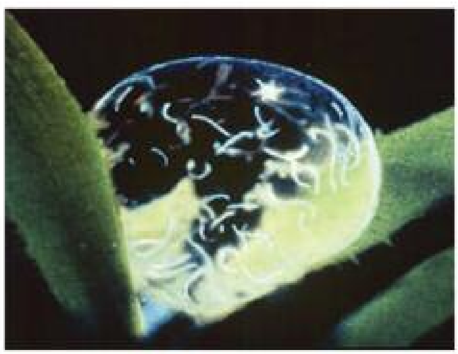


Figure 2. Infective larvae in dew drop on forage

Epizootiology

Another way to look at the life cycle is in four phases. Phase 1 is the Parasitic Phase which is the interaction between the host and the parasite. Phase 2 is the Contamination Phase which is the result of eggs that are passed in the feces during defecation. Phase 3 is the Free-Living Phase when larval stages develop and survive. Phase 4 is the Infection Phase when available infective larvae are consumed during grazing. There are a number of factors that affect what happens and influences control strategies during each of these phases (Figure 3).

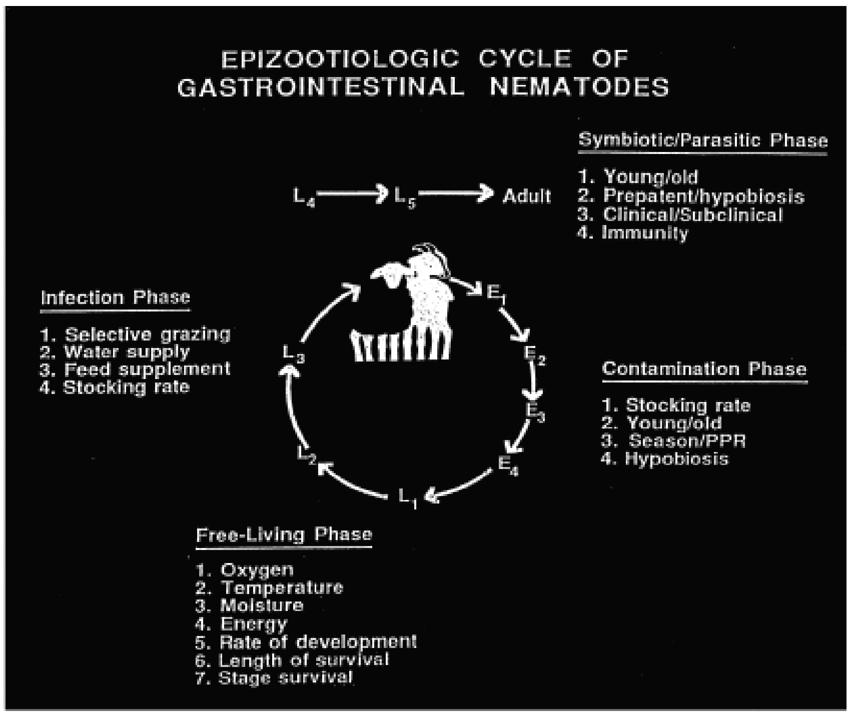


Figure 3. **Epizootiologic cycle**

Phase 1 - Parasitic Phase

During Phase 1, the parasite has to develop and survive in the host. After ingestion, infective larvae lose their protective sheath and invade the mucosa (lining) of the abomasum, small intestine or large intestine depending on what worm is involved. While in the mucosa, larvae develop to the next larval stage and then return to the surface of the gut mucosa where they become adult worms. The goats major defense mechanism against parasites is the immune system. When infectious agents enter the body, the immune system reacts through a series of activities that mobilize various components (antibodies, killer cells, etc.) that then attack and kill the invaders. These components act on the larval stages in the mucosa and the adults. How strong the immune response is depends on several factors. The immune system has to mature with age, therefore, young animals are relatively susceptible to infection and become more resistant with age. So, young animals usually harbor the heaviest infection levels and suffer the most severe consequences. Adult animals have developed stronger immunity and harbor lower infection levels. One way infection level is measured is by quantifying the number of eggs being passed in the feces. So, relatively high and low egg counts are usually seen in young and adult animals, respectively. Young animals are more subject to clinical disease where signs of infection (diarrhea, rough hair coat, anemia, weigh loss, bottle jaw, etc.) are seen. In older animals, infection usually becomes more subclinical where the only subtle sign may be reduced weight gain. However, nutrition (as mentioned above) and/or stress can alter a host's immune competence. Under poor nutrition and/or stressful conditions, the immune system loses some effectiveness and can not respond adequately. Therefore, no matter what the age of the animal, the effects of infection will become worse. The prepatent period of most worms is about 3 weeks, but this period can be extended for worms that have the capability to enter a period of delayed or arrested development called hypobiosis. This occurs during the season of the year when the environmental conditions are unfavorable for development and survival of the free-living larval stages. In warm climates, this happens either during summer or winter depending on the worm. In colder climates, all worms capable of hypobiosis will arrest in the winter.

Phase 2 - Contamination Phase

The magnitude of pasture contamination during Phase 2 is affected mainly by stocking rate (number of animals per grazing area), age of the animals, season of the year and hypobiosis. The higher/lower the stocking rate, the more/less feces are deposited on the grazing area, thus more/fewer eggs. More eggs are also passed from young vs. older animals. Most worms have a definite seasonality, so during their 'season,' more eggs are produced and passed. Of particular note in small ruminants, is a phenomena called the peri-parturient rise (PPR) in fecal egg output. This occurs at or around parturition (kidding) and extends through most of the lactation period. Because parturition and lactation are stressful conditions, the dam's immune system is compromised. Furthermore, nutrients are partitioned preferentially to support mammary and fetal development and then lactation, which also decreases the animals' ability to generate an effective immune response to worm infection. This allows the existing female worms to increase the number of eggs laid, thus increasing the number of eggs deposited in the feces. If a worm species undergoes hypobiosis, the development time to the adult stage is extended by several months. This will result in fewer adult worms over time and fewer eggs deposited in feces. However, when these hypobiotic larvae resume development, massive numbers become mature adults over a short period of time and the resultant egg production and deposition in the feces can be very high as well as having severe adverse effects on the animal.

Phase 3 - Free Living Phase

Development and survival of the free-living stages during Phase 3 depends on prevailing environmental (temperature and moisture) and nutritional (oxygen and energy) conditions. Initially, the first stage larvae develops in the egg which then hatches, and then development and survival to second-stage and finally third-stage (infective) larvae occurs within the fecal mass. The first- and second-stage larvae are unprotected and need oxygen and energy (feed on nutrients and microorganisms) to grow. The infective larvae is enclosed in a protective sheath and does not feed. Temperatures conducive for normal development and survival are between 65-85EF. The lower or higher the temperature gets, development and survival is reduced. Moisture is also crucial for development and survival. Because the initial development and survival occurs within feces, moisture is usually adequate to complete development to the infective larvae; however, if the feces dries out quickly, due to high temperatures and/or physical disruption, the first- and second-stage larvae are susceptible to dessication and will die. If feces remain intact, retain some moisture and do not get too hot or too cold, infective larvae may remain alive for months. A moisture medium (rain/dew) is necessary for infective larvae to migrate out of feces, and they are relatively resistant to environmental conditions encountered due to their protective sheath. Temperature is usually the only factor that may adversely affect the infective larvae. Generally, infective larvae can survive very low temperatures, but may die off during hard freezes. Sustained temperatures above 95EF are usually lethal. The moisture conditions at ground level under forage cover usually is adequate for infective larvae to move around and survive. Since they don't feed, their length of survival depends on how fast they use up their energy reserves. So, the hotter it is, the faster they move and use up energy stores and survival is shorter. Eventually, infective larvae move up and down the forage when there is a moisture medium (i.e. advancing and receding dew). Rain also provides a moisture medium for larval movement on forage. For the most part, infective larvae do not move much past 12-24 in from feces or 2-3 in up the forage. So, the lower the animals graze and the closer to feces, consumption of infective larvae is increased and vice versa.

Phase 4 - Infectious Phase

Phase 4 is affected again by stocking rate in 2 ways. If the same animals are grazing, the stocking rate determines how many eggs initially contaminated (Phase 2) the pasture and, consequently, how many infective larvae will be available for consumption. If the initial contaminating animals are removed and replaced by new animals, the new stocking rate will determine the level of exposure each animal has to infective larvae during grazing, i.e. the higher the stocking rate, the more chance of exposure and vice versa. It is well known that grazing animals usually do not graze close to feces so the further the distance between fecal deposits, exposure is reduced. Eventually feces disintegrate, forage grows well with the fertilization and animals will graze over the area where exposure can be high. Natural sources of water, such as streams, ponds or lakes provide moisture along the banks where forage can grow readily. When animals congregate to drink and consume the attractive forage, defecation in these areas usually leads to increased contamination and eventually more infective larvae. The same can be said for areas where supplements, especially hay, are fed on the ground if conditions are right for development and survival of the free-living stages. Similarly, trees provide an area for animal congregation and shade. Under all these situations, essentially a high stocking rate has been artificially created in a relatively small area where forage is kept closely grazed.

Abomasal worms

Haemonchus contortus (Barberpole Worm, Wire Worm)

Haemonchus contortus is a voracious blood feeding worm. It gets it's name due to the barberpole appearance consisting of the white ovaries that twist around the red blood filled gut. This worm is rather large compared to other stomach and intestinal worms of goats, measuring up to 3/4 of an inch. When large numbers are present, worms can readily be seen as thin (diameter of a paper clip wire) red hair-like worms on the stomach surface (Figure 4). Female worms are prolific egg laying machines and in large numbers with favorable conditions, they can contaminate the environment with a very large number of eggs. These worms thrive under hot and moist environmental conditions, which are conducive for survival and development of the free-living stages, and are found predominantly in tropical and subtropical regions of the world. In the US, these conditions prevail in the southeast. However, in the rest of the US where similar environmental conditions are encountered during the summer, *H. contortus* transmission also frequently occurs.

Figure 4. Haemonchus contortus on stomach surface showing areas of hemorrhage.

Generally speaking, *H. contortus* transmission and infection is at the lowest level during the winter. Transmission and infection increases with the warmer temperatures and increasing moisture during the spring and peaks during the summer. As temperatures and moisture dissipate during the fall, transmission and infection decreases. Hypobiosis has not been observed to occur to any great extent in the SE US because the life cycle can be maintained year around, but it does occur in more northern/western temperate (cold/dry) regions of the US.

Animals infected with *H. contortus* show symptoms associated with blood loss (anemia), which include pale mucous membranes (most visible be viewing inside the lower eyelid) and bottle jaw (an accumulation of fluid under the chin, Figure 5). The greater the infection level the more blood is lost and eventually the animal may die.

Figure 5. Bottle jaw - accumulation of fluid under the chin.

Telodorsagia (Ostertagia) circumcinta (Brown Stomach Worm)

The other abomasal worm of importance is *Telodorsagia circumcincta* which is smaller than *H. contortus* and is not readily visible since it is about as big as an eyelash. These worms feed mostly on nutrients in mucous and do not feed on blood, per se, but can ingest some blood if present. Female worms do not produce as many eggs as *H. contortus*. Infection causes direct damage to the stomach lining thereby interfering with digestion and appetite. Infection is usually considered a production disease as animals do not grow very well. However, under very high infection conditions, death can result. When infections reach levels that cause disease to be seen, the primary symptom is diarrhea. This worm thrives in cooler wet environmental conditions which are encountered in the more temperate regions of the US (excludes most of the SE). Hypobiosis occurs when environmental conditions are too cold (winter) or too dry (summer).

Small intestinal worms

Trichostrongylus colubriformis (Bankrupt worm)

Trichostrongylus colubriformis is a very small threadlike worm and is the most predominant small intestinal worm. It is found throughout the US, but seems to thrive better under more cool and wet conditions similar to *T. circumcincta*. However, in the southeast US, this worm is the next most common and important after *Haemonchus* and on some farms can cause considerable problems. As with *Telodorsagia*, this worm feeds on nutrients in mucous and interferes with digestive function resulting in diarrhea. It is called the bankrupt worm because death is seldom the end result and animals just become poor doers leading to loss of production and income.

Nemutodirum spp. (Long-necked bankrupt worm)

Nematodirus spp. are relatively large worms (easily seen) and can be found throughout the US although usually in rather small numbers. Problems are rare in the southeast, but in cooler areas of the US there is a possibility of greater numbers of worms accumulating. If heavy infection occurs, production and income losses will result (similar to that of *T. colubriformis*).

Large intestinal worms

Oesophagostomum spp. (Nodular worm)

Oesophagostomum spp. are relatively large (easily seen) worms and can be found throughout the US, usually in rather small numbers. These worms feed on blood and can contribute to the overall anemia being caused by *H. contortus*. Although this worm resides in the large intestine, the larvae are found in the mucosa of both the small and large intestine where they form nodules, thus the name nodular worm. Once the larvae leave theses nodules they reside in the large intestine.

Trichuris spp. (Whipworm)

Trichuris spp. are usually found in small numbers and the posterior end of the worm is rather large and can be seen. The anterior end of the worm is thread-like, thus the name whipworm. These worms are also blood feeders and, like *Oesophagostomum*, contribute to the overall blood loss due to other worms. Female worms produce characteristic ‘football’ shaped eggs with protruding plugs at each end.

Diagnostic methods (measure how wormy animals are)

General appearance/signs

Parasitized animals can show many signs of infection depending on the parasites present. The general signs include rough hair coat, diarrhea, depression, weight loss (or reduced weight gain), bottle jaw and anorexia (off feed). Laboratory diagnostic findings may include anemia (low PCV), increased FEC and loss of plasma protein.

Fecal egg count

The FEC is exactly that, a method to evaluate the number of parasite eggs (Figure 6) excreted per gram of feces (epg). While this is the best method for use with live animals, there are some difficulties associated with measurement including: egg production does not always reflect the number of worms present which depends on the species; eggs cannot be completely identified to species, i.e., they may be grouped in various categories but not absolutely identified; how long infection has persisted; level of host immunity; fecal consistency (solid-diarrhea) and some methodologies used for epg determination may be less precise than others.

The FEC (specifically for *H. contortus*) has been shown, for the most part, to reflect the animals' worm burden and also serves as an indicator of seasonal changes in level of infection. Trends in FEC over time can be seen, thus reflecting the relative direction of infection. When worms other than *H. contortus* predominate, FEC is a less accurate predictor of adult worm burdens.

It is important to know that if heavy infection occurs over a short period of time (1-2 weeks) with *Haemonchus*, animals may lose substantial amounts of blood with few eggs in the feces as the prepatent period is about 3 weeks.

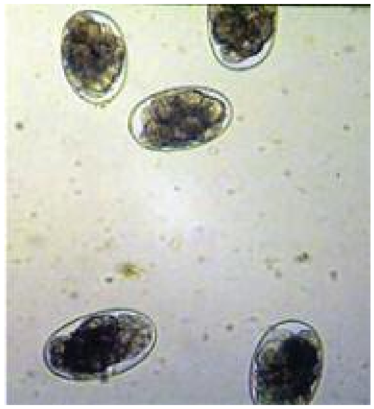


Figure 6. Worm eggs in fecal exam.

Blood packed cell volume

Nematode parasites can affect an animals' ability to maintain erythropoesis (making red blood cells). The PCV is the percent of the blood that is red blood cells and normal is usually above 30%. When PCV drops below 20%, symptoms of anemia usually start to appear. PCV is determined by centrifuging blood in a capillary tube (similar in size to a ball point pen refill) which packs the cells and percent is measured. All nematode parasites can result in chronic anemia where red blood cells are not being made fast enough to keep up with demand. Of special note, *H. contortus* can lead to substantial acute blood loss and death. PCV values have been used to support other response criteria, and is not necessarily used as a "stand-by-itself" diagnostic tool.

Anemia and FAMACHA©

Level of anemia can be roughly evaluated by observing the color of mucous membranes which are areas where there are a lot of capillaries (very small blood vessels) close to the surface so that tissue color reflects blood color. Such areas are inside the lower eyelid, the gums (only where pigmentation is not present) and inside the vulva. If such membranes are pale (essentially white), impending death is near and deworming is indicated immediately.

The FAMACHA eye color chart system(Figure 7) was developed in South Africa to help producers monitor and evaluate level of anemia without having to rely on laboratory testing. In this method, the lower eyelid mucous membranes are examined and compared to a laminated color chart bearing pictures of sheep eyes at 5 different levels of anemia.: 1 (red, non-anemic); 2 (red-pink, non-anemic); 3 (pink, mild-anemic); 4 (pink-white, anemic); 5 (white, severely anemic). Since anemia is the primary pathologic effect from infection with *H. contortus*, this system can be an effective tool for identifying those animals that require treatment (but only for *H. contortus*). FAMACHA has been extensively tested in South Africa and now the US with excellent results. It has been shown that where animals have been examined at weekly intervals and salvage treatments only were administered, up to 70% of adult animals may not require deworming and only a few required more than one treatment. Compared to previous treatment regimens, total number of treatments may be decreased by up to 90%. Since most of the worms would not be exposed to dewormers, this reduces the development of dewormer resistance. Information on FAMACHA and training workshops (held in many localities) can be found on the website of the

Southern Consortium for Small Ruminant Parasite Control (SCSRPC, www.scsrpc.org).

Figure 7. FAMACHA© eye color chart being used to check level of anemia.

Worm count and identification

The most absolute and direct method for documenting the number of worms present in an animal is to open it up and collect, identify, and count the worms present. When an animal dies, this can only be done by a properly trained veterinarian or other professional and it might be very expensive. However, one can get an idea of the magnitude of *Haemonchus* infection by looking for the worms that are visible (see above) on the lining of the abomasum. It should be noted that for this to be of any value, the animal can not have been dead for very long. The fresher the animal is after death, the greater the chance to find worms because after death, the worms will move as far down the gut as they can get and eventually die. It is important to note that *Telodorsagia* and *Trichostrongylus* are too small to see except under a microscope. Even if thousands of these worms are present, they cannot be seen by the naked eye while mixed in with the gut contents.

Dewormers (Anthelmintics)

Dewomers are chemicals (drugs) that have been evaluated and tested (effectiveness and safety) for use in animals to remove worm parasites (Table 1). For the most part, pharmaceutical companies will not market a dewormer unless it is essentially 100% effective. As long as dewormers remain effective (at the manufacture's recommended dosage), control is relatively easy and cost effective. However, resistance to almost all dewormers has been developed by many worm species. Therefore, reliance on the use of dewormers has become limited. Only FDA approved dewormers can be used legally without restrictions. All other dewormers, if used, are "extra-label" and are subject to specific regulations as delineated by FDA. Because of public concern over food product residues and environmental contamination with chemicals that may be harmful, the FDA has recently revised the rules and regulations governing use of chemicals in food animal production. In summary, producers and veterinarians have to pay attention to "extra-label" use, which means using a product other than for which it is approved. Because small ruminants are relatively minor livestock species, pharmaceutical companies can not recover the costs that would be incurred for them to pursue approval and labeling. For a veterinarian to use a dewomer "extra-label", there has to be a valid veterinarian-client relationship. The veterinarian has to have contact with the animals and make a diagnosis that the parasite situation is potentially life threatening. The veterinarian has to establish that none of the approved dewormers will work (i.e. fecal egg count reduction testing). Once the approved dewormers have been tested and if none work, then other dewormers can be used “extra-label.” The veterinarian has to take responsibility for prescribing the dewormer and the producer has to take responsibility for using it properly. In the absence of a valid veterinarian-client relationship, the producer is restricted and can not legally use an unapproved product “extra-label.”

Table 1. Commonly used dewomers in goats (Oral route of administration only)

			Withdrawal Time	
Dewormer	**Approval**	**Dosage/ 100 lbs**	**Meat**	**Milk**
Fenbendazole (Safeguard/Panacur)	Approved	2.3 ml	14 days	4 days
Morantel tartrate (Rumatel)	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

Classes

The three general classes of dewormers are benzimidazoles, imidazothiazoles and macrolides. The more commonly used benzimidazole dewormers are fenbendazole (Safeguard, Panacur) and albendazole (Valbazen); imidazothiazole dewormers are levamisole (Levisol, Tramisol) and morantel tartrate (Rumatel) and macrolide dewormers are ivermectin (Ivomec) and moxidectin (Cydectin). Of these, fenbendazole and morantel tartrate are approved for use in goats and albendazole, levamisole, ivermectin and moxidectin are approved for use in sheep. All others or use in non-approved species would be “extra-label. A number of these dewormers have gone off patent and are now marketed under different generic names.

Formulations

Formulations of dewormers include drench, injection and pour-on. In addition, some dewormers are marketed in feed supplement blocks, mineral mixes, pellets and cubes. For small ruminants, only specific formulations are approved for use.

Administration

Oral administration is preferred and during administration of liquids, it is very important to make sure the product is delivered over the base of the tongue. By doing so, the dose is delivered to the rumen where it will be mixed with the ingesta and then distributed evenly throughout the gastrointestinal tract. If the dose is delivered into the front part of the mouth, some may be spit out (wasted = reduced dose) and when swallowed the reflex may stimulate closure of the esophageal groove which allows what is swallowed to bypass the rumen. When the rumen is bypassed, the dose goes directly into the omasum (third stomach) and moves quickly through the gastrointestinal tract, thus not allowing sufficient time for the anthelmintic to achieve full effectiveness.

The other form of oral administration of products is in feed which does not ensure that all animals will receive an effective dose because individual animals utilize these products differently. Some animals eat more/less than others due to their appetite, their place in the "pecking order" or they just may not like the formulation (specifically supplement blocks and mineral mixes).

If one elects to use injectable products (not recommended), injections are subcutaneous (under the skin) and best administered in an area of exposed skin (usually under the front legs) so that one can see the dose being delivered. It is best to not "tent" the skin, just lay the needle on the skin and insert quickly. If the skin is tented, the needle may come out the other side and the injected material will be administered on the skin surface (again wasted). If the injection is given in an area covered by hair, it can be difficult to ensure that the needle actually penetrates the skin and the dose is delivered appropriately. Sometimes the injected material will run back out of the needle hole (again wasted), so make sure to press a finger over the injection site for a few seconds to prevent leakage.

If one elects to use a pour-on product (not recommended), the material has to be delivered on to the skin. Parting of the hair (if long) may be necessary to achieve this. There are mixed reports as to whether pour-ons (approved for use in cattle only) work on small ruminants and for the most part, they do not seem to be that effective.

Resistance

The major problem encountered in controlling nematode parasitism in small ruminants is the resistance that many worm populations (specifically *H. contortus*) have developed to essentially all of our dewormers. Resistance has developed primarily because dewormers have been used and rotated too frequently and many times under-dosing occurs. Continuing to use such a dewormer will increase the selection of more resistant worms which will eventually result in a population of "superworms" that can't be controlled with drugs. There is no "silver" bullet that can be relied on. Resistance is genetically controlled and once it is established, it is set in the population and those dewormers can no longer be used effectively.

Control Program

Smart use of dewormers

The most important aspect of using dewormers is to conserve their effectiveness. This can be achieved by using them as little as possible and only when infection levels dictate that intervention is necessary. The old concepts of treat all animals when a few show signs or all animals at regular intervals (shorter than every 3-4 months) is no longer warranted because it promotes dewormer resistance. Even if new dewormers are discovered and marketed (which is a long way down the line), they should not be used indiscriminately as that is the reason the dewormer resistance problem has evolved.

It would be prudent to establish which dewormers are effective against a worm population. This can be achieved by conducting FEC reduction testing and should be done by a qualified professional such as a veterinarian, veterinary school parasitology lab or a diagnostic lab that offers such a service. However, FEC are not hard to do, but a microscope is required. The procedures for conducting a FEC are available on the SCSRPC and other websites. The concept is to do FEC before and after (10-14 days) treatment. If the counts after treatment are "0" (essentially 100% reduction), the dewormer is very effective. However, this should not be expected with most of the dewormers and the best one (highest % reduction) should be considered for use only when there are no other options, thus extending its useful life. Fecal egg count reduction testing may seem somewhat expensive, but it will be worth the effort and expense to know what you have. The worst thing is not knowing and continuing down the wrong path. Once the most effective dewomer has been selected, using it along with others needs to be done "smartly." Some of these "smart" concepts are:

1. Do not use the most effective dewormer exclusively unless it is the only dewormer that works. Reserve it's use for deworming those animals which need it the most and use less effective dewormers otherwise.
2. If one feels the need to rotate dewomers, do so at yearly intervals and rotate between classes using the most effective in each class.
3. Only deworm those animals that need to be dewormed and not the whole population. As a general rule, a minority of the population harbors the majority of the worm population, thus most of the animals may not need deworming and it is not prudent to do so. By doing this, much of the worm population is not exposed to the dewormer and development of resistance can be slowed substantially. This is where the FAMACHA monitoring system comes into play.
4. If there is substantial resistance to all dewomers tested, increasing the dosage may help with some or using combinations (from different classes, levamisole and albendazole has been used successfully) may improve effectiveness. Another concept that has also been reported to have some success in improving effectiveness is to take animals off feed for 24 hour before administering the dewomer. This will reduce rumen motility and the dewomer will pass through the gut slower and have more contact time with the target worms.
5. Do not deworm and move to clean pasture (no animal grazing for at least 3 months) as those worms that survive dewoming are probably resistant and then the new pasture will become more highly contaminated with eggs/larvae of resistant worms. That is not what one needs when trying to combat these parasites.

Pasture Management

Parasites and pastures

One of the best ingredients of a parasite control program is reducing the number of parasites that the goats are exposed to in the first place. One way to accomplish this is to manage your pastures in a way that will reduce its parasite load. There are several ways to do this:

1. Take a hay crop. This type of pasture can be incorporated into a dose-and-move program in which goats are grazed on one pasture in the early grazing season and then moved to another goat pasture which was used for a first cutting of hay. Another move before the end of the grazing season will probably provide the best parasite control.
2. Incorporate annual pastures into the grazing system and drag some implement in the stubble before planting.
3. Incorporate into the grazing system plants containing high concentrations of tannins such as

sericea lespedeza and chicory. Alternatively, incorporate fodder shrubs that contain high concentrations of tannins, such as black locust.

4. Graze a contaminated pasture with another livestock species. The goat parasite larvae cannot survive in the gastrointestinal tract of another herbivore species. THIS DOES NOT APPLY TO SHEEP, which share worms with goats. Another approach is to use a first grazer, second grazer system using two livestock species.
5. Use control grazing practices to optimize pasture production. This is a better practice than continuous grazing on the same pasture because goats will return to the same areas where their favorite plants are growing, thus those areas will become heavily infected by gastrointestinal parasite larvae.
6. In extensive situations with an abundance of pasture land compared to the number of goats, allow the goats to have plenty of forage, thus giving them the opportunity to select the most nutritious parts of plants. In such situations, goats will not graze close to the ground and thus will not ingest many gastrointestinal parasites.
7. Put goats in a browse area (woodlot) when environmental conditions favor the rapid life cycle of gastrointestinal parasites (hot and humid). By browsing, goats will not consume forage close to the ground where the parasite larvae are located (0 to 5 inches from the ground level). In addition, many browse plants have the additional benefit of harboring high tannin concentrations. Tannins have been shown to reduce fecal egg counts and possible gastrointestinal parasite larvae numbers.
8. Always put goats with the highest nutritional requirements on the best quality pastures you have on your farm. Good nutrition allows a more effective immune response to fight gastrointestinal parasites.
9. Rest a pasture. Unfortunately, it takes a long time for the worm eggs and larvae to die off if the pasture is just left empty. A year or at least an entire grazing season is required, which is usually impractical.

Control grazing and strip grazing

The basic principle of control grazing is to allow goats to graze for a limited time leaving a leafy stubble, and then to move them to another pasture or paddock (a subdivision of a pasture) or sub-paddock. Smaller paddocks are more uniformly grazed and surplus paddocks can be harvested for hay. The pasture forage plants, with some leaves still attached, can then use the energy from the sun through photosynthesis to grow back without using up all of their root reserves. Even brush will need a recovery time if it is being used as forage for goats. Without this rest period, the goats can kill the brush through continuous browsing.

Under control grazing, legumes and native grasses may reappear in the pasture, and producers often report that the pasture plant community becomes more diverse. Control grazing can be used to improve the pasture, extend the grazing season, and enable the producer to provide a higher qualityforage at a lower cost with fewer purchased inputs. Control grazing can also be useful in reducing internal parasite problems, if meat goat producers are careful to move the goats to a new pasture before the forage plants are grazed too short (less than about 4 inches). In addition, the use of the FAMACHA system to selectively deworm goats will overcome the problems of pasture infestations by resistant intestinal nematodes due to increased refugia. Refugia is the proportion of nematodes that provide a pool of susceptible genes and dilutes dewormer-resistant genes in that population..

Strip grazing can be easily superimposed on control grazing in large paddocks by placing movable electric fences ahead and behind the goats, giving them sufficient forage for 2 to 3 days. Strip grazing is very effective and results in high pasture utilization because otherwise goats will not graze soiled forage well. Strip grazing results in high average daily gain, increased gain per acre, and in rapid improvement of body condition when pasture is vegetative and of excellent quality such as during cool weather when plant quality declines only slowly. Strip grazing is very effective with stockpiled fescue during late fall and early winter. Strip grazing is not recommended when pasture is of low quality because of reduced goat selectivity.

Control grazing versus continuous grazing

Control grazing allows the manager a better utilization of the forage at hand because this grazing method gives more control over grazing animals. During periods of fast growth, the excess forage can be harvested for hay. Control grazing can stretch forage availability and the grazing season as spring forage growth slows during the hot summer months. It also slows the gradual predominance of less palatable and less nutritious plants because goats are forced to consume all plants before moving on.

Another level of managerial control is achieved by having more than one pasture. Under a control grazing system a) goats are easier to handle and more docile because they are in frequent contact with humans when fences, water tanks and mineral troughs are moved, b) plants that are sensitive to close and continuous grazing will persist longer and producer better, c) less forage is wasted by trampling and soiling, d) urine and dung are distributed more uniformly, e) managerial and observational skills of the producer will improve because goats will be observed more frequently, and pasture species and productivity will be evaluated more carefully. Conversely, control grazing may not be beneficial because of a) high cost, b) unsatisfactory layout such as long, narrow paddocks or wet and dry areas within the same paddock, c) overstocked pastures, d) rest period is too long between grazing such that the available forage becomes mature and of low nutritive value with a lesser amount of young green leaves, d) pastures dominated by low forage quality.

Continuous grazing or stocking means that goats are maintained on one pasture for the entire grazing season. Therefore, the goat makes the decision as to where to graze, when to graze, where to congregate and to selectively graze unless the stocking rate is too high. Goats may overgraze the plants they prefer and undergraze other, less preferred plants if the stocking density is not adjusted as conditions change. Forage availability may be ideal, too high or too low during different periods of the same grazing season. Therefore, adjusting the stocking density as needed greatly improves forage utilization. Temporary fences can be used to fence off portions of the pasture and harvest surplus forage for hay. Finally, certain forage species such as switchgrass, big bluestem, indiangrass and johnsongrass are not suitable for continuous grazing unless the stocking rate is low enough to maintain a 6 to 8 inch leafy stubble.

Co-and Multi-Species Grazing

The differences in feeding behavior among cattle, sheep and goats uniquely fit each species to the utilization of different feeds available on a farm. These differences should be considered in determining the best animal specie to utilize a particular feed resource.

Feeding behavior is also important in determining whether single or multi species will best utilize available plant materials. Most studies indicate greater production and better pasture utilization are achieved when sheep and cattle or sheep, cattle and goats are grazed together as opposed to grazing only sheep, goats or cattle alone. This is especially true where a diverse plant population exists.

Because of the complimentary grazing habits, the differential preferences and the wide variation in vegetation within most pastures, one to two goats can be grazed with every beef cow without adversely affecting the feed supply of the beef herd. The selective grazing habits of goats in combination with cattle will eventually produce pastures which are more productive, of higher quality, and with little weed and brush problems as a result of mixed-species grazing.

Judicial mixed-species grazing can have additional benefits. Because gastrointestinal parasites from goats or sheep cannot not survive in the stomach of cattle, and because gastrointestinal parasites from cattle cannot survive in the stomach of goats or sheep, mixed-species grazing will decrease gastrointestinal parasite loads and slow resistance of gastrointestinal parasites to conventional dewormers. Several strategies can be used to one's advantage. In fields with a low parasite load, animals can be grazed together (co-grazing) or animals with the highest nutritional requirements can have access to the field first, followed by the animal species having lower nutritional requirements (first grazers, last grazers). A variation of co-grazing with nursing animals is to have openings in the fence giving forward access to ungrazed pasture to young stock. Alternatively, in a field infected with a high load of goat or sheep parasites, cattle should be grazed first, followed by goats or sheep.

Non-Chemical Alternative Control Methods

Mixed/alternative livestock species grazing

For the most part, each livestock species harbors it's own parasite fauna except that small ruminants have the same parasites. Only one worm species is known to be found in essentially all livestock species and that is *Trichostrongylus axei*, a minor abomasal worm and one not to be concerned about. If practical, cattle and small ruminants can be grazed together where each consumes the parasites of the other which, in turn, reduces available infective larvae for the preferred host species. If co-grazing is not preferred, cattle and small ruminants can be grazing alternately on the same pastures. Again, each consumes the others parasites and when returned to the same pasture, available infective larvae have been reduced. Both livestock species should gain from this over time. The one situation that requires some care with this strategy is if there are young calves present. Calves can become infected with *H. contortus*, but problems in the calves should still be much less than that in the goats.

Pasture rotation (??)

The concept of pasture rotation or rotational grazing to break the parasite cycle has been tossed around for years. The main reason to use pasture rotation is not for parasite control but to provide the most nutritious forage for growth and development. If grazed correctly, most forages reach the next most nutritious stage in about 30 days, so many rotation schemes have the animals returning to pastures at around 30 day intervals. Unfortunately, this 30 day interval is also about the same time necessary to ensure that the previous worm parasite contamination has now been converted into the highest level of infectivity for the next grazing group. Thus, 30 day rotation schemes may actually lead to increased worm parasite problems. In fact, heavy exposure over a short period of time can lead to disastrous clinical disease and losses. Rotation schemes of 2-3 months have been shown to have some effect on reducing pasture infectivity in tropical and subtropical environments (maybe SE US), but in more temperate environments, infectivity can extend out to 8-12 months depending on the conditions. For the most part, it is impractical to leave pastures ungrazed for such extended periods of time; therefore, one needs to be aware of the possible problems associated with whatever rotation scheme being used. Some success at reducing infectivity can be achieved by cutting pasture for hay between grazing periods. It should also be emphasized that when rotation schemes are used, stocking rate is usually high and the resultant increase in contamination may make the problem worse.

Copper oxide wire particles

Copper oxide wire particles (COWP) have been marketed for years as a supplement for livestock being managed in copper deficient areas. COWP come in adult cattle, calf and ewe boluses (25, 12.5 and 4 grams, respectively). Only the cattle boluses are available in the US. Due to potential toxicity in sheep, only one dose per year is recommended. It is also well known that copper has some anthelmintic activity against abomasal worms, but not other gastrointestinal worms. That makes it a very narrow spectrum product. But, in view of the potentially devastating problem of anthelmintic resistance by *H. contortus*, recent work has revisited the possibility of using COWP to specifically target *H. contortus*. Such work has shown that as little as a gram or less and 2 grams may remove substantial numbers of *H. contortus* in lambs and ewes, respectively. Similar work in goats has not been tested adequately to establish what is needed, but similar doses may be appropriate. As mentioned, copper has to be used cautiously in sheep because toxicity can develop due to liver accumulation. Toxicity may not be an issue in goats as they have been reported as not being that sensitive to excess copper intake. Thus, higher doses and/or more treatments during haemonchosis season may be useful in goats.

Condensed tannin containing forages

An approach to parasite control that has not been adequately explored in the US is use of medicinal plants with anthelmintic properties. There is growing evidence in work from New Zealand and Europe that grazing or feeding of plants containing condensed tannins (CT) can reduce FEC, larval development in feces, and adult worm numbers in the abomasum and small intestine. There are a number of CT-containing forages that grow well throughout the southern US, but most of these have not been tested for their potential anthelmintic properties.

Preliminary tests with sericea lespedeza (SL, *Lespedeza cuneata*), a CT-containing perennial warm-season legume, have shown positive effects of reduced FEC in grazing sheep and goats, and in sheep and goats in confinement when the forage was fed as hay, ground hay or pellets. In addition, an effect on reducing worm burden has also been reported. Similar results have been observed using CT-containing quebracho extract for small intestinal worms, but not abomasal worms.

In addition to its potential use in controlling worms, SL is a useful crop for limited resource producers in the southern USA It is adapted to hot, drought climatic conditions and acid, infertile soils not suitable for crop production or growth of high-input forages, such as alfalfa. It can be overseeded on existing pasture or grown in pure stands for grazing or hay. Farmers could increase profits by marketing LS anthelmintic hay, or using it themselves and reducing their deworming costs. In South Africa, SL has been reported to increase profits with rangeland farmers by bringing poor, drought-prone, infertile land into useful production for sheep, and any anthelmintic uses would increase the value of SL even further. The same is true in the southern US, which has a climate and soils ideal for growth of this plant.

In addition to grazing, SL is being evaluated in the form of hay, ground hay, pellets and cubes to be fed as a supplement to grazing animals or as a deworming method under temporary short-term confinement.

SL processed products are expected to become available in the near future.

Genetic improvement

There is considerable evidence that part of the variation in host resistance to worm infection is under genetic control. Resistance is most likely based on inheritance of genes which play a primary role in expression of host immunity. Based on survival of the fittest management conditions, several sheep and goat breeds are known to be relatively resistant to infection. Such breeds include: sheep - Scottish Blackface, Red Maasai, Romanov, St. Croix, Barbados Blackbelly and the Gulf Coast Native; goat - Small East African, West African Dwarf and Thai Native. Katahdin sheep have been considered as being more parasite resistant, but studies to document this are few and not conclusive. Using resistant breeds exclusively or in crossbreeding programs would certainly lead to improved resistance to worm infection, but some level of production might be sacrificed. While such a strategy may be acceptable to some, selection for resistant animals within a breed is also a viable option. Selection for resistant lines within breed has been demonstrated with sheep (Merino and Romney) and goats (Scottish Cashmere). Within breed, animals become more resistant to infection with age as their immune system becomes more competent to combat infection. However, some animals within such a population do not respond very well and remain relatively susceptible to disease. This means that the majority of the worm population resides in a minority of the animal population. It would make sense to encourage culling practices (based on FEC, PCV, FAMACHA, etc.) where these minority "parasitized" animals were eliminated, thus retaining more resistant stock. To augment this process, finding sires that throw relatively resistant offspring, would speed up this process. This approach has been used successfully in sheep (New Zealand and Australia) and goats (Scotland), but it may take quite a long time (up to 8-10 years) to achieve satisfactory results. Heritabilities for FEC, a common measurement for assessing parasite burden, range from 0.17 to 0.40 which is quite good. Thus, selection for resistance and/or selection against susceptibility using a measurement such as FEC has been moderately successful. The real benefit to this approach is that reliance on dewormer intervention for control can be reduced, thus conserving the activity of such dewormers for when they are needed.

Nematode-trapping fungi

Research with nematode-trapping fungi in Denmark with beef cattle, horses, and pigs has demonstrated the potential of nematode-trapping fungi as a biological control agent against the free-living stages of parasitic worms in livestock under both experimental and natural conditions. The concept of using microfungi as a biological control agent against worms was introduced as early as the late 1930s and early 1940s. These fungi occur ubiquitously in the soil/rhizosphere throughout the world where they feed on a variety of free-living soil nematodes. These fungi capture nematodes by producing sticky, sophisticated traps on their growing hyphae. Of the various fungi tested, *Duddingtonia flagrans* possesses the greatest potential for survival in the gastrointestinal tract of ruminants. After passing through the gastrointestinal tract, spores of this fungus are able to trap the developing larval stages of the parasitic worms in a fecal environment. This technology has been successfully applied under field conditions with cattle, sheep and goats. This is an environmentally-safe biological approach for control of worms in small ruminants under sustainable, forage-based feeding systems.

To date, the only delivery system is incorporating the fungal spores into supplement feedstuffs that have to be fed daily. This requires a management system that can accommodate daily feeding to ensure that all animals consume an equivalent amount of feed. To achieve adequate control of larvae in the feces during the transmission season, spores have to be fed for a period of no shorter than 60 days. This can be expensive and time consuming. A bolus prototype is being developed which would allow a single administration where spores would then be slowly released over a 60 day period.

This product is not available at this time.

Vaccines

As a consequence of drug resistance among worms of grazing ruminants, efforts have increased in recent years to develop functional vaccines. This has been made possible by newer technologies in gene discovery and antigen identification, characterization and production. Successful vaccines have been developed for lungworms in cattle and tapeworms in sheep. The most promising vaccine for nematodes has been what is called a "hidden gut" antigen and it specifically targets *H. contortus*. This antigen is derived from the gut of the worm and when administered to the animal, antibodies are made. When the worm ingests blood during feeding, it also ingests these antibodies. The antibodies then attack the target gut cells of the worm and disrupt the worm's ability to process the nutrients necessary to maintain proper growth and maintenance. Thus, worms die. This vaccine has been tested successfully in sheep under experimental conditions and has had limited success under field conditions. Reasons for this are unclear. Effect of this vaccine on *H. contortus* in goats has not been evaluated. The one drawback to this vaccine is that the antigen is normally "hidden" from the host and a number of vaccinations may be required to maintain antibody levels high enough to combat infection. This may be quite expensive. In addition, massive numbers of whole worms are necessary to extract limited amounts of antigen; therefore, this will only be practical when methods are derived to artificially make the antigen so that it can be mass produced at a lower cost. Vaccines for other worms that do not feed on blood have focused on using antigens found in worm secretory and excretory products. These antigens do have contact with the host and should stimulate continuous antibody production. However, protection has been quite variable and marketing such products has not been pursued.

Vaccines are not available at this time.

Integrated approaches

The control of worms traditionally relies on grazing management and/or dewormer treatment. However, grazing management schemes are often impractical due to the expense and the hardiness of infective larvae on pasture. Currently in the US, there are 4 dewomers approved for use in sheep and 2 in goats. The 4 for sheep are levamisole (Levasol and Tramisol, oral drench), albendazole (Valbazen, oral drench), ivermectin (Ivomec for Sheep, oral drench) and moxidectin (Cydectin Oral Sheep Drench). The 2 for goats are fenbendazole (Safeguard/Panacur, oral drench) and morantel tartrate (Rumatel, feed additive). Use of any other dewormers or other methods of administration are not approved and constitute extra-label use. There are FDA rules and regulations governing use of such drugs where extra-label use may be necessary. The evolution of dewormer resistance in worm populations is recognized globally and threatens the success of drug treatment programs. In South America, South Africa, and the southeastern US, prevalence of resistance to dewormers has reached alarming proportions and threatens future viability of small ruminant production. In the only comprehensive study in the US on prevalence of dewormer resistance in goats, 90% of all farms had resistance to 2 of 3 drug classes and 30% of farms had worms resistant to all 3 drug classes. Fortunately, the one dewormer that may still remain effective in some circumstances is moxidectin (Cydectin). However, there are now several reports of moxidectin resistance. There is an urgent and increasing need to develop alternative strategies that could constitute major components in a sustainable worm control program. The most promising of these methods that are immediately applicable are smart drenching, copper-oxide wire particles and FAMACHA.

An integrated approach using these current methods should have an immediate impact on productivity and profitability of small ruminant production systems in the southeastern US and other regions where *H. contortus* and/or other worms can be a problem. Producers will be able to reduce overall dewormer usage by integrating an alternative compound (copper-oxide wire particles) with identification of animals in need of treatment (FAMACHA) and adopting smart drenching procedures, thereby reducing cost of production while improving animal health and productivity. Lower frequency of deworming will also reduce potential environmental impact of excreted anthelmintics and will decrease the development of resistance, thereby prolonging the usefulness of available dewormers. This integrated approach will provide a cornerstone for inclusion of future environmentally sound worm prevention and control technologies to secure a sustainable, growing small ruminant industry.

Integration of other methodology/technology certainly will be instituted when evaluation is complete and ready for use.

Other parasites

Moniezia (Tapeworm)

Many producers are concerned about tapeworms (*Moniezia* spp.) because they can see the moving segments (white rice grain-like "worms") in freshly deposited feces. Tapeworm eggs are ingested by field mites and infection is transmitted when mites are consumed with forage. Adult tapeworms reside in the small intestine, feed by absorbing nutrients from digested feed and cause very little damage. However, growth in kids (not adults) may be somewhat reduced and intestinal blockage may rarely occur. Infection can be controlled with albendazole, fenbendazole, or oxfendazole.

Fasciola hepatica (Liver fluke)

Fasciola hepatica can be a major problem in low lying perennial wet areas of the southeast. This parasite resides in and damages the liver resulting in unthriftiness, weight loss/reduced gains, and sometimes death. The life cycle is indirect requiring an amphibious snail as an intermediate host. Fluke eggs are passed in the feces and a larval stage called a miracidium develops inside the egg over a period of 2-3 weeks. Eggs then hatch releasing the miracidium which infects a snail. Asexual reproduction occurs in the snail over a period of 5-7 weeks and then the mature larval stage called a cercaria leaves the snail and encysts on forage where it develops to a metacercaria. Animals ingest the metacercaria when grazing. Snails are active mainly from January/February through May/June, depending on environmental conditions, providing the source of infection (transmission). Snails burrow into the mud and become dormant the rest of the year, especially the hot summer months. Development to the adult fluke takes about 6-8 weeks. Because transmission ceases in late spring/early summer, treatment to control flukes can be divided into two periods, one period when immature and adult flukes are present (February-August) and another when adults only are present (September-January). Diagnosis is by using a sedimentation procedure to find eggs in feces. Regular floatation techniques are not good as the floatation medium induces premature hatching of the eggs and they do not float. Clorsulon (Curatrem) is the only product that is effective against immature flukes. Clorsulon and albendazole are effective against adult flukes. Therefore, selection of either of these depends on the time of year. Another liver fluke, the deer fluke (*Fascioloides magna)*, can kill small ruminants by destroying the liver. Infection is rare, but should be considered where deer have access to pastures grazed by small ruminants. Control is difficult.

Dictyocaulus filaria, Muellerius, Protostrongylus (Lungworms)

Problems with lungworm infection occur sporadically in the southeast. Infection results in respiratory distress (chronic coughing), unthriftiness, and sometimes death. The life cycle of *Dictyocaulis filaria* is direct and adult worms live in the lungs (Figure8) with larva being passed in the feces. Transmission usually occurs during the cooler months (November-April) of the year. Because larvae, not eggs, are found in feces, diagnosis is by using the Baermann procedure which extracts the larvae from feces. Infection can be controlled with albendazole, fenbendazole, ivermectin, or oxfendazole. There are 2 other minor lungworms (*Muellerius capillaris* and *Protostrongylus* spp.) whose life cycles are indirect requiring land snails/slugs as intermediate hosts. Control is not as easy and fortunately pathogenesis is minor.

Figure 8. Adult lungworms in the bronchi of the lungs.

Parelaphostrongylus tenuis (Meningeal worm)

The meningeal worm (*Parelaphostrongylus tenuis*), also known as the deer worm or meningeal deer worm, frequently infects llamas, alpacas and sometimes goats. White-tailed deer are the natural host for the parasite, so goats are at potential risk everywhere that white-tailed deer are found. Small ground dwelling slugs and snails are intermediate hosts. Goats, which are not normal hosts, can ingest the slugs/snails harboring the infective form and the larvae migrate into places where they don't normally reside in the deer. Migration is up the spinal nerves to the spinal cord but then they seem to get lost. The larvae then migrate throughout the spinal cord and the brain (actually around the spinal cord and brain, not in it). This causes damage to the central nervous system which may be severe enough to result in death.

Animals can become infected in the spring, summer or fall. Disease is usually seen in the fall and winter about 3 to 4 months after infection. Often only one animal is infected at a time on a single farm. Infected animals will show a wide variety of symptoms which include, but are not limited to: rear leg weakness and ataxia (uncoordinated walking), paralysis, hypermetria (exaggerated stepping motions), circling, abnormal head position, blindness and gradual weight loss. Generally, animals with more severe symptoms have a worse prognosis.

Diagnosis is difficult in the live animal and is usually made when animals die and the larvae are found on examining the spinal cord and brain microscopically. The use of ivermectin at monthly intervals during the transmission season (spring and summer) has been used in attempts to prevent infection, but this strategy has not been proven. However, this frequent administration interval most likely will have an effect on the development of resistance by the other resident worms.

Eimeria spp. (Coccidia)

Coccidia are protozoan parasites that infect cells in the small intestine and is a disease associated with filth, moisture and times of depressed immunity such as kidding, weaning or during transportation. Infection results in destruction of the intestinal lining leading to scours, unthriftiness, weight loss/reduced weight gains, and sometimes death. Mature oocysts (Figure 9) are passed in the feces and can develop to infective stages (within the oocyst) in 2-7 days. Upon ingestion, infective stages invade the intestinal lining and undergo asexual reproduction producing many more invasive stages. This can occur repeatedly and eventually sexual reproduction occurs forming oocysts to complete the cycle. Devastating losses can occur quickly because of the asexual process and usually is a problem at weaning when kids are stressed. Preventing and/or controlling coccidiosis can be achieved by providing an anticoccidial product in the feed or water. There are several effective products on the market, such as amprolium and monensin. Individual clinical cases can be treated with sulfa products. Fortunately, a solid immunity develops subsequent to infection, however, if infection was severe, stunting usually results.

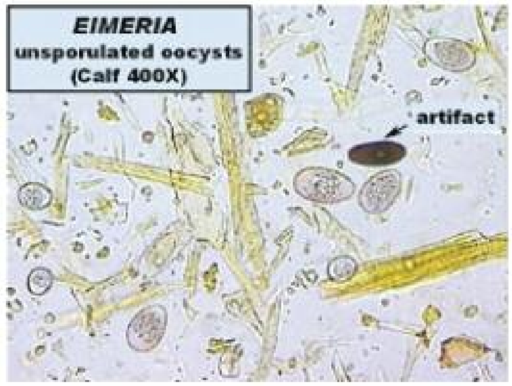


Figure 9. Coccidia oocysts in fecal exam.

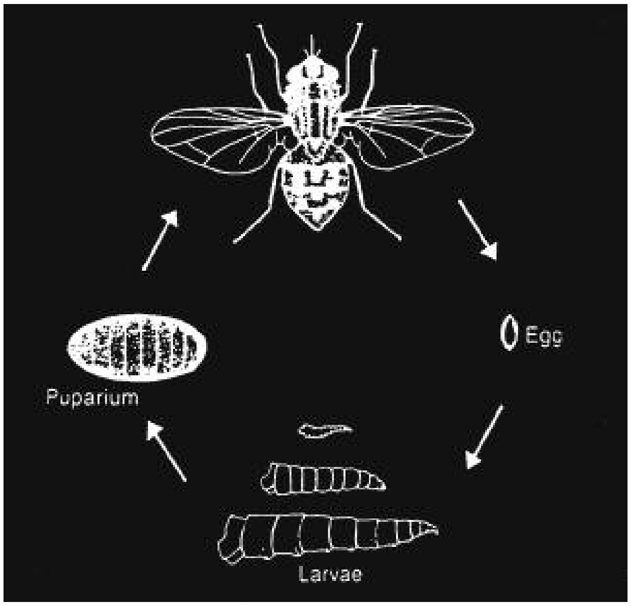
External parasites (Arthropods)

General life cycles

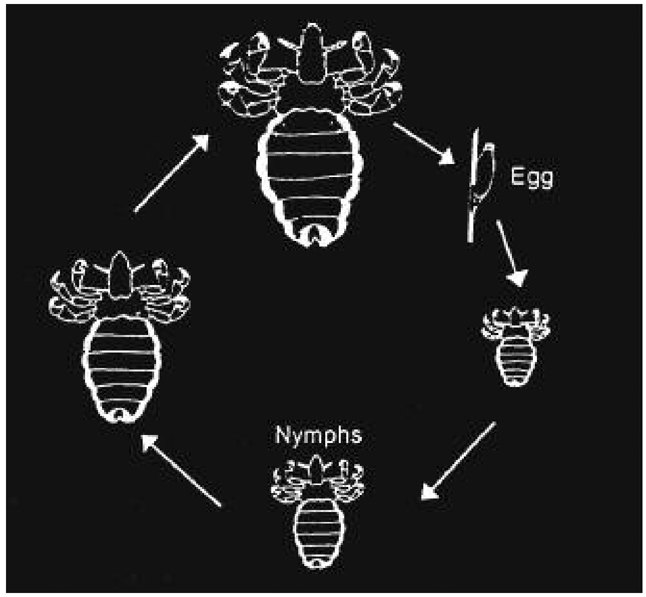
Life cycles of arthropods involve a series of structural changes known as metamorphoses, the actual sequence of which varies with different parasite groups. Complete metamorphosis begins when adults lay eggs from which larvae hatch (Figure 10A). The larval forms grow and shed their skins (moult) several times, each time to accommodate their increases in size. Larvae either may live freely or may be dependent on their hosts for obtaining nourishment. Eventually a hard-cased structure called a pupa is formed, which may have the capacity to survive winter. The pupa hatches into the adult parasite, the final stage of metamorphosis. Thus, there are four distinct stages in the life cycle: egg, larva, pupa, and adult. Incomplete metamorphosis involves a larva that grows and moults one or more times to become an adult-like form known as a nymph, which in turn grows and moults one or more times to become an adult (Figure 10B). In this case there are only three distinct stages, namely eggs, larvae, and immature adults (nymphs) that grow to maturity without further change in body type.

Figure 10. Life Cycle of Arthropods

A. Complete Metamorphosis



B. Incomplete Metamorphosis



Flies

There are a number of fly species which are primarily a nuisance, especially under confinement conditions. The fly season is April-October. The constant buzzing of nuisance flies is irritating and can result in reduced foraging that may lead to production losses. Blood loss due to large numbers of feeding mosquitos, as can be encountered in the southeast, may lead to anemia, unthriftiness, and weight loss/reduced gains. However, these fly problems are not all that common and control measures are usually not emphasized. There are many insecticides that can be used for control when necessary. Routine disposal of manure and organic materials will help control nuisance flies, and the local mosquito control program will help control mosquitos.

Lice and mites

These parasites are relatively permanent residents on the animal. Infestation (commonly called mange when mites are involved) may be seen as intense irritation with the animal scratching and chewing creating skin lesions that can become ugly. They thrive and reproduce during the cooler months (October-March) of the year. Transmission from animal to animal is by contact, so crowding should be avoided. Control can be accomplished by using appropriate insecticidal products at the onset of cooler conditions and as necessary thereafter.

Ticks

Ticks thrive on blood obtained from the host. They are subdivided into hard and soft ticks according to structural characteristics.

The bodies of hard ticks are roughly oval and pointed at the front. The anterior segment is a false head the structure of which may help to identify them. The structures on the head anchor the tick to the host's skin and facilitate blood feeding. The abdomen, flattened top and bottom, can expand to several times its original size as a tick feeds on its host. This phenomenon, referred to as engorgement, is seen only in females. The patterns of pigmentation on the top side of the tick also helps with identification. A further classification of hard ticks is made based on whether their life cycle involves one, two, or three hosts. Ticks have a life cycle incorporating incomplete metamorphosis. Adult ticks feed and mate on mammals. Engorged females drop to the ground and lay eggs. The eggs hatch, producing larvae, called seed ticks. The seed tick moults twice, passing through a nymphal stage before reaching maturity. A blood meal must be taken before each moult can occur. Ticks are classified as one-, two-, or three-host ticks, depending on how many times they drop off, moult, and seek a new animal. A one-host tick remains on the animal from the seed-tick stage to maturity. A two-host tick drops off the initial host to moult from larva to nymph. The nymph seeks a second animal for the final blood meal before final moult to adult. The three-host tick drops to the ground for each moult, after which a new host is sought.

Soft ticks differ from hard ticks in many respects. They have a leathery outer skin rather than a hard cuticle, and both males and females engorge when feeding on the host. Their shapes vary among species and their false head is located on the bottom side of the tick near its front so it is not pointed as in hard ticks. *Otobius megnini,* the spinose ear tick, is an example of a soft tick. Only larvae and nymphs of this species are parasitic and can cause swelling of the ear resulting in scratching and signs of disorientation. Adults live in hidden areas in the environment, such as within cracks in the wood of barns.

Insecticides recommended for other ectoparasites will control ticks. Dipping or high pressure sprays provide the best results. The spinose tick can be controlled by applying an insecticide directly into the ears.

Diagnostic Methods

In general, most external parasites can be collected with various equipments. For flying insects, nets and aspirators are used. For crawling insects/ticks, jars, traps, combs and forceps are used. For mites, skin scrapings are used. Most external parasites can be seen readily and identified using published descriptions and keys. However, the use of a microscope is usually necessary.

Sources of Information

Books

Bowman, D.D. and Georgi, J.R., 2002. Georgi's Parasitology for Veterinarians, 8th Ed., Elsevier Health Sciences Division, St. Louis, MO: 592pp.

Ensminger, M.E., 2002. Sheep and Goat Science, 6th Ed., Interstate Publishers, Inc., Danville, IL: 693 pp.

Harwood, R.F. and James, M.T., 1979. Entomology in Human and Animal Health, 7th Ed., Macmillan Publishing Co., Inc., New York, NY: 548 pp.

Web sites

Southern Consortium for Small Ruminant Parasite Control
www.SCSRPC.org
Langston University Goat Research
www2.luresext.edu/
Langston University Web-based Training and Certification Program for Meat Goat Producers
http://www2.luresext.edu/goats/training/qatoc.html
Maryland Small Ruminant Page
www.sheepandgoat.com
Internal Parasites of the Goat
www.imagecyte.com/parasites.html
Controlling Goat Parasite - Is it a Losing Battle?
www.sheepandgoat.com/articles/controlgoatparasites.html
Worms and Parasites
www.goatworld.com/articles/worms

Other

State and university agricultural extension offices, local veterinarians and veterinary school faculty, producer and scientific publications.

FAMACHA© and Smart Drenching

Suggestions for training sheep and goat producers in FAMACHA©
(2.5 Hours of lecture and 1.5 hours of hands on for 25-30 participants)

Phases
1. Explain the problem of haemonchosis (barber pole worm)
2. Explain the FAMACHA© system
3. Demonstrate the technique using live sheep or goats
4. Allow participants to make their own evaluations under supervision

1. Explain the problem
Veterinarians/Extension personnel will use background information as supplied in the presentation to supplement and reinforce information given in the FAMACHA© information guide. While the exact format used is up to the trainer, it is suggested that program covers at least the following:
- Worms in general and their effects
- *Haemonchus* as the biggest problem
- Explain its bloodsucking nature and how this leads to anemia
- Explain what anemia is and how it is measured
- Explain how it can be seen in mucous membranes
- Mention other causes of anemia
- The importance of an integrated worm management program that includes monitoring fecal egg counts (remember there are other GI nematodes besides *Haemonchus*)
- Explain the aggregated nature of worm infections where a small percent of the animals harbor most of the worms
- Explain the problem of resistance to anthelmintics

2. Explain the FAMCHA© card
- Explain the design and use of the card and be sure that everyone understands
- Be prepared to repeat something not properly understood
- Be sure that participants all know what they should do
    - Emphasize advantages and problems
- Provide precautions that must be taken when using the system

3. Demonstration of use
- Take participants to a number of sheep or goats and show them what has been discussec
- Make sure they understand the proper way to examine the eye
- Allow time for questions
- Don't be afraid of repetition

4. Supervised evaluation
- Allow participants to evaluate sheep/goats on their own
- Correct where necessary
- Try to have animals at all categories of anemia (at least 1 – 4)
- Issue certificate to successful participants

FAMACHA WORKSHOP DATA SHEET

Trainee Names:____

Pen Number	Animal ID	FAMACHA Score
1		
1		
1		
1		
2		
2		
2		
2		
3		
3		
3		
3		

Pen Number	Animal ID	FAMACHA Score
4		
4		
4		
4		
5		
5		
5		
5		
6		
6		
6		
6		

Comments:____

FAMACHA©
Information Guide

Originally compiled by the Faculty of Veterinary Science, University of Pretoria, the Onderstepoort Veterinary Institute, the Worm Workshop of the South African Veterinary Association, and Intervet South Africa, with the support of the Food and Agriculture Organization of the United Nations, the National Wool Growers' Association and the National and Provincial Departments of Agriculture in South Africa.

Modified by Dr. Ray M. Kaplan and Dr. James E. Miller within the framework of USDA SARE grant # LS02-143 to address use of FAMACHA© in the United States

IMPORTANT NOTE FOR ALL USERS OF FAMACHA©:

- To properly implement FAMACHA©, it is essential for all users to: (1) obtain practical hands-on instruction in the use of FAMACHA©; (2) be sure they understand the information supplied; and (3) read and carefully follow all the instructions in this guide.

WARNING:

- As this Information Guide is used in circumstances outside the compilers' and distributors' control, users must undertake to use it at their own risk. The compilers and distributors, and/or any of their employees do not accept liability for any damage or loss suffered by any person as a result of or arising from the use of this guide.

WHY THE FAMACHA© SYSTEM WAS DEVELOPED:

- *Haemonchus contortus* (barber's pole worm) is usually the biggest disease problem of sheep and goats throughout the warm regions of the world, particularly in the subtropical and tropical areas. Major production losses and deaths can arise where the worm is not adequately controlled.
- Due to overuse of dewormers over many years, resistance to these dewormers is an ever increasing problem. On many farms in many countries, there is resistance to all the groups of deworming drugs and the viability of sheep and goat farming is threatened. No one can rely on the excessive use of drugs alone to control this parasite in the future.
- While most sheep and goats (especially the adults) are able to withstand the unfavorable effects of *Haemonchus*, a small minority cannot. In the past, treatment strategies were designed for the minority of animals that did not have the ability to withstand infection.
- Selectively deworming only those animals that require treatment greatly decreases the development of resistance because the eggs produced by the few resistant worms that survive treatment will be greatly diluted by all the eggs produced by the animals that did not receive treatment. In contrast, where all animals are treated and moved to parasite-"safe", or "clean" pasture, only resistant worms that survive treatment will produce all the eggs that form the next generation of worms.
- Both resistance (the ability to prevent or suppress infection) and resilience (the ability to withstand the effects of parasites) have been shown to be moderately heritable. This means that sheep and goats can be either culled or selected for these traits.
- Once sheep and goats that are unable to cope with existing worm challenge infections are identified, they can be targeted for special attention without the whole herd or flock having to be treated. In the long term, by culling animals that are repeatedly identified as unable to cope with moderate worm burdens, a more resistant and resilient flock, genetically suited to the environment can be bred.

CLINICAL DIAGNOSIS OF ANEMIA: PRINCIPLE ON WHICH FAMACHA© IS BASED:

Blood consists of a clear, fluid part (called plasma) and a cellular part (mainly red blood cells). The proportion of red cells to plasma determines whether the animal is healthy or unhealthy. This proportion can be measured in a laboratory (called PCV or hematocrit), but with training and practice can also be estimated fairly accurately by assessing the color of the mucous membranes of (especially) the eyes. As *Haemonchus* are blood suckers, the effects of a heavy parasite burden in non-resilient animal will therefore be evident as a low ratio of red cells to plasma. This is seen in the mucous membranes of the eyes as a visible paleness generally known as anemia. By monitoring anemia, resilient and susceptible animals can be identified.

USES AND ADVANTAGES:

- **A significant drop in the amount and frequency of deworming can be expected for the majority of the herd or flock, which will reduce the amount of money spent on drugs.**
- **Because fewer animals are treated, the development of resistance in worm populations will be slowed down.**
- **In the long term, elimination of non-resilient animals will allow for the breeding of better adapted animals.**
- **There will probably only be a small to moderate number of sheep or goats that need to be treated at each examination.**
- **These animals can be treated before the symptoms and effects of anemia become too severe, if the flock is examined regularly.**
- **Individual animals that repeatedly fail to cope with *Haemonchus* in spite of an effectively designed control program can be identified and eliminated from the herd or flock.**
- **Animals that escaped treatment or were underdosed or improperly drenched (e.g. owing to faulty drenching syringe), can be identified before severe problems occur.**
- **If an ineffective dewormer for *Haemonchus* is used, this will become apparent because many anemic sheep are seen after treatment. However, if an effective dewormer is used, pale mucous membranes should become noticeably redder in color within a week or so, provided protein intake is sufficient and body condition is adequate.**
- **If there is a severe build-up of infective larvae on the pasture, an early warning of the impending danger can be a sudden increase in the number of anemic animals.**
- **Paddocks, pens, and pastures that repeatedly present problems can be identified and appropriate action taken.**
- **The process of inspecting the eyes is quick and can readily be integrated with other activities like vaccination, weighing, condition scoring or counting. In South Africa it is reported that up to 500 sheep can be inspected per hour with good facilities and practice.**
- **Because animals are examined frequently, other unrelated problems are quickly discovered.**
- **The technique is very easy and sufficiently reliable once learned under the guidance of a competent instructor.**
- **Animals become tamer and easier to handle.**

PRECAUTIONS AND POTENTIAL PROBLEMS:

- **The FAMACHA® system should be used only after it has been fully explained and demonstrated by properly trained instructors.**
- **Only *Haemonchus* infection can be monitored by this technique.**

- **FAMACHA© is only a component of a good management program for *Haemonchus* and cannot be used on its own. A good, integrated control program using smart drenching principles must still be used.**
- **Other worms can also be important. *Trichostrongylus* (bankruptworm) is found in sheep and goats throughout the US and *Teladorsagia* (brown stomach worm) is common in the northern parts of the US. A program for controlling these and other worms may be needed as well. If either of these worms are the primary problem and *Haemonchus* is only present in low to moderate numbers, then FAMACHA© may fail to provide a sound basis for treatment decisions.**
- **Herd or flock fecal egg counts should be monitored on a periodic basis.**
- **Animals should be monitored regularly (at least every 2-3 weeks during the *Haemonchus* transmission season, and possibly as often as weekly at the peak of the worm season).**
- **Animals should always be scored with the help of the chart, not from memory.**
- **Kids/lambs and pregnant or lactating does/ewes are more susceptible and need special attention.**
- ***Haemonchus* is by far the most important cause of anemia in goats and sheep; however, there are other causes of anemia that could cause confusion. Some examples are:**
    - **Hookworms (very uncommon in the US)**
    - **Liver fluke (most likely only a problem in the Gulf Coast and Northwestern States)**
    - **External parasites**
    - **Blood parasites (very uncommon in the US)**
    - **Bacterial and viral infections**
    - **Nutritional deficiencies**
- **On the other hand, certain conditions can make the eye's membranes appear redder than expected and thus mask the presence of anemia. Some examples are:**
    - **Hot and/or dusty conditions which irritate the eyes**
    - **Driving animals a long distance with no rest period afterwards**
    - **Any fever**
    - **Infectious eye diseases**
    - **Diseases associated with blood circulatory failure**
- **With FAMACHA©, animals are allowed to become anemic prior to being treated. Therefore, *it is critical to use an effective dewormer*. Drug resistance to all available dewormers is becoming quite common. <u>Therefore, testing to determine which drugs are effective against the worms on your farm should be done before applying the FAMACHA© system.</u>**
    - **Available tests for resistance include the fecal egg count reduction test which is performed on the farm by your veterinarian, and the DrenchRite© test, which is performed in a laboratory from a fresh fecal sample that is mailed to the lab.**
- **Protect the card from light when not in use and replace the card after 1 year of use.**

PRACTICAL USE OF THE FAMACHA© SYSTEM:

- **Beginning in spring or several weeks prior to lambing/kidding, examination of the herd or flock using FAMACHA© should be made every 2-3 weeks by properly trained persons.**
- **During high worm transmission periods (warm wet weather), it may be necessary to monitor the flock more often, even on a weekly basis.**
- **The FAMACHA© guide should always be used on inspections. Do not rely on memory from previous examinations.**

- Treatment can be safely withheld from adult animals until they score as 4s or 5s provided that animals are in good body condition and good overall general health, are examined frequently (e.g., every 2-3 weeks) and good husbandry is used to identify animals in need of treatment (e.g., unthrifty, lagging behind, bottle jaw) between FAMACHA© examinations. It is advisable to treat animals scored as 3s if any of these conditions are not met.
- Lambs and kids have comparatively small blood volumes and can progress rapidly from moderate to severe anemia. Ewes and does have decreased immunity to worms starting approximately 2 weeks before lambing/kidding and extending through the lactation period (called periparturient period). These animals should always be treated if scored as 3s.
- If 5-10% or more of the herd or flock is found to be anemic (categories 4 and 5) at any examination, it may be advisable to dose all animals scored in categories 3-5 and change pastures if available. Animals scored as 3 should also be treated when potential outbreaks of disease from *Haemonchus* are expected. Such periods of significant *Haemonchus* challenge appear to be heralded by a rapid downward trend in the number of 1s and a reciprocal increase in the number of 2s and 3s. Consult your veterinarian if in doubt.
- The essential decision to be taken at each examination is which animals are to be treated, and which are not. Assignment to precise categories is less important. It is better to err on the side of treatment if you are unsure.
- All animals treated with dewormer should be marked or identified in some permanent way (ear tags, ear marks, notches, cable ties, etc.) unless individual animal records are kept. It is recommended that animals permanently marked should also be given a temporary mark so that the same animal is not unfairly marked permanently at the next examination.
- Animals needing two doses more than the herd or flock's average could be considered for culling, while those needing three or more extra doses should definitely be culled.
- The proportions of the flock in each category (from 1 to 5) can easily be recorded by counting off each animal in the FAMACHA® block histogram (anemia score sheet) provided.
- If the herd or flock is very large, a random sample of 50 animals can be checked. If the combined percentage of categories 1 and 2 exceeds 80% (preferably 90%) and there are no category 4 and 5 sheep in the sample, it is unlikely that there is danger in not checking the whole flock. However, if any sheep are scored as 4 or 5, or the 3 category exceeds 10 – 20%, it would be safer to examine all the animals.
- Examine especially those animals that lag behind the herd or flock whether or not it is time for a scheduled FAMACHA® examination. These late-comers may be suffering from the effects of anemia.
- Always check animals for "bottle jaw" (presence of a soft swelling under the jaw). All animals with bottle jaw, whether they appear anemic or not, must be treated.

Inquiries and Orders:

US ONLY	INTERNATIONAL
Dr. Ray M. Kaplan	Prof Gareth Bath
University of Georgia, College of Veterinary Medicine	South Africa
famacha@vet.uga.edu	gareth.bath@up.ac.za
(706) 542- 0742	

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FAMACHA ANEMIA RECORD

Group ID:________________________

Category	1	2	3	4	5	Totals 1	Totals 2	Totals 3	Totals 4	Totals 5
Date: Treatment:										
						1	2	3	4	5
Date: Treatment:										
						1	2	3	4	5
Date: Treatment:										
						1	2	3	4	5
Date: Treatment:										
						1	2	3	4	5
Date: Treatment:										

● Counted   Counted and Treated   × Bottle Jaw - Treated

Ray M. Kaplan, DVM, PhD   FAMACHA Anemia Record   5/30/03

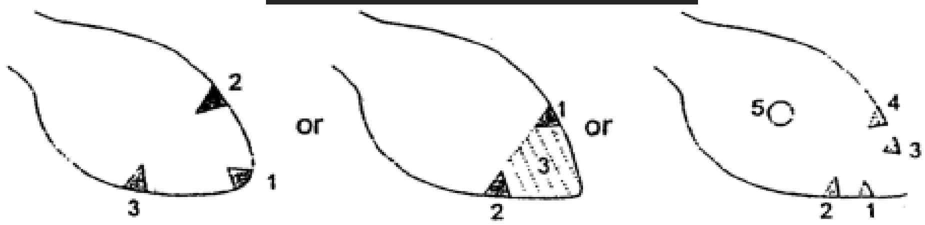
FAMACHA ANEMIA RECORD

Group ID:

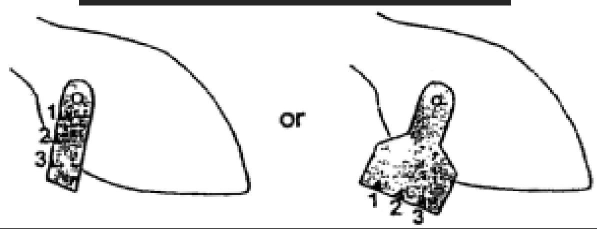
	FAMACHA SCORES					TOTALS				
Category	1	2	3	4	5	1	2	3	4	5
Date										
Treatment										
Date										
Treatment										
Date										
Treatment										

Possible methods of marking sheep that have been treated

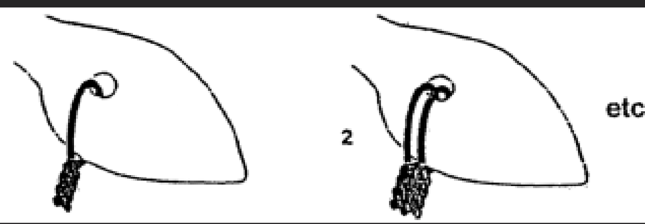
1. Ear notches



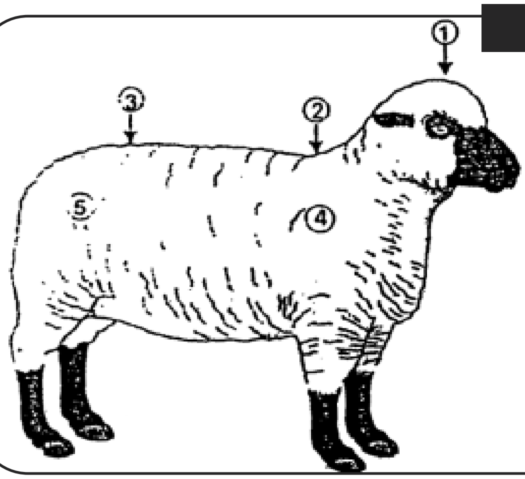
2. Ear tags



3. Colored wire loops (insulated electrical wire)

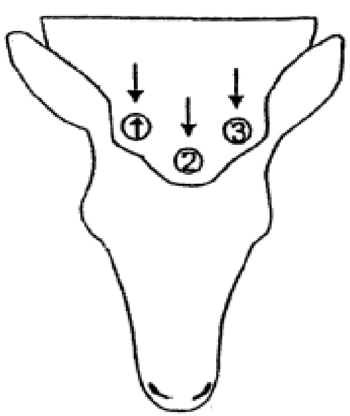


4. Wool "paint" (markers)

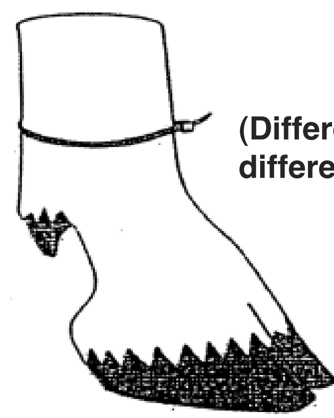


Use commercial products or make your own: Buy cement coloring powder from a hardware store (different colors are available: and mix with grease or margarine to make a thick paste.

5. Wool clipping (for long-wool sheep)



6. Cable ties



(Different colors & different legs)

CERTIFICATE OF COMPETENCE: FAMACHA© ANEMIA GUIDE

It Is Hereby Certified That

____

Of

____

Has successfully completed a course in the use of the FAMACHA© Anemia Guide to assist with the control of *Haemonchus contortus* (barber pole worm) in sheep and goats.

______________________________ ______________

Veterinarian Date

FAMACHA© is distributed in the United States by Dr. Ray Kaplan under the auspices of the Southern Consortium for Small Ruminant Parasite Control (www.SCSRPC.org).

Open letter to sheep and goat producers regarding the FAMACHA© program:

Thank you for your interest in finding out more about the FAMACHA© system for control of *Haemonchus contortus* (barber pole worm). FAMACHA© provides a tool to identify anemic animals, thus reducing the number of dewormer treatments given, while also maintaining good overall parasite control. This will significantly slow the development of resistance to dewormers which is becoming an extremely important concern in small ruminant production.

Recent evidence suggests that the most important factor affecting the rate of development of drug resistance is the proportion of drug-treated worms to untreated worms in a worm population. The untreated portion of the population, referred to as refugia, provide a pool of genes sensitive to dewormers, thus diluting the frequency of resistant genes. At the moment of treatment, refugia consist of all the worm eggs and larvae already on pasture and all the worms (and future eggs and larvae) in the animals that were not treated. Parasitologists now believe that the most important factor responsible for the widespread development of dewormer resistance is the common practice of treating all animals in a herd at one time. This practice leaves no worms in refugia; the only eggs deposited onto the pasture for several weeks following treatment are from those worms that survived treatment. We know that worm burdens are not evenly distributed in animal populations; 20-30% of the animals harbor about 70-80% of the worms. These 20-30% are primarily responsible for contaminating the environment with infective parasite larvae for all the other animals. If farmers could identify and treat only those animals that truly needed treatment with dewormer, they would save money by reducing the number of treatments given on a herd basis and greatly reduce the selection for resistance by maintaining a large refugia. Additionally, identification and culling of animals requiring repeated treatments could be used as a tool to improve the overall genetic resistance of the herd. The major problem preventing implementation of selective treatment for *H. contortus* has been lack of a simple and reliable field test for anemia.

Recently, a clinical on-farm system, called FAMACHA©, was developed in South Africa for classifying animals into categories based upon level of anemia. Since anemia is the primary pathologic effect from infection with *H. contortus*, this system can be an effective tool for identifying those animals that require treatment (but only for *H. contortus*). To use FAMACHA©, the color of ocular mucus membranes are observed and compared to a laminated card which has colored illustrations of eyes from sheep at different levels of anemia. The scale goes from 1 (mucous membranes are red) to 5 (mucous membranes are white); all animals are examined at regular intervals and only animals scored as being anemic are treated. In evaluation trials in South Africa, use of FAMACHA© reduced the number of dewormer treatments given by up to 90% as compared to previous years. This system has recently been validated in the US by my colleagues in the Southern Consortium for Small Ruminant Parasite Control (SCSRPC) and myself as part of our "Novel methods for sustainable control of gastrointestinal nematodes in small ruminants" project funded by USDA-SARE (Sustainable Agriculture Research and Education).

FAMACHA© is distributed under the auspices of the South African Veterinary Association. Professor GF Bath (project coordinator for FAMACHA© in South Africa) has requested that distribution in the US be made only through the SCSRPC via the laboratory of Dr. Kaplan (University of Georgia) and that FAMACHA© cards are only to be sold directly to veterinarians or other trained animal health professionals. These individuals are expected to provide training in the proper use of the FAMACHA© system prior to re-selling the cards. The exception to this will be when sheep or goat producers attend a formal FAMACHA© training workshop. This restriction in distribution is required by the agreement that we have with Professor Bath in South Africa. Extensive experience in South Africa and our recent personal experiences in training sheep/goat producers reveal that although the system seems simple, without adequate training most lay individuals lack the necessary knowledge to properly implement the system. Failure to understand the limitations and potential problems with the system combined with the problem of drug resistance may lead to improper implementation. This could result in disappointing results and animal death. Such an outcome will have the effect of giving FAMACHA© an unwarranted bad reputation.

As a result, it is recommended that FAMACHA© only be used after proper instruction is given and when veterinary support is available. Therefore, sheep and goat producers will need to work with a veterinarian or other animal health professional in order to acquire a FAMACHA© card unless they attend a training workshop. Those producers that do not have a veterinarian in their area who is willing to work with them on parasite control issues will need to find an extension agent or animal scientist who is willing to take on this role, or participate in a training workshop if they wish to obtain a FAMACHA© card.

Veterinarians and other animal health professionals trained in the proper use of FAMACHA© who purchase FAMACHA© cards will be required to sign a document stating that they understand that they have an obligation to train their clients/trainees in the proper use of the FAMACHA© system prior to re-selling the cards. If you are interested in learning more about FAMACHA, please see the SCSRPC website at www.scsrpc.org or have your veterinarian or extension agent send an email request for more information to: famacha@vet.uga.edu Veterinarians can purchase FAMACHA© cards by making requests using this same address.

Sincerely,

Dr. Ray M. Kaplan
University of Georgia
College of Veterinary Medicine

Producer Resources

- **Managing Internal Parasites in Sheep and Goats**
- **Sheep 201 – Internal Parasite Control**
- **Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles**
- **Tools for Managing Internal Parasites in Small Ruminants: *Sericea Lespedeza***
- **Parasite Management Principles**

Managing Internal Parasites in Sheep and Goats

A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Margo Hale
NCAT Agriculture Specialist
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Internal parasite management, especially of *Haemonchus contortus* (barberpole worm, stomach worm), is a primary concern for the majority of sheep and goat producers. These parasites have become more difficult to manage because of developed resistance to nearly all available dewormers. This publication discusses new techniques to manage parasites and to prolong the efficacy of dewormers. New management tools that remain under investigation are also discussed. A list of resources follows the narrative.

Contents

Owners of this Katahdin ewe and her lambs are able to manage internal parasites using sustainable techniques. NCAT photo by Margo Hale.

Introduction

The management of internal parasites, primarily *Haemonchus contortus* (barberpole worm), is considered by many to be the biggest production concern for small ruminants. "There are many important diseases of sheep and goats," notes University of Georgia researcher Ray Kaplan, DVM, PhD, "but none are as ubiquitous or present as direct a threat to the health of goats as internal parasites." (Kaplan, 2004a). The cost of internal parasite infection includes treatment expense, reduced animal weight gains, and even animal death.

These parasites are difficult to manage because on some farms they have developed resistance to all available commercial dewormers. (Zajac, Gipson, 2000) Resistance to dewormers is now seen worldwide (Kaplan, 2004b). Producers can no longer rely on drugs alone to control internal parasites. Rather, an integrated approach that relies on sustainable methods to manage internal parasites should be employed.

ATTRA—National Sustainable Agriculture Information Service is managed by the National Center for Appropriate Technology (NCAT) and is funded under a grant from the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT Web site (www.ncat.org/agri.html) for more information on our sustainable agriculture projects.

Most animals in a flock are not visibly affected by parasites and do not need to be treated with dewormers. Photo by Linda Coffey.

Parasite Primer

Internal parasites (worms) exist by feeding off of their host. Some types do this directly, by attaching to the wall of the digestive system and feeding on the host's blood. These types of parasites cause anemia in the host, as well as other symptoms. Haemonchus contortus (barberpole worm) is one example of this type. Others live off the nutrients eaten by the host; these cause weight loss but not anemia.

Mature parasites breed inside the host and "lay eggs," which pass through the host and are shed in the feces. After the eggs pass out of the host, they hatch into larvae. Warm, humid conditions encourage hatching. The larvae need moisture to develop and move. They migrate out of the feces and up blades of grass (usually 1 to 2 inches). When an animal (sheep or goat) grazes, they may take in parasite larvae along with the grass blade. An animal can also pick up parasite larvae by eating from a feed trough that is contaminated by manure.

Parasite numbers increase over time when conditions are favorable (warm, wet). Internal parasites get out of control and cause damage when their numbers grow beyond what the animal can tolerate. In order to manage internal parasites, it is important to understand the parasite cycle and factors that encourage their production.

Internal parasite numbers:

- Increase with number of host animals
- Increase during warm, humid weather
- Increase when pastures are grazed too short
- Decrease during hot, dry weather
- Decrease if a non-host animal (cattle or horses) graze the same pasture
- Decrease with pasture rest time, as the larvae naturally die off

Parasitism

Animals raised in confinement or on pasture-based systems will almost certainly be exposed to internal parasites at some point in their lives. Dry environments, such as arid rangelands, will pose less of a threat for parasite infections. Warm, humid climates are ideal for worms, and therefore animals will have more problems with internal parasites in these climates.

Sheep and goats should be managed so that parasitism is not evident. Sheep and goats will always host some level of parasite burden. Certain signs of parasitism are seen when the parasite load becomes excessive or when the animal's immunity can no longer overcome the adverse effects of the parasitism. (Scarfe, 1993) Young animals and those with weakened immune systems due to other diseases are most affected by internal parasitism. A combination of treatment and management is necessary to control parasitism so that it will not cause economic loss to the producer. (Scarfe, 1993)

While it is ideal to manage animals so there are no visible effects of parasitism, some will nonetheless succumb to the burden of internal parasites. Learn to recognize the signs of internal parasite infections and offer early treatment.

Due to lowered immunity, young stock and pregnant or lactating animals are more likely to be affected by internal parasites. Photo by Linda Coffey.

Loss of condition and rough hair coat indicate parasitism.
Photo courtesy of Jean-Marie Luginbuhl.

Bottle jaw is a sign of parasitism.
Photo courtesy of Jean-Marie Luginbuhl.

Signs of Parasitism

- Loss of condition
- Rough hair coat
- Scours, diarrhea
- Bottle jaw
- Pale mucous membranes (eyelids, gums), indicating anemia
- Death

Resistance to Dewormers

Producers were once instructed to deworm all of their animals every three to six months. Many producers dewormed even more often, as often as every four weeks in humid climates. It is now known that this practice is not sustainable.

Drug resistance is the ability of worms in a population to survive drug treatments that are generally effective against the same species and stage of infection at the same dose rate. (Kaplan, 2004b) Over-use of dewormers has led to resistance, and available dewormers are now ineffective. In an article from 1993, David Scarfe predicted the development of drug resistance.

> Suppressive deworming is probably the most effective means of keeping parasite numbers lowered for a period of time. However, this method will also eventually lead to resistance to the anthelminthics(s) used much more rapidly than if other strategies of control are utilized. One point to consider here is alternating the use of different drugs.
>
> It is considered by this author, and several expert parasitologists, that rapid rotation of different drugs is ill-advised as this will lead to resistance of multiple drugs – something that the small ruminant industries certainly do not need. (Scarfe, 1993)

Scarfe recognized the unsustainable practices that were being used long before parasites were resistant to dewormers in the U.S.

Some farms still have dewormers that continue to work, while others have no effective dewormers. This is a problem because no new dewormersc for sheep and goats are currently under development. (Kaplan, 2004b)

Development of Resistance to Dewormers

Internal parasites, especially *H. contortus*, have developed drug resistance. Drug treatment gets rid of the worms that are susceptible to that particular drug; resistant parasites survive and pass on "resistant" genes.

Overview of Available Dewormers for Sheep and Goats

Several types of dewormers are available for use in sheep and goats. Many are not approved for use in sheep and goats, however, so work with a veterinarian to ensure proper "off-label" use. The different classes of dewormers have different modes to kill worms. The level of resistance depends on the class of dewormer and how often the drug was used on a particular farm.

Drug Class	Common Names/ Brands	Effectiveness
Benzimidazoles	Albendazole (Valbazen®), Fenbendazole (Safeguard®)	High prevalence of resistance
Avermectin/ Milbemycins	Ivermectin (Ivomec®) Moxidectin (Cydectin®)	Ivermectin— least effective of all available drugs Moxidectin—resistance becoming common where used frequently
Imidazothiazoles/ Tetrahydropyrimidine	Levamisole (Tramisol®), Pyrantel (Strongid®), Morantel (Rumatel®)	Low to moderate prevalence of resistance

Worms that are not treated are called "refugia." The concept of refugia has been largely overlooked in the past. Having some worms in refugia (not treated) insures that a level of genes remain sensitive to dewormers. (Kaplan, n.d.) A surviving population of untreated worms dilutes the frequency of resistant genes. Consequently, when a dewormer is required, it will be effective because the worms will be susceptible to treatment. (Kaplan, n.d.)

When fewer numbers of animals receive treatment, the refugia population remains large. The more refugia, the better. Sustainable techniques, such as FAMACHA®, fight drug resistance by increasing refugia.

In contrast, several practices accelerate drug resistance. They include frequent deworming (more than three times a year), underdosing (often caused by miscalculation of body weight), treating and moving to clean pasture, and treating all animals, regardless of need. These practices lead to resistance because they decrease the number of worms susceptible to dewormers (refugia).

Since no dewormer is 100 percent effective 100 percent of the time, worms that survive a dose of dewormer are resistant to that dewormer. Frequent deworming increases the rate resistance develops.

Each time animals are dewormed, the susceptible worms are killed. The strong ones survive and lead to a population of very resistant worms. Underdosing causes larger numbers of stronger worms to survive. The weakest, most susceptible worms are killed. But because of the weak dose, more of the stronger worms will be able to survive and reproduce, creating a population of stronger worms. Once an animal has been treated, only resistant worms remain. If the animals are moved to a clean pasture they deposit only resistant worms on the pasture. There are no susceptible worms to dilute the worm population. Treating all animals regardless of need ignores the importance of refugia and will lead, in time, to a population of worms unkillable by dewormers.

Pasture Management

Numerous techniques can be used to control parasitism. Pasture management should be a primary tool to control internal parasites. Sheep and goats ingest infective parasite larvae from pasture. The rate at which they are ingested can be controlled through pasture management.

Related ATTRA Publications

Integrated Parasite Management for Livestock

Goats: Sustainable Production Overview

Meat Goats: Sustainable Production

Dairy Goats: Sustainable Production

Sustainable Sheep Production

Dairy Sheep

Small Ruminant Sustainability Checksheet

Eating higher off the ground reduces the number of parasite larvae consumed. Photo by Margo Hale.

Most worm larvae crawl up the plant only one to two inches from the ground. Preventing animals from grazing below that point decreases the number of worm larvae ingested. Animals that eat closer to the ground tend to have more problems with internal parasites. It is important to monitor animals and the pasture. Allowing animals to graze pastures too short results in more parasites consumed and reduced feed intake, therefore harming the animal in two ways. It also inhibits pasture regrowth.

Larvae migrate no more than 12 inches from a manure pile. Livestock not forced to eat close to their own manure will consume fewer larvae. Providing areas where animals can browse (eat brush, small trees, etc.) and eat higher off of the ground helps to control parasite problems.

Decreasing the stocking rate decreases the number of worms spread on a pasture. The more animals you have on one pasture, the more densely the worms are deposited. Animals on densely stocked pastures are more likely to have parasite problems. Grazing sheep and goats with cattle, or in a rotation with cattle, can also reduce internal parasite problems. Cattle do not share the same internal parasites as sheep and goats. Cattle consume sheep and goat parasite larvae, which helps "clean" the pasture for the small ruminants.

Sheep grazing at Maple Gorge Farm in Prairie Grove, Arkansas. Photo by Margo Hale.

Certain forages have also been shown to control parasite problems. Tannin-rich forages, such as sericea lespedeza, have been shown to help reduce internal parasite egg counts. (Min and Hart, 2003; Shaik et al., 2004) Other plants, including plantain, chicory, and wormwood, also have an anthelmintic effect, although wormwood also produces toxic compounds. Providing tannin-rich forages and diverse pastures can help animals battle internal parasites.

High levels of tannins in forages such as sericea lespedeza reduce worm burdens. Photo courtesy of Jean-Marie Luginbuhl.

New Techniques

FAMACHA©

FAMACHA© is a system for classifying animals into categories based upon level of anemia. (Kaplan, n.d.) It was developed in South Africa and has been validated in the U.S. (Kaplan et al, 2004)

This system identifies anemic animals on a 1 to 5 scale by examining the eyelids of sheep and goats (see photo next page). The system treats only animals that are anemic (a sign of parasitism). This reduces the use of dewormers, slows the development of resistant worms, and saves the producer money. Most importantly, it also allows the producer to select animals that are healthier. By breeding the healthiest animals and culling the weaker individuals, the flock or herd becomes stronger over time. FAMACHA© is only effective for

FAMACHA© System Saves Money and Reduces Stress

On Maple Gorge Farm, in Prairie Grove, Arkansas, busy schedules prevented the farmers from monitoring parasites. By late summer, the sheep had been grazing for months with no treatment. The farmers noticed a young lamb with bottle jaw and feared they had a huge problem on their hands.

They considered not bringing the animals in for treatment because they were low on dewormer. They knew they wouldn't have enough to treat all of the animals. Then they remembered the FAMACHA© system that they had recently been trained in. Using the FAMACHA© system, they decided to sort off, identify and treat only the 4s and 5s (anemic animals), and a few 3s that were thin.

To their surprise, only 9 of the 65 sheep actually needed treatment. Identification numbers and FAMACHA© scores were recorded. They decided any ewe scoring a 4 or 5 would not be kept in the flock.

This whole process took less than an hour. Treating only the animals in need reduced stress for the animals and farmers, and also saved money. After using the FAMACHA© system and seeing how easy it was and the impact it had on their flock, the farmers at Maple Gorge Farm are believers in the system.

Demonstration of the FAMACHA© technique. Photo by Margo Hale.

the treatment of *H. contortus*. Producers must be trained by a veterinarian or other trained animal health professional in order to use FAMACHA©. (Kaplan, n.d.) However, this technique is simple to learn and quick and easy to use. For more information on FAMACHA©, see *Other Resources*, page 8.

Other Techniques

Selecting Resistant Animals

Several other techniques can be used to help manage internal parasites. There are several breeds of sheep and goats that show resistance to parasites. There is something in their genetic makeup that causes them to host a smaller parasite load. Breeds such as Gulf Coast Native, St. Croix, Katahdin, and Barbados Blackbelly show an increased resistance to parasite loads. Spanish, Myotonic, and Kiko goat breeds have also shown a tolerance to parasites. Resistance will vary within breeds as well. Some animals, regardless of breed, will be more resistant to parasites than others. Having parasite-resistant animals will decrease the need for dewormers.

Sheep breeds such as Gulf Coast Native show resistance to parasites. Photo by Linda Coffey.

Within any breed, certain animals are more tolerant of parasite loads than others. These resilient animals can host a large parasite burden, yet show few signs of parasitism. Some animals will carry a heavier parasite load than others. Research shows that 20 to 30 percent of the animals carry 70 to 80 percent of the worms. (Kaplan, n.d.) Producers should cull animals that are always "wormy," and select for animals that have a natural resistance or tolerance to a slight parasite burden. The FAMACHA© system will help you identify those more tolerant animals.

Copper Wire Particles

Recent research has been performed on the use of copper wire particles to control internal parasites. Studies show that copper wire particle boluses administered to lambs decrease parasite loads. (Burke et al., 2004) However, higher doses may increase the risk for copper toxicity in sheep. Copper wire particle treatments do not appear to be effective in mature sheep (Burke et al., 2005), but may work in mature goats. (Chartier et al., 2000)

Smart Drenching

Smart Drenching refers to the ways producers can use dewormers (drenches) more selectively and effectively.
—Southern Consortium for Small Ruminant Parasite Control, SCSRPC, n.d.

Used in conjunction with FAMACHA©, Smart Drenching helps slow the development of parasite resistance. The components of Smart Drenching are:

1. Find out which dewormers work by performing a fecal egg count reduction test or a DrenchRite larval developmental assay.

2. Weigh each animal prior to deworming. Double the cattle/sheep dose when deworming goats for all dewormers, except Levamisole, which should be dosed at 1.5 times the cattle/sheep dose in goats.

3. Deliver the dewormer over the tongue in the back of the throat with a drench tip or drench gun.

4. Withhold feed 12 to 24 hours prior to drenching with benzimidazoles, ivermectin, doramectrin, and Moxidectin, if possible.

5. Benzimidazole efficacy is greatly enhanced by repeating the drench 12 hours after the first dose. Albendazole should not be used during early pregnancy (during buck/ram exposure and up to 30 days after their removal).

6. Simultaneously use two classes of dewormers if resistance is suspected.

7. Drench only the animals that need treatment . (SCSRPC, n.d.)

Research is still underway on this technique, especially for long-term studies to determine the copper levels that are toxic to sheep.

Nematode-Trapping Fungus

Another tool currently being researched is the use of nematode-trapping fungus. This fungus traps parasite larva in the feces, interrupting its life cycle. Research has shown that it is "effective in significantly reducing development of L3 and appears to be an effective tool for biocontrol of parasitic nematodes in goats" (Terrill et al., 2004). The use of these fungi is still being researched.

Conclusion

Control of internal parasites in sheep and goats can be a daunting task. Previous control methods are no longer viable, so new techniques must be used Techniques such as increased pasture management, Smart Drenching, FAMACHA®, and selecting parasite-resistant animals can help to manage internal parasites. These techniques reduce dependence on dewormers and lead to a more sustainable parasite management program. New techniques, such as copper wire particles and nematode-trapping fungus, are being researched and developed. These developments may increase the tools available to battle internal parasites of small ruminants.

Resources

The following publications are available from ATTRA. These publications are free of cost. Copies can be requested by calling 800-346-9140 or at our website: *www.attra.ncat.org.*

- Goats: Sustainable Production Overview
- Meat Goats: Sustainable Production
- Dairy Goats: Sustainable Production
- Sustainable Sheep Production
- Dairy Sheep
- Small Ruminant Sustainability Checksheet
- Small Ruminant Resources
- Integrated Parasite Management for Livestock
- Predator Control for Sustainable and Organic Livestock Production
- Multispecies Grazing
- Matching Livestock and Forage Resources
- Rotational Grazing
- Pastures: Sustainable Management

Other Resources

Southern Consortium for Small Ruminant Parasite Control, *www.scsrpc.org*

Association of Small Ruminant Practitioners
1910 Lyda Avenue, Bowling Green, KY 42104-5809
Phone: 270-793-0781, *http://aasrp.org*

Management of Barber Pole Worm in Sheep and Goats in the Southern U.S.
www.attra.org/downloads/goat_barber_pole.pdf

Maryland Small Ruminant Page
www.sheepandgoat.com

FAMACHA® Information
www.vet.utk.edu/departments/LACS/pdf/FAMACHA.pdf
www.scsrpc.org/SCSPRC/FAMACHA/famacha.htm

Langston University, Oklahoma:

- E. (Kika) de la Garza Institute for Goat Research *www.luresext.edu/goats/index.htm*
- Information about Internal & External Parasites of Goats, *www.luresext.edu/goats/training/parasites.html*

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Managing Internal Parasites in Sheep and Goats
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Sheep 201
A Beginner's Guide to Raising Sheep

Internal Parasite Control

by Susan Schoenian

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In most sheep-raising areas, internal parasites (i.e. worms) are usually the primary disease affecting sheep and lambs. Sheep are more susceptible to internal parasites than most other types of farm livestock. Their small fecal pellets disintegrate very easily thus releasing the worm larvae onto pastures. They graze close to the soil surface and to their feces. They are slow to acquire immunity. It takes 10 to 12 months for most lambs to develop immunity to parasites. Sheep also suffer a loss of immunity at the time of lambing, which does not restore itself until approximately four weeks after lambing.

The primary causes of internal parasitism in sheep and lambs are overstocking of pasture and insufficient pasture rest periods.

Photo: British Virgin Islands

Heavy stocking rates and insufficient pasture rest periods further contribute to the incidence of parasitic disease in sheep and lambs. Internal parasites tend to be much less of a problem under range-type conditions where sheep do not graze the same pasture twice in the same grazing season. They are also less of a problem in arid regions, because parasites require moisture for their development.

In the past, sheep producers relied heavily on anti-parasitic drugs, called "anthelmintics" to control internal parasites in their flocks. But the long-time use and in some cases misuse of these drugs has resulted in parasites that have become increasingly resistant to anthelmintics. Drug resistance has been documented in all three drug families and is most commonly reported with ivermectin and the benzimidazoles. In the U.S., few anthelmintics are FDA-approved for use in sheep and lambs, and no new drugs are likely to be developed. As a result, producers must develop more integrated programs for controlling parasites, which do not rely exclusively on drug therapy.

The Parasites

Click HERE to see a table listing the Internal Parasites of Sheep.

Gastro-Intestinal Worms (roundworms, nematodes, stomach worms)

In warm, moist climates, the parasite that causes the most problems to sheep and lambs is usually *Haemonchus Contortis,* better known as the "barber pole" or wire worm. The barber pole worm is a blood-sucking parasite that pierces the lining of the abomasum (the sheep's fourth or "true" stomach), causing blood plasma and protein loss to the sheep. Females are identified as barber pole worms because their white ovaries are wound around their red blood-filled intestine. Male worms are red. The barber pole worm is the largest and most deadly stomach worm.

The symptom most commonly associated with barber pole worm infection is anemia, characterized by pale mucous membranes, especially in the lower eye lid; and "bottle jaw," an accumulation (or swelling) of fluid under the jaw. Infections with barber pole worm rarely result in diarrhea (scours). The other worm species are more likely to cause diarrhea. The barber pole worm is difficult to control because it has a short, direct life cycle and is a prolific egg producer. A female barber pole worm can produce 5,000 to 10,000 eggs per day. The barber pole worm is also capable of going into a "hypobiotic" or arrested state when environmental conditions are not conducive to its development and resuming its life cycle once environmental conditions improve. Some worm larvae are able to survive on pastures over the winter.

The stomach worms usually of secondary importance are *Trichostrongylus* spp. and *Ostertagia spp.* Their importance is usually as an additive effect in mixed infections with *haemonchus.* However, in warmer sub-tropical areas, *Trichostrongylus* spp. are important pathogens in grazing ruminants. *Ostertagia* appears to be much less important in the United States than in cooler parts of the world such as Northern Europe and the British Isles. In the southern United States, *Ostertagia circumcincta* is of no real significance in small ruminants because the hot and often dry summers are hostile to the survival of its pre-parasitic stages In the western U.S. particularly the cooler, wetter, coastal areas of Washington, Oregon and Northern California, *Ostertagia circumcincta* is the dominant nematode of sheep (and goats). *Nematodirus* is not usually a primary pathogen in ruminants in North America. However, *Nematodirus battus* does cause significant disease in lambs in Britain because of its unusual hatching requirements. *Cooperia* infections are usually secondary contributors to parasitic disease.

The barber pole worm causes anemia, as evidenced by pale mucous membranes (above) and "bottle jaw" (below).

Click ***HERE*** to view the *Stomach Worm Life Cycle.*

Tapeworms (*Moniezia* spp.)

Because tapeworm segments can be seen in sheep feces, they often cause alarm to producers. Experts disagree about the importance of effects of the parasite. Although dramatically large numbers of tapeworms may occupy the small intestine, damage to sheep is generally much less than that done by the gastrointestinal nematodes such as *Haemonchus* and *Ostertagia*. In extreme cases, tapeworms may cause intestinal blockages. There is some evidence that lamb growth rates may be affected when large numbers of tapeworms are present. Tapeworms have an indirect life cycle. They require pasture mites to complete their life cycle. Only certain anthelmintics (benzimidazoles) are effective against tapeworms.

Click HERE to view the *Tapeworm Life Cycle.*

Lungworms *(Dictyocaulus filaria, Muellerius capillaris)*

Wet, low-lying pastures and cool, damp weather favor the development of lungworm disease in sheep. Lungworm eggs are passed in the feces. After the eggs hatch and are ingested by the sheep, they travel through the sheep's tissues to the lungs (trachea and bronchi). Only in severe infestations do lungworms produce clinical disease, causing fever, coughing, nasal discharge, rapid breathing, and poor performance. Secondary infection by bacteria may cause death.

Click **HERE** to view the *Lungworm Life Cycle.*

Liver Flukes *(Fasciola hepatica)*

Liver flukes can cause death in sheep and lambs or liver damage in sub-acute cases. In the U.S., they are primarily a concern in California, the Gulf States and Pacific Northwest. Liver flukes require snails as an intermediate host. Two drugs are available in the United States for the treatment of liver flukes: Clorsulon and Albendazole.

Click **HERE** to view the *Liver Fluke Life Cycle.*
Click **HERE** to see a map showing the *Approximate Geographic Distribution of Sheep Liver Flukes in the U.S.*

Meningeal Worm *(Paralaphostrongylus tenius)*
The meningeal (deer or brain) worm is an internal parasite of white tailed deer. The life cycle of the meningeal worm requires terrestrial snails or slugs as intermediate hosts. Sheep are unnatural, dead-end hosts for the parasite. When sheep ingest snails containing infective larvae, the parasite moves into the brain and/or spinal cord causing often fatal neurological disease. The neurological signs observed in infected sheep depend upon the number of larvae present in the nervous tissue and the portion of the rain or spinal cord that has been affected. A mild infection may produce a slight limp or weakness in one or more legs, while a more severe infection may cause an animal to be partially or completely paralyzed.

Meningeal worm infection cannot be diagnosed in the live animal. Treatment usually involves high, repetitive doses of anthelmintics, along with steroids and other supportive therapies. Preventative measures include fencing off areas which receive high deer utilization and removing sheep from pastures before weather turns cool and wet. Fencing sheep away from likely snail and slug habitats (e.g. ponds, swamps, wetlands, low lying and poorly drained fields, and woodlands) may also help to prevent the problem. In high risk areas, monthly deworming has been advocated.

Click **HERE** to read an article on the *Meningeal Worm* (sheepandgoat.com).

Coccidia *(Eimeria spp.)*
Coccidia are single-cell protozoa that damage the lining of the small intestine. They are host-specific, meaning the species that affects cattle, swine, and poultry does not affect sheep and vice versa. Coccidiosis is very common in sheep, especially young, growing lambs. Older sheep serves as sources of infection for young sheep. Lambs in lambing pens, intensive grazing areas, and feedlots are at greatest risk. Transmission of coccidiosis to lambs favors warm, wet environmental conditions. Stress often induces outbreaks of coccidiosis. Coccidiosis often follows weaning or shipping stresses. Clinical signs include diarrhea (sometimes containing blood or mucous), dehydration, fever, weight loss, loss of appetite, anemia, and death. The coccidia organism does not respond to the standard deworming products. Medications used to treat clinical coccidiosis differ from medications use to prevent it.


Lambs in lambing pens, intensive grazing areas, and feed lots are at greatest risk for coccidiosis.

Outbreaks of coccidiosis are usually treated with sulfa drugs and amprolium (Corid). These drugs must be prescribed by a veterinarian. Feed additives for the prevention of coccidiosis in lambs are currently in use by the sheep industry. They include two FDA-approved products, lasalocid (Bovatec®) and decoquinate (Deccox®), and one non-approved product, monensin (Rumensin®). Monensin requires a veterinary prescription. Preventive medications such as monensin, lasalocid, and decoquinate, are collectively referred to as coccidiostats, meaning that they slow down the shedding of coccidia into the environment. They are only effective in preventing disease if they are added to the feed before lambs become exposed. On the other hand, treatment medications such as sulfa compounds and amprolium are coccidiacidal, meaning that they actually kill the coccidia organisms in the intestine of the treated animal.

Rumensin® is very ***toxic*** to horses. Bovatec® and Deccox® should not be fed to horses or other equines.

Click **HERE** to view the *Coccidia Life Cycle.*
Click **HERE** to view a table of the *Drugs Used to Treat and Prevent Coccidiosis* (sheepandgoat.com).

Integrated Parasite Management (IPM)

Good Management and Common Sense

Internal parasite control starts with good management and common sense. Sheep should not be fed on the ground. Feeders which cannot easily be contaminated with feces should be utilized for grain, hay, and minerals. Water should be clean and free from fecal matter. Pastures and pens should not be overstocked. When new sheep are acquired they should be isolated from the rest of the flock for 30 days and aggressively dewormed to prevent the introduction of drug-resistant worms.

Use of Clean or Safe Pastures

Clean or safe pastures are pastures which are not contaminated with the worm larvae that affect sheep. Examples of clean pastures include pastures that have not been grazed by sheep or goats for the past 6 to 12 months; pastures which have been grazed by horses or cattle; pasture fields in which a hay or silage crop has been removed; pasture fields which have been rotated with field crops; and pastures than have been recently established or renovated by tillage. While burning a pasture will remove worm larvae, there are no pasture treatments that will effectively eliminate or reduce worm larvae.

Pasture Rest and Rotation

It is a common misconception that rotational grazing helps to control internal parasites in sheep. Intensive rotational grazing may actually contribute to parasitic problems. This is because rotating large groups of ewes and lambs through small paddocks concentrates livestock and infective parasite larvae onto the same small area. Researchers in the Netherlands found that it takes three months of rest for an infected pasture to return to a low level of infectivity. Researchers at Langston University (Oklahoma) determined that a 65-day rest period was sufficient (for goats). Rotational grazing is an effective management tool for managing parasites, but only if pasture rest periods are long enough (i.e. 60 days or more). On the other hand, better nutrition provided by rotational grazing may offset the effects of higher parasite loads on the pasture.

Grazing Strategies

Approximately 80 percent of the worm larvae can be found in the first two inches of grass. Therefore, sheep grazing taller forages will have fewer parasite problems. Sheep should not be allowed to graze forages shorter than 2 inches in height. Sheep that browse also have fewer parasite problems. Another grazing strategy is to wait until the dew has lifted from the grass or grass has dried after a rain. Dry conditions force parasites to stay at the base of the plants where they are less likely to be consumed by the livestock.

Multi-species Grazing

Sheep (and goats) are generally not affected by the same internal parasites as cattle and horses. Consequently, pastures grazed by cattle and horses are safe(r) for sheep (and goats) and conversely. Sheep can be co-grazed with cattle and/or horses. A leader-follower system can be utilized or pastures can be alternated between sheep and cattle and/or horses. There are numerous other benefits to multi-species grazing. Each species has different grazing behavior that complements one another. For example, sheep prefer to eat weeds and short, tender grasses and clover, while cattle prefer to eat taller grasses. Cattle may offer some protection from predators.

Alternative Forages

Some pasture plants have anthelmintic properties, such as those containing condensed tannins. Research has shown that sheep grazing tannin-rich forages have lower fecal egg counts than animals grazing traditional grass pastures. The tannins may also decrease the hatch rate of worm eggs and larval development in feces. Forage species which contain high levels of condensed tannins include sericea lespedeza, birdsfoot trefoil, and chicory. Sericea lespedeza is a warm, season legume. Birdsfoot trefoil is a long-lived perennial legume. Chicory is a low-growing, leafy perennial. Generally speaking, trees and shrubs contain higher levels of tannins than pasture grasses, and tropical legumes contain more condensed tannins than temperate legumes.

Click **HERE** to read *Tannins for Suppression of Internal Parasites* by Langston University.

Healthy Soil

Earthworms have been shown to ingest worm eggs and larvae, either killing them or carrying them below the soil surface. Certain types of fungi will trap and kill parasitic larvae. Dung beetles ingest and disperse manure, thus keeping eggs and larvae from developing. Anything that is done to maintain soil health and promote these types of organisms will aid in parasite control. Scientists are examining the possibility of feeding nematophagous fungi to livestock to kill larvae in manure piles.

Click **HERE** to read *Dung Beetle Benefits in the Pasture Ecosystem from ATTRA.*

Nutritional Management

Supplemental feeding should not be overlooked as a means to control parasites. Sheep and lambs on a higher plane of nutrition mount a better immune response to internal parasites than animals whose nutritional status is compromised. Animals on low protein diets are more susceptible to infection because they produce less IgA (immunoglobulin). Higher levels of protein have been shown to improve the pregnant ewe's immune response to parasites after lambing. Lambs receiving protein supplementation have reduced fecal egg counts.

Zero Grazing

Keeping sheep and/or lambs in confinement (i.e. "zero grazing") is a means of reducing parasitism and preventing reinfection. Under a zero grazing situation, sheep and/or lambs do not have access to any vegetation for grazing. They are housed in a bedded barn, dirt lot, or facility with slotted floors. Feed should be fed off the ground in feeders. Watering containers should be kept free from fecal matter. Slotted floors offer the best protection against internal parasites because sheep generally do not come into contact with their feces.

Hair sheep breeds are more resistant and resilient to internal parasites.

Parasite resistance - the ability to limit fecal egg counts (FEC) when challenged with infective larvae and thus limiting or preventing infection. Resistance is moderately heritable and results in lower pasture contamination.

Parasite resilience - the ability to maintain a reasonable productivity when subjected to a parasite challenge. It is less heritable and more difficult to measure. With barber pole worm infections, resilience is measured by "packed cell volume (PCV), a measure of red blood cells

Genetics

Genetics is probably the best long term weapon against internal parasites in sheep. Some sheep breeds are more resistant and resilient to internal parasites. They include the Florida (or Gulf Coast) Native and the hair sheep breeds: St. Croix, Barbados Blackbelly (and its derivatives), and Katahdin. Grazing resistant breeds of sheep with susceptible breeds, may act to “sweep” pastures and reduce contamination to susceptible animals.

Regardless of the breed raised, producers can also breed sheep which are less resistant to parasites by culling ewes that are persistently affected by parasites and favoring parasite resistant ewes and rams in their selection programs. Both fecal egg counts and FAMACHA© scores can be used to identify sheep with resistant and susceptible genetics. In New Zealand, it is possible to select rams that shed 60 to 70 percent fewer parasite eggs than historical averages. Scientists are currently looking for genetic markers for worm resistance so that a DNA test could be used to show producers which of their animals are resistant to internal parasites.

Proper Anthelmintic Use

Anthelmintics are still an important part of parasite control. However, they must be used properly to ensure effectiveness of treatment and slow down the rate by which worms develop drug resistance. To start with, the weights of sheep and lambs must be known or approximated accurately in order to calculate the proper dosage of medicine. Underdosing results in the survival of worms which are resistant to the anthelmintic used. Flocks should be divided into groups for deworming or drenching equipment should be calibrated for the heaviest animals in the group. Oral drenching is the recommended method of treatment for sheep. Oral medications should be delivered over the tongue. If the medicine is deposited into the mouth to stimulate the closure of the esophageal groove and bypass the rumen.

If an anthelmintic is more slowly absorbed in the gut, drug levels are prolonged and the treatment may be more effective. Thus, fasting sheep for up to 24 hours may improve efficacy of dewormers, especially when using benzimidazoles and ivermectin. However, water should not be restricted.

Using the same anthelmintic or drugs from the same chemical family will increase the rate at which worms become resistant to the drugs. To lessen the effect, anthelmintics (or drug groups) should be rotated on an annual basis. On the other hand, anthelmintics should not be rotated after each use; otherwise, worms will develop resistance to each drug simultaneously.

If you do not deworm your animals much (e.g. < 3 times per year), you might not have much of a drug resistant problem. But if you introduce new animals to your flock, you could introduce drug-resistant worms. This is especially true if you purchase animals from a farm that deworms frequently. To prevent the introduction of drug-resistant worms, you should deworm newly purchased animals with drugs from at least two of the three anthelmintic families. Moxidectin should be favored over ivermectin due to its superior potency. Levamisole should probably be the other choice, since widespread resistance is believed to exist in the benzimidazole group of dewormers. After deworming, the animal(s) should be released onto a wormy pasture to help dilute any "super-resistant" worms that may remain in his system.

Drug (chemical) families	
Benzimidazoles (white dewormers)	Fenbendazole Albendazole Oxybendazole
Macrolides	Ivermectin Doramectin Moxidectin
Nicotinics	Levamisole (clear dewormer) Rumantel Pyrantel

Click **HERE** to view a table of *Anthelmintics* (sheepandgoat.com).

Alternative Dewormers

Currently, there is a lot of interest in using "natural" products as an alternative to chemical control of parasites. Such products include herbal dewormers and diatomaceous earth. Unfortunately, there is no research to indicate that any of these products have a substantial effect on internal parasites in sheep, only testimonials. However, this is an area of increasing research interest and hopefully recommendations will be forthcoming in the years ahead.

Copper oxide particles (administered as a bolus) have been shown to reduce barber pole worm infections in sheep. They have been used with mixed results in goats. Copper oxide is available for cattle as a supplement to alleviate copper deficiency and has been used in sheep for the same purpose. Scientists are currently evaluating different dosage rates to avoid copper toxicity in sheep.

Click **HERE** to go to a page on *Alternative Dewormers* (University of Aberdeen).

Refugia

Worms in "refugia" are those which have not been exposed to drug treatment. They include free-living stages on pasture and worms in untreated animals. Refugia are being viewed as an important tool to slow down anthelmintic resistance. To increase refugia, it is suggested that a portion of the flock not be dewormed. Fecal egg counts and FAMACHA© scores can be used to identify which animals do not require deworming. Another strategy for increasing refugia is to return treated animals to a wormy pasture. The reason for this recommendation is because if treated animals are moved to a "clean" pasture, the only worms that will be on that pasture will be resistant to anthelmintic treatment.

Fecal Egg Analysis

Fecal egg analysis is an important part of a internal parasite control program. Primarily, a fecal analysis tells you how contaminated your pastures are. Fecal analysis can also be used to make selection and culling decisions by identifying animals with both high and low egg counts. Probably the most valuable use of fecal analysis is determining drug resistance. The test to determine drug resistance is called the fecal egg count reduction test (FECRT). To conduct a FECRT, animal are weighed and dewormed with the anthelmintic you wish to test. Fecal samples are collected twice: first at the time of deworming and second, 7 to 10 days later. Six or more (ideally 10) animals should be tested for each anthelmintic. Fecal samples should also be collected and analyzed for a similar group of untreated animals. For an anthelmintic to be considered effective it should reduce fecal egg counts by 90 percent (ideally 95%). There is severe drug resistance if treatment fails to reduce egg counts by more than 60 percent.

To do your own fecal analysis, you need a microscope, flotation solution, mixing vials, strainer, stirring rod, slides, and cover slips. You do not need an elaborate microscope. 100X power is sufficient. You can purchase flotation solution from veterinary supply companies or make your own by mixing a saturated salt or sugar solution. Your mixing vials can be jars, pill bottles, film canisters, test tubes, or something similar. You can use a tea strainer or cheese cloth to strain the feces. The stirring rod can be a pencil or popsicle stick. If you want to count eggs, you want to get a McMaster Egg Counting slide available ***HERE***. The McMaster slide has chambers that making egg counting easier. The Paracount-EPG™ Fecal Analysis Kit with McMaster-Type Counting Slides is available for $40 from the Chalex Corporation.

Identifying Worm Eggs. "Strongyle-type" eggs *(Haemonchus, Ostertagia and Trichostrongylus)* are elliptical or oval, with smooth, thin shells. *Nematodirus* eggs are the largest strongyle-type eggs, but eggs of the species in the group cannot usually be identified precisely. Worming recommendations can be based on the quantity of *strongyle* eggs. Since fecal counts only estimate the parasite load, there is no clear cut level at which worming is indicated. As a ***general*** guide, a level of about 500 eggs per gram of feces would indicate that worming is needed for sheep. A more effective way of deciding when to treat would be to monitor fecals every 4-8 weeks and deworm when there is a dramatic rise in egg counts.

FAMACHA© is named for its originator, Francois Malan, a South African livestock parasitologist.

Tapeworm eggs are square or triangular. Tapeworm (*Moniezia* sp.) eggs may be seen in fecal examination but they are in no way indicative of the level of infection. Since lungworm eggs hatch before being passed in the feces the eggs generally are not seen by the flotation method. Nematode larvae, when present in the feces, are indicative of lung-worm. Fluke eggs are oval and have a smooth shell with a cap or operculum at one end. Liver flukes are prolific egg producers, but egg counts are not necessarily a good indication of infection levels. Coccidia eggs are very small, about a tenth the size of a Strongyle egg. Coccidia oocysts are passed in the feces of most livestock. Oocysts are only a moderate indicator of level of infection.

FAMACHA©

The FAMACHA© system was developed in South Africa due to the emergence of drug-resistant worms. The system utilizes an eye anemia guide to evaluate the eyelid color of a sheep (or goat) to determine the severity of parasite infection (as evidenced by anemia) and the need for deworming. A bright red color indicates that the animal has few or no worms or that the sheep has the capacity to tolerate its worms. An almost white eyelid color a warning sign of very bad anemia; the worms present in the sheep's gut are in such numbers they are draining the animal of blood. If left untreated, such an animal will soon die.

The FAMACHA© chart contains five eye scores (1-5), which have been correlated with packed cell volumes (percentage of blood made up of red blood cells, also called haematocrit). Animals in categories 1 or 2 (red or red-pink) do not require treatment whereas animals in categories 4 and 5 (pink-white and white) do. Animals in category 3 may or may not require treatment depending upon other factors. Mature sheep in category 3 (pink color) probably do not requiring treatment, whereas lambs or other susceptible animals should be treated if they are in category 3. The frequency of examination depends upon the season and weather pattern, with more frequent examination usually necessary in July, August, and September, the peak worm season.

FAMACHA© System			
Clinical Category	**Eye lid color**	**Packed cell volume**	**Treatment guideline**
1	Red	≥ 28	No
2	Red-Pink	23-27	No
3	Pink	18-22	???
4	Pink-White	13-17	Yes
5	White	≤ 12	Yes

The FAMACHA© system results in fewer animals being treated, which slows down drug resistance. It identifies wormy animals that require treatment. Persistently wormy animals should be marked for culling. The process of inspecting the eyes is quick and can be incorporated with other management practices.

The FAMACHA© system is only effective for the barber pole worm. It should not be used in a vacuum, but rather it should be incorporated into an integrated worm control program that includes other management practices, such as pasture rest, good nutrition, multi-species grazing, alternative forages, zero grazing, and strategic deworming. FAMACHA© should only be used by properly trained individuals.

Click **HERE** for a list of FAMACHA© training opportunities in the U.S.

Click **HERE** to read *Smart Drenching and FAMACHA©* by the University of Georgia.

To learn more about internal parasites, visit the
Southern Consortium for Small Ruminant Parasite Control.

Return to Sheep 201 Home Page
Return to Sheep101.

Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles

A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Margo Hale, Joan Burke, Jim Miller, and Tom Terrill

NCAT/ATTRA and Southern Consortium for Small Ruminant Parasite Control

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Contents

Sheep and goat producers must rely on a combination of techniques to manage internal parasites.

Introduction

Internal parasite management, especially of *Haemonchus contortus* (barber pole worm, stomach worm), is a primary concern for the majority of sheep and goat producers. These parasites have become more difficult to manage because of developed resistance to nearly all available dewormers. A severe infection of barber pole worm causes anemia, reduced animal production, bottle jaw, and—if not treated—death of infected sheep and goats.

Mature parasites breed inside the host and "lay eggs," which pass through the host and are shed in the feces. After the eggs pass out of the host, they hatch into larvae in the pellet. Warm, moist conditions encourage hatching of the eggs and development into infective larvae. The larvae need moisture, such as dew or rain, to break open the fecal pellet, releasing the larvae. The infective larvae migrate out of the feces and up blades of grass (usually 1 to 3 inches). When an animal (sheep or goat) grazes, it may take in parasite larvae along with the grass blade, resulting in infection. Numbers of infective larvae on the pasture increase over time when environmental conditions are favorable (warm, wet).

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Parasites are now developing resistance to all commercially available anthelmintics (dewormers). Drug resistance is the ability of worms in a population to survive drug treatment of the animal at the standard prescribed dosage. Over-use of dewormers (frequent deworming and treating all animals regardless of need) has led to dewormer resistance, and as a consequence most available dewormers are now ineffective. Producers cannot rely on anthelmintics alone to control internal parasites. Therefore, it is important to use several tools to manage internal parasites.

Over-use of dewormers has led to dewormer resistance, and as a consequence most available dewormers are now ineffective.

The following are tools that can be used to manage internal parasites. For more information see ATTRA's *Managing Internal Parasites in Sheep and Goats.*

Pasture Management

- Maintain forage height greater than 2 inches
- Provide areas of browse (brush, shrubs, small trees, etc.)
- Maintain low stocking rate
- Graze sheep and goats with cattle, or in a rotation with cattle or horses
- Provide tannin-rich forages, such as sericea lespedeza
- Harvest hay off pastures
- Avoid wet patches in a pasture, such as from a leaky water trough
- Fence-off naturally-wet areas

Selective Deworming or FAMACHA©

- A system for classifying animals based on levels of anemia (according to eye mucous membrane color)
- Treat only animals with symptoms of the barber pole worm (anemia)
- Reduces the use of dewormers and slows development of resistance
- Is only effective for the treatment of *H. contortus* (barber pole worm)

Selecting Resistant Animals

- Several breeds show resistance to internal parasites
- Individual animals can demonstrate resistance to parasites
  - o Resistant animals have a lower host parasite burden and are not negatively affected by the parasites (don't show signs of parasitism, remain productive)
  - o FAMACHA scores can be helpful for selection

Copper Oxide Wire Particles

Copper oxide wire particles (COWP) have also been found to reduce parasite loads in sheep and goats. COWP were developed for copper deficiency in cattle and sheep. Sheep are very susceptible to copper toxicity, which can result in death. The form of copper used

Things you should know about copper…

- Copper is important for immune function in livestock.
- Sheep are very sensitive to copper accumulation in the liver, which causes toxicity.
- The amount of copper required by sheep is not greatly different from the toxic level, making copper level an important consideration when mixing sheep rations or feeding mineral.
  - o The margin of safety between the required amount of copper (10 ppm) and toxic level (25 ppm) is very narrow in sheep.
- Some sheep breeds are more susceptible to copper toxicity than others (Texel and dairy breeds).
- Copper sulfate is more readily absorbed than copper oxide, creating a greater risk for copper toxicity.
  - o Recommending COWP use for controlling worms does not endorse the use of high copper sulfate mineral mixes to control parasites.
- There are complex mineral interactions that affect copper absorption; deficiencies in other minerals can increase the risk for copper toxicity.
  - o Low levels of molybdenum can increase risk of copper toxicity
- Pastures fertilized with poultry waste may have high copper levels.
  - o Sheep should not be fed poultry wastes, due to the high copper levels
- Goats are less susceptible to copper toxicity, tolerating up to 80 ppm.
  - o While not common, copper toxicity in goats can occur (13).

in COWP is poorly absorbed, reducing the risk of copper toxicity.

The exact mechanism of how copper wire particles control internal parasites is not yet fully understood. Researchers believe copper has a direct effect on internal parasites. It may also help to boost the immune system. Both effects help to manage internal parasites.

Copper Oxide Wire Particle Boluses

COWP boluses can be made and administered on farm. Copper boluses (Copasure®) are available for use for copper deficiency in cattle. These boluses can be repackaged into doses suitable for growing sheep and goats. The minimum dose that has demonstrated control in some studies is 0.5 g, but as much as 2-4 g may be necessary.

How to make COWP boluses for parasite control in sheep and goats

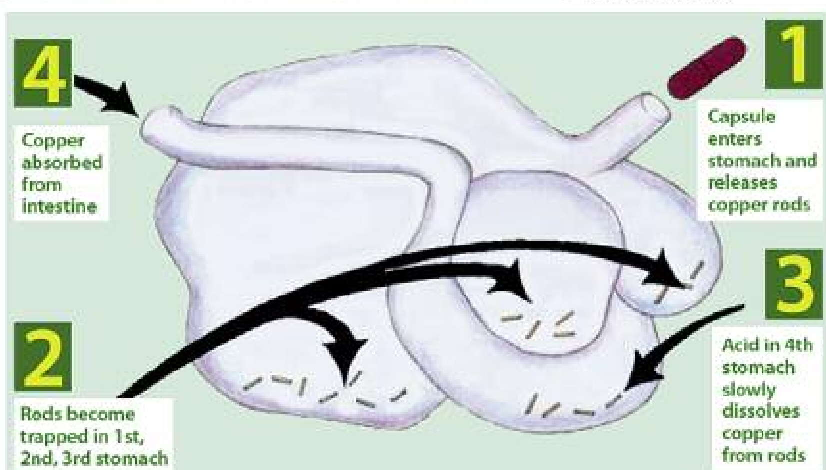
- Purchase copper boluses (Copasure©, available in 12.5 g and 25 g boluses)
- Obtain smaller gel capsules
  - o Available at your local pharmacy or health food store, also available from veterinary supply houses at times.
- Repackage cattle bolus into smaller gel capsule to make 0.5g dose
  - o Size 1 gelatin capsules filled 1/3 full
  - o Size 3 capsules filled ¾ full
- Administer bolus with a pill gun designed for pets or wooden dowel with PVC pipe

Gelatin capsules, Size 3 and Size 1, filled with 0.5 g or 500 mg of COWP. Photo courtesy of Dr. Joan Burke.

Animals can be treated again after 4-6 weeks, if necessary. Animals should receive no more than four (if 0.5 or 1 g is used) or two (if 2 or 4 g is used) COWP boluses in a worm season. It should be noted that COWP has been found to be effective on reducing abomasal (*H. contortus*) only and not intestinal worms. COWP has been found to be effective against *H. contortus* in mature goats most of the time, though sometimes marginally effective. Other control strategies may be more effective in mature animals. As with all anthelmintic treatments, it is important to work with your veterinarian.

COWP should not be the only method used for controlling internal parasites. COWP boluses should be thought of as one component of a complete parasite management strategy. COWP boluses should be used selectively, treating only the animals that need it. Using the FAMACHA® system is one way to determine animals that should receive a COWP bolus. Selective treatment is advised to reduce the risk of worms developing resistance to COWP. Other parasite management techniques are mentioned earlier in this publication. The use of COWP can also help slow the development of anthelmintic drug resistance, as fewer anthelmintics are used.

Suggested pill guns to administer COWP to sheep and goats. Top pill gun is marketed for dogs and cats (Dr. Hanson's® Bullseye pill gun) and bottom is wooden dowel inserted into a ½ inch PVC pipe with a rubber band wrapped around the dowel to serve as a stop. Photo courtesy of Dr. Joan Burke.



Illustrates the fate of COWP boluses in the animal. (adapted from www.animax-vet.com)

COWP Results

There have been several research trials studying the effects of COWP on internal parasites in sheep and goats. The following table summarizes the results.

Animals Used	Treatment	Results	Notes
Crossbred (Katahdin, Dorper, St. Croix cross) ram lambs	0.5 g or 1 g COWP every 6 weeks (May-October)	Fecal egg counts (FEC) reduced, fewer *H. contortus* found in fecals of lambs treated with COWP	Lower COWP doses just as effective at reducing internal parasites as higher doses in other studies. COWP was highly effective in reducing nematode infection for 4-6 weeks (3)
5-6 month old hair breed lambs	0, 2, 4, or 6 g COWP	FEC reduced in lambs receiving 2, 4, or 6 g COWP; *H. contortus* numbers in the abomasums were reduced (5)	
Mature Katahdin ewes, prior to lambing	0, 2, or 4 g COWP	FEC reduced for those receiving COWP (2 g-66%; 4 g- 55%), FEC increased in untreated animals	Evidence that lambs received copper from treated ewes (in utero and through milk) (4)
Lactating Polypay ewes and their offspring	Mature ewes—0, 0.5, 1, or 2 g COWP 60 days after lambing Offspring—0, 0.5, 0.75, 1 or 2 g COWP at 2 months of age	Ewes—FEC were lower for those treated with 1 or 2 g COWP Offspring—All doses of COWP lowered FEC	In this study, a beneficial effect for ewes was seen with 2 g COWP. COWP appear to be less effective in mature ewes compared with lambs. (7)
Boer-cross yearling goats	0, 5, or 10 g COWP bolus	FEC were lower for animals treated with COWP	While FEC were lower for animals treated with COWP, they still were over 2000 eggs/g. (9)
Boer-cross weanling goats	0 or 2.5 g COWP	FEC initially decreased by ~50% (from 2930 eggs/g to 1525 eggs/g) for those treated with COWP, but then rose to over 3000 eggs/g	FEC started to rise 3 weeks after COWP treatment. (10)
Mature Spanish does grazing winter pasture	0 or 4 g COWP	Overall FEC were similar between 0 and 4 g COWP.	On days 0, 7, and 14 FEC of untreated goats increased while FEC of COWP treated goats remained low. (8)
Yearling Spanish x boer cross bucks	0, 5, or 10 g COWP	FEC were similar in 0, 5, or 10 g COWP treated goats and decreased between day 0 and 35.	Concentrations of copper in the liver were greater in COWP-treated goats than untreated goats. (8)
Boer x Spanish doe and wether kids	0, 0.5, 1, 2, or 4 g COWP	FEC were lower on days 7, 14, and 21 compared with untreated kids, but were similar by day 28.	Average daily gain tended to increase with dose of COWP up to 2 g then decreased at 4 g. (8)

Animals Used	Treatment	Results	Notes
Boer x Spanish wether kids	0 g COWP, 5 g COWP, apple cider vinegar drench, or vinegar drench and 5 g COWP	There was no effect of vinegar drenching on FEC in 0 or 5 g COWP treated kids. FEC were reduced in COWP treated kids. (8)	
Boer and Spanish x Boer does	0 or 2 g COWP while supplemented with 220 g of corn and soybean meal or 220 g of cottonseed meal	FEC were reduced in COWP treated goats and remained lower than untreated does until day 21 for corn soybean meal-supplemented does and day 28 in cottonseed meal-supplemented does. FEC were lower in CSM than corn soybean meal-supplemented does that received COWP.	At the end of this study, 2 g COWP was administered to all goats and resulted in a 79% reduction in FEC 7 days later. (8)
Boer yearling does	0 or 5 g COWP grazing either tall fescue or sericea lespedeza	Doses of 5 g COWP decreased FEC and sericea lespedeza grazing tended to decrease FEC.	By day 28 approx. 50% of untreated does required deworming, but no COWP-treated does required deworming. (8)
Yearling Spanish does, prior to breeding	Multi-trace element/vitamin ruminal bolus containing copper oxide	Fecal egg counts were reduced (by 80%) and remained low, while untreated animals' FEC increased (6)	
Spanish and Boer does, 6 weeks before kidding	Multi-trace element/vitamin ruminal bolus containing copper oxide	*H. contortus* decreased; FEC were reduced (by 60%)	Reduction in FEC lasted 3-4 weeks, similar to anthelmintic treatments (6)

Producers must use a holistic approach to managing internal parasites.

Summary

Copper oxide wire particles (COWP) have been proven to be an effective method of controlling *H. contortus* (barber pole worm) in sheep and goats. While COWP have shown positive results in reducing parasite loads, they should not be the only method of parasite control used. Research continues on the use of COWP to determine the most effective treatments for sheep and goats. COWP can be an effective component of a holistic parasite management strategy.

Resources:

Managing Internal Parasites in Sheep and Goats
http://attra.ncat.org/attra-pub/parasitesheep.html

Southern Consortium for Small Ruminant Parasite Control
www.scsrpc.org

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Related ATTRA Publications

- Managing Internal Parasites in Sheep and Goats
- Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza
- Integrated Parasite Management for Livestock
- Small Ruminant Sustainability Checksheet

Notes:

Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles

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Amy Smith, Production

This publication is available on the Web at:
www.attra.ncat.org/attra-pub/copper_wire.html
or
www.attra.ncat.org/attra-pub/PDF/copper_wire.pdf

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ATTRA

Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza

A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Linda Coffey, Margo Hale, Tom Terrill, Jorge Mosjidis, Jim Miller, and Joan Burke

NCAT/ATTRA and Southern Consortium for Small Ruminant Parasite Control

2007

Goat grazing sericea lespedeza. Photo by Jean-Marie Luginbuhl.

Contents

Introduction

Control of internal parasites, especially of *Haemonchus contortus* (barber pole worm, stomach worm), is a primary concern for the majority of sheep and goat producers. These parasites have become more difficult to manage because of increasing resistance to nearly all available dewormers. A severe infection of barber pole worm causes anemia, bottle jaw, and —if not treated—death of infected sheep and goats.

Mature parasites breed inside the host and "lay eggs," which pass through the host and are shed in the feces. After the eggs pass out of the host, they hatch into larvae. Warm, humid conditions encourage hatching of the eggs and development into infective larvae. The larvae need moisture, such as dew or rain, to break open the fecal pellet and move. They migrate out of the feces and up blades of grass (usually 1 to 3 inches). When an animal (sheep or goat) grazes, they may take in parasite larvae along with the grass blade. Parasite numbers increase over time when conditions are favorable (warm, wet).

Parasites are now developing resistance to anthelmintics (dewormers). Drug resistance is the ability of worms in a population to survive drug (deworming) treatment of the animal at the prescribed dosage. Over-use of dewormers has led to resistance, and many available dewormers are now ineffective.

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NCAT

Ideas and research were generated by the Southern Consortium for Small Ruminant Parasite Control *(www.scsrpc.org)* and was supported by USDA, CSREES, Integrated Organic Program (Award No. 2005-51300-02392), USDA Sustainable Agriculture Research and Education (SARE) program (Project No. LS05-177) and USDA 1890 Institutional Teaching and Research Capacity Building Grants Program for funding support of this work (Award No. 2005-38814-16429). Mention of trade names or commercial products in this manuscript is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Producers can no longer rely on anthelmintics alone to control internal parasites. It is important to use multiple management practices to control internal parasites.

The following are tools that can be used to manage internal parasites. For more information see ATTRA's *Managing Internal Parasites in Sheep and Goats.*

Pasture Management

- Maintain forage height greater than 3 inches (beware of patch grazing)
- Provide areas of browse (brush, shrubs, small trees, etc.)
- Maintain low stocking rate
- Graze sheep and goats with cattle, or in a rotation with cattle or horses
- Provide tannin-rich forages, such as sericea lespedeza
- Harvest hay from pastures
- Avoid wet patches in pasture, such as from a leaky water trough

Selective deworming

- Use a visual system (FAMACHA®) for classifying animals based on levels of anemia
    - o FAMACHA® is only effective for diagnosing infection by *H. contortus* (barber pole worm)
    - o Treat only animals that are anemic (a sign of parasitism)
    - o Reduces the use of dewormers
    - o Helps slow down drug resistance problems
    - o Saves money

Selecting Resistant Animals

- Several breeds show ***resistance*** to internal parasites (that is, when exposed to parasites, the animal immune system does not allow the parasites to be established in its body). Select a resistant breed if it fits your system.
- Select individual animals that demonstrate resistance to parasites
- ***Resilient*** animals can host a parasite burden and not be negatively affected by the parasites (don't show signs of parasitism, and they remain productive); however, they may be shedding high numbers of parasite eggs and causing illness in other animals.
- Cull animals that are most susceptible to parasites and those that contribute most to pasture contamination.

Alternative Treatments

- Copper Oxide Wire Particles (COWP) boluses
- Garlic and other botanical materials and formulations (being tested)
- Nematode-trapping fungus (not commercially available yet)
- Condensed-tannin (CT)-containing supplements (such as sericea hay)

Condensed tannins and, in particular, the high-CT forage sericea lespedeza are discussed in this paper. An overview of current research on the topic, as well as additional resources and references, are provided. Producers can use this information to keep their animals healthier.

Tannins

- Tannins are plant compounds that bind to proteins and other molecules.
- Tannin is related to "tanning", as in preserving hides, and tannins are found in many plants.
- There are two main types of tannins; hydrolyzable (HT), some of which may have toxic effects on animals, and condensed tannins (CT), which are found in forage legumes (including sericea lespedeza) and other plants.
- Effects of tannins vary depending on type of tannin, concentration, and on the animal consuming the tannins.

- Negative effects may include reduced intake and reduced digestibility, leading to a decline in animal productivity. Negative effects are seen more often when CT concentration is high (above 55 g CT/kg DM in the forage). (Min et al., 2003)
- Positive effects may include an increase in by-pass protein (causing the animal to use protein more efficiently), a reduction in bloating, increased milk production, and a reduction in internal parasite numbers, egg output, and hatchability.

For more information on tannins, see the references listed at the end of this publication and the Resources section, especially *<http://www.ansci.cornell.edu/plants/toxicagents/ tannin>*.

According to Min et al. (2003), low concentrations of CT (20-45 g CT/kg DM) are helpful to animals, while high forage CT concentrations (>55 g CT/kg DM) may have negative effects. Results vary according to CT concentration and structure and the animal that is grazing the forage, however.

Researchers have shown that big trefoil, sulla, sanfoin, and sericea lespedeza are useful in controlling internal parasite infection in sheep and goats. Providing condensed-tannin-containing forages is one way to boost the health of sheep or goats.

Sericea lespedeza is a high-tannin forage that has been scientifically proven to reduce parasite loads in sheep and goats.

Table 1. Condensed tannin (CT) content in different forage species.*
(Adapted from Min and Hart, 2003 and Min et al., 2005).

Forage	CT, g/kg of DM	%DM
Birdsfoot trefoil	48	4.8
Big trefoil	77	7.7
Sanfoin	29	2.9
Sulla	51–84	5.1–8.4
Lucerne (alfalfa)	0.5	.05
Sericea lespedeza	46-152	4.6–15.2
Perennial ryegrass	1.8	0.18
Chicory	3.1	0.31
Crabgrass/tall fescue mixture	3.2	0.32

*The standard used for analysis will affect the results. For these studies, a Quebracho standard was used.

Sericea Lespedeza

Sericea lespedeza is a high-tannin forage (4–15% DM) that has been scientifically proven to reduce parasite loads in sheep and goats. The mechanism of action is not yet known. Researchers believe that the plant tannins may affect parasites either directly or indirectly (or both). Tannins may react directly with adult worms by attaching to their "skin", causing them distress, or indirectly by improving protein nutrition of the goat and boosting the immune system. In addition, tannins appear to reduce the hatching of fecal eggs and development of larvae, perhaps by binding to the larvae. (Min et al., 2005). The tannins could also bind with feed nutrients and possibly prevent bacterial growth in the feces (larva feed on bacteria) and so limit the feed available for larval growth, or in some other way inhibit larvae growth and movement. Adult worms

Goat grazing sericea lespedeza. Photo by Margo Hale.

residing in animals that are grazing sericea lespedeza shed fewer eggs, and the eggs that are produced have reduced hatching ability. However, when animals are moved off sericea lespedeza pastures and on to other forages, egg counts go back up, indicating that mature worms were inhibited but not killed in the short term. As animals are fed with sericea for longer periods of time, research has shown a reduction in mature worms as well (Min et al., 2005, Shaik et al., 2006, Lange et al., 2006). Reducing pasture contamination and animal worm burdens will help sheep and goats to be healthier and more productive.

Things you should know about sericea lespedeza

- Sericea lespedeza is a legume that grows in low fertility and acid soils and was widely planted to rebuild eroded and depleted soils. It is one of the most commonly used species for planting on surface mine spoils, road banks, and other disturbed or eroding areas.
- Sericea is listed as a noxious weed in some states (Colorado and Kansas, at the time of this writing) and may become invasive or weedy in some areas.
- Where sericea is considered a noxious or invasive weed, sheep and goat grazing can help to control the plant while also helping sheep or goat parasite problems. It will not be invasive when grazed and prevented from producing seed.
- Sheep and goats may need time to adjust to grazing sericea if they are not familiar with the forage; however, they will graze it readily once they go through the adjustment period. Cattle will graze sericea if it is not too mature.
- No adjustment period is needed for feeding sericea hay, as it is readily consumed by all classes of livestock.
- Researchers are investigating the performance of animals grazing sericea or being fed sericea hay or supplement.
- Research has shown that sericea is effective against internal parasites when grazed or when fed in dried forms, such as hay or pellets.

Sericea Lespedeza Results

There have been several research trials studying the effects of sericea lespedeza on internal parasites in sheep and goats. The following table summarizes the results. References are included in the last column.

Animals Used	Treatment	Results	Notes
Spanish wether goats, grazing	15 days grazing sericea or rye/crabgrass, switch to other forage 15 days	Fecal egg counts (FEC) reduced (2500 vs. 710 eggs per gram), percentage of eggs developing to larvae reduced (99% vs. 58.2%)	FEC increased after switching to rye/crabgrass; tannins seemed to have short residual effect (Min et al., 2004)
Goats, confined and fed hay	Ground hay–sericea or bermudagrass– 4 week trial, all on bermudagrass hay for 3 weeks following	Reduced fecal egg counts (FEC) for sericea-fed goats (significant in 3rd and 4th weeks of trial)	FEC not significantly different once animals were taken off sericea, but still numerically lower (Shaik et al., 2004

Animals Used	Treatment	Results	Notes
Goats, confined and fed hay (75% of diet) and grain (25%)	Ground sericea (0, 25, 50, 75%) and/or bermudagrass (75, 50, 25, 0%) in combinations equaling 75% hay; levels testing dose of SL needed, 6 weeks	FEC reduced for those fed SL at all levels, greater reduction as % SL increases and with time; at 6 weeks, 75% SL hay, 91.9% reduction	Optimum level of SL hay appeared to be 50-75% of total diet (Dykes et al., 2006), but 25% was also beneficial, reducing number of adult barber pole worms in the stomach by 58% (unpublished data)
Goats, confined and fed hay and grain	Sericea hay or bermudagrass hay, 7 weeks	FEC reduced, number of adult worms reduced, hatchability of eggs into L-3 larvae reduced in goats fed sericea hay	Egg counts dropped by about 80% one week after sericea feeding started; reduction increased to almost 90% by end of trial. Both abomasal and small intestinal worms reduced and female worms reduced more than male worms. Male and female *H. contortus* were reduced by 61 and 76%, respectively (Shaik et al., 2006)
Lambs, fed hay; natural and experimental *Haemonchus contortus* infections	Sericea hay or bermudagrass hay, 7 weeks, bermudagrass an additional 2 weeks	FEC reduced for those receiving sericea (67-98%); FEC increased after sericea feeding stopped. Sericea also reduced worm numbers.	SL fed as hay reduced naturally infected worm burdens 67%; reduced establishment of incoming larvae 26%. (Lange et al., 2006)
Angora does, grazing	Sericea or crabgrass/tall fescue grazing, 81 days	Goats on sericea had reduced FEC and fewer adult worms. Inhibited larval activity. Improved weight gain and immune responses. No adverse effect on does and kids (3.6 kg/kid).	Goats grazing sericea reduced both *H. contortus* (89%) and *Trichostrongylus* parasites (50%). (Min et al., 2005)
Kiko-Spanish kids fed ground hay and pellets; natural infection	Sericea hay in ground and pelleted forms, ground bermudagrass hay	Pelleted sericea reduced FEC 78%; increased PCV 32% compared with bermudagrass	Pelleting increased effectiveness of sericea hay against parasitic worms; reduced adult *H. contortus* 75% (Terrill et al., 2007)

Using Sericea Lespedeza

Producers should not rely on sericea as the sole method for controlling internal parasites. However, sericea can be useful as one part of a complete parasite management strategy. Sericea has been shown to reduce hatchability and fecundity (egg laying ability) of internal parasites, and in that way it will help reduce pasture contamination with larvae. Also, when used for longer periods of time, it can reduce the number of adult worms. Researchers are working to determine the most effective and economical ways to use sericea lespedeza as a substitute for anthelmintics, or as a "deworming pasture." More information will be available as the research is done. Continue to check the Southern Consortium for Small Ruminant Parasite Control Web site at *www.scsrpc.org* for updates.

Resources:

Managing Internal Parasites in Sheep and Goats
www.attra.ncat.org/attra-pub/parasitesheep.html
This concise paper includes information gathered from the research of the Southern Consortium for Small Ruminant Parasite Control (see below) and includes helpful information and pictures explaining many of the concepts needed for an integrated parasite control program.

Southern Consortium for Small Ruminant Parasite Control
www.scsrpc.org
The Consortium is a group of researchers and educators who are working on the parasite problem. This site includes publications, upcoming events such as FAMACHA© trainings, contacts for Consortium members, and many other items helpful to producers and educators. This is the place to look for current research results and information about the latest recommendations for sustainable parasite control.

Tannins
www.ansci.cornell.edu/plants/toxicagents/tannin
An interesting look at the properties and uses of tannins.

Sericea Lespedeza
http://www.aces.edu/dept/forages
Alabama forages site; this includes link to Alabama forages lespedeza page, as well as access to articles and experiment station results from Auburn University. The lespedeza page includes three articles; titles are listed below.

- AU Grazer - A Sericea Lespedeza that Tolerates Heavy Grazing
- Invasive Plant Misconception
- Sericea Lespedeza: A Pasture, Hay, and Conservation Plant

http://www.ag.auburn.edu/agrn/mosjidis/sericea1lespedeza.htm
This links to the research page; includes the articles above and an article about establishing lespedeza stands. Exploring the buttons on the left will yield information about cultivars and about Auburn research.

http://www.aces.edu/pubs/docs/A/ANR-1318/ANR-1318.pdf
Sericea Lespedeza: A Pasture, Hay, and Conservation Plant. Extension publication, 4 p. Written by Don Ball and Jorge Mosjidis, this concise paper includes information about establishment, management, varieties, and use for internal parasite control.

http://plants.usda.gov/factsheet/pdf/fs_lecu.pdf
USDA Plant Fact Sheet: Chinese lespedeza. 2 p.

http://plants.usda.gov/java/profile?symbol=LECU
From the USDA Plants database. Lots of information, including a map showing distribution, links to other sites, pictures, taxonomy and other specific information.

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Related ATTRA Publications

- Managing Internal Parasites in Sheep and Goats
- Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles
- Integrated Parasite Management for Livestock
- Small Ruminant Sustainability Checksheet

Notes:

Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza

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NCAT/ATTRA and Southern Consortium for Small Ruminant Parasite Control, 2007

Tracy Mumma, Editor
Amy Smith, Production

This publication is available on the Web at:
www.attra.ncat.org/attra-pub/sericea_lespedeza.html
or *www.attra.ncat.org/attra-pub/PDF/sericea_lespedeza..pdf*

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PARASITE MANAGEMENT PRINCIPLES

A: FLOCK MANAGEMENT REQUIREMENTS

- **Separation of Groups**
  Since different classes of animals vary in their susceptibility to parasite infection and its effects, they should be separated into groups, which are grazed, treated and managed as distinct entities. The more susceptible animals are young/weanlings; and pregnant/lactating animals.

- **Separation of pastures**
  Unless pastures are divided, all animals will be exposed to a similar challenge, regardless of whether they are susceptible or resistant to parasite infection and its effects. Division of pastures is not only good for internal parasite control, it also aids pasture management. Electric fences can be used as temporary pasturage dividers.

- **Resting of pastures**
  If pastures can be separated, it is then possible to rest them effectively. If pastures can be rested long enough, this will also have a significant effect on the survival of worm larvae and therefore the infection rate of the flock. Although the time needed for effective resting of pastures will vary with the climate, weather and parasite species, a useful rule of thumb for effective resting is at least 3 months. The longer the rest, the better it is.

- **Alternation of host species**
  Sheep and goats share the same worm species and alternation with one another is ineffective for worm management. However, other species like cattle, horses are generally not susceptible to the parasites of sheep and goats. If they are used to graze pastures before or after sheep or goats, they act as "vacuum cleaners" on the pasture, as they ingest many larvae which cannot develop further into egg-laying adults.

- **Repair water leaks**
  Water troughs, should not be allowed to leak, the area can become contaminated by larvae.

- **Avoid manure buildup and grass in pens**
  Where sheep or goats have to be penned for lengthy periods (usually at night for theft or predation) there can be a large buildup of larvae.

- **Fence off moist areas**
  Areas particularly prone to high moisture and therefore the survival of worm larvae, like streams and marshes, should be separated.

- **Strategic movement of flocks**
  The aim should be to create "safe" (not necessarily "worm free") pastures. By planning changes in paddocks, flock will be subject to lower challenges and need less treatment.

- **Quarantine and treatment**

  Do not introduce newly purchased animals into the flock or herd. They must be quarantined in a worm-unfriendly pen (dirt floor or concrete) and treated intensively using multiple drugs. Perform FECRT to ensure minimum carry-over of drug-resistant parasites.

B. GENETIC SELECTION

- **Selection for resistance**

  Resistance is heritable and can be selected for, by measuring the fecal egg counts and using only those animals with the lowest FEC's for breeding. For practical and economical reasons, this is usually only done for males.

- **Selection for resilience**

  Resilience (the ability to withstand the effects of infection and produce satisfactorily) is also heritable. At present, only two proven methods, FAMACHA© and PCV determination exist, although preliminary results suggest that Body Condition Scoring may also be useful.

C. MONITORING SYSTEMS

- **FEC**

  Regular (monthly or bimonthly) monitoring of a composite fecal egg counts on a group or flock basis will help to indicate when treatment is really needed, and equally important, when it can be delayed or even omitted.
- **FECRT or Drenchrite**

  Every farmer should have the flock tested for drug resistance for the worm population on the farm, at regular intervals of not less than two years. Only by knowing exactly what the state of anthelmintic resistance on a farm is, then, treatment and control recommendations can be made.
- **FAMACHA© evaluation**

  Apart form selection and culling, this system also allows frequent, cheap and easy monitoring of the current situation as regards to parasite infection, but applies only to hemonchosis.

D. OPTIMISE ANTHELMINTIC USE

- **Establish the important parasites species present**

  Unless the prevalence and importance of worm species is known, worm management becomes dangerous and unpredictable guesswork.

- **Use the most suitable drug**

  If the parasite susceptibility to anthelmintics is known, it is possible to decide which drug(s) and formulations will be the most suitable in each situation.

- **Avoid too frequent treatment**

  The old approach of "dosing clean animals" must be completely abandoned. The aim has to be to treat only sufficient times and individual animals to maintain the equilibrium between parasite, host and environment (that is, worm management). Overtreatment ensures that only resistant parasites can survive. Minimal treatment programs must be the new watchword, but is must be ensured that every treatment is effective.

- **Treat all and stay**

  This is a major departure from the recommendations made for close to a century for "treat and move". If **all** animals are to be treated, they should remain in the pasture/ paddock where they were grazing. This will prevent them from contaminating a new pasture with only resistant parasites which survived treatment, in the process thus unwittingly causing the selection of resistance parasites. In most cases they should remain in the paddock/ pasture for at least 2-3 weeks after treatment to pick up unselected larvae for propagation of the susceptible worms in the new paddock.

- **Treat selectively**

  It is preferable to treat only those sheep or goats unable to cope with the current infection challenge. This can be done with the FAMACHA© system.

E. IMPROVED ANTHELMINTIC EFFICACY

- **Dose over the tongue**

  By placing the tip of the gun towards the back of the mouth, over the tongue, closure of the esophageal groove does not occur and thus the full dose lands in the rumen where it is absorbed more slowly - this is particularly important for anthelmintic groups which rely on prolonged blood levels for their effect, like the benzimidazoles and macrocyclic lactones.
  This prolonged level of activity (a long so-called "killing zone") means that the drug against which worms have developed a moderate degree of resistance can be made more effective.

- **Reduce feed intake**

  It has been shown, in the case of benzimidazoles and closantel, that reducing feed intake for 24 hours prior to treatment will improve the absorption of the drug because of the lower rate of flow of ingesta, resulting in a more effective exposure of the parasite to the drug.

- **Repeat the dose**

  This only applies to benzimidazoles and macrocyclic lactones. Two doses given 12 hours apart will again increase the "killing zone" of these drugs, allowing more time for a cumulative killing effect for resistant worms.

- **Increase the dose**

  This only applies to drugs which rely mainly on peak concentrations for their effect. In this case, a double amount of drug given at one time can overcome drug resistance in worms. This is useful for the levamisole. There is however a relatively low safety margin specially in goats.

- **Correct dosage**
  It may seem too obvious, but a lot of problems are caused by not weighing sheep and goats, not calibrating and checking the dosing gun for accuracy and repeatability. Underdosing may be a factor leading to anthelmintic resistance, but it is more likely to be the cause of ineffective treatment.

- **Drug combinations**
  Combining drugs from different classes, may temporarily improve the effective clinical action of these drugs.

- **Goats are different**
  Because of differences in the rate of metabolizing drugs, goats must be treated as different from sheep. This means that goats must often be given a higher dosage rate than sheep except where there is a possibility of toxicity. Note that many anthelmintics may not be approved for use in goats, or that the recommended dose given is the same as for sheep.

F. EFFECTIVE PLANNING

- **Use the expert**
  Knowledgeable veterinarians, who know the area, farming systems and risks can construct a simple, practical, economic and effective total strategy. They should consult with parasitologists where necessary.

- **Use a program**
  Unless a basic planned system is in place and is used, actions will inevitably be largely reactive and based on panic decisions.

- **Treatment strategy**
  It is probably true on most farms that animals are either dosed too often, or with inappropriate drugs, or at the wrong times, or with no coherent plan. By setting up a well thought out dosing plan, we can cut out ineffective doses which only add to the selection pressure for parasite resistance. This is one of the areas in which the knowledge and skills of the local veterinarian are vital for success.

- **Flexibility**
  The program must be flexible to allow for changes in weather, management and farming systems, drug costs or other factors.

Small Ruminants Fecal Egg Count and Dewormer Guides

- **Modified McMasters Egg Counting Procedure**
- **Procedure for Counting Fecal Eggs**
- **Dewormer Chart for Sheep**
- **Dewormer Chart for Goats**
- **Commonly Used Anthelmintics in Sheep and Goats**

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Louisiana State University

Modified McMaster Egg Counting For Qiantitation of Nematode Eggs.

Fecal worm egg examination methods are based on the principle of differential density. In other words, parasite eggs sink in water, but they will float in various chemical solutions that are more dense than water (technically, they have a higher specific gravity) because the eggs are lighter than the fluid used as a floatation solution. The most inexpensive and easiest floatation solution to make is using table salt. One quart of flotation solution is sufficient for about 30 McMaster examinations.

The first step is to collect freshly passed feces that are uncontaminated by soil or bedding. The best way is to use a rubber glove and extract feces directly from the rectum. Alternatively, a feces can be picked up off the ground if done soon after deposited. The collection container should be labeled with the name (number) of the animal and the date of collection. Fresh samples work best, but accurate results can be obtained if the sample is kept refrigerated during the interim. If samples are not refrigerated the eggs will hatch within 12 to 24 hrs. Once hatched, they cannot be counted.

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).

**To order this slide, contact:

Chalex Corporation
5004 228th Ave., S.E.
Issaquah, WA 98029-9224
Phone (425) 391-1169
FAX (425) 391-6669
E-mail: chalexcorp@att.net
Web site: www.vetslides.com

Procedure:

1. Weigh out 2 grams of feces into a 50 ml centrifuge tube and fill to 30 ml with salt solution.
    a. It is recommended to purchase a small scale and weigh feces, but if you do not have a scale you can still get a close estimation by putting28 ml of salt solution into a 50 ml centrifuge tube first, and then adding feces until a volume of 30 ml is achieved.
2. Pour off approximately 25 ml of the salt solution into another small container keeping feces in the tube (can use tongue depressor).
3. Let soak for a few minutes and mix (soft feces) or break up (fecal pellets) with a tongue blade. .
4. Add back about ½ of the salt solution and mix well, breaking up any remaining feces as best as possible.
5. Add back the remaining salt solution and screw the cap back onto the tube.
6. Shake tube vigorously for about 1 minute to disrupt any remaining feces as much as possible.
7. Set tube aside for a few minutes to let bubbles dissipate.
8. Wet McMaster chamber with water and dry top and bottom on paper towels.
9. Rock (don't shake) tube several times to thoroughly mix solution without causing large air bubbles to form.
10. Immediately pipet (using 1 ml syringe or eye dropper) a sample of the suspension and fill both sides of counting chamber. Work quickly. If it takes more than a few seconds to load the first chamber, then mix fecal solution again and refill pipet before loading the second chamber.
11. Let stand for 1-2 minutes to allow eggs to float to top.
12. Count all eggs inside of grid areas (greater than ½ of egg inside grid) using low power (10x) objective. Focus on the top layer, which contains the very small air bubbles (small black circles, if numerous large air bubbles are visible, remove the fluid and refill).
13. Count only trichostrongyle/strongyle eggs (oval shaped, ~ 80-90 microns long). Do not count strongyloides (oval, ~ 50 microns long), tapeworm eggs (triangular/D-shaped) or coccidia (various sizes). Notations are made as to the presence of other species, but only the trichostrongyle/strongyle eggs are counted.
14. Once filled, the chambers can sit for no longer than 60 min before counting without causing problems. Longer than this and drying/crystal formation may begin.
15. Total egg count (both chambers) x 50 = EPG (eggs per gram).
    a. Note: This is a dilution technique and theoretically this ratio of feces to flotation solution will not detect infections with less than 50 eggs per gram of feces (1 egg seen on slide), so it is not very accurate for samples with low numbers of eggs. On a practical level this is not important because from a clinical standpoint, slight differences in results when egg counts are low do not matter.

Notes:
Fairly soon after counting is complete thoroughly rinse out the McMaster chamber with warm running water. Doing so will keep the chamber clean and ready it to be used again. If fecal solution dries in the chamber do not soak in soapy water for long periods as this will cause the chamber to become cloudy. If the chamber gets dirty, soak for only a few minutes in water containing dish soap and then rinse completely with tap water.

This is one method for performing a McMaster fecal egg count. Other different but similar protocols are routinely used in many labs, so you may see a slightly different procedure recommended elsewhere. The important thing is to use the same procedure each time.

Procedure for Counting Fecal Eggs

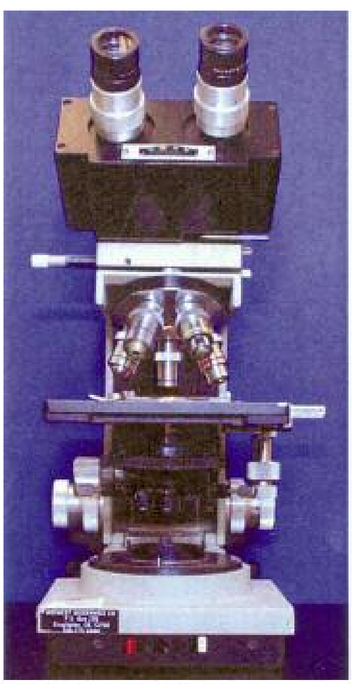
Conducting a fecal egg count is an easy method for determining the severity of internal parasite infection in a goat. The procedure is simple but does require some special pieces of equipment. However, once all of the required items have been acquired, very little time is needed to count fecal eggs and the information provided to a producer can be very valuable in making health and management decisions. Further, once the procedure has been mastered, it is possible for a producer to test the effectiveness of the dewormer (anthelmintic) being used, whether conventional or alternative, through performing a fecal egg count reduction test.

The fecal egg counting procedure described here is a modified version of the McMaster technique. The principle of the procedure is that fecal eggs excreted in the manure will be separated from the manure so that they can be counted. This is accomplished through the use of a flotation solution, a special microscope slide, and a microscope.

Equipment needed

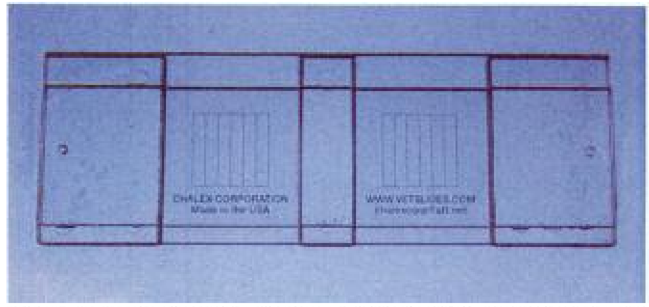
The equipment needed to conduct a fecal egg count includes:

- Microscope having a 10× objective and 10× wide field (WF) eyepiece. A mechanical stage allowing ease of movement of the slide is preferable.



Suitable microscope.

- McMaster slide, the special slide in which the fecal eggs are counted. These are available from Chalex Corporation phone 425-391-1169 or WWW.vetslides.com.



McMaster fecal egg counting slide.

- Thirty cc syringe.
- Three cc syringe with the end cut off or
- Balance or scale that weighs accurately to 0.1 grams.
- Teaspoon/tongue depressor/popsicle stick/spatula.
- Eyedropper.
- Small dish, such as a salsa dish.
- Tea strainer.

Fecal egg counting equipment using a scale.

Flotation solutions

One of the following flotation solutions having a specific gravity of 1.20 needed to float eggs must be made or purchased.

- Add 1¼ cup sugar to 1 cup water and mix (easiest to mix) or,
- 34% solution of zinc sulfate (used for footbath) or,
- Saturated sodium nitrate solution (28%, fertilizer) or,
- Saturated solution of salt, rock salt or uniodized salt (requires heating and a lot of stirring) or,
- Fecasol or generic fecal float solution available for $5-10/gal from a veterinary supply store.

Collecting fecal samples

For most producers, it is unrealistic to expect that every goat will be sampled and tested. The following suggestions may serve as guidelines for the number of goats needed to be sampled and tested.

- If the herd consists of fewer than 8 goats, sample all goats.
- For herds up to 50 in number, sample 8 to 12 goats.
- For herds up to 100, sample 15 to 20 goats.
- If goats are sampled several times during the year to monitor fecal eggs, it is best if the same animals are being sampled.

The fecal samples collected must be fresh. This can be accomplished in two ways. A producer can watch his/her goats and collect fresh pellets after defecation or the producer can put on an examination glove, lubricate with water and tease five to six pellets from the rectum. In either case, the pellets should be stored in a ziplock bag and animal number recorded. Pellets can be stored in the refrigerator or on ice for 3 to 4 days but should not be frozen. However, it is best to conduct the test directly after collecting the fecal samples.

Procedure

1. Fill the 30 cc syringe to exactly 28 cc with the flotation solution.
2. Add the 28 cc to the small dish.

28 cc (ml) of flotation solution.

3. Add the correct amount of feces in one of two ways. If using a balance, weigh 2 grams of feces. It may be necessary to break a pellet to get within 0.1 grams of 2.0 grams. If a balance is not available, refer to the following section on ***an alternative procedure for measuring 2 grams of feces.***

2 grams of feces on scale.

4. Place 2.0 grams of feces into the tea strainer sitting in the small dish with the flotation solution.

The 2 grams of feces is put in the tea strainer in the small dish.

5. Use a spoon or other tool to crush and break up feces forming a slurry. This usually takes roughly 2 minutes.

A teaspoon is used to mash the feces.

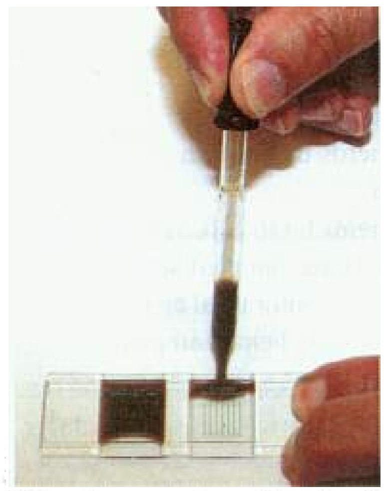
6. Lift the tea strainer out of small dish and discard the fecal residue.

Tea strainer with the fecal residue is removed.

7. Stir the solution in the dish 8 times with a spoon using a back and forth motion.

Stir the solution.

8. Then use an eyedropper to fill one chamber of the McMaster slide.
9. Repeat step 7 and fill the other chamber of the slide.
10. Allow slide to sit 5 minutes.



Filling the second counting chamber.

11. Look at the slide under a microscope. Focusing on air bubbles trapped in the slide will give proper focus.
12. Orient the slide to begin in one corner of the marked lanes. The slide has two squares each of which is marked off into 6 lanes. Begin in the corner of one square and start counting up

Corner of slide.

one lane, ensuring that both marked sides of the lane are visible. Move the slide over to the next lane and count down. Repeat this procedure until all 6 lanes are counted.

13. The eggs of interest will appear oval and similar to rounded-end footballs in shape.

View in microscope of three Haemonchus contortus (barberpole worm) eggs.

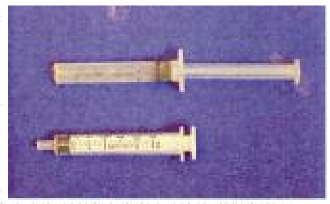
14. While it is possible to identify tapeworm eggs and coccidia, the eggs of most interest are the oval shaped roundworm eggs. These should be counted.
15. Count all eggs in 6 lanes in one chamber or half of the slide then repeat on the other half.
16. Total the number of eggs from both squares. (The number of eggs in each square should be similar. If this is not the case, the slides may need to be reloaded and recounted.)
17. Multiply that number by 50 to calculate eggs per gram feces.

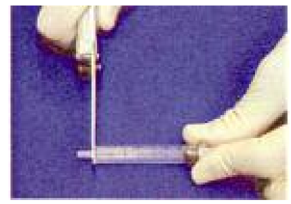
Some general recommendations for deworming are to deworm dry does and bucks when 2,000 eggs per gram of feces are found. All other animals should be dewormed when having 1,000 eggs per gram of feces. After deworming, do not return animals to contaminated pastures.

An Alternative Procedure for Measuring 2 Grams of Feces

A simple and cheaper alternative to purchasing a digital scale for weighing 2 grams of feces is to use a 3 cc (ml) syringe with tip cut off.

Use a sharp knife to cut off the very end of the syringe.





Cutting the syringe tip off.

Fill the cut syringe to the 3 cc mark with feces.

Filling the syringe with feces.

To pack the syringe and get rid of air spaces, place the syringe upside down and press on the plunger.

Packing the syringe.

2 ml of feces.

After packing the feces, depress the plunger to the 2 cc mark and cut off the excess fecal material.

Push the 2 cc of feces into the strainer.

Once the feces are in the strainer, the remaining steps are identical to the procedure using fecal pellets.

Conducting a Fecal Egg Count Reduction Test

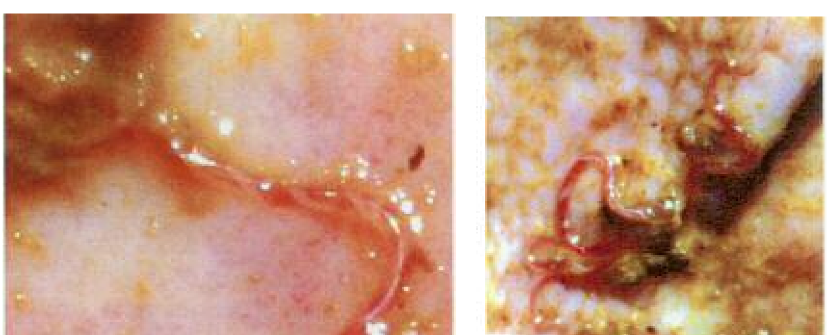
The problem of internal parasites developing resistance to dewormers is growing throughout the world. To determine the effectiveness of an anthelmintic, conventional or alternative, used on farm, a fecal egg count reduction test (FECRT) can be performed. The FECRT will assist the producer in determining the percentage of reduction of internal parasite eggs due to the anthelmintic treatment.

The steps in conducting a FECRT are as follows:

1. Use a minimum of 12 - 24 animals depending upon herd size.
2. Divide the animals into a control and a treatment group.
3. Collect fecal samples from all animals.
4. Deworm the treatment group animals based upon liveweight.
5. Conduct fecal egg counts on all collected samples (Time 1).
6. Between 7 and 10 days after deworming, collect fecal samples from all animals in both groups (Time 2).
7. Conduct fecal egg counts on all samples.
8. Calculate the percentage reduction in fecal eggs as follows:

$$\text{FECR (\% reduction)} = \left(1 - \frac{T_2}{C_2}\right) \times 100$$

Where T_2 is the average fecal egg count of all treatment animals at Time 2 and C_2 is the average fecal egg count of all control animals at Time 2. A reduction of less than 95% is evidence of anthelmintic resistance. If the fecal egg count reduction is less than 65%, the dewormer is not effective.



Haemonchus contortus (barberpole worms) in the abomasum of a goat.

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DEWORMER CHART FOR SHEEP

***Important ---**
Please read notes below before using this chart.*

Give drugs **ORALLY**. 1 ml = 1 cc	**Valbazen (albendazole)**	**SafeGuard (fenbendazole)**	**Ivomec (ivermectin)**	**Levasole (levamisole)**	**Cydectin Sheep Drench (moxidectin)**
Weight Pounds (lbs)	**7.5 mg/kg 0.75 mls/ 25 lb**	**5 mg/kg 0.6 ml/ 25 lb**	**0.2 mg/kg 2.9 mls/ 25 lb**	**8 mg/kg 2 mls/ 25 lb**	**0.2 mg/kg mls/25 lb**
20	0.6	0.5	2.3	1.6	1.8
25	0.75	0.6	2.9	2.0	2.3
30	0.9	0.7	3.4	2.4	2.7
35	1.1	0.8	4.0	2.8	3.2
40	1.2	0.9	4.5	3.2	3.6
45	1.4	1.0	5.1	3.6	4.1
50	1.5	1.1	5.7	4.0	4.5
55	1.7	1.3	6.2	4.4	5.0
60	1.8	1.4	6.8	4.8	5.4
65	2.0	1.5	7.4	5.2	5.9
70	2.1	1.6	8.0	5.6	6.3
75	2.3	1.7	8.5	6.0	6.8
80	2.4	1.8	9.1	6.5	7.2
85	2.6	1.9	9.7	6.9	7.7
90	2.7	2.0	10.2	7.3	8.1
95	2.9	2.1	10.8	7.7	8.6
100	3.0	2.2	11.4	8.1	9.1
105	3.2	2.3	1.02	8.5	9.5
110	3.3	2.5	12.5	9.0	10
115	3.5	2.6	13.1	9.3	10.5
120	3.6	2.7	13.7	9.7	10.9
125	3.8	2.8	14.2	10.1	11.4
130	3.9	2.9	14.8	10.6	11.8
140	4.0	3.0	15.4	11	12.7
150	4.2	3.1	16.0	12.2	13.6

Valbazen Suspension (11.36 % or 113.6 mg/ml): approved for sheep at a dose of 7.5 mg/kg orally with a meat withdrawal of 7 days. Do not use in pregnant ewes in the 1st trimester of pregnancy.
Safe-Guard/ Panacur Suspension (10% or 100 mg/ml): approved for sheep at 5 mg/kg orally with meat withdrawal time of 6 days.
Ivomec Sheep Drench (0.08% or 0.8 mg/ml): Approved for use in sheep at a dose of 0.2 mg/kg orally with a meat withdrawal time of 11 days. Protect from light.
Levasole (Tramisol) Soluble Drench Powder: Approved for use in sheep, with a meat withdrawal time of 3 days. Oral solution ONLY. To prepare use 1 packet (13 gm/11.7 gm active ingredient) dissolved in 262 ml water (44.7 mg/ml) {or 52 gram packet dissolved in 1048 ml water.} NOTE: This is different dilution from the label directions for administration (1/2 the amount of water).
Cydectin Sheep Drench (1 mg/ml): use orally at 0.2 mg/kg. Meat withdrawal time is 7 days.

NOTE for Guideline for Anthelmintic Dosages in Sheep

This chart was developed by Lisa Williamson, DVM, MS and Ray M. Kaplan, DVM, PhD (University of Georgia). It is provided as a possible guideline for anthelmintic (deworming) dosages for sheep. Producers should consult their veterinarian for advice on their specific management situation for determining dosages for their herd.

Drug resistance in parasites of sheep is extremely common. The effectiveness of an anthelmintic should always be tested before being used by performing a Fecal Egg Count Reduction Test (FECRT) or DrenchRite larval development assay (contact Dr. Kaplan's laboratory [706-542-5670] for more information about the DrenchRite test, cost = $350).

DEWORMER CHART FOR GOATS

***Important ---**
Please read notes below before using this chart.*

Give Drugs <u>ORALLY</u>. 1 ml = 1 cc	Valbazen Albendazole	SafeGuard Fenbendazole	Ivomec Ivermectin	Tramisole Levamisole	Cydectin Sheep Drench Moxidectin	Cydectin *Injectable Moxidectin
Weight Pounds (lbs)	**20 mg/kg 2 mls/ 25 lb**	**10 mg/kg 1.1 ml/ 25 lb**	**0.4 mg/kg 6 mls/ 25 lb**	**12 mg/kg 3 mls/ 25 lb**	**0.4 mg/kg 4.5 mls/25 lb**	***GIVE SQ 0.2 mg/kg 1 ml/ 110 lb**
20	1.6	0.9	4.8	2.4	3.6	0.2
25	2.0	1.1	6.0	3.0	4.5	0.2
30	2.4	1.4	7.2	3.6	5.4	0.3
35	2.8	1.6	8.4	4.2	6.5	0.3
40	3.2	1.8	9.6	4.8	7.3	0.4
45	3.6	2.1	10.8	5.4	8.2	0.4
50	4.0	2.3	12.0	6.0	9.0	0.5
55	4.4	2.5	13.2	6.6	10	0.5
60	4.8	2.7	14.4	7.2	11	0.5
65	5.2	3.0	15.6	7.8	12	0.6
70	5.6	3.2	16.8	8.4	12.7	0.6
75	6.0	3.4	18.0	9.0	13.6	0.7
80	6.4	3.6	19.2	9.6	14.6	0.7
85	6.8	3.9	20.4	10.2	15.4	0.8
90	7.2	4.1	21.6	10.8	16.4	0.8
95	7.6	4.3	22.8	11.4	17.3	0.9
100	8.0	4.6	24.0	12.0	18	0.9
105	8.4	4.8	25.2	12.6	19	1.0
110	8.8	5.0	26.4	13.2	20	1.0
115	9.2	5.2	27.6	13.8	21	1.0
120	9.6	5.5	28.8	14.4	22	1.1
125	10.0	5.7	30.0	15.0	22.7	1.1
130	10.4	5.9	31.2	15.6	23.6	1.2
140	11.2	6.4	33.6	16.8	25.4	1.3
150	12.0	6.8	36.0	18.0	27.3	1.4

Valbazen Suspension (11.36 % or 113.6 mg/ml): 20 mg/kg orally; meat withdrawal time is 9 days and 7 days for milk Do NOT use in pregnant does in the first trimester of pregnancy

Safe-Guard/ Panacur Suspension (10% or 100 mg/ml): the label dose in goats is 5 mg/kg, but a 10 mg/kg dosage is required for good efficacy. At 10 mg/kg dosage, meat withdrawal is 16 days and 4 days for milk.

Ivomec Sheep Drench (0.08% or 0.8 mg/ml): 0.4 mg/kg orally; meat withdrawal time is 14 days.

Levasole Soluble Drench Powder (Sheep): 12 mg/kg oral dose with meat withdrawal of 4 days. Solution prepared by dissolving 1 packet (13 gm/11.7 gm active ingredient) in 262 ml water (44.7 mg/ml) {or 52 gram packet dissolved in 1048 ml water}. NOTE: This is different dilution from the label directions.

Cydectin Sheep drench (1 mg/ml): use orally at 0.4 mg/kg orally; meat withdrawal time is 23 days. Milk withdrawal not established; do not use in lactating goats.

Cydectin Injectable for Cattle (10 mg/ml): GIVE SQ at 0.2 mg/kg. Meat withdrawal time is 30 days. Not for use in lactating dairy goats. The current recommendation is to use the Cydectin cattle injectable formulation instead of the pour-on formulation (orally or topically) or the Cydectin sheep oral drench. When administered by subcutaneous injection, moxidectin provides improved drug levels as compared to when administered orally. When this product is not available, use Cydecin sheep drench by the oral route.

NOTE on Guideline for Anthelmintic Dosages in Goats

The attached chart was developed by Ray M. Kaplan, DVM, PhD (University of Georgia) and modified by Lisa Williamson, DVM, MS (University of Georgia) and Patty Scharko DVM, MPH (University of Kentucky). It is provided as a possible guideline for anthelmintic (deworming) dosages for goats. Producers should consult their veterinarian for advice on their specific management situation for determining dosages for their herd.

With the exception of fenbendazole administered at the 5 mg/kg dose, these drugs are **not** approved by the Food and Drug Administration (FDA) for use in goats, and when used in goats are considered extra label use. Fenbendazole at the recommended dose rate of 10 mg/kg is considered extra-label usage. The FDA regards extra-label use of drugs as an exclusive privilege of the veterinary profession and is only permitted when a bona fide veterinarian-client-patient relationship exists and an appropriate medical diagnosis has been made. The following chart is intended to serve as guideline for improving accuracy when dosing goats with an anthelmintic, but these drugs should be used in goats only when appropriate veterinary advice has been received.

Drug resistance in parasites of goats is extremely common. The effectiveness of an anthelmintic should always be tested before being used by performing a Fecal Egg Count Reduction Test (FECRT) or DrenchRite larval development assay (contact Dr. Kaplan's laboratory [706-542-5670] for more information about the DrenchRite test, cost = $350).

ADDITIONAL NOTE ON CYDECTIN: In meat goats, Cydectin (moxidectin) reaches higher drug levels in the blood when administered by subcutaneous injection as compared to when administered orally. Therefore, the current recommendation is to use the Cydectin cattle injectable formulation in meat goats, at the same dose as it recommended for cattle. However, if the injectable formulation is not available, use the recommended doses for the Cydectin Sheep Oral Drench listed on the chart.

Table 1: Commonly used anthelmintics in sheep and goats.

Drug	Class	Approved Sheep	Approved Goats	Dosage (mg/kg)	How Supplied	Prevalence of Resistance*	Meat WDT	Milk WDT For Goats	Remarks
Ivermectin	AM	Yes	No	Sheep 0.2 Goats 0.4	Sheep oral drench	high	Sheep 11 days Goats 14 days**	8 days**	Cattle injectable formulation not recommended
Doramectin	AM	No	No	Sheep 0.2 Goats 0.4	Injectable	high	ND	NE	Not recommended because long residual activity promotes resistance
Moxidectin	AM	Yes	No	Sheep 0.2 Goats 0.2	Sheep oral drench Cattle injectable	low to moderate	Sheep 14 days Goats 30 days**	NE	Use oral drench in sheep Use cattle injectable in meat goats (if using sheep oral drench dose = 0.4 mg/kg) Kills ivermectin-resistant *Haemonchus* Minimize use to preserve efficacy
Levamisole	I/T	Yes	No	Sheep 8.0 Goats 12.0	Soluble drench powder	low to moderate	Sheep 3 days Goats 4 days**	NE	Toxic side effects = salivation, restlessness, muscle fasciculations Recommend weighing goats before treatment
Morantel	I/T	No	Yes	10	Feed premix	moderate	30 days	0 days	Approved for use in lactating goats Surveys for prevalence of resistance have not been performed
Fenbendazole	BZ	No[a]	Yes	Sheep 5.0 Goats 5.0[b]	Paste Suspension Feed block Mineral Pellets	high	Goats 6 days[c] (for suspension only)	0 days[c] (for suspension only)	[a]Approved in Big-horned sheep [b]Label dose is 5.0 mg/kg but 10 mg/kg is recommended for goats [c]Listed WDT are for the 5 mg/kg dose. At 10 mg/kg, WDT should be extended to 16 days for meat and 4 days for milk**
Albendazole	BZ	Yes	No	Sheep 7.5 Goats 15-20	Paste Suspension	high	Sheep 7 days Goats 9 days**	7 days**	Don't use within 30 days of conception Effective against Moniezia tapeworms

AM = Avermectin/Milbemycin (Macrocyclic Lactone)
BZ = Benzimidazole
I/T = Imidazothiazole/Tetrahydropyrimidine
WDT = Withdrawal time
NE = Milk WDT has not been established in goats; product should not be used in lactating dairy goats
ND = Meat withdrawal time has not been established. To be safe it is suggested to double cattle WDT
*In the southern United States. Prevalence of resistance has not been established elsewhere.
**Based on FARAD recommendations

Table is modified from one published in 5th edition of *Current Veterinary Therapy: Food Animal Practice* "Anthelmintic Therapy in an Era of Resistance," by Ray M. Kaplan, DVM, PhD, DipEVPC

*****This table is intended for veterinary use only. Others should consult with their veterinarian before using any drug in an extra-label manner*****