

**Internal & External Parasites of Goats**  
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**Unit Objective**

After completion of this module of instruction the producer should be able to observe goat's symptoms for possible infestation of parasites by personal observations and by using the FAMACHA<sup>®</sup> Eye Color Chart. The producer should be able to identify specific parasite problems within the goat herd and develop a management/control program for controlling parasites within the goat herd. The producer should be able to complete all assignments with 100% accuracy and score a minimum of 85% on the module test.

**Specific Objectives**

After completion of this instructional module the producer should be able to:

1. State the most serious constraint affecting small ruminant production worldwide.
2. Identify economic losses due to parasites within the goat herd.
3. State the parasite effect with goats when goats are managed as browsers.
4. Identify one of the most serious nematodes that affects goats.
5. Identify some systems of goats affected by the Barber-pole worm.
6. State the effect of nutrition as related to parasite interaction.
7. Identify the stages in the life cycle of the parasite.
8. State the four phases of the Epizootiologic cycle of parasites.
9. Distinguish between the Barberpole worm and the Brown stomach worm.
10. Distinguish between the Bankrupt worm and the Long-necked bankrupt worm.
11. Distinguish between the nodular worm and the whipworm.
12. Identify general signs of parasitized animals.
13. State the function of a fecal egg count.
14. State the meaning and interpretation of Blood Packed Cell Volume.
15. State the affect of anemia with parasite infestation.
16. Match the FAMACHA<sup>®</sup> Eye Color Chart level of anemia to the meaning/interpretation of the different levels.
17. State the purpose of dewormers.
18. Identify the three general classes of dewormers.
19. State the three general formulations of dewormers.
20. Identify the different ways of administering dewormers.
21. Identify some commonly used dewormers in goats including amount to give and withdrawal time from meat and milk.
22. State why goats develop a resistance from some dewormers.
23. State some facts for smart use of dewormers.
24. State meaning of mixed/alternate livestock species grazing.
25. State the effect of parasite control by using pasture rotation.
26. State the benefit of genetic improvement with parasite control.
27. Identify the two approved dewormers for goats.

28. State the meaning of integrated approaches for controlling parasites within the goat herd.
29. Match the category of other parasites that affect goats to their description.
30. Use the FAMACHA<sup>®</sup> Eye Color Chart to check the eyes of your goats.
31. Develop a management/control plan for controlling parasites within the goat herd.

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## 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**

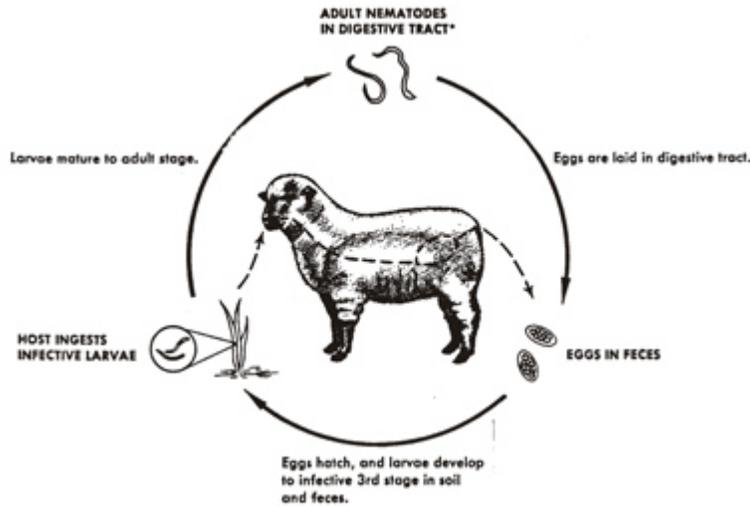
### ***Gastrointestinal nematodes (worms)***

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

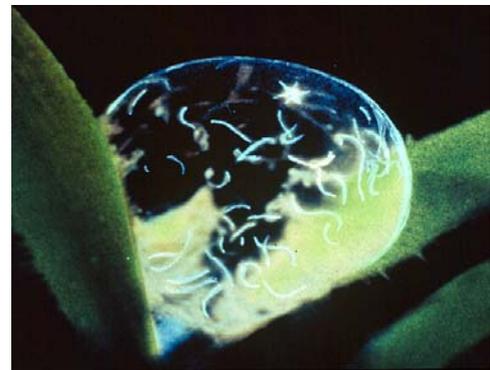
### ***General life cycle***

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 goat and part of their life on the pasture (Figure 1).

**Figure 1. General life cycle of gastrointestinal worm parasites**



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 (Figure 2) where they can be consumed during grazing thus completing the cycle. 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.



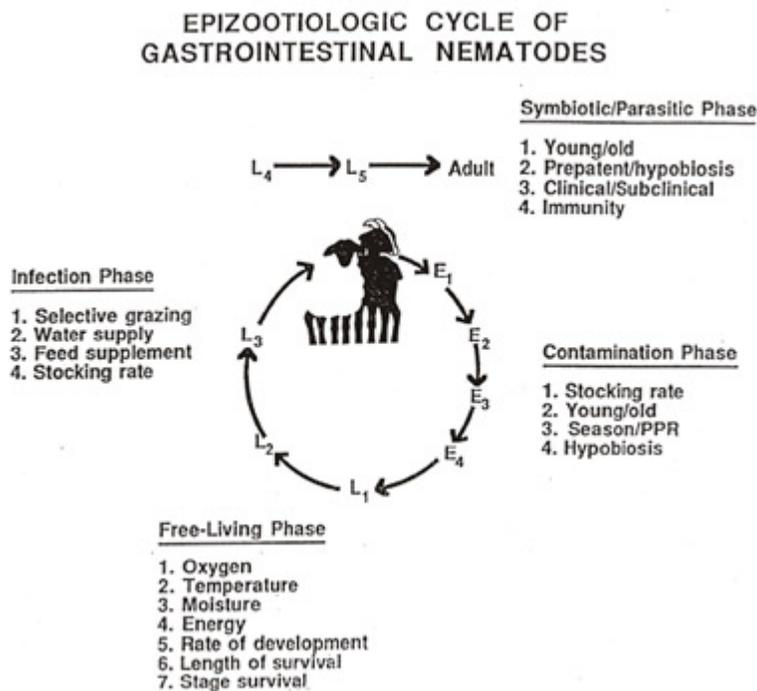
**Figure 2. Infective larvae in dew drop on forage.**

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 goat (deworming) and/or reducing the chances that infective larvae have to reinfest the goat (management). Depending on the worm species, the time of the year that is most favorable for transmission varies. This will be addressed below.

## 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 goat 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 of gastrointestinal nematodes.**



### 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 goat's 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 - 85°F (18 - 30°C). 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 desiccation 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 95°F (35°C) 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 - Infection 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)

*Haemonchus contortus* is a voracious blood feeding worm (Figure 4). It gets its name due to the barberpole appearance consisting of the white ovaries that twist around the red blood filled gut (Figure 5). 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 6). 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. Head of *Haemonchus contortus* showing lancet that is used to initiate blood flow for feeding.**



**Figure 5. *Haemonchus contortus* showing barber-pole appearance with white ovaries twisted around red, blood-filled gut.**



**Figure 6. *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 by viewing inside the lower eyelid) and bottle jaw (an accumulation of fluid under the chin) (Figure 7). The greater the infection level the more blood is lost and eventually the animal may die.



**Figure 7. Bottle jaw - accumulation of fluid under the chin.**

### ***Teladorsagia (Ostertagia) circumcincta* (Brown stomach worm)**

The other abomasal worm of importance is *Teladorsagia 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 in goats 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 *Teladorsagia*, 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.

#### ***Nematodirus* spp. (Long-necked bankrupt worm)**

*Nematodirus* spp. are relatively large worms (easily seen) and can be found in goats 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 in goats 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 these 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 8) 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



**Figure 8. Worm eggs in fecal exam.**

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.

### ***Blood packed cell volume***

Nematode parasites can affect an animals' ability to maintain erythropoiesis (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<sup>®</sup>***

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<sup>®</sup> eye color chart system (Figure 9) 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<sup>®</sup> 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



**Figure 9. FAMACHA<sup>®</sup> eye color chart being used to check level of anemia.**

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<sup>®</sup> 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](http://www.scsrpc.org)).

### ***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 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 *Teladorsagia* 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)**

Dewormers are chemicals (drugs) that have been evaluated and tested (effectiveness and safety) for use in animals to remove worm parasites. 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 manufacturer'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 (see [Classes](#)) 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 goats are a 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 dewormer "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 - see [Smart Use of Dewormers](#)). Once the approved dewormers have been tested and if none work, then other dewormers can be used "extra-label." Table 1 provides Food Animal Residue Avoidance Databank (FARAD) recommendations on the dosage and withdrawal times for commonly used dewormers. 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."

## *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, only fenbendazole and morantel tartrate are approved for use in goats. All others would be used as 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 goats, only the drench formulation of fenbendazole and the feed formulation of morantel tartrate are approved for use.

## *Administration*

Oral administration is preferred and with drenches, 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 is in feed products 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 goats. For the most part, pour-ons do not seem to be that effective in goats.

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

<b>Dewormer</b>	<b>Approval</b>	<b>Dosage/ 100 lbs</b>	<b>Withdrawal Time</b>	
			<b>Meat</b>	<b>Milk</b>
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

***Resistance***

Make sure that the exhibition center provides adequate housing, that pens are cleaned and disinfected and that ventilation is adequate. Make sure that all animals entering the show will be examined by the show veterinarian and that all state and local animal health laws will be enforced. Work with your veterinarian to establish a herd health program for your show goats and for the goats staying home that will be exposed to the show goat on its return. Do not mask signs of illness in your goat. If it is sick then stay home. Make sure that you have a Scrapie Tag for your goat (wethers excluded) and that you have any required health tests performed and that you have a current Certificate of Veterinary Inspection. Minimize stress on your goat by providing it with a pen that is as close to those in the exhibition facility as is possible and use the same bedding, feed and water source as you will have at the show. Keep fans on the goat at home, the white noise they produce will be the same as you will recreate at the show. Transport your goat in your own trailer. Avoid traveling in a commercial trailer or commingling with other livestock.

The major problem encountered in controlling nematode parasitism in goats 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 "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 Programs

### *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 dewormer 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 dewormers, 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<sup>®</sup> monitoring system comes into play.
4. If there is substantial resistance to all dewormers 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 dewormer. This will reduce rumen motility and the dewormer 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 deworming 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.

### ***Non-drug***

#### **Mixed/alternate livestock species grazing**

For the most part, each livestock species harbors its own parasite fauna except that sheep and goats 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 goats 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 goats 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 goats, and in sheep and goats in confinement when the forage was fed as hay. 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 hay, SL is being evaluated in the form of meal, 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.

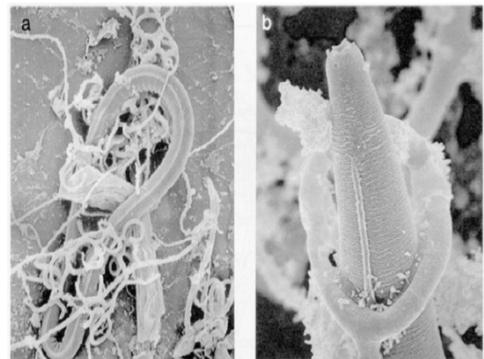
### **Genetic improvement**

There is considerable evidence that part of the variation in host resistance to worm infection is under genetic control in goats and sheep. 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 goat and sheep breeds are known to be relatively resistant to infection. Such breeds include: goat - Small East African, West African Dwarf and Thai Native; sheep - Scottish Blackface, Red Maasai, Romanov, St. Croix, Barbados Blackbelly and the Gulf Coast 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 goats (Scottish Cashmere) and sheep (Merino and Romney). 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<sup>®</sup>, 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 goats (Scotland) and sheep (New Zealand and Australia), 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 (Figure 10) 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 goats under sustainable, forage-based feeding systems.



**Figure 10. Sticky loops, or traps, produced by nematode-trapping fungi, and trapped larvae.**

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 only 3 dewormers approved for use in sheep and 2 in goats. The 3 for sheep are levamisole (Levasol and Tramisol, oral drench), albendazole (Valbazen, oral drench) and ivermectin (Ivomec for Sheep, oral 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<sup>®</sup>.

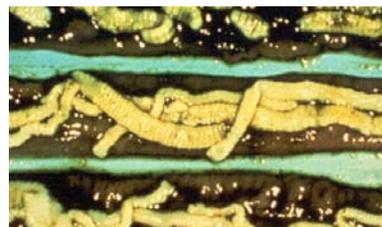
An integrated approach using these current methods should have an immediate impact on productivity and profitability of small ruminant production systems in the southeastern US and other regions where *H. contortus* and/or other worms can be a problem. Producers will be able to reduce overall dewormer usage by integrating an alternative compound (copper-oxide wire particles) with identification of animals in need of treatment (FAMACHA<sup>®</sup>) 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 themoving 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 (Figure 11), 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.



**Figure 11. Adult tapeworms in small intestine.**

### ***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 (Figure 12) 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).

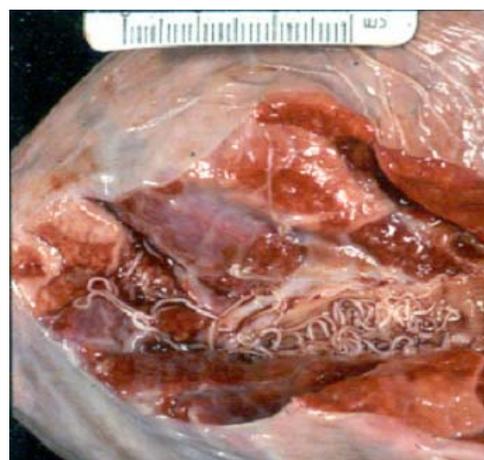


**Figure 12. Adult liver fluke showing leaf-like appearance.**

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 *Dictyocaulus filaria* is direct and adult worms live in the lungs (Figure 13) 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



**Figure 13. Adult lungworms in the bronchi of the lungs.**

requiring land snails/slugs as intermediate hosts. Control is not as easy and fortunately pathogenesis is minor.

### ***Parelaphostrongylus tenuis* (Meningeal worm)**

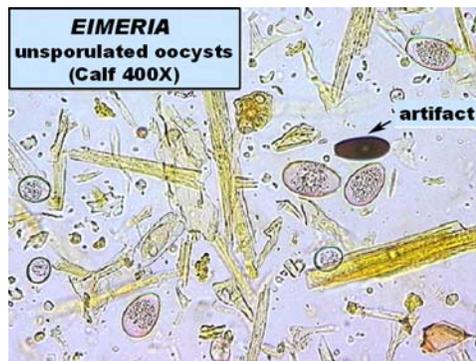
The meningeal worm (*Parelaphostrongylus tenuis*), also known as the deer worm or meningeal deer worm, frequently infects llamas, alpacas and sometimes goats. White-tailed deer are the natural host for the parasite, so goats are at potential risk everywhere that white-tailed deer are found. Small ground 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 14) 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



**Figure 14. Coccidia oocysts in fecal exam.**

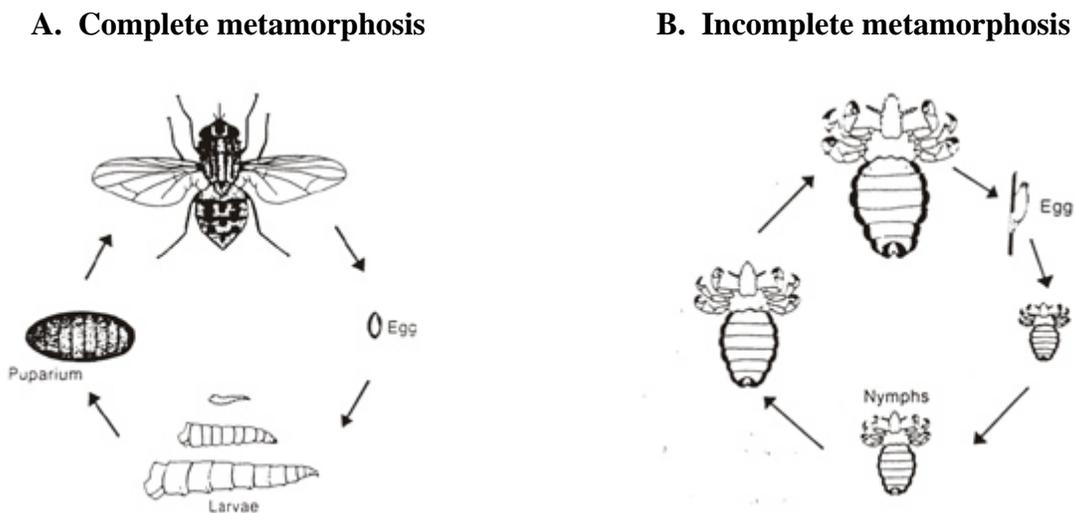
when kids are stressed. Preventing and/or controlling coccidiosis can be achieved by providing an anticoccidial product in the feed or water. There are several effective products on the market, such as amprolium and monensin. Individual clinical cases can be treated with sulfa products. Fortunately, a solid immunity develops subsequent to infection, however, if infection was severe, stunting usually results.

## 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 15A). 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 15B). 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 15. Life cycles of arthropods**



### *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 equipment. 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.

### ***Websites***

- Southern Consortium for Small Ruminant Parasite Control
  - [www.SCSRPC.org](http://www.SCSRPC.org)
- Langston University Goat Research
  - [www2.luresext.edu/](http://www2.luresext.edu/)
- Maryland Small Ruminant Page
  - [www.sheepandgoat.com](http://www.sheepandgoat.com)
- Internal Parasites of the Goat
  - [www.imagecyte.com/parasites.html](http://www.imagecyte.com/parasites.html)
- Controlling Goat Parasite - Is it a Losing Battle?
  - [www.sheepandgoat.com/articles/controlgoatparasites.html](http://www.sheepandgoat.com/articles/controlgoatparasites.html)
- Worms and Parasites
  - [www.goatworld.com/articles/worms](http://www.goatworld.com/articles/worms)

### ***Other***

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

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