Internal parasites are the single largest threat to livestock health and wellbeing faced by Texas sheep and goat producers. Favorable environmental conditions for parasite propagation and survival outside the host occur annually. Some years are worse than others, depending on rainfall during spring and summer. The incidence of internal parasites that are resistant to dewormers (anthelmintics) has become a major issue. A more integrated management plan for internal parasites in sheep and goats needs to be identified and implemented.

Characterization of *Haemonchus contortus*

Although, other gastrointestinal nematodes are present, *Haemonchus contortus* presents the greatest concern in Texas sheep and goats. Common names for *Haemonchus contortus* include stomach worm, barber’s pole worm, candy cane worm, and wire worm. The adult worm, found in the abomasum, is 10 to 30 mm long. Females are very prolific, each capable of producing as many as 5,000 eggs daily. An infection of 10,000 larva can cause 30 mL of daily blood loss. For young animals, high infection rates can deplete blood supply within a couple of weeks.

The life cycle (egg to mature adult) is approximately 21 days (Fig. 1). Time from egg to infective larva can vary between 3 to 10 days, depending on temperature and humidity. Eggs can survive and develop between 50 and 100 degrees Fahrenheit, with maximum hatching rate at high temperatures. Survival rates are greatest at low temperatures. Most eggs do not survive extended exposure (> 24 hours) to temperatures below freezing or above 100 degrees Fahrenheit. When moisture is limited (< 50 percent humidity) egg and developing larva survival decreases substantially. After the larva has hatched and fed on material in the fecal pellet it undergoes a final moult, which retains the outer coat (cuticle) and can no longer feed but is protected from drying out. This is the infective stage that can leave the fecal pellet and move onto the vegetation in a film of water. Infective larvae that are ingested by a sheep or goat will develop into adults and begin laying eggs within 3 to 4 weeks. In general, most larvae die within 3 months in the summer and 6 months in the winter, with adequate moisture. These adults can live for many months in the animal.

An important adaptation of *Haemonchus contortus* is the ability to overwinter in the abomasum of
its host in a dormant state known as hypobiosis. Ingested larvae begin undergoing hypobiosis as they are acquired during September and October. These larvae do not feed or lay eggs and do no damage to their hosts while in this state. However, when the ewe or doe reproduces, the worms receive signals that it will soon be spring and they resume development. The lactating ewe or doe is less able to rid herself of the now adult worms and large numbers of eggs are shed into pastures. When the weather warms up, larvae will be waiting for newborns as well as ewes or does to ingest them.

While most of the worms in hypobiosis survive, the larvae in the pastures die off, especially if it is a hot dry summer or cold dry winter. Therefore, most of the worm population is in the host, not on the pasture most of the year. The larvae develop more slowly in the late winter or early spring but survive until the hot dry summer weather conditions desiccate them.

Signs of infection include acute anemia, edema (bottle jaw), weak and listless behavior, and ultimately death. When diarrhea is seen, it may be due to a related, small intestinal worm, *Trichostrongylus colubriformis*, or extremely large numbers of *Haemonchus*.

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**Sources of resistance**

The variety of anthelmintic products available to Texas sheep and goat producers is limited. In the US, new product development, relative to the size of its market, is cost prohibitive for pharmaceutical companies. The commercially available dewormers have been used for decades. As such, *Haemonchus contortus* has developed resistance to all major anthelmintics classes. Most Texas sheep and goat ranches have used a variety of dewormers and methods, so the resistance of *Haemonchus* to dewormers within these flocks and herds are different.

Several scenarios can result in resistance development. These include:

1. **Insufficient dose**: The margin of safety for all approved products is at least twice the recommended dose. Levamisole is the product with the narrowest margin of safety. The dosage selected for all animals should be appropriate for the heaviest animal in that group (grouped by weight). Underdosing might save a few cents in the short term but can be quite costly should resistance develop.

2. **Inappropriate route of administration**: Anthelmintics available to livestock producers may be delivered in many forms—oral dose, subcutaneous injection, pour-on, or feed additives. The appropriate method for sheep and goats is oral administration of products designed for oral delivery. In general, injectable and pour-on treatments remain in the system longer but at lower levels. This allows for partially resistant worms to survive that would not have survived a treatment at higher levels.

3. **Ineffective compound**: Anthelmintics available to U.S. producers can be divided into three groups according to active ingredient (Table 1). Using an ineffective product is a waste of money and could lead to resistance development. If the efficacy of a product drops below 98 percent, it should no longer be used. If you continue to use a product until efficacy is 50 percent or below, the product will not have value in future product rotations or combination treatments.
Rotations of anthelmintics should not be done during a grazing season unless you are trying to control another parasite or a product is no longer effective. Rotation during a grazing season selects for resistance to all of the drugs in the rotation more rapidly. When rotating products, the appropriate rotation is across classes of compounds (not within a class of compound). For example, rotate from Valbazen to Cydectin to Prohibit, not from Valbazen to Safe-Guard to Panacur.

Combination drenchers (two or more active ingredients) are commercially available in other countries. Mixing 2 drenches together is not recommended, rather, administer two treatments back-to-back. Research indicates that resistance develops slower when two or more active ingredients are used in a single treatment. However, if not used properly, resistance will develop to both products.

4. Massive reexposure: Deworming animals and returning them to a heavily infested pasture is an exercise in futility. Animals will immediately begin the reinfection process. Animals that were anemic due to a heavy parasite load are not able to fight off new infection, until they have replenished their blood supply and body condition. Grazing management (pasture rotation) is an integral part of an internal parasite management plan. Animals with significant worm burdens can continue to shed viable eggs for several hours or days after you administer an anthelmintic. If possible, hold treated animals in the pen for 48 hours posttreatment and then release them to an uncontaminated pasture. However, this practice selects for a population of parasites that is solely resistant to the product used.

5. Lack of refugia: Refugia is a population of worms from untreated livestock or wildlife. These worms have a much lower chance of having the genes for resistance. They mate with resistant worms in the abomasum resulting in offspring who have both resistance and susceptibility to anthelmintics. The anthelmintic will only kill the susceptible worms but the numbers removed may prevent disease.

Frequent deworming of all animals rapidly selects for a parasite population that is resistant to the dewormer. It is recommended to intentionally allow sheep and goats to be exposed to parasites that have not had a chance to develop resistance to a dewormer. Most often, this is accomplished by not treating some animals that are low risk for parasitism. These would include animals that do not show signs of parasitism, have a good body condition score, and/or are nonlactating mature animals.

**Resistance management strategies**

Prevention, rather than cure, is the philosophy used in developing management programs for *Haemonchus contortus*. Assume that this parasite cannot be eradicated but can be limited to the extent that it does not cause morbidity or mortality. The following strategies take advantage of livestock management and parasite population dynamics when implementing a management plan.

**Host immunity**: Sheep have an immunological ability to expel internal parasites or suppress egg laying. Goats have this ability as well, but to a lesser
degree than sheep. Some breeds of sheep, such as St. Croix, Royal White, and Katahdin are better at managing internal parasite infection than others. Within breeds, there are some animals that resist better than others. Estimated breeding values (EBVs) for fecal egg count are available via the National Sheep Improvement Program and are considered the gold standard for genetic selection for parasite resistance.

For sheep and goat to mount an immunological response, they must have adequate nutritional resources. As such, sheep and goats that are on a low quality, low protein diet are more susceptible to parasites. It is recommended to supplement animals that are not in ideal body condition, preferably with high protein feedstuffs.

FAMACHA© is a technique developed in South Africa in which a color eye chart depicting varying degrees of anemia is used to determine the need for anthelmintic treatment (Fig. 2). It was developed as a tool for anthelmintics resistance management and integrated parasite management. It only works for the barber pole worm. It was developed for sheep, but should work with goats with slight modifications. The FAMACHA© technique reduces the number of treatments because only animals showing physical signs of infection are dewormed. It identifies worm susceptible animals for culling and slows anthelmintics resistance, as worms have less exposure to the drugs.

**Strategic drenching:** Administer anthelmintics while the parasite population is concentrated in the host, transmission rate is very slow and pasture contamination is at an annual low. In Texas, the most appropriate time for implementing a strategic treatment is after the first hard killing frost and before spring greenup. The primary targets of this mid-winter treatment are the hypobiotic larvae in the host. Therefore, a product labeled for inhibited larvae (L4 stage) must be used.

Another appropriate time for strategic treatment is 30 days before or after lambing/kidding. This treatment helps the animals that are most susceptible to parasitism. Some dewormers are not labeled for pregnant females. Treating lactating females does provide a low dose of anthelmintic to their off-

spring. This is not a problem unless the animals are old enough to have picked up parasites. This will not be an effective dose and might select for resistant parasites in the lambs.

A tactical treatment approach could be to treat animals when weather conditions have been favorable for parasite development. Moisture (heavy dew or rain) must be present on the soil surface to facilitate larva movement from the fecal pellet to the forage. The purpose of the tactical treatment is to eliminate the active worms in the gut before they have the opportunity to further contaminate the environment. Timing of the tactical treatment may then be based on 1) precipitation and warm weather 1 to 2 weeks before treatment or, 2) increasing fecal egg counts.

**Fecal egg count**

Frequently during the spring, summer, and early fall, subjective observations suggest that internal parasites are the cause of poor livestock performance. While parasites are frequently the culprit, other performance inhibitors do exist. Fecal egg counting is a practical, cost-effective diagnostic tool for determining parasite burden. This procedure involves collecting a fresh fecal sample, mixing
2 grams of the fecal material in a flotation solution and examining a known quantity of that solution under a microscope. For details on the egg counting procedure, see the Texas A&M AgriLife Extension Service leaflet EL-5094, Monitoring Internal Parasite Infection in Small Ruminants. For reference, sketches showing the relative sizes of eggs from commonly observed parasites are shown in Figure 3. Several points concerning fecal sample collection warrant further consideration.

1. Fecal pellets may be taken from the rectum or picked up off the ground. An excellent opportunity for sample collection is early in the morning as the animals are leaving their bed grounds. Fresh samples are easily distinguished from older, weathered droppings.

2. Collect 8 to 10 warm, moist, soft pellets per sample and place them in a sealable plastic bag with as much air removed as possible (to protect against dehydration). Samples should be kept cool (<50°F) until analysis. If immediate or same-day analysis is not possible, samples may be refrigerated (not frozen) for up to 72 hours.

3. Collect at least 6 individual samples per parasite management unit before administering any anthelmintic. Management units might be pastures, flocks, separate ranches, etc. Collection of a composite sample, while better than no fecal egg count at all, yields a less accurate assessment of parasite burden.

4. Early detection of resistance development and evaluation of anthelmintic efficacy involves fecal collections and analysis 7 to 10 days posttreatment. Again, a minimum of 6 samples is suggested. Posttreatment samples verify product efficacy.

Results of the analysis should be reported in eggs per gram of feces. Anthelmintic treatment can be based on the “rules of thumb” listed in Table 2. These rules of thumb are not definitive for every Texas sheep and goat producer. They are merely benchmarks for producers to use in the development of their specific IPM program.

<table>
<thead>
<tr>
<th>Time of year</th>
<th>Mature animals</th>
<th>Yearlings and younger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring greenup – July 4</td>
<td>1000 epg*</td>
<td>500 epg*</td>
</tr>
<tr>
<td>July 4 – First frost</td>
<td>2000 epg*</td>
<td>1000 epg*</td>
</tr>
</tbody>
</table>

*epg = eggs per gram of feces
Egg counts equal to or above these levels warrant anthelmintic administration.