IMPROVING PARASITE CONTROL IN SMALL RUMINANTS

Anne Zajac, DVM, PhD, DACVM, Virginia Tech

Virginia-Maryland College of Veterinary Medicine

Do you know if your drug(s) is/are working?

Time 0 Later Later still Still later

Eventually

Anthelmintic Resistance

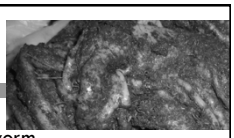
- Assume if a worm population resistant to 1 drug in a group, resistant to all in group
- **By the time you really suspect drug resistance, so many worms are resistant that not using the drug wonresistance here to stay**

Benzimidazoles	Macrolides A-avermectin M-milbemycin	Nicotinics
Fenben-dazole **(Safeguard Pancur)**	ivermectin-A **(Ivomec etc.)**	levamisole **(Prohibit)**
albendazole **(Valbazen)**	eprinomectin-A (Eprinex)	Pyrantel(Strongid)
Oxfendazole (Synanthic)	doramectin-A **(Dectomax)**	morantel **(Rumatel, Goat Care, Positive Pellet)**
Oxibenda-zole (Anthelcide)	moxidectin-M **(Cydectin)**	

Drug Resistance

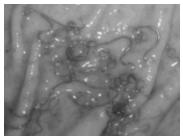
- Even if you do everything right with pasture and drug management you can still have drug resistant parasites

GI Parasites--Worms



- Most important--barber pole worm, *Haemonchus contortus*
  - Bloodsucking stomach parasite
  - Large numbers can cause anemia and bottle jaw, weakness, death
  - Decreased gains, growth



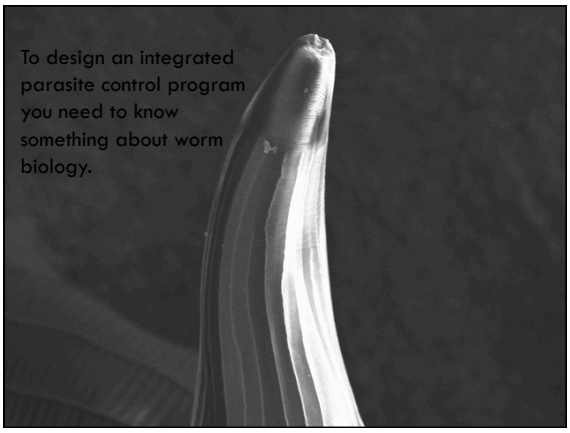


Parasites

- Barber pole worm doesn't produce diarrhea but other similarparasites may
- Usually not that important by themselves in this area
- Coccidia more likely to cause diarrhea in young animals

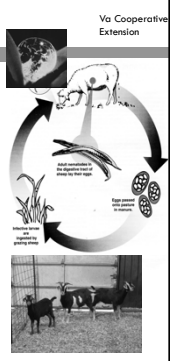

www.nadis.org.uk


www. Sheepandgoat.come



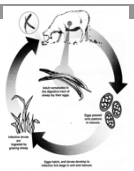
Life as a Worm

- All *Haemonchus*-type worms have same life cycle
  - Eggs passed in manure
  - Eggs develop, larva hatches
  - Larva develops to infective stage
    - The cooler it is, the longer it takes
  - Larvae move onto forage
    - Sheep, goats infected when grazing
    - Adult lifespan measured in months
- ALL GRAZING ANIMALS HAVE WORMS
  - Generally these worms do not survive well in housing or on dry lots



Life as a Worm

- How long can the infective larvae last on pasture?
  - Once metabolic reserves used up, they die
  - Hotter it is, the faster they wiggle, the quicker they die
  - In coolerl, moister conditions they live for months



Life as a Worm

- Can larvae on pasture survive winter weather?
  - Eggs, larvae of some species survive winter weather
  - Barber pole worm doesn't like freezing, mostly die
- But there is another strategy for surviving winter
  - Larvae ingested in the fall become dormant in GI tract (arrested)
  - Wait to become adults till spring
    - While arrested-- No disease, no eggs in manure

When is Worm Season?

- When do temperature and moisture best support transmission and multiplication of barber pole worm
  - Vermont worm season July-August
  - Virginia worm season June-October
    - Milder winters probably extend worm season
  - Florida worm season almost all year

Parasite Control in Sustainable Systems

- We have ways of controlling parasites
- Most don't work as dramatically as a fully effective modern dewormers
- So each producer has to decide which elements of control can best be combined for each farm to give good control
- INTEGRATED PARASITE CONTROL PROGRAM

not equal to

Pasture based

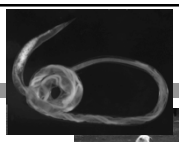
- Babies get the best
- Rotation/sward height
- Stocking rate/time on pasture
- Alternate or mixed grazing
- "Deworming" plants

Animal based

- **Targeted treatment**
- **Genetic selection**
- Dewormers
- Copper boluses
- Nutrition

Really not separate lists because change in one affects the other

Sheep and Goat Response to Worms



- Sheep and goats develop immunity to GI worms
  - Control parasites, doesn't eliminate them
    - Immune animals will have eggs in manure
  - Goats more susceptible than sheep
  - Immunity in place about the time of maturity
    - First lambing ewes and does more susceptible than older animals
  - Dry, non pregnant ewes/does most immune
  - Some animals have better immunity than others regardless of age, breed, sex, etc. based on genetics

Use Normal Immunity Strategically

- Don't treat animals that don't need treating—Targeted Treatment
  - Slows development of resistance so drugs last longer
- Make conscious effort to improve immunity in flock

Use Normal Immunity Strategically

- For routine selective deworming, FAMACHA© best for small ruminants in eastern, midwestern US
  - Direct assessment of effects of parasite
    - Match color of ocular membranes to card to evaluate whether treatment is needed
  - Every sheep and goat producer should have a card
  - Saves lives!

Targeted Selective Treatment

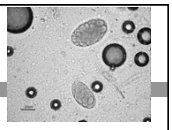
http://web.uri.edu/sheepngoat/parasite-control/

- FAMACHA© training
- Requirement for hands on training
  - Difficult for some producers to get to programs
- Option for on-line training through University of Rhode Island
- Important to Remember
  - Don't wait too long between scorings
  - Get a new card after a year or two

FAMACHA experience

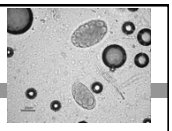
- VA Tech FAMACHA Experience
- 54 ewes and lambs (approx. 90), dewormed in May
  - Mostly hair crosses, some Suffolk
  - Half dewormed monthly
    - 280 individual treatments
  - Half dewormed based on FAMACHA
    - No ewe treatments, 21 lamb treatments

Use Normal Immunity Strategically



- Benefits of age
  - Earlier lambing season produces older animals at the start of grazing season
  - Adult animals can help clean up larvae on contaminated pasture (sheep especially)
- Don't let parasite susceptible animals pass along those genes
  - Example: a lamb needs 4 dewormings in 2 months, others only 1 or 2

Use Normal Immunity Strategically



- Make selection for resistance to parasites part of breeding program
  - From within your flock
    - Use fecal egg counts with FAMACHA to assess
    - Enroll in NSIP Lamb Plan and use EBVs
  - From outside your flock
    - Get fecal egg count/EBV information from breeders
    - Ram test with parasite evaluation
- You can make any group of any breed more parasite resistant with selection

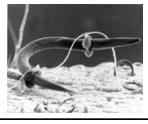
Fecal Egg Counts

- Don't need to do every animal
- Can do them yourself: http://web.uri.edu/sheepngoat/video/
- VDACS and Virginia Tech--$15.00
  - Seems expensive but not compared to value of animals that are healthier because more parasite resistant

Use Normal Immunity Strategically

- Breeds with higher levels of resistance to parasites
  - St. Croix
  - Katahdin
  - Gulf Coast/Florida Native
- Have to keep selecting for parasite resistance even in more resistant breeds
- Less research on variation in resistance in goat breeds

I'll just wait for the new products!



- New drugs
  - Monepantel
    - Thought would be available around 2015
    - Drug company merger—who knows
  - Two other new products in Canada
    - Unlikely to come here
- *Haemonchus* vaccine
  - Not coming to U.S. probably
- Nematophagous fungi
  - Kills larvae in feces
  - Australian company close to having commercial product
  - Expected 2018 for zoo animals, possible use in others?

ATTRA Sustainable Agriculture
A program of the National Center for Appropriate Technology • 1-800-346-9140 • www.attra.ncat.org

Managing Internal Parasites in Sheep and Goats

By Margo Hale, NCAT Agriculture Specialist
Published 2006
Updated April 2015

IP293

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. This publication discusses 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

Introduction.....1
Parasite Primer.....2
Resistance to Dewormers.....3
Assessment of Animals.....5
Dewormer Assessment.....6
Management Techniques for Controlling Parasites.....7
Treatment.....8
Conclusion.....9
References.....9
Further Resources.....10

Owners of these lambs are able to manage internal parasites using sustainable techniques. Photo: Robyn Metzger, NCAT

USDA This work was supported by the USDA, NIFA Organic Research and Education Initiative (Project No. 2010-51300-21641).

ATTRA *(www.attra.ncat.org)* is a program of the National Center for Appropriate Technology (NCAT). The program is funded through a cooperative agreement with the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT website (*www.ncat.org*) for more information on our other sustainable agriculture and energy projects.

Introduction

Many consider the management of internal parasites, primarily *Haemonchus contortus* (barber pole worm), 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" (2013). 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 many farms they have developed resistance to all available commercial dewormers (Howell et al., 2008). Resistance to dewormers is now seen worldwide (Kaplan, 2013). Producers can no longer rely on drugs alone to control internal parasites. Instead, they should employ an integrated approach that relies on sustainable methods to manage internal parasites.

Related ATTRA Publications
www.attra.ncat.org

Coccidiosis: Symptoms, Prevention, and Treatment in Sheep, Goats, and Calves
Goats: Sustainable Production Overview
Managing Internal Parasites: Success Stories
Multispecies Grazing
Pastures: Sustainable Management
Rotational Grazing
Ruminant Nutrition for Graziers
Small Ruminant Resources
Small Ruminant Sustainability Checksheet
Sustainable Sheep Production
Tips for Managing Internal Parasites
Tips for Preventing Internal Parasites
Tips for Treating Internal Parasites
Tips for Working with a Veterinarian
Tools for Managing Internal Parasites in Small Ruminants: Animal Selection
Tools for Managing Internal Parasites in Small Ruminants: Copper Oxide Wire Particles
Tools for Managing Internal Parasites in Small Ruminants: Pasture Management
Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza

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* (barber pole worm) is one example of this type. Others live off the nutrients eaten by the host; these cause weight loss but not anemia.

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

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 and development. The larvae need moisture to develop and move. They migrate out of the feces and up blades of grass (usually one to two inches). When an animal (sheep or goat) grazes, it 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 or from bedding in a pen.

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. This can happen quickly: barber pole worm, for example, can complete development to the adult stage in two to three weeks, and then begin producing eggs. Mature female barber pole worms can produce up to 10,000 eggs per day (Zajac, 2013). Pastures can quickly become heavily contaminated if animals are not rotated frequently or if animals have a high level of worms.

Infective larvae survive on pasture for a time, and this period is dependent on environmental conditions. Very hot weather will cause them to die faster, and most larvae may be naturally killed off in three months (Zajac, 2013).

Cold weather is not going to "kill the worms," unfortunately, because some internal parasites go into a kind of hibernation inside the animal until conditions are more favorable. This is called "hypobiosis" or "arrested" (terminology used on dewormer labels) and is the survival strategy for barber pole worm in the winter. In late winter and spring, the development will re-start, and this raises numbers of parasites just when lambing is happening (Zajac, 2013). To manage internal parasites properly, it is important to understand the parasite life cycle and factors that encourage multiplication of parasites.

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

Signs of Parasitism

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

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

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

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. Young animals and those with weakened immune systems due to other diseases are most affected by internal parasitism. One important time when immunity is weakened is at lambing time. This results in a periparturient (around birth) rise, and this weakened immunity coincides with the development of hypobiotic larva, which causes a release of more parasites into the environment (Zajac, 2013). Some breeds or animals within a breed are more resistant to parasites and do not display the periparturient rise (Notter and Burke, no date), which helps with control. A combination of treatment and management is necessary to control parasitism so that it will not cause economic loss to the producer.

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 and effective treatment.

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. Now we recognize that this practice is not sustainable because it leads to development of resistance.

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, 2013). Over-use and misuse of dewormers has led to resistance, and available dewormers are now ineffective in many instances.

Some farms still have dewormers that continue to work, while others have no effective dewormers. Although there are two new classes of dewormers available in some countries, they are not approved in the United States as of this writing, and even if they are eventually approved, "…the positive effect of such valuable resources for the control of parasites might not last long if used following the same application strategies as the three broad spectrum anthelmintic classes…"(Knox et al., 2012). In other words, new dewormers won't last very long unless we change our tactics. In fact, there are already reports of dewormer resistance

Table 1: 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	Common Names/Brands	Effectiveness
Benzimidazoles	Albendazole (Valbazen®), Fenbendazole (Safeguard®), Panacur®, Oxfendazole (Synanthic®)	High prevalence of resistance
Avermectin/ Milbemycins	Ivermectin (Ivomec®), Eprinomectin (Eprinex®), Moxidectin (Cydectin®), Doramectin (Dectomax®)	Ivermectin—High prevalence of resistance. Often the least effective of all available drugs Moxidectin—Resistance becoming common where used frequently
Imidazothiazoles/ Tetrahydropyrimidine	Levamisole (Tramisol®, Prohibit®), Pyrantel (Strongid®), Morantel (Rumatel®)	Low to moderate prevalence of resistance

Source: Adapted from Kaplan, 2013 and Williamson, 2013.

to the new drugs in New Zealand and Australia (Kaplan, 2013).

Development of Resistance to Dewormers

Internal parasites, especially *H. contortus*, have developed drug resistance (Howell et al., 2008). Drug treatment gets rid of the worms that are susceptible to that particular drug; resistant parasites survive and pass on "resistant" genes. No dewormer is 100% effective, and we know that worms that survive a dose of dewormer are resistant to that dewormer. Therefore, each time you deworm, the proportion of resistant worms increases, and consequently, frequent deworming greatly increases the rate at which resistance develops.

Each time animals are dewormed, the susceptible worms are killed. The resistant ones survive and will reproduce, thus leading to a population of very resistant worms. Meanwhile, underdosing causes larger numbers of the intermediate-strength 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 in the next generation. Once an animal has been treated (if dosed properly), only resistant worms remain. If the animals are moved to a clean pasture they deposit only resistant worms on the pasture, and there are no susceptible worms to dilute the worm population.

Refugia

Worms that are not treated are called "refugia." Refugia includes both worms and their consequent eggs in animals that were not treated, as well as eggs and larvae that were on the pasture at the time of deworming and thus not exposed to the dewormer. There is no change in the dewormer-resistance status of these worms. However, in animals that were dewormed, all the worms that survived are obviously resistant to the dewormer. Having some worms in refugia (not treated) ensures that drug-susceptible worms will be maintained in the population (Van Wyk, 2001; Kaplan, no date). A surviving population of untreated (drug-susceptible) worms dilutes the population of resistant worms. Consequently, refugia help ensure that when a dewormer is required, it will be effective because most of the worms will be susceptible to treatment (Kaplan, no date). The concept of refugia has been largely overlooked in the past (Van Wyk, 2001).

When fewer numbers of animals receive treatment, the refugia population remains large. When it comes to slowing the rate with which resistance develops, the more refugia, the better. Sustainable techniques, such as FAMACHA©, reduce the development of drug resistance by increasing refugia.

In contrast, several practices accelerate drug resistance. These include frequent deworming (more

than three times a year), underdosing (often caused by miscalculation of body weight), treating before 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.

Treating all animals regardless of need ignores the importance of refugia and will lead, in time, to a population of worms that cannot be controlled by dewormers. Preserving refugia is one principle of sustainable internal parasite control. Knowing what dewormers work on your farm and how to preserve their efficacy is another. Learn more about using dewormers wisely from "Extending the Efficacy of Anthelmintics" at www.acsrpc.org/#!2013-conference/c1bp4 (Williamson, 2013).

Assessment of Animals

In order to preserve refugia, it is important to treat only the animals that need it. Producers need to be able to identify the animals that need deworming. One way to assess the parasite load in animals is to take a fecal sample and examine for parasite eggs, using a quantitative method. This is called a "fecal egg count" (FEC), and it is a good method. However, it is time-consuming and requires a microscope. Producers can learn to do this themselves. This training is often a part of internal parasite workshops, and online tutorials are available, including one from Langston University: www2.luresext.edu/goats/library/fec.html. You can also get training in doing fecal egg counts by watching a video or reading the resources found at www.acsrpc.org/#!fecal-egg-counting/c24s2.

Visual examination of animals also provides diagnostic help, and is more immediate. Observing the flock or herd daily enables a producer to notice animals that are separating from the group, lagging behind, showing a lack of energy and vitality, have diarrhea or bottle jaw, and are losing weight. Those animals should be examined and dewormed if needed. Two more systematic methods of visual examination are described below: FAMACHA and the Five Point Check©.

FAMACHA

FAMACHA is a system for assessing the degree of anemia in animals. It works in diagnosing infection with barber pole worm because anemia is the major symptom of the barber pole worm. The FAMACHA system classifies animals into categories (1 to 5) based upon level of anemia (Kaplan, no date). The system was developed in South Africa and has been validated in the United States (Kaplan et al., 2004).

To use the system, you examine the eyelids of sheep and goats (see photo), then treat only the animals that are anemic. 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 (Burke and Miller, 2008). Breeding the healthiest animals and culling the weaker individuals makes the flock or herd stronger over time. Note that FAMACHA is only effective for the treatment of *H. contortus* (barber pole worm) because other worms do not cause anemia and so are not detected by this method. Producers must be trained by a veterinarian or other FAMACHA-trained animal health professional in order to use FAMACHA (Kaplan, no date). However, this technique is simple to learn and quick and easy to use. More information on FAMACHA is online at www.acsrpc.org/#!famacha/c9i, including a very helpful video.

Many producers have been trained in this technique, and more than 20,000 FAMACHA cards have been sold in the United States since 2003. In a survey of farmers who were trained in integrated parasite management, including FAMACHA, respondents identified the following benefits (Terrill et al., 2012):

- helped control internal parasitism—94%
- had less parasite problems after training—74%
- saved money in the first year after training, through reduced drug use and fewer animal deaths—88%

Demonstration of the FAMACHA technique. Photo: Robyn Metzger, NCAT

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.

Similar results were found in another survey (Whitley et al., 2014), confirming that using integrated parasite management does help producers save money and avoid problems with internal parasitism.

Five Point Check

Five Point Check is a system for identifying animals that need treatment for internal parasites. This system was developed by the same researchers that developed FAMACHA (Bath and Van Wyk, 2009). While FAMACHA is used for identifying only animals that are suffering from *H. contortus* infection, Five Point Check identifies symptoms of other internal parasites, as well. The five points are areas of the animal to observe. It is important to note that each of these symptoms can also be caused by other parasites, or by causes not listed.

Dewormer Assessment

Once you know who to treat, you need an effective dewormer to use. There are a couple of methods that can be used to determine whether a dewormer is effective against the parasites on your farm. The DrenchRite® Assay is a test performed to detect drug resistance in *Haemonchus contortus* parasites in your herd or flock. A fecal sample is sent to a laboratory for this test. The results will tell you what parasites are present in your herd or flock and what drugs are effective against those parasites (Howell and Storey, 2012). For more information on the DrenchRite Assay, visit the American Consortium for Small Ruminant Parasite Control website at www.acsrpc.org/#!storeyhowell2012/c4qh.

Another tool that can be used to determine dewormer efficacy is a fecal egg count reduction test (FECRT). This test involves collecting fecal samples from animals, treating those animals with a dewormer, and then taking fecal samples from those same animals 10 to 14 days later. By measuring the reduction in fecal egg counts from the first sample to the second, you can determine the effectiveness of your dewormer. For more information on fecal egg counts and conducting a fecal egg count reduction test, consult the American Consortium for Small Ruminant Parasite Control website at www.acsrpc.org/#!fecal-egg-counting/c24s2.

Table 2. Five Point Check

Point		What to check	Parasite possibility
1	Eye	Anemia (FAMACHA score)	Barber pole worm
2	Back	Body Condition Score	All
3	Rear	Dag Score	Brown stomach worm
4	Jaw	Bottle jaw	Barber pole worm
5*	Nose	Nasal discharge	Nasal bots
5*	Coat	Coat condition	Barber pole worm

*This system was developed for sheep. Goats are not affected by nasal bots, so the coat condition checkpoint is used instead.

Source: Adapted from Susan Schoenian www.sheep101.info/201/parasite.html and www.slideshare.net/schoenian (The Five Point Check).

Management Techniques for Controlling Parasites

Pasture Management

Producers can use numerous techniques to control parasitism. Pasture management should be a primary tool that producers use to control internal parasites. Sheep and goats ingest infective parasite larvae from pasture, so the rate at which these are ingested can be controlled through pasture management.

Most worm larvae crawl up the plant only one to two inches from the ground. A small percentage will crawl up as much as four inches, but very few get higher than this. 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 the height of forages in the pasture. Allowing animals to graze pastures too short results in more parasites consumed and in reduced feed intake, therefore harming the animal in two ways. It also inhibits pasture regrowth. So, for the good of the pasture and the animals, do not graze below four inches.

Most 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, either by reducing the number of animals or reducing the amount of time animals spend on a pasture, decreases the number of worms spread on that 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, unless they are rotated away from the parasites before they can consume larvae. That means within three to four days in ideal conditions (Zajac, 2013). 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. For more information on using pasture management techniques for parasite control, consult ATTRA's publication *Tools for Managing Internal Parasites in Small Ruminants: Pasture Management*.

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

Certain forages have also been shown to control parasite problems. Tannin-rich forages, such as sericea lespedeza, 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. ATTRA's publication *Tools for Managing Internal Parasites in Small Ruminants: Sericia Lespedeza* provides a more detailed discussion of this topic.

At left: Eating higher off the ground reduces the number of parasite larvae consumed. Photo: Margo Hale, NCAT

High levels of tannins in forages such as sericea lespedea reduce worm burdens. Photo: Courtesy of Jean-Marie Luginbuhl

Sheep breeds such as Gulf Coast Native show resistance to parasites. Photo: Linda Coffey, NCAT

Selecting Resistant Animals

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. Sheep 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 among individuals within breeds as well. Some animals, regardless of breed, will be more resistant to parasites than others. Research shows that 20% to 30% of the animals carry 70% to 80% of the worms in a flock or herd (Kaplan, no date). Having parasite-resistant animals will decrease the need for dewormers.

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. 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 resistant or more tolerant animals. The ATTRA publication *Tools for Managing Internal Parasites in Small Ruminants: Animal Selection* provides information on selecting animals for parasite resistance and building a stronger herd or flock.

Nutrition

Research shows that animals are more tolerant of internal parasites, and perhaps more resistant, when their immune systems are supported with good nutrition (Knox et al., 2012; Turner et al., 2012; Coop and Kyriazakis, 2001). Better health and better production are likely when animals are provided adequate energy, protein, minerals, and water. More information on this topic is included in the ATTRA publication *Tools for Managing Internal Parasites in Sheep and Goats: Pasture Management.*

Treatment

Copper Wire Particles

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 are effective against barber pole worm but not other genera of worms and

Smart Drenching

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

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, no date.)

only against the mature parasite (Bang et al., 1990; Chartier et al., 2000; Burke et al., 2005; Burke et al., 2007b). The copper particles will increase concentrations of copper in the blood, so it is important to use low doses (0.5- to 1-gram doses for lambs or kids less than one year of age; 1- to 2-gram doses for ewes or does older than one year of age) (Burke and Miller, 2006; Burke et al., 2007a). Refer to the ATTRA publication *Tools for Managing Parasites in Small Ruminants: Copper Oxide Wire Particles* for more information on how to use copper wire particles to treat internal parasites.

Nematode-trapping Fungus

Another parasite-management tool currently being researched is the use of nematode-trapping fungus. This fungus traps parasite larva in the feces, interrupting the parasite's life cycle. Research has shown that the fungus 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. The fungi is not yet available in the United States but may become available in the near future. You can read more about it at www.acsrpc.org/#!fungus/cp9i.

Alternative Treatments

There are many other alternative treatments that sheep and goat producers have used to manage internal parasite infections. Some of these alternatives have been researched, while others are used based on anecdotal information. The researchers of the American Consortium for Small Ruminant Parasite Control (ACSRPC) have investigated many alternative treatments. You can find information about many of these on the ACSRPC website, at www.acsrpc.org/#!alternatives/cyv8. Garlic, papaya, and the herbal dewormers tested by Burke et al. did not control internal parasites (2009a and 2009b). Escobar (2013) reviewed other alternatives in www.acsrpc.org/#!2013-conference/c1bp4.

Conclusion

Control of internal parasites in sheep and goats can be a daunting task. Previous control methods are no longer viable, so other techniques must be used—techniques such as increased pasture management, Smart Drenching, FAMACHA, the Five Point Check, and selecting parasite-resistant animals can help to manage internal parasites. Attention to nutrition and to pasture management will also help control levels of infection. These techniques reduce dependence on dewormers and lead to a more sustainable parasite-management program. Combining many of these techniques in a program will be much more effective than only relying on any one. ATTRA publications on this subject can help in assessing and improving the health of sheep and goats.

References

Bang, K. S., A.S Familton, and A.R. Sykes. 1990. Effect of ostertagiasis on copper status in sheep: a study involving use of copper oxide wire particles. Research in Veterinary Science. Vol. 49. p. 306–314.

Bath, G.F., and J.A. Van Wyk. 2009. The Five Point Check for targeted selective treatment of internal parasites in small ruminants. Small Ruminant Research. Vol. 86. p. 6–13.

Burke, J., J. Miller, D. Olcott, B. Olcutt, and T. Terrill. 2004. Effect of copper oxide wire particles dosage and feed supplement level on Haemonchus contortus infection in lambs. Veterinary Parasitology. Vol. 123. p. 235–243.

Burke, J., J.Miller and D. Brauer. 2005. The effectiveness of copper oxide wire particles as an anthelmintic in pregnant ewes, and safety in offspring. Veterinary Parasitology. Vol. 131. p. 291–297.

Burke, J.M., and J.E. Miller. 2006. Evaluation of multiple low dose copper oxide wire particles compared with levamisole for control of Haemonchus contortus in lambs. Veterinary Parasitology. Vol. 139. p. 145-149.

Burke, J.M., D. Morrical, and J.E. Miller. 2007a. Control of gastrointestinal nematodes with copper oxide wire particles in a flock of lactating Polypay ewes and offspring in Iowa. Veterinary Parasitology. Vol. 146. p. 372–375.

Burke, J.M., T.H. Terrill, R.R Kallu, and J.E. Miller. 2007b. Use of copper oxide wire particles to control gastrointestinal nematodes in goats. Journal of Animal Science. Vol. 85. p. 2753–2761.

Burke, J.M., and J.E. Miller. 2008. Use of FAMACHA system to evaluate gastrointestinal nematode resistance/resilience in offspring of stud rams. Veterinary Parasitology. Vol. 153. p. 85–92.

Burke, J.M., A. Wells, P. Casey, and R.M. Kaplan. 2009a. Herbal dewormer fails to control gastrointestinal nematodes in goats. Veterinary Parasitology. Vol. 160. p. 168–170.

Burke, J.M., A. Wells, P. Casey, and J.E. Miller. 2009b. Garlic and papaya lack control over gastrointestinal nematodes in goats. Veterinary Parasitology. Vol. 160. p. 168–170.

Chartier, C., E. Etter, H. Heste, I. Pors, C. Koch, and B. Dellac. 2000. Efficacy of copper oxide needles for the control of nematode parasites in dairy goats. Veterinary Research Communications. Vol. 24. p. 389–399.

Coop, R.L, and I.K. Kyriazakis. 2001. Influence of host nutrition on the development and consequences of nematode parasitism in ruminants. Trends Parasitology. Vol. 17. p. 325–330.

Escobar, E.N. 2013. Alternative compounds to commercially available anthelmintics to be used in sheep and goats. In: Proceedings of American Consortium for Small Ruminant Parasite Control Tenth Anniversary Conference. American Consortium for Small Ruminant Parasite Control, Fort Valley, Georgia. www.acsrpc.org/#!2013-conference/c1bp4

Howell, S.B., J.M. Burke, J.E. Miller, T.H. Terrill, E.Valencia, M.J. Williams, L.H. Williamson, A.M. Zajac, and R. M. Kaplan. 2008. Prevalence of anthelmintic resistance on sheep and goat farms in the southeastern United States. Journal of the American Veterinary Medical Association. Volume 233, No. 12. p. 1913–1919.

Howell, S., and B. Storey. 2012. The DrenchRite® Assay. American Consortium for Small Ruminant Parasite Control. www.acsrpc.org/#!storeyhowell2012/c4qh

Kaplan, R. No date. Open letter to sheep and goat producers regarding the FAMACHA© program. American Consortium for Small Ruminant Parasite Control. www.acsrpc.org/#!famacha/c9i

Kaplan, R., J. Burke, T. Terrill, J. Miller, W. Getz, S. Mobini, et al. 2004. Validation of the FAMACHA© eye color chart for detecting clinical anemia in sheep and goats on farms in the southern United States. Veterinary Parasitology. Vol. 123. p. 105-120.

Kaplan, R.M. 2013. Recommendations for control of gastrointestinal nematode parasites in small ruminants: These ain't your father's parasites. The Bovine Practitioner. Vol. 47, No. 2. p. 97–109.

Knox, M.R., R.B. Besier, L.F. LeJanbre, R.M. Kaplan, J.F.J. Torres-Acosta, J.E. Miller, and I. Sutherland. 2012. Novel approaches for the control of helminth parasites of livestock VI: Summary of discussions and conclusions. Veterinary Parasitology. Vol. 186. p. 143–149.

Min, B., and S. Hart. 2003. Tannins for suppression of internal parasites. Journal of Animal Science. Vol.81 (E. Supplement 2). p. E102-E109.

Notter, D., and J.M. Burke. No date. Unpublished data supplied by authors.

Shaik, S., T. Terrill J. Miller, B. Kauakou, G. Kannan, R. Kallu, et al. 2004. Effects of feeding sericea lespedeza hay to goats infected with Haemonchus contortus. South African Journal of Animal Science. Vol. 34 (Supplement 1). p. 248-250.

Southern Consortium for Small Ruminant Parasite Control (SCSRPC) [Now the American Consortium for Small Ruminant Parasite Control]. No date. Smart Drenching for Sheep and Goats [Brochure]. Fort Valley, GA.

Terrill, T.H., M. Larsen, O. Samples, S. Husted, J.E. Miller, R.M. Kaplan, et al. 2004. Capability of the nematode-trapping fungus Duddingtonia flagrans to reduce infective larvae of gastrointestinal nematodes in goat feces in the southeastern United States: dose titration and dose time interval studies. Veterinary Parasitology. Vol. 102. p. 285–296.

Terrill, T.H., J.E. Miller, J.M. Burke, J.A. Mosjidis, and R.M. Kaplan. 2012. Experiences with integrated concepts for the control of Haemonchus contortus in sheep and goats in the United States. Veterinary Parasitology. Vol. 186. p. 28–37.

Turner, K.E., K.A. Cassida, and A.M. Zajac. 2012. Weight gains, blood parameters and faecal egg counts when meat-goat kids were finished on alfalfa, red clover and orchardgrass pastures. Grass and Forage Science. Volume 68. p. 245–259.

Van Wyk, J.A. 2001. Refugia—overlooked as perhaps the most potent factor concerning the development of anthelmintic resistance. Onderstepoort Journal of Veterinary Research. Vol. 68. p. 55–67.

Whitley, N.C., S.–H. Oh, S.J. Lee, S. Schoenian, R.M. Kaplan, B. Storey, T. H. Terrill, S. Mobini, J.M. Burke, J.E. Miller, and M.A. Perdue. 2014. Impact of integrated gastrointestinal nematode management training for U.S. goat and sheep producers. Veterinary Parasitology. Vol. 200. p. 271–275.

Williamson, L. 2013. Extending the efficacy of anthelmintics. In: Proceedings of American Consortium for Small Ruminant Parasite Control Tenth Anniversary Conference. American Consortium for Small Ruminant Parasite Control, Fort Valley, Georgia. www.acsrpc.org/#!2013-conference/c1bp4

Zajac, A. 2013. Biology of parasites. In: Proceedings of American Consortium for Small Ruminant Parasite Control Tenth Anniversary Conference. American Consortium for Small Ruminant Parasite Control, Fort Valley, Georgia. www.acsrpc.org/#!2013-conference/c1bp

Further Resources

ATTRA Resources

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

- Meat Goats: Sustainable Production
- Dairy Goats: Sustainable Production
- Tips for Marketing Sheep and Goat Products: Live Animals
- Tips for Marketing Sheep and Goat Products: Meat
- Tips for Marketing Sheep and Goat Products: Dairy

- Tips for Marketing Sheep and Goat Products: Fiber
- Tips for Marketing Sheep and Goat Products: Vegetation Management Services
- Dairy Sheep
- Predator Control for Sustainable and Organic Livestock Production

Other Resources

American Consortium for Small Ruminant Parasite Control (ACSRPC)
www.acsrpc.org

Packed with a wealth of up-to-date information for producers, this site also holds the Proceedings of the 10th Anniversary Conference of the American Consortium for Small Ruminant Parasite Control. Find the papers at www.acsrpc.org/#!2013-conference/c1bp4.

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

This site includes a listing of members and an opportunity to subscribe to Wool and Wattle and to the listserv. Find a veterinarian, or refer your veterinarian to this page for more support in working with sheep and goats.

Maryland Small Ruminant Page
www.sheepandgoat.com

This is an enormous collection of articles, presentations, and archived webinars on any topic you can think of related to sheep and goats.

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

Explore this site for Goat Field Day Proceedings, online tutorials for fecal egg counting, information about nutrition and a Web-based training course.

Managing Internal Parasites in Sheep and Goats

By Margo Hale, NCAT Agriculture Specialist

Published 2006
Updated April 2015

Tracy Mumma, Editor • Robyn Metzger, Production

This publication is available on the Web at:
www.attra.ncat.org

IP293
Slot 289
Version 050615

National Sustainable Agriculture Information Service
ATTRA A project of the National Center for Appropriate Technology NCAT 1-800-346-9140 • www.attra.ncat.org

Tools for Managing Internal Parasites in Small Ruminants: Animal Selection

By Linda Coffey, NCAT Agriculture Specialist

IP400

Contents

Introduction 1
Animal Selection 3
Breeds.....4
Measuring Resistance or Resilience 6
How to Use This Information 8
Encouragement.....9
Summary 10
Internal Parasite Management Assessment.....11
References 12
Further Resources 13

United States Department of Agriculture
National Institute of Food and Agriculture

This project was supported by grants from the USDA, NIFA, OREI (Award No. 2010-51300-21641); and the Southern Region Sustainable Agriculture Research and Education (Award No. 2005-51300-02392). 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. USDA is an equal opportunity provider and employer.

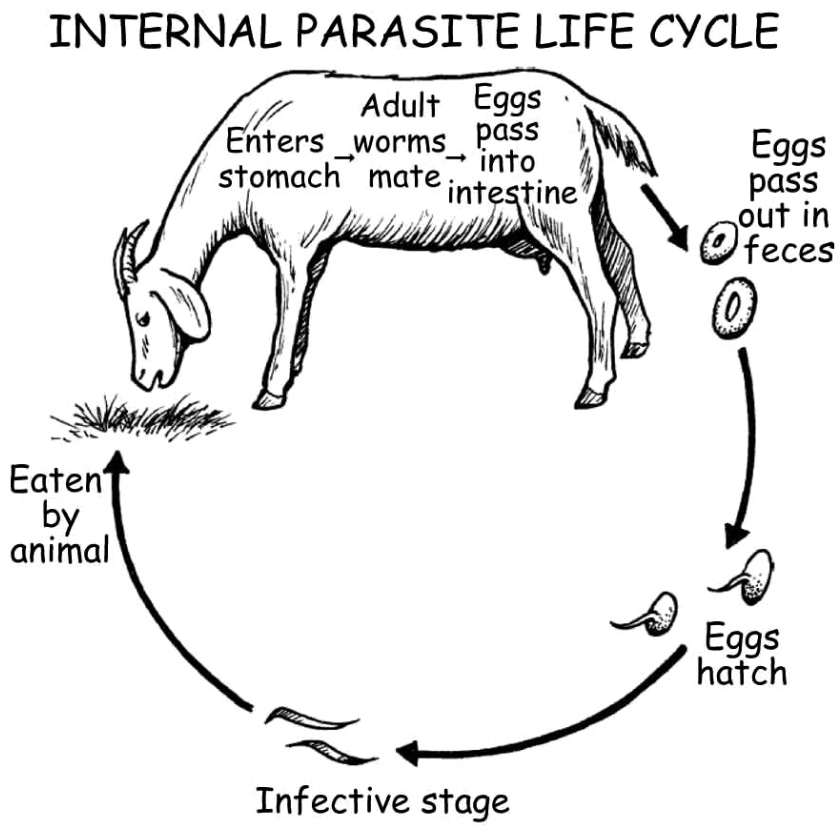
For long-term animal health, improving sheep and goat resistance or resilience to internal parasites is a very important strategy. Animal breeding can build a stronger, more resistant herd or flock if producers will identify and select the best animals for long-term health. This publication discusses methods and rationale for selecting sheep and goats with improved resistance or resilience to internal parasites. It also briefly describes other management tools helpful to producers and to the small ruminants raised in humid areas.

Animals can be selected for their resistance to parasites, resulting in a stronger flock. Photo: Linda Coffey, NCAT

Introduction

Internal parasites are a major health problem for sheep and goats raised in humid areas, especially where land is limited. For years, anthelmintics have mitigated the effects of these parasites and enabled farmers and ranchers to maintain the productivity and health of their livestock. However, internal parasites have developed resistance to anthelmintics (dewormers). Today's sheep or goat producer must use all available tools to help manage internal parasites.

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 travel up blades of grass. When an animal (sheep or goat) grazes, it may take in parasite larvae along with the grass blade. Parasite numbers increase over time when conditions are favorable



Source: ATTRA's "An Illustrated Guide to Sheep and Goat Production"
Artist: Robert Armstrong

(warm, wet). The larvae mature inside the host, and the cycle continues.

Adult internal parasites affect their host in various ways. They can damage the lining of the stomach or intestines, which can lead to weight loss and anemia, along with related symptoms such as weakness, bottle jaw, and anorexia (loss of appetite). *Haemonchus contortus* (barberpole worms) disrupt and damage the stomach lining and feed on blood, which can result in anemia. Other worms and coccidia cause intestinal lining damage, which can result in reduced absorption of nutrients and lead to scours (diarrhea) and weight loss or poor weight gain.

This publication is concerned with breeding resistance to gastrointestinal nematodes (roundworms). Coccidia are mentioned in passing, as they are important internal parasites in lambs and kids, and producers should be alert to the possibility of coccidia and get a good diagnosis so that effective treatments can be used. To learn more about coccidiosis and the prevention and treatment of this disease, see http://old.cvm.msu.edu/extension/Rook/ROOKpdf/coccidia.PDF.

Related ATTRA Publications
www.attra.ncat.org

Managing Internal Parasites in Sheep and Goats

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

Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza

When adult parasite numbers inside the host animal reach a level that causes obvious illness, producers have historically relied on anthelmintics (dewormers) to kill the parasites and allow the animal to heal and recover. However, as the animal grazes, it may be continually ingesting more parasite larvae, giving a new "crop" of parasites a home inside the animal. The presence of parasite larvae in the environment is often referred to as a "challenge," and animals that can perform well in spite of the challenge are either resilient (tolerant) or resistant to internal parasites. Selecting animals that are resistant will lower the challenge on the

Bottle jaw. Photo: J.M. Luginbuhl, NCSU

This goat is suffering from internal parasites. Note the posture, extreme thinness, poor hair coat and lack of vigor. Photo: J.M. Luginbuhl, NCSU

This goat appears healthy and in good condition. Photo: Linda Coffey, NCAT

farm over time. Selecting animals that are resilient may not impact the number of parasite larvae in the environment, but will result in better animal survival and production in the face of a challenge.

Is there a problem?

Signs of internal parasite infection commonly include some or all of the following. Note that some signs may be caused by other conditions as well.

- Poor growth or reduced milk production
- Loss in body condition (animal becomes thinner in spite of good nutrition)
- Rough hair coat or poor fleece
- Scouring (diarrhea: wet feces rather than pelleted; not seen with all parasites)
- Reduced vigor (animals appear lethargic and lag behind the flock or herd)
- Reduced appetite
- Anemia (seen in pale mucous membranes; caused by bloodsucking parasites, such as *Haemonchus contortus*)
- Bottle jaw
- Sudden death after a stress (e.g., an animal is chased on a hot, humid day)

Because internal parasites are so adaptable, difficult to control, and damaging to animal health, it is important that producers use every available tool to protect their livestock and keep internal parasite populations in check.

What can you do?

Strategies or tools that can be employed to fight internal parasite infection include:

- Good nutrition to support the immune system
- Selective deworming based on FAMACHA© or other criteria
- Pasture management
- Alternative control methods (e.g., botanicals, copper oxide wire particles)
- Selecting resistant animals
- For more about these strategies, see the ATTRA publication *Managing Internal Parasites in Sheep and Goats.*

The remainder of this publication explores various aspects of selecting animals for internal parasite resistance.

Animal Selection

Resistance to internal parasites means that an animal exposed to internal parasites suppresses establishment of parasites inside the body, or suppresses fecundity (egg-laying) of the worms if they do establish. Shedding of parasite eggs will be minimal in a resistant animal, so a resistant animal will benefit the whole flock by reducing contamination of the farm.

Research has shown that internal parasites are not evenly distributed in a herd or flock. Often 80% of the internal parasites will be in 20% of the animals. This is referred to as the "80/20 rule." If you can identify those animals harboring the most parasites and remove them from your herd, you can lower pasture contamination significantly. Also, because resistance is heritable, breeding those animals that are more resistant will result in a stronger herd over time. For example, one study found that Merino sheep that were selected for resistance had fecal egg counts (FEC) reduced by 69%. Also, the FEC in untreated selected sheep were lower than the FEC in strategically drenched unselected sheep; in other words, the effect of breeding was greater than the effect of strategic treatment (Eady et al., 2003). In an Australian study, Merino ewes selected for increased resistance to *H. contortus* had significantly lower egg counts at all times before and during the peri-parturient period, compared to ewes selected for susceptibility (Woolaston, 1992). Heritability in goats is thought to be lower and resistance is expressed later (at older ages), but selecting for resistance is still feasible and will result in lower pasture contamination over time (Vagenas et al., 2002).

Research has shown that internal parasites are not evenly distributed in a herd or flock.

Rams and bucks have a large impact on the parasite status of the farm. These Gulf Coast rams have never needed deworming. Photo: Linda Coffey, NCAT

Just as coat color is heritable, so is resistance to internal parasite infection. Photo: Linda Coffey, NCAT

Resistance is measured by taking fecal samples and doing quantitative fecal egg counts on animals that have not been dewormed in at least six weeks (preferably all animals treated or untreated similarly). Animals shedding fewer eggs are then identified and retained for breeding, while animals shedding the most eggs would be identified and then culled. Rams and bucks provide half of the genetic material for the lamb and kid crop, so choosing a more resistant sire would have a large impact on the parasite resistance and contamination level on the farm in years to come.

The problem with selecting for resistance is that sometimes production traits are negatively correlated with resistance (Bisset, 1996; Hoste and Chartier, 1993). Because stress impacts the immune system and makes an animal more susceptible to internal parasites, producers might observe that a doe that produces the most milk (causing a nutritional or metabolic stress) also has the most trouble with parasites. Also, lambs being raised as twins usually have a higher fecal egg count than those raised as singles (Wolf et al., 2008). Producers will have to balance the factors of observed internal parasite resistance and production traits and consider the whole farm system (Torres-Acosta and Hoste, 2008).

Breeds

Because of the variability mentioned earlier and the heritability, it is possible to make progress within a breed by focusing on resistance to internal parasites as a selection trait. Katahdin breeders are working on this now. See an interesting presentation about a SARE project at http://mysare.sare.org/2008conference/speakers/Bielek.ppt.

Additionally, there are some breeds that have been naturally selected for resistance to internal parasites. These breeds usually were developed in situations and climates that favored internal parasites. The animals were then selected by "survival of the fittest," and they will be significantly more resistant on average than other breeds that were not raised under those conditions. A note of caution is in order: these resistant breeds will still have variability within their ranks, and each animal will need to be evaluated on its merits. On a pasture-based buck test in Oklahoma in 2008, the best buck and the worst buck for internal parasite resistance were the same breed (see www.kerrcenter.com/publications/goat_report_08.pdf).

It is possible to have parasite problems even though the breed is known to be resistant, and that resistance can be lost when the animals are no longer subjected to the same selection pressure that was present when the breed was being developed. When a producer stops paying attention to internal parasite resistance and selects animals with no regard to that trait, weaker animals may be retained for breeding.

Still, it is useful to know which breeds have shown parasite resistance. Incorporating one of those breeds may have almost immediate impact on internal parasite problems and will have long-term benefits. Again, the farm goals and production traits of importance must be kept in mind. Also, when using a resistant breed for crossbreeding, there will be a lot of variability in the F1 and F2 generation. (Crossing two breeds results in the F1 generation; crossing the F1 ewes with F1

This lamb is the F1 generation from Gulf Coast and Suffolk parents. Photo: Linda Coffey, NCAT

Gulf Coast Native sheep are resistant to internal parasites. Photo: Linda Coffey, NCAT

St. Croix and Katahdin sheep. Photo: Joan Burke, ARS

rams yields the F2 generation.) See, for example, the work of J. E. Miller, who experimented with Suffolk (susceptible) and Gulf Coast Native (resistant) sheep (Miller et al., 2006). During that experiment, he found in one infection period FEC in the F2 sheep ranging from 167-149,933 eggs per gram. An article that includes a table listing resistant breeds of sheep is available at www.aces.edu/pubs/docs/U/UNP-0006.

In general, breeds with some tropical influence are thought to be more resistant to internal parasites. For example, Hampshire ewes were shown to be less resistant than St. Croix, Katahdin, and Dorper ewes (Burke and Miller, 2002). Also, Dorper lambs were less resistant than Katahdin lambs, which were less resistant than St. Croix lambs (Burke and Miller, 2004). Katahdin was more resistant than Dorper and Dorset breeds (Vanimisetti et al., 2004). Gulf Coast Native, Florida Native, St. Croix, and Barbados Blackbelly are sheep that were selected in tropical areas, and they have been shown to be more resistant than Rambouillet; Hampshire; Finn-Dorset x Rambouillet; Suffolk; and Dorset x Rambouillet (summarized in Amarante and Amarante, 2003).

Some animals are not resistant to parasites but are able to produce well and remain healthy in spite of internal parasite exposure. These animals are termed "resilient" or "tolerant." There are obvious advantages to resilient animals because they may require fewer treatments and can continue being productive under challenge. The disadvantage is that resilient animals may be spreading a lot of internal parasite eggs in their manure, thereby contaminating the farm and causing health problems for other (non-resilient and non-resistant) animals.

It can be difficult to see the difference between resistance and resilience, unless you do fecal egg counts to get a sense of the worm population within the animal and the overall challenge on the herd. A resistant animal, like a resilient one, should appear healthy and vigorous. If *H. contortus* (a bloodsucker) is the main problem, then both resilient and resistant animals will not be anemic, while susceptible animals with sufficient challenge will show illness, including pale membranes.

Also, on farms where there is not much challenge (not many parasite larvae present in the environment), all animals can appear resistant or resilient. The first years of having small ruminants on a farm often are trouble-free (concerning internal parasite infection), lulling the producer into a false sense of security. Unfortunately, when there is sufficient challenge to identify the resistant or resilient animals, there will be susceptible animals suffering from illness and needing deworming treatment.

The good news is that selecting animals for resistance to internal parasites seems to be sustainable. After selecting sheep lines for 10 years for high or low FEC when exposed to *H. contortus*, researchers challenged the sheep with both *H. contortus* and *Trichostrongylus colubriformis*. The parasites did not adapt to the resistant animals, as they can to drugs (Kemper et al., 2009). Also, as shown in this research and in others, selecting animals for resistance to one species of parasite also helps confer resistance to another (Gruner et al., 2004; Hoste and Chartier, 1998; Sreter et al., 1994; Gauly and Erhardt, 2001; Green et al., 1999; Wolf et al., 2008).

Measuring Resistance or Resilience

Measuring fecal egg counts is the most accurate way to identify animals with internal parasite resistance within a herd or flock. Resistant animals' immune systems will not allow larvae to establish and develop into mature egg-laying adults, or will suppress the egg-laying ability of the adults that do establish. Therefore, resistant animals will not be shedding as many eggs in their feces as similarly exposed non-resistant animals.

However, there are many factors that affect fecal egg counts besides the susceptibility of the animal. These include the level of exposure (challenge), stage of production of the animals (young or lactating animals may shed more eggs), and the type of forage being grazed (consuming high-tannin forage such as sericea lespedeza causes fecal egg counts to drop dramatically). Supplementation or otherwise providing better nutrition has been shown to lower FEC (Kahn et al., 2003; Eady et al., 2003) and reduce anemia (Burke et al., 2004). Also, the parasites themselves account for some variation. Some parasites (such as *Haemonchus contortus*) are very prolific and will produce a lot of eggs. Other species may not; for those, a lower egg count may still mean a serious internal parasite infection. Also, internal parasites don't lay eggs continuously and so eggs are not evenly distributed in feces. If you sample an animal twice, you will find some variation in fecal egg count even on the same day. And the number of adult worms inside the animal may not be well correlated with the fecal egg count (Saddiqi et al., 2010); immature adults and older worms produce less and males produce none.

Katahdin ewe and lambs. Photo: Margo Hale, NCAT

With all this in mind, it is clear that fecal egg counts are not a perfect tool. However, the information gained is very useful and doing fecal egg counts is the best way to assess challenge on the flock or herd and to find those animals that are harboring fewer internal parasites (Gray, 1998). Breeding decisions can be based on one or two samples if fecal egg counts are done during a time of high challenge, such as at weaning or early post-weaning for lambs, and during lactation for ewes. During those times, the animals that are resistant will stand out, and this is the time when heritability is higher (Gauly and Erhardt, 2001). Doing more than one sample improves the assessment of heritability, but this must be balanced against the cost.

Many producers do their own fecal egg counts. The process is fairly simple, and it can be expensive to have a veterinarian process samples. Also, not all veterinarians report quantitative results. There are workshops where the procedure is taught, and there are also instructions available online. See the Further Resources section to find links to tutorials.

The National Sheep Improvement Center (NSIP, http://nsip.org) calculates estimated breeding values (EBV) for sheep producers and breed associations. The EBV is based on progeny performance and evaluates the genetic merit of an animal for a particular trait. The Katahdin breed is currently the only U.S. breed that has EBVs for parasite resistance, using fecal egg counts from lambs at weaning and early post-weaning. Australian breeds have been calculating EBVs for parasite resistance for much longer.

To improve a herd or flock, producers will want to consider internal parasite resistance or resilience in conjunction with other goals, such as growth, reproduction, milk production, and overall health. Also, using data such as fecal egg counts requires consideration of all the factors that influence fecal egg counts. It would not be fair to compare the fecal egg count of a dry four-year-old ewe to that of a twin four-month-old lamb or that of a yearling ewe raising twins. A single lamb that has had access to excellent pasture and creep feed will have an edge over one that has been a nursing triplet on average pasture. Be sure to compare "apples to apples" when using the fecal egg count data to select animals for breeding.

This yearling dairy doe is nursing twins and may have a higher fecal egg count than an older or dry doe. Photo: Linda Coffey, NCAT

Factors Affecting Fecal Egg Counts

- Level of larval challenge affected by:
  - — Pasture management
  - — Weather
  - — Stocking rate (animal density)
- Species composition (types of worms)
- Worm burden
- Immune response of animal (affecting worm establishment and adult fecundity) affected by:
  - — Genetics
  - — Age
  - — Production stage
  - — Stress (including nutritional)
- Dietary factors
  - — Quality of pasture, especially protein levels
  - — Pasture species composition
  - — Pasture height and presence of browse or forbs
  - — Pasture management
  - — Overall quality and quantity of diet
- Selective grazing habits
- Variability of egg distribution within the fecal sample
- Diurnal patterns of egg laying
- Food transit times
- Fecal throughput and consistency
- Laboratory technique
  - — Collecting sample
  - — Preparing sample
  - — Counting eggs

Given all of these factors, the accuracy of fecal egg counts is improved if you take more than one sample—and you need to compare numbers within sampling time (don't compare across seasons or years) and within groups of animals (don't compare across ages or production stages). There is some indication that you can save effort and expense and still get a good indication of genetic merit of a sire by doing a pooled sample within a group of half-siblings.

Focusing on selecting resistant sires may be the most cost-effective and helpful approach for flock improvement (Douch et al., 1996). Sire evaluation accuracy increases with the number of offspring evaluated and the number of farms where the sire is used, as this decreases the variability caused by dam and by management. In a study conducted with Katahdin lambs where fecal egg counts were measured at 8 and 22 weeks, there were "large and significant" sire effects at both times, and these sires maintained their ranking across years, flocks, and measurement times. This emphasizes the importance of selecting good rams to improve the health of your flock (Notter et al., 2007).

Fecal egg counts provide more detailed information to guide producers in selecting animals that are not shedding as many internal parasite eggs. However, it is labor-intensive and can be costly. There is an alternative method for finding resistant or resilient animals, if *Haemonchus contortus* (barberpole worm, a blood-sucking parasite) is the primary parasite. The FAMACHA© system was developed in South Africa as a means of assessing anemia, a symptom of infection of barberpole worm. To use this method, a trained producer simply examines the inner surface of the lower eyelid and compares the color of the membranes to the five shades of pink on the FAMACHA© card. A score of 1 (bright pink) indicates no anemia, while a score of 5 (white) means severe anemia and severe infection. Producers can chart the scores of the flock or herd and record the scores on each animal every two weeks during the parasite season, and deworm only those animals that are anemic (scores of 4 and 5, or 3 if other indications, such as poor body condition, are present). In areas where barberpole worm is the main parasite, FAMACHA© can serve as a quick and inexpensive way to select animals with fewer parasite problems. However, some animals can have a good FAMACHA© score (brighter pink, a 1 or 2) and yet be shedding some eggs in their feces. These animals are resilient rather than resistant.

Focusing on selecting resistant sires may be the most cost-effective and helpful approach for flock improvement.

The FAMACHA© system can help identify resistant or resilient animals. Photo: Margo Hale, NCAT

What do you learn from a FAMACHA© score?

If a given animal has a FAMACHA© score of 1, you can say that the animal is not anemic. But you don't know why unless you look at more data; it could be that the animal has not been challenged by *Haemonchus contortus.* Or it could be that the animal has been challenged, but is resilient. Finally, it might be that the animal has been challenged but is resistant.

To decide which is true, you have to look at the rest of the flock: are any of them anemic, or are all scoring well with FAMACHA©? If all are doing well (not anemic), then probably the challenge is not high enough yet to cause illness. Keep watching. And remember that many internal parasites do not cause anemia; be alert for other signs of illness, including loss of weight, animals that are lagging behind, or scours.

If some are anemic (indicating that *Haemonchus* is causing a problem) while others are doing well, then you have identified some animals that handle the challenge of *Haemonchus*. Are they resilient or resistant? A fecal egg count can help sort that out; high counts on an animal that is not anemic may indicate resilience. Very low counts point to a resistant animal. Repeated observations are necessary for more accurate decisions.

The point is that a single FAMACHA© score does not really tell what is happening on a farm or even in a particular animal. Noting the condition of the whole flock or herd—and doing this over the course of the whole season—and using fecal egg counts to gain further information can help a producer understand the state of the internal parasites that reside on the farm. Charting the FAMACHA© scores and observing the trend is a great help in managing the health of the flock or herd, and checking animals on a regular schedule will eventually give confidence in the ability of a particular animal to remain healthy. But one good FAMACHA© score is not a reason for complacency. Use the system as it is intended for a quick, inexpensive way to diagnose animals needing treatment and, more importantly, to select the most resistant or resilient animals for breeding.

Still, research has shown a good correlation with FAMACHA© score, packed cell volume (PCV, a measure of anemia), and fecal egg counts where *H. contortus* is the main parasite in the population (Bisset et al., 2001; Kaplan et al., 2004; Burke and Miller, 2008). For more on the use of the FAMACHA© system, see www.acsrpc.org.

Another way to assess the health of animals (and in doing so, be able to identify more parasite-resistant animals) is called the Five Point Check© (see Table 1, next page). This system has been taught in South Africa and is a reminder to look at the whole animal when deciding whether or not internal parasites are a problem (Bath and van Wyk, 2009). This approach helps detect the presence of internal parasites in addition to *Haemonchus contortus.* Many producers already do a version of this.

Of course, body condition score may be low for other reasons, including poor nutrition, heavy milking, diseases such as Johne's, or poor teeth. Nasal discharge can also occur for other reasons, and nose bots are not a problem in all regions. One additional point to make concerning "dag score"—fecal soiling, due to scouring— is that there is evidence that some animals with resistance to internal parasites have more diarrhea (scouring). It is thought that their immune response includes diarrhea as a way to shed internal parasites. Therefore, some animals that have been treated with dewormers because of this symptom are actually resistant to internal parasites (Wolf et al., 2008). Scouring also can be a result of lush pasture, or it can indicate coccidiosis. It is important to examine all the evidence when assessing animal health.

Another important piece of evidence is animal vigor. An animal that is lethargic or lagging behind the flock is likely to have some health issue, and internal parasites are often the culprit. It is a good idea to examine those animals closely and treat as needed.

How to Use This Information in Selecting Animals in Your Herd or Flock

- What resources do you have, and how much time and money can you spend?
  - — *Minimal* - always record anthelmintic treatments and cull those individuals

Table 1: Five Point Check

Point	What to Check		Which Parasites
1	Eye	Paling of ocular membranes FAMACHA© score	Barber pole worm Liver fluke
2	Back	Body condition score	All
3	Rear	Dag score Fecal soiling Evidence of scouring	Brown stomach worm Hair worm Threadworm Nodule worm
4	Jaw	Sub-mandibular edema "bottle jaw"	Barber pole worm Liver fluke
5	Nose	Nasal discharge	Nasal bots

Source: www.sheep101.info/201/parasite.html

needing more than three treatments a year; don't select ram lambs or buck kids from dams or sires that require frequent treatment or from farms that do not keep records

— *Medium* - as above, but also do FAMACHA© if *Haemonchus contortus* is a problem in your area, and keep those records. Record weights of lambs and kids. Use an index to factor in age of dam, type of birth, and days of age; retain those animals that can thrive in your system and perform well with less intervention

— *More resources* and/or more motivation to improve quickly—as above, but also take fecal samples and have quantitative counts, and record those. If *H. contortus* is present, use FAMACHA© to monitor internal parasite infection and take fecal samples during a time when animals are challenged. Taking another sample a month later can add confidence for breeding decisions. Again, remember to consider age of the animal and production stage and number of nursing progeny, or this favors single births and dams nursing singles or not lactating.

As your flock or herd improves, you can select with greater pressure; cull any animal needing two treatments a year, or one, for example. As contamination decreases on the farm, your animals should have less and less trouble with parasites and have better production.

Encouragement

It may seem that selecting for resistance to internal parasites involves a lot of extra work. Researchers admit that it will take a lot of time to make significant progress so that a flock will be relatively free of clinical disease even under challenge. Internal parasites have many advantages in this game, including the ability to wait for the right time to become active again and infect animals or to actively breed and lay eggs so that eggs will be deposited during a favorable time of the year. Parasites are prolific and can cause enormous problems to the host in a relatively short period of time.

Keeping records and selecting animals with the ability to fight off parasites is the best long-term strategy for managing internal parasites. Photo: Linda Coffey, NCAT

But research has shown that significant progress can be made and that health and production of the sheep and goats will improve as a result. Strategies for identifying sires with superior resistance do exist and can make a great difference in a flock or herd when they are employed. Selecting for resistance while keeping production traits also in mind can save a producer a lot of money and heartache as the animals themselves help fight internal parasites and remain healthier. Pasture contamination is reduced when resistant animals are present.

Ten years from now, sheep and goats could be much more resistant if producers will put time and effort into identifying and selecting the sires that are more resistant. Next year, your own flock could be more resistant than it is now. Each breeder who puts effort into selecting for this trait will benefit the business. Organic producers will benefit from having resistant stock, but so will non-organic producers because anthelmintics are not always effective and parasites have developed resistance to many of the existing drugs.

As mentioned earlier, some breeders are taking advantage of the National Sheep Improvement Program (NSIP) services to establish estimated breeding values (EBVs) for parasite resistance. This has been done in Australia with great results. The NSIP is now teaming up with Australian geneticists to strengthen the capacity of U.S. and Australian breeders to make improvements. See http://nsip.org for more information. Producers who support breeders who are using EBVs for internal parasite resistance will be voting with their dollars for a more sustainable system. It takes a concerted effort among breeders within a particular breed to develop resistant genetics.

Summary

Selecting animals with the ability to fight off internal parasites (and other diseases) is the best long-term strategy for managing internal parasite problems. There are a variety of methods accessible to the producer to help with this aspect of animal selection. Animal selection is a vital tool in improving sheep and goat herds.

Still, animal selection is not the only tool a producer will need. To have a profitable and productive enterprise, a producer will want to use all the tools, especially pasture management, because none of the other tools will be effective without good pasture management. Using as many of the tools as possible and paying attention (and spending time and money) on identifying and selecting those animals that can resist internal parasites and/or be resilient to the effects of internal parasites will pay dividends for years to come. Animal selection is a vital component of a holistic parasite management strategy.

Internal Parasite Management Assessment

YES NO

❑ ❑ 1. Are parasites kept at a level that does not affect animal performance?

How do you know? _____ _____

_____

How do you monitor the parasite load in your animals? _____

_____

2. What practices do you use to reduce parasite problems and avoid the use of anthelmintics?

❑ ❑ Cull animals that get dewormed the most
❑ ❑ Use cleaner pastures (rest pastures, cut for hay, graze cattle)
❑ ❑ Graze diverse pastures
❑ ❑ Reduce stocking rate
❑ ❑ Avoid grazing pastures shorter than 3 inches
❑ ❑ Use browse and/or forages with high condensed tannin content
❑ ❑ Graze cattle or horses with goats or sheep
❑ ❑ Separate classes of susceptible animals
❑ ❑ Raise breeds and individuals with resistance to parasites
❑ ❑ Select rams or bucks with parasite resistance

3. What parasite control program do you use to reduce the use of anthelmintics and manage parasite loads? (www.scsrpc.org for information about these techniques.)

❑ ❑ Visual observation to detect animals with parasite problems
❑ ❑ Use FAMACHA© (see www.acsrpc.org)
❑ ❑ Check fecal egg counts prior to and following treatment to monitor loads and check effectiveness of anthelmintics
❑ ❑ Change class of anthelmintic once resistance is noticed
❑ ❑ Strategic deworming just before kidding or lambing
❑ ❑ Deworm all new animals (and check fecal egg counts seven to 10 days later to be sure there are no eggs in the feces)
❑ ❑ Use Smart Drenching (see www.acsrpc.org)
❑ ❑ Deworm only those animals that need it
❑ ❑ Cull animals that need frequent deworming (more than three treatments per season for adults; less, as your flock or herd gets stronger)

Other: list here_____

_____

_____

Source: ATTRA's Small Ruminant Sustainability Checksheet

References

Amarante, A.F.T., and M.R.V. Amarante. 2003. Breeding sheep for resistance to nematode infections. Journal of Animal and Veterinary Advances 2 Volume 3 p. 147–161.

Bath, G.F., and J. A. van Wyk. 2009. The Five Point Check© for targeted selective treatment of internal parasites in small ruminants. Small Ruminant Research. Volume 86, Issue 1. p. 6–13.

Bisset, S.A. and C.A. Morris. 1996. Feasibility and implications of breeding sheep for resilience to nematode challenge. International Journal for Parasitology. Vol. 26. p. 857-868.

Bisset, S.A., J.A. Van Wyk, G.F. Bath, C.A. Morris, M.O. Senson, and F.S. Malan. 2001. Phenotypic and genetic relationships amongst FAMACHA score, faecal egg count and performance data in Merino sheep exposed to *Haemonchus contortus* infection in South Africa. Proceeding of the 5th International Sheep Veterinary Congress. Cape Town, South Africa.

Burke, J.M., and J.E. Miller. 2002. Relative resistance of Dorper crossbred ewes to gastrointestinal nematode infection compared with St. Croix and Katahdin ewes in the southeastern United States. Veterinary Parasitology. Vol. 109, Issues 3-4. p. 265-275.

Burke, J.M. and J.E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in the southeastern region of the United States. Small Ruminant Research. Vol. 54, Issues 1-2. p. 43-51.

Burke, J.M., J.E. Miller, D.D. Olcott, B.M. Olcott, and T.H. Terrill. 2004. Effect of copper oxide wire particles dosage and feed supplement level on *Haemonchus contortus* infection in lambs. Veterinary Parasitology. Vol. 123. p. 235–243.

Burke, J.M. and J.E. Miller. 2008. Use of FAMACHA system to evaluate gastrointestinal nematode resistance/ resilience in offspring of stud rams. Veterinary Parasitology. Vol. 153. p. 85-92.

Douch, P.G.C., R.S. Green, C.A. Morris, J.C. McEwan, and R.G. Windon. 1996. Phenotypic markers for selection of nematode-resistant sheep. International Journal for Parasitology. Vol. 26, Issues 8-9. p. 899-911.

Eady, S.J., R.R. Woolaston, and I.A. Barger. 2003. Comparison of genetic and nongenetic strategies for control of gastrointestinal nematodes of sheep. Livestock Production Science. Vol. 81, Issue 1. p. 11-23.

Gauly, M. and G. Erhardt. 2001. Genetic resistance to gastrointestinal nematode parasites in Rhön sheep following natural infection. Veterinary Parasitology. Vol. 102, Issue 3. p. 253-259.

Gray, G.D. 1997. The use of genetically resistant sheep to control nematode parasitism. Veterinary Parasitology. Vol. 72, Issues 3-4. p. 345-366.

Green, R.S, C.A. Morris, P.G.C. Douch, M. Wheeler, C.J. West, and S.M. Hickey. 1999. Means and heritabilities of concentrations of antibody to *Trichostrongylus colubriformis* and other nematode parasites in lambs from three to seventeen months of age. Livestock Production Science. Vol. 58, Issue 2. p. 129-135.

Gruner, L., J. Bouix, J.C. Brunel. 2004. High genetic correlation between resistance to *Haemonchus contortus* and to *Trichostrongylus colubriformis* in INRA 401 sheep. Veterinary Parasitology. Vol. 119, Issue 1. p. 51-58.

Hoste, H. and C. Chartier. 1993. Comparison of the effects on milk production of concurrent infection with *Haemonchus contortus* and *Trichostrongylus colubriformis* in high- and low-producing dairy goats. American Journal of Veterinary Research. Vol. 54, No. 11. p. 1888–1893.

Hoste, H. and C. Chartier. 1998. Response to challenge infection with *Haemonchus contortus* and *Trichostrongylus colubriformis* in dairy goats. Consequences on milk production. Veterinary Parasitology. Vol. 74, Issue 1. p. 43-54.

Kahn, L.P., M.R. Knox, S.W. Walkden-Brown, and J.M. Lea. 2003. Regulation of the resistance to nematode parasites of single- and twin-bearing Merino ewes through nutrition and genetic selection. Veterinary Parasitology. Vol. 114, Issue 1. p. 15-31.

Kaplan, R.M., J.M. Burke, T.H. Terrill, J.E. Miller, W.R. Getz, S. Mobini, E. Valencia, M.J. Williamson, M. Larsen, and A.F. Vatta. 2004. Validation of the FAMACHA eye color chart for detecting clinical anemia in sheep and goats on farms in the southern United States. Veterinary Parasitology. Vol. 123, Issues 1-2. p. 105-120.

Kemper, K.E., R.L. Elwin, S.C. Bishop, M.E. Goddard, and R.R. Woolaston. 2009. *Haemonchus contortus* and *Trichostrongylus colubriformis* did not adapt to long-term exposure to sheep that were genetically resistant or susceptible to nematode infections. International Journal for Parasitology. Vol. 39, Issue 5. p. 607-614.

Miller, J.E., S.C. Bishop, N.E. Cockett, and R.A. McGraw. 2006. Segregation of natural and experimental gastrointestinal nematode infection in F2 progeny of susceptible Suffolk and resistant Gulf Coast Native sheep and its usefulness in assessment of genetic variation. Veterinary Parasitology. Vol. 140, Issues 1-2. p. 83-89.

Notter, David, J. Morgan, and B. Vanimisetti. 2007. Tools for Genetic Improvement of Parasite Resistance: Development of a Fecal Egg Count EPD. Katahdin NSIP Notebook.

Saddiqi, Hafiz, H.A. Abubaker, Z. Iqbal, M.N. Khan, and G. Muhammad. 2010. Comparative resistance of sheep breeds to *Haemonchus contortus* in a natural pasture infection. International Journal of Agriculture and Biology. Vol. 12, No. 5. p. 739-743.

Sréter, T., T. Kassai, and E. Takács. 1994. The heritability and specificity of responsiveness to infection with *Haemonchus contortus* in sheep. International Journal for Parasitology. Vol. 24, Issue 6. p. 871-876.

Torres-Acosta, J.F.J. and H. Hoste. 2008. Alternative or improved methods to limit gastro-intestinal parasitism in grazing sheep and goats. Small Ruminant Research. Vol. 77, Issues 2-3. p. 159-173.

Vagenas, D., F. Jackson, A.J.F. Russel, M. Merchant, I.A. Wright, and S.C. Bishop, 2002. Genetic control of resistance to gastro-intestinal parasites in crossbred cashmere-producing goats: responses to selection, genetic parameters and relationships with production traits. Animal Science. Vol. 74. p. 199-208.

Vanimisetti, H.B., S.P. Greiner, A.M. Zajac, and D.R. Notter. 2004. Performance of hair sheep composite breeds; resistance of lambs to *Haemonchus contortus*. Journal of Animal Science. Vol. 82, No. 2. p. 595-604.

Woolaston, R.R. 1992. Selection of merino sheep for increased and decreased resistance to *Haemonchus contortus*: peri-parturient effects on faecal egg counts. International Journal for Parasitology. Vol. 22, No. 7. p. 947-953.

Wolf, B.T., K. Howells, C. Nakielny, W. Haresign, R.M. Lewis, O. L. Davies and M.H. Davies. 2008. Genetic parameters for strongyle and Nematodirus faecal egg counts in lambs and their relationships with performance traits. Livestock Science. Vol. 113, Issues 2-3. p. 209-217.

Further Resources

Sustainable Agriculture Research and Education (SARE)
www.sare.org

The SARE website holds many research reports of interest to sheep and goat producers. To access these reports, go to the homepage, click on "project reports" and then search "internal parasite" to bring up a list of reports that can be informative on this subject. There is a PowerPoint presentation on the subject of selecting animals for internal parasite resistance that is very informative and interesting. The presentation illustrates many important concepts of selecting animals for internal parasite resistance. Go to: mysare.sare.org/2008Conference/speakers/Bielek.ppt and also see the report on that Farmer/Rancher SARE project, FNC05-583.

The American Consortium for Small Ruminant Parasite Control (ACSRPC)
www.scsrpc.org or www.acsrpc.org

ACSRPC was formerly known as the Southern Consortium for Small Ruminant Parasite Control (SCSRPC) and provides up-to-date scientific research and recommendations for producers. There is a six-part series of articles written for producers and previously published in the Goat World. Part 1 is at www.scsrpc.org/SCSRPC/Publications/part1.htm. Part 6 includes instructions for doing fecal egg counts, and a good discussion. There are other articles listed on the site, including information about FAMACHA©and Smart Drenching.

A summary of SARE-funded work done by the SCSRPC is collected in this article: www.sare.org/Learning-Center/Fact-Sheets/National-SARE-Fact-Sheets/Sustainable-Control-of-Internal-Parasites-in-Small-Ruminant-Production

Langston University
www.luresext.edu

Langston University's website includes two tutorials for doing fecal egg counts (located at www.luresext.edu/goats/library/fec0.html and www.luresext.edu/goats/library/fec.html). The information is slightly different in these presentations. Also see the chapter in the web-based training manual at www.luresext.edu/goats/training/parasites.html#diag for more complete information about internal and external parasite control.

Maryland Small Ruminant Page
www.sheepandgoat.com

Susan Schoenian is an educator with the University of Maryland Cooperative Extension Service. She has generously shared information with the world through this website. She also has posted some excellent presentations at Slideshare, including some about integrated parasite management. These presentations are very helpful and will add to understanding of the problem and solutions. Access them from the main website.

SHEEP Dewormer Chart

ACSRPC
(www.acsrpc.org)

Important --Please read notes below before using this chart

1 ml = 1cc	Valbazen (albendazole) ORALLY	SafeGuard (fenbendazole) ORALLY	Ivomec Sheep Drench (ivermectin) ORALLY	Prohibit (levamisole) ORALLY	Cydectin Sheep Drench (moxidectin) ORALLY
Weight Pounds (lbs)	7.5 mg/kg 0.75 ml/ 25 lb	5 mg/kg 0.6 ml/ 25 lb	0.2 mg/kg 2.9 ml/ 25 lb	8 mg/kg 2 ml/ 25 lb	0.2 mg/kg 2.3 ml/25 lb
20	0.6	0.5	2.3	1.5	1.8
25	0.75	0.6	2.9	1.8	2.3
30	0.9	0.7	3.4	2.2	2.7
35	1.1	0.8	4.0	2.6	3.2
40	1.2	0.9	4.5	2.9	3.6
45	1.4	1.0	5.1	3.3	4.1
50	1.5	1.1	5.7	3.7	4.5
55	1.7	1.3	6.2	4.0	5.0
60	1.8	1.4	6.8	4.4	5.4
65	2.0	1.5	7.4	4.7	5.9
70	2.1	1.6	8.0	5.1	6.3
75	2.3	1.7	8.5	5.5	6.8
80	2.4	1.8	9.1	5.8	7.2
85	2.6	1.9	9.7	6.2	7.7
90	2.7	2.0	10.2	6.6	8.1
95	2.9	2.1	10.8	6.9	8.6
100	3.0	2.2	11.4	7.3	9.1
105	3.2	2.3	1.02	7.7	9.5
110	3.3	2.5	12.5	8.0	10
115	3.5	2.6	13.1	8.4	10.5
120	3.6	2.7	13.7	8.8	10.9
125	3.8	2.8	14.2	9.1	11.4
130	3.9	2.9	14.8	9.5	11.8
140	4.2	3.0	15.4	10.2	12.7
150	4.5	3.1	16.0	11.0	13.6

Valbazen Suspension (11.36 % or 113.6 mg/ml): 7.5 mg/kg orally; approved in sheep with meat withdrawal time of 7 days. Do NOT use in pregnant ewes in the first trimester of pregnancy.

Safe-Guard/ Panacur Suspension (10% or 100 mg/ml): Note that SafeGard is not approved for use in sheep. Sheep dose is 5 mg/kg orally; meat withdrawal time of 6 days.

Ivomec Drench for Sheep (0.08% or 0.8 mg/ml): 0.2 mg/kg orally; approved in sheep with meat withdrawal time of 11 days. Protect from light.

Prohibit Soluble Drench Powder (Sheep): (Note that this drug is also sold as Levasol and Tramsiol) 8 mg/kg ORAL dose. Approved for use in sheep with meat withdrawal of 3 days. Solution prepared by dissolving a 52 gram packet in 1 quart (943 ml) of water. This yields a solution with 49.6 mg/ml. Always make sure to follow directions on packet when preparing.
If dosing lambs, it is safer to dilute further (1 packet in 2 quarts of water), and then administer twice the amount listed on the chart. The larger volume administered will provide a wider margin for safety if there are small errors in dosing.

Cydectin Sheep drench (1 mg/ml): 0.2 mg/kg orally; approved in sheep with meat withdrawal time of 14 days.

ACSRPC
(www.acsrpc.org)

NOTE for Guideline for Dewormer (Anthelmintic) Dosages in Sheep

This chart was developed by Ray M. Kaplan, DVM, PhD and Lisa Williamson, DVM, MS (University of Georgia). It is provided as a possible guideline for anthelmintic (deworming) dosages for sheep. Producers should always consult their veterinarian for advice on their specific management situation for determining which dewormer(s) are best to use in their flock, and the proper dosages for their flock. Meat withdrawal times should always be strictly adhered to.

Note that drug resistance in parasites of sheep is extremely common. The effectiveness of a particular dewormer should always be tested before being used by performing either a Fecal Egg Count Reduction Test (FECRT) or DrenchRite larval development assay (contact Dr. Kaplan's laboratory [706-542-0742] for more information about the DrenchRite test).

Updated September 2014

ACSRPC
(www.acsrpc.org)

Dewormer Chart for Goats

Important --Please read notes below before using this chart

1 ml = 1cc	Valbazen (albendazole) ORALLY	SafeGuard (fenbendazole) ORALLY	Ivomec Sheep Drench (ivermectin) ORALLY	Prohibit (levamisole) ORALLY	Cydectin Sheep Drench (moxidectin) ORALLY	Rumatel (morantel) Feed Pre-mix ORALLY
Weight Pounds (lbs)	**20 mg/kg 2 ml/ 25 lb**	**10 mg/kg 1.1 ml/ 25 lb**	**0.4 mg/kg 6 ml/ 25 lb**	**12 mg/kg 2.7 ml/ 25 lb**	**0.4 mg/kg 4.5 ml/25 lb**	**10 mg/kg 45 gm/100 lb BW (Durvet)**
20	1.6	0.9	4.8	2.2	3.6	
25	2.0	1.1	6.0	2.7	4.5	11 grams
30	2.4	1.4	7.2	3.3	5.4	
35	2.8	1.6	8.4	3.8	6.5	
40	3.2	1.8	9.6	4.4	7.3	
45	3.6	2.1	10.8	4.9	8.2	
50	4.0	2.3	12.0	5.5	9.0	23 grams
55	4.4	2.5	13.2	6.0	10	
60	4.8	2.7	14.4	6.6	11	
65	5.2	3.0	15.6	7.1	12	
70	5.6	3.2	16.8	7.7	12.7	
75	6.0	3.4	18.0	8.2	13.6	34 grams
80	6.4	3.6	19.2	8.8	14.6	
85	6.8	3.9	20.4	9.3	15.4	
90	7.2	4.1	21.6	9.9	16.4	
95	7.6	4.3	22.8	10.4	17.3	
100	8.0	4.6	24.0	11.0	18	45 grams
105	8.4	4.8	25.2	11.5	19	
110	8.8	5.0	26.4	12.1	20	
115	9.2	5.2	27.6	12.6	21	
120	9.6	5.5	28.8	13.2	22	
125	10.0	5.7	30.0	13.7	22.7	56 grams
130	10.4	5.9	31.2	14.3	23.6	
140	11.2	6.4	33.6	15.4	25.4	
150	12.0	6.8	36.0	16.5	27.3	68 grams

Valbazen Suspension (11.36 % or 113.6 mg/ml): 20 mg/kg orally; withdrawal time is 9 days for meat 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 recommended. At 10 mg/kg, withdrawal time is 16 days meat and 4 days for milk. Add 1 day for each additional day the drug is used (e.g. if administered 2 days in a row then withhold milk for 5 days after 2nd dose).

Ivomec Sheep Drench (0.08% or 0.8 mg/ml): 0.4 mg/kg orally; meat withdrawal time is 14 days and milk withdrawal is 9 days.

Prohibit Soluble Drench Powder (Sheep): (Note that this drug is also sold as Levasol and Tramsiol) 12 mg/kg oral dose with meat withdrawal of 4 days and milk withdrawal of 3 days. Solution prepared by dissolving a 52 gram packet in 1 quart (943 ml) of water. This yields a solution with 49.6 mg/ml. If dosing kids, it is safer to dilute further (1 packet in 2 quarts of water), and then administer twice the amount listed on the chart. The larger volume administered will then provide a wider margin for safety if there are small errors in dosing.

Cydectin Sheep drench (1 mg/ml): use orally at 0.4 mg/kg orally; for a single dose the meat withdrawal time is 17 days and milk withdrawal is 8 days. Note that these withdrawal times are only applicable for the sheep oral drench at the dose given here. Higher doses will require a longer withdrawal time.

Morantel tartrate (Rumatel) recommended label dose for goats is 10 mg/kg, orally. There is 0 (zero) withdrawal time for milk in lactating cattle and dairy goats. Meat withdrawal time for goats is 30 days. Because of the large differences in morantel concentration among the various products, it is important to carefully read the label and make sure you are dosing correctly. The dosage on the chart above is for Durvet Rumatel. {With Durvet Rumatel, feed 0.1 lb (45 grams) per 100 lbs. BW; and with Manna Pro feed 1.0 lb per 100 lb. BW}. There is also a highly concentrated form called Rumatel 88, but this is meant for mixing into large volumes of feed (feed 0.1 lb (45 gram) per 2000 lb BW). Note that the 10 mg/kg dose used for the chart is the label dose; administering 1.5 – 2X this dose may improve efficacy. If an elevated dose is used then withdrawal times would need to be extended.

NOTE on Guideline for Anthelmintic Dosages in Goats

The attached chart was developed by Ray M. Kaplan, DVM, PhD, DACVM, DEVPC (University of Georgia) with subsequent contributions by Patty Scharko DVM, MPH (Clemson University). It is provided as a possible guideline for anthelmintic (deworming) dosages for goats. Producers should always consult their veterinarian for advice on their specific management situation, for determining which of the dewormers remain effective on the farm, and for determining the most appropriate dosages for their herd. Meat and milk withdrawal times listed in this document are based on the most current information available from FARAD as of it's writing. Be aware that these recommended withdrawal times may change over time as new pharmacologic information is obtained.

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 also 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 a 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. Cattle pour-on dewormers should NEVER be used in goats to treat internal parasites.

Drug resistance to multiple drugs and sometimes to all available drugs in parasites of goats is extremely common. The effectiveness of a dewormer should always be tested before being used by performing a Fecal Egg Count Reduction Test (FECRT) or DrenchRite larval development assay (contact Sue Howell in Dr. Kaplan's laboratory [706-542-0742; or drenchrt@uga.edu] for more information about the DrenchRite test, current cost = $450).

To improve the effectiveness of deworming treatments, multiple dewormers may be administered at the same time sequentially. It is important not to mix the different drugs together as they are not chemically compatible. They should be given separately, but can all be given at the same time, one right after the other. It is always recommended to treat goats selectively given their individual need for treatment based on FAMACHA score, fecal egg count, body condition score, and other health measurements as a guide. This recommendation is even more important when using drugs in combination. If all animals in the herd are treated, resistance to the dewormers will develop rapidly, and if using a combination there will be nothing left to use when this happens.

ADDITIONAL NOTE ON CYDECTIN: For a short period, it was recommended to administer Cydectin (moxidectin) by injection. However, new information suggests that the oral route is preferred. If the cattle injectable is used, FARAD recommends a 120-130 day meat withdrawal time. NOTE that the cattle pour-on formulation should NOT be administered to goats orally – this is not permissible under extra-label use law. ALWAYS use the sheep oral drench. Check http://www.acsrpc.org/ website for more information on drug choice and drug resistance.

Updated September 2014

ACSRPC
(www.acsrpc.org)

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**	9 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 0.4	Sheep oral drench	low to moderate	Sheep 14 days Goats 17 days**	8 days**	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**	3 days	Toxic side effects = salivation, restlessness, muscle fasciculations. Recommend weighing goats before treatment.
Morantel	I/T	No	Yes	Goats 10	Feed premix	moderate	Goats 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 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. It has been updated to reflect changes as of September 2014.
*****This table is intended for veterinary use only. Others should consult with their veterinarian before using any drug in an extra-label manner*****

Why and How To Do FAMACHA© Scoring

Use of the FAMACHA© system allows small ruminant producers to make deworming decisions based on an estimate of the the level of anemia in sheep and goats associated with barber pole worm (*Haemonchus contortus)* infection.

Figure 1. Barber pole worm (*Haemonchus contortus*)

The barber pole worm (Figure 1) is the most economically important parasite affecting sheep and goat production on pasture and the most common cause of anemia during the grazing season in most of the U.S. It has a small "tooth" that lacerates the animal's stomach (abomasum) wall, and it feeds on the blood that is released. This can result in anemia, (reduction below normal in the number of red cells in the blood) and in severe cases, death.

The FAMACHA© card, developed in South Africa, was introduced to the U.S. by the American Consortium for Small Ruminant Parasite Control (***www.acsrpc.org***). It is a tool that matches the color of the eye mucous membranes of small ruminants with a laminated color chart showing 5 color categories that correspond to different levels of anemia. Category 1 represents "not anemic" with category 5 representing "severely anemic."

The FAMACHA© system uses the scores determined with the card to identify and selectively deworm sheep and goats with anemia. Selective deworming minimizes drug use and slows the development of drug resistant GIN parasites. It can also aid in selective breeding decisions by identifying those animals that are most susceptible to barber pole worm infection.

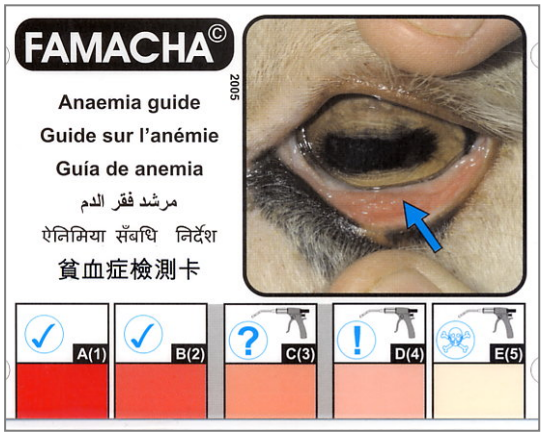


Figure 2. FAMACHA© card. *www.acsrpc.org*

Precautions

- FAMACHA© is only applicable where the barber pole worm (*H. contortus)* is the main GIN parasite causing clinical disease.
- Redness of the ocular membranes can be caused by eye disease, environmental irritants, and systemic disease. Though they are uncommon, these conditions can mask anemia.
- Other causes of anemia exist, but they are uncommon compared to barber pole worm infection during the grazing season.
- An elevated FAMACHA© score is not the only reason to deworm an animal. GIN can play a role in other signs of disease including:
    - Diarrhea
    - Bottle jaw
    - Poor body condition
    - Dull hair coat or abnormal fleece
    - Exercise or heat intolerance

General guidelines for using the FAMACHA© card

- Always check eyes outside in direct, natural light. If options are limited due to handling needs, an area of the barn where natural light enters directly in the morning or afternoon (such as a door or window) is acceptable. When scoring, there does not need to be bright sunshine, but it should be performed in full daylight.
- Always use the card when scoring your animals and do not try to score from memory of the colors.

How to examine your animals with the FAMACHA© card:

- Proper FAMACHA© scoring technique includes exposing the lower eye mucous membranes and matching them to the equivalent color on the FAMACHA© card (Figure 3). **COVER, PUSH, PULL, POP** is a 4-step process describing the proper technique.

Figure 3. FAMACHA© scoring a goat. The lower eye mucous membranes are exposed and compared to the colors on the FAMACHA© card to estimate the level of anemia. Use the COVER, PUSH, PULL, POP! method described above.

1. **COVER** the eye by rolling the upper eyelid down over the eyeball.
2. **PUSH** down on the eyeball. An easy way to tell if you are using enough pressure is that you should see that the eyelashes of the upper eyelid are curling up over your thumb.
3. **PULL** down the lower eyelid.
4. **POP!** The mucous membranes will pop into view. Make sure that you do not score the inner surface of the lower eyelid, but rather <u>score the bed of mucous membranes</u>.

- Match the color of the pinkest portion of the mucous membranes to the FAMACHA© card.
- Make sure that you do not shade the eye with your body.
- Be quick – make your decision and move on. The longer the mucous membranes are exposed, the redder they get. Go with your first impression.
- Repeat the process and score the other eye because it may be different. Use the higher score and err on the side of caution.
- There are no half numbers!

Interpreting the FAMACHA© results

Animals in FAMACHA© category 4 & 5:

- *Always* deworm sheep & goats in categories 4 & 5.

Animals in FAMACHA© category 1 & 2:

- Don't deworm 1's & 2's unless there is other evidence of parasitic disease such as the presence of diarrhea, poor body condition, dull hair coat or abnormal fleece.

Animals in FAMACHA© category 3:

- Consider deworming if:
  - >10% of flock/herd scores a 4 or 5.
  - Lambs and kids (usually recommended).
  - Pregnant or lactating ewes/does (usually recommended).
  - Animals in poor body condition.
  - Concerned about an animal's general health and well being, for example, if an animal is in poor body condition, or suffering from another disease.
  - Always err on the side of caution.

How often do I monitor?

If <10% of herd/flock scores in categories 4 or 5:

- Every 2 weeks during the grazing season. Susceptible animals can go downhill rapidly when worm numbers are high (warm, moist conditions / summer months).

- During spring and fall, when temperatures are cooler and the barber pole worm may be less active, this interval could be extended to 3-4 weeks.

- During winter the interval can be extended, but remember that ewes/does may develop problems with the barber pole worm when lambing/kidding coincides with arrested parasites resuming development, and they should be checked more often.

If >10% of flock/herd scores in categories 4 or 5:

- Recheck weekly
- Treat all 3's
- Change pastures (if possible)

Anemic animals recover most quickly if they are removed from heavily infected pasture. If animals are dewormed and turned back out on the same pasture that first led to disease, they may take an extended period to return to a score of 1 or 2 since they will continue to be re-infected by the larva on pasture. It is okay to re-treat those animals based on FAMACHA© score.

Maintaining the FAMACHA© card

- Store in dark place when not in use because the card will fade with time.
- Replace card after 12 to 24 months of use (varies depending upon use and storage conditions).
- Keep a spare card in a location protected from light (compare with the card in use).
- Training is required to gain the initial card. Contact your veterinarian, your local Cooperative Extension small ruminant specialist or the American Consortium for Small Ruminant Parasite Control (***www.acsrpc.org***) for more information including available workshops. As part of a Northeast SARE grant, the University of Rhode Island is offering an online training program for FAMACHA© certification. Visit our website for more information and detailed instructions, **http://web.uri.edu/sheepngoat/famacha/**. Replacement cards can be obtained through the University of Georgia (***famacha@uga.edu***), your veterinarian or your FAMACHA© trainer.

Recordkeeping

Keep records of FAMACHA© scores and other parasite monitoring performed on your animals each year. FAMACHA© cards come with a recordkeeping template, or view our project recordkeeping sheets available on our website.

For more information, including our demonstration video on FAMACHA© scoring and our online training program for FAMACHA© certification, visit our website: ***http://web.uri.edu/sheepngoat*****.** The video can also be viewed directly from the URI YouTube channel page (**UniversityOfRI**): ***https://www.youtube.com/watch?v=I5rcuvVG56Q*****.**

Program contact: Katherine Petersson, Ph.D., Associate Professor
Dept. Fisheries, Animal & Veterinary Sciences, University of Rhode Island
Phone: 401-874-2951; Email: ***kpetersson@uri.edu***

This information sheet was developed by Anne Zajac, DVM, Ph.D. Parasitologist, Virginia-Maryland Regional College of Veterinary Medicine / Virginia Tech; Katherine Petersson, Ph.D, Animal Scientist, Dept. Fisheries, Animal and Veterinary Sciences, and Holly Burdett, Cooperative Extension, College of the Environment and Life Sciences, University of Rhode Island.

THE UNIVERSITY OF RHODE ISLAND

NORTHEAST SARE Sustainable Agriculture Research & Education

VirginiaTech

This material is based on funding from the Northeast Sustainable Agriculture Research and Education Program Project LNE10-300, which is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture. This work is also based on funding from the Rhode Island Agricultural Experiment Station (RI00H-900-INT). This is contribution number 5413 of the College of the Environment and Life Sciences, University of Rhode Island. October 2014, updated April 2016. URI provides equal program opportunity.