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.

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.

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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 animal.

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.

When adult parasites are present, producers may use 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 animal.

### Tools for Managing Internal Parasites in Small Ruminants: Animal Selection

Related ATTRA Publications

- 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

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](http://old.cvm.msu.edu/extension/Rook/ROOKpdf/coccidia.PDF).

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
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).

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
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
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 lespedea 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.

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.
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.

**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

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

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.
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.
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


### 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.