American Consortium for Small Ruminant Parasite Control

Best Management Practices for Internal Parasite Control in Small Ruminants

On-Farm Selection for Resistance to Parasites

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The focus of this article is to provide guidance for small ruminant producers to select for resistance to parasites. Specifically, it is for those whose flocks/herds are not currently enrolled in a national genetic evaluation program, such as the National Sheep Improvement Program (NSIP; nsip.org).

WHAT IS THE PROBLEM?

The biggest economic loss and most serious health risk for most small ruminants raised on pasture is the barber pole worm (*Haemonchus contortus*). The barber pole worm decreases productivity and can cause death by feasting on blood in the abomasum, the fourth chamber of the ruminant stomach (third chamber in camelids; C-3). This loss of blood can cause life-threatening anemia, as well as other symptoms.

WHO DOES IT AFFECT?

Young animals and lactating females are most at risk due to their immature or stressed immune systems. Even mature males during the breeding season can be affected. Small ruminants kept in confinement (or dry lot) usually have little to no risk of infection due to lack of exposure.

WHERE DOES IT OCCUR?

The barber pole worm is present in all regions of the United States but thrives most in areas with warm, moist environments. Northern regions tend to have a shorter “worm” season (3 to 4 months), whereas southern regions can be affected year-round. Areas with higher rainfall or irrigated pastures are more affected than dry areas, though dry climates can experience problems when it does rain.

THERE ARE FIVE REQUIREMENTS FOR EFFECTIVE ON-FARM SELECTION FOR RESISTANCE TO PARASITES (SEE TABLE 2)

1) Individual animal identification
2) Animals of similar age managed together
3) Significant exposure to parasites
4) Fecal egg counts (FEC) from all animals
5) A large spread in fecal egg counts to separate more resistant animals from those more susceptible.

WHY FECAL EGG COUNTS?

Why can’t we just cull animals with poor FAMACHA© scores (lower eyelid color) and/or bottle jaw (sub-mandibular edema)? Culling animals with clinical signs will only remove a small percentage of susceptible animals from the flock/herd. Many animals, especially those with good nutrition, can carry a high load of worms without any outward signs of infection. Yet, they are contaminating the pastures when they deposit their manure onto the pasture. They are difficult to identify but need to be so that they can be removed from the flock/herd.

Collection and evaluation of fecal egg counts is the most effective method to differentiate resistant from susceptible animals. Other methods of determining worm load have limitations (Table 1). Fecal egg counts of animals raised together can range from 0 to more than 25,000 eggs per gram (EPG) of feces, making them a powerful tool for identification. All other methods, including FAMACHA© , body condition, and bottle jaw (not always observed in heavily infected animals), have a small range of values; thus, less accuracy in differentiating resistant and susceptible animals.

HOW TO IDENTIFY RESISTANT ANIMALS

First, animals need to be individually identified. There are many different options for animal identification, including ear tags, ear notches, tattoos, and microchips (RFID). Animals need to be of similar age. The ability of the immune system to fight off worms changes from when a lamb/kid begins grazing to 6 to 8 months of age and beyond. Next, animals need to be raised together so that the exposure to parasites is the same for each animal in the group. If some animals are fed more grain or managed on different pastures, there is different exposure to worms, and it is not possible to accurately compare animals. Finally, there needs to be significant exposure to parasites. This is key.

Collection and evaluation of fecal egg counts is the most effective method to differentiate resistant from susceptible animals.

If few animals have high FAMACHA© scores (4 or 5) and/or require deworming at the time fecal samples are collected, there is a good chance that there has not been enough exposure. Research has determined that a group average fecal egg count of at least 500 eggs per gram (EPG) is needed to ensure that all animals have been exposed to enough worms. If animals are raised in confinement (or dry lot), there is not likely going to be enough exposure for accurate selection. It is important that the differences in fecal egg count be due to the animals' level of resistance and not to inadequate exposure or other environmental influences.

Table 1. Selection traits for resistance and resilience to parasites

	Range of values	Advantages	Disadvantages
Deworming history	Yes-No	Easy	Marginal impact Selects more for resilience
Bottle jaw	Yes-No	Easy	Marginal impact Selects more for resilience
Body condition score (BCS)	1-5	Easy to perform	Not specific for identifying worm resistance or resilience since other factors can reduce BCS Need to be careful not to select against highly productive females which may have reduced BCS.
FAMACHA© eye anemia score	1-5	Easy to perform More accurate than above criteria Better correlation with FEC	Also selects for resilience Animals with low FAMACHA© may still be shedding a lot of eggs. Training required
Fecal egg count (FEC)	0 to 25,000+	Greater variability in data enables more accurate selection Selects for resistance rather than resilience. Best way to identify resistant (or susceptible) animals.	Labor intensive Most expensive

Adapted from Kathy Bielek, Blueprint for selecting resistant sheep: a shepherd's perspective (2017)

Table 2. Requirements for selection for resistance to parasites

Individual animal ID	Permanent ID options include ear tags, ear notches, electronic ID, and tattoos.
Same contemporary group **Animals of similar age, raised together**	Lambs/kids born within 35 days of age of each other and managed in the same pasture
	Periparturient ewes/does in the same management group during gestation and the first few 2 to 3 weeks of lactation.
	Yearlings that have been managed together for at least six weeks or for six weeks after deworming.
Significant exposure to worms	Grazing at a time of the year in which there are worms.
	Grazing for at least 30 to 45 days
	Animals need to be ingesting significant amounts of pasture. The more harvested feed they are fed, the less likely they are going to have high enough FEC.
High enough fecal egg count	Average of 500 EPG or more
Significant range in fecal egg count	A difference of at least 1500 between lowest and highest fecal egg counts e.g. 0 to 4000 or 250 to 6000 epg or higher
Quantitative fecal egg count	McMaster's method is the standard. It provides a number (eggs per gram) for each fecal sample.

WHEN TO SELECT

Small ruminants can be selected for parasite resistance at various stages in their life cycle. While it is most common to select animals when they are young and still growing, the age at which to begin selection varies by species, breed, and age of first exposure. Lambs/kids begin grazing at different ages, depending upon the management system. Resistant breeds of sheep develop immunity at a younger age and can be selected earlier for parasite resistance as compared to non-resistant breeds. For these breeds, it may be possible to begin selection as early as 40 days of age, if the lambs have had sufficient exposure to parasites.

Resistant sheep breeds include Caribbean-derived hair sheep (St. Croix, Barbados Blackbelly) and their composites (e.g. Katahdin) and wooled breeds native to the southeastern US (Gulf Coast and Louisiana Natives and Florida Native/Cracker). For more susceptible breeds of sheep, three months is probably the earliest age at which selection decisions should be made. In fact, most selection decisions (regardless of breed) are usually made post-weaning (more than 90 days of age). When selecting at early ages, it is important not to discriminate against multiple births, as they would be expected to have higher fecal egg counts.

Collecting a fecal sample Image by S. Schoenian

Goats develop immunity to parasites at an older age than sheep, so selection should be delayed until they are probably at least six months of age. There is some evidence to suggest that Myotonic goats are more resistant to parasites than Boers, with Spanish and Kiko in-between, so perhaps selection could be imposed earlier. Sometimes, selection is delayed until sheep/goats are yearlings (between 1 and 2 years of age). When selecting yearlings for parasite resistance, it is important to manage the yearlings together for at least 6 weeks prior to collecting fecal samples and/or to wait at least six weeks after deworming the whole group.

You can also deworm lambs/kids before collecting fecal samples and making selection decisions. The reason for deworming everyone is to ensure that all animals have equal exposure to parasites. Deworming removes infection. Waiting six weeks to collect samples should allow animals enough time to get re-infected. This is commonly done with rams/bucks in central performance tests. Any time animals are dewormed prior to sample collection, it is important that they be given an effective treatment, but not with a long-acting dewormer (LongRange®). Due to widespread resistance to dewormers, it may be necessary to give a combination treatment. A combination treatment is when dewormers from different drug chemistries are given sequentially to the same animal. The most potent drug from each drug group is advised. Combination treatments for goats and camelids require extra label drug use and a valid veterinarian-client-patient relationship.

Fecal egg count data from periparturient ewes has been proposed as an alternative to evaluating lambs. The periparturient period is the period immediately before and several weeks after parturition. Most small ruminant females suffer a temporary reduction in immunity to parasites during the periparturient period. Fecal egg counts usually peak 20 to 30 days after lambing. The eggs deposited during this period become a significant source of infection for the more susceptible offspring.

To improve accuracy of selection, ewes should be managed together during gestation and the early part of lactation. Samples can be collected at parturition and several weeks after. When using fecal data from periparturient females, it is important not to discriminate against first time moms (especially yearlings), older ewes (more than 7 years of age), and ewes that are nursing multiples, as they would be expected to have higher fecal egg counts.

Periparturient female image by S. Schoenian

HOW DO WE INTERPRET FECAL EGG COUNTS?

In Table 3, let us look at examples of fecal egg counts taken from three groups of lambs/kids. Ideally, each group would have at least 20 animals. Group A has a small range of fecal egg counts and a low average EPG. These fecal egg counts are of very limited value for selection. Either the lambs/kids do not have enough challenge (since the average fecal egg count is below 500 eggs per gram (EPG) or the lambs/kids are already resistant (rare). The spread is also not wide enough to show differences in resistance. With such a small spread, it is like comparing the weaning weights of three lambs/kids that only differ by a couple of pounds. Selecting the lambs/kids with the lowest fecal egg counts (A1, A2) from group A will not likely result in improved resistance to parasites since the criteria for accurate selection have not been met.

Table 3. Fecal egg counts from three groups of animals

Group A			Group B			Group C		
Animal	**FEC**	**Keep-cull**	**Animal**	**FEC**	**Keep-cull**	**Animal**	**FEC**	**Keep-cull**
A1	0	Unsure	B1	0	Keep	C1	750	Keep
A2	0	Unsure	B2	250	Keep	C2	2250	Maybe
A3	100	Unsure	B3	500	Keep	C3	2500	Maybe
A4	150	Unsure	B4	750	Maybe	C4	2750	Maybe
A5	200	Unsure	B5	1100	Maybe	C5	3750	Cull
A6	250	Unsure	B6	2500	Cull	C6	4500	Cull
A7	250	Unsure	B7	3000	Cull	C7	6500	Cull
A8	450	Unsure	B8	3500	Cull	C8	8000	Cull
Avg	**175**		**Avg**	**1325**		**Avg**	**3875**	

Kiko bucks grazing in a central performance test

Image by S. Schoenian

Group B does have a high enough average egg count (1325 epg) and a decent spread to select on. B1, B2 and B3 have enough spread in EPG to identify these three lambs/kids as more resistant than the others. They should be favored for selection. B4 and B5 are in the middle and care should be taken on how to use these results. Selecting B4 or B5 may or may not improve resistance of the flock/herd. B1 with 0 EPG is probably not biologically different from B2 and B3, but is probably different than B6, B7 and B8. B6, B7, and B8 should not be retained in the flock/herd if parasite resistance is a goal of selection.

Group C has the widest distribution of fecal egg counts that probably allows for the most accurate selection. C1 has a very different fecal egg count than the other seven lambs/kids. Due to its significantly lower egg count, C1 should be favored for selection. If you need to retain more animals, you should favor the ones with the next lowest egg counts (C2, C3, C4). The other lambs/kids in the group have much higher egg counts and should probably not be kept for breeding.

These examples should provide guidance on how to use fecal egg counts to select for parasite resistance. On the other hand, since they are in different groups, it is impossible to say that B1 is better than C1, since the C group probably had much more exposure. In fact, it is very possible that a lamb/kid with 750 EPG would have a lower fecal egg count in a less contaminated pasture group or a higher egg count in a more contaminated pasture.

HOW DO I TELL . . .

if a ram/buck from another flock/herd is more resistant than rams/bucks I have raised? This is difficult, if not impossible to do with on-farm data, as evaluation of worms on pasture varies greatly between farms and thus, comparison is an “apples-to-oranges” situation. But there is help. Katahdin flocks that have submitted fecal egg count data to the National Sheep Improvement Program (NSIP; nsip.org)) have Estimated Breeding Values (EBVs) which enable producers to compare resistance between flocks. EBVs factor in the performance of both the animal and its relatives and minimize the impact of nutrition, management, and pasture contamination. NSIP can calculate fecal egg count EBVs for any breed of sheep or goat. Sheep and goat producers are encouraged to enroll their flocks/herds in NSIP and submit fecal egg count data.

WHAT ABOUT RAM/BUCK TESTS?

Ram/Buck tests can be a good compromise to using EBVs for comparing males from different flocks/herds. Because rams/bucks (of similar ages) from different farms are brought to a central location and managed the same, a significant portion of the differences in performance due to environmental influences is removed. Thus, the observed differences

Select males that are low egg shedders. ***Image by S. Schoenian***

have a large enough genetic component to improve the accuracy of selection.

Several ram/buck performance tests collect fecal egg count data. However, similar to on-farm selection programs, there must be enough exposure to worms with a significant range in fecal egg counts in order to separate resistant from susceptible males. Simply having a lower egg count does not mean an animal is more resistant. Some tests artificially challenge the rams/bucks with worm larvae as an alternative (or supplement) to natural exposure. It is important to note that the selection accuracy for central performance tests is much less than EBVs since the data from only one animal is being considered.

WHAT TO EXPECT

Selection is a marathon not a sprint. It requires a long-term commitment. It may take several years before the benefits of fecal egg count selection are realized. Because the heritability of fecal egg count in goats is lower than sheep, progress will likely be even slower with goats. But despite the slow progress, it is worth it. Selection offers the best long-term solution for internal parasite control in small ruminants. While other practices may provide short-term relief, genetic change is permanent. At the same time, single trait selection should be avoided. Animals selected for lower fecal egg count should not be deficient in other economically-important traits, including reproductive and structural soundness. Balanced selection (selecting for multiple traits of importance) is usually the best way to go.

Selection is a marathon not a sprint.

Some members of the American Consortium for Small Ruminant Parasite Control (ACSRPC) have labs which now offer low cost ($5/sample) fecal egg counting for the purpose of selecting for parasite resistance: West Virginia University, Louisiana State University, and Texas A&M AgriLife Research & Extension Center. To learn more, go to http://www.wormx.info/lowcostfec.

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For a complete list of fact sheets, go to https://www.wormx.info/bmps.