American Consortium for Small Ruminant Parasite Control
Best Management Practices for Internal Parasite Control in Small Ruminants

Genetic Selection

Using Crossbreeding and Estimated Breeding Values

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Due to dewormer resistance in worm populations, alternatives are needed to better control these infections in sheep and goat production. These alternatives include pasture management, nutritional supplementation, selective deworming, and genetic selection. While any one of these alone is likely insufficient to control worm infection, a combination of all these practices in an integrated parasite management system may provide sustainable control. Here, opportunities for genetic selection will be discussed as one of the tools available to combat parasitic worm infection.

Host immune response is the key factor in determining whether an animal can resist or allow infection to establish. This immune response is controlled by the individual's genotype. Therefore, if the host's genetics allow them to produce a more effective immune response, then that sheep or goat will be able to resist larval establishment or worm egg shedding. This would result in reduced symptoms and lower pasture contamination.

Therefore, it is critical to identify which animals have lower parasitism. Traditionally, this has been accomplished using fecal egg counts (FEC). Based on FEC, some breeds have known "parasite-resistance." However, within all breeds and the larger population, there exists a range in FEC. Thus, it is important to consider both within-breed selection or improvement using crossbreeding.

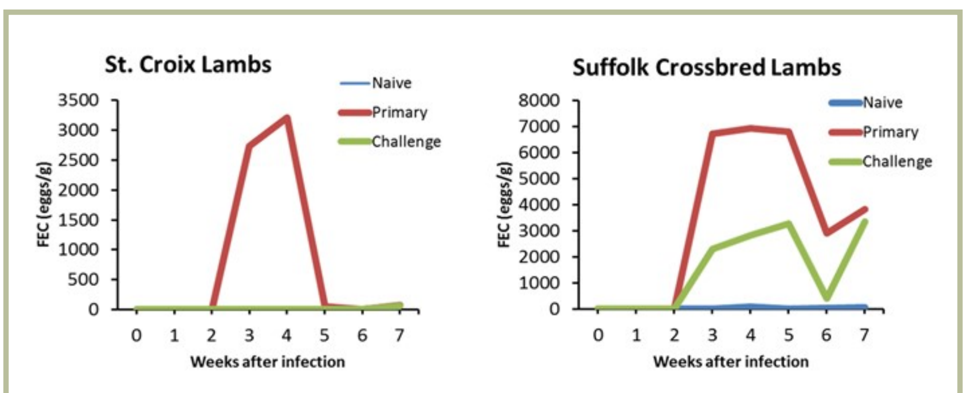
Most resistant sheep breed: St. Croix Image by: Javier Garza

BREED SELECTION

Traditionally, breed selection for resistance has been our best method for breeding sheep resistant to worm infection. Here, breeds of Caribbean origin such as the St. Croix and Barbados Blackbelly could be used as "parasite resistant" breeds to add those genetics to your flock. Many classify the Katahdin, a composite breed made up of Caribbean hair sheep and wool sheep ancestry, as a parasite resistant breed. However, great variation has been described in the breed, and breeding values should be used to

Figure 1: St. Croix sheep demonstrate marked resistance to *Haemonchus contortus*

Lambs in this study were maintained parasite-naïve and given a single dose of 10,000 *H. contortus* larvae (primary infection). Lambs in challenge group were given a primary dose and infection was allowed to establish for 5 weeks. The lambs were dewormed, rested and given challenge infection of 10,000 *H. contortus* larvae. Naïve lambs remained free of parasites.



identify more resistant individuals. In general, wool breeds, especially black-faced breeds such as the Suffolk, are more susceptible to infection than hair breeds. Caution should be used when raising these sheep in parasite-favorable conditions. The exception in wool breeds includes the Louisiana (Gulf Coast) Native and the Florida Native breeds, due to natural selection.

Selection using breeds classified as having greater resistance is one tool to reduce the level of worm burden in a flock (Figure 1). However, this method typically implies the use of crossbreeding which is not desired in purebred flocks. Additionally, hair breeds which are typically classified as resistant, do not have all the economically-relevant traits sought after in today's industry. One example of compensating for this would be the use of the "parasite-resistant" St. Croix as the basis for your ewe flock and then crossbreeding to the more muscular Texel to produce market lambs. Even so, the ability to select for sheep within a breed that are more resistant than their contemporaries may be a better alternative.

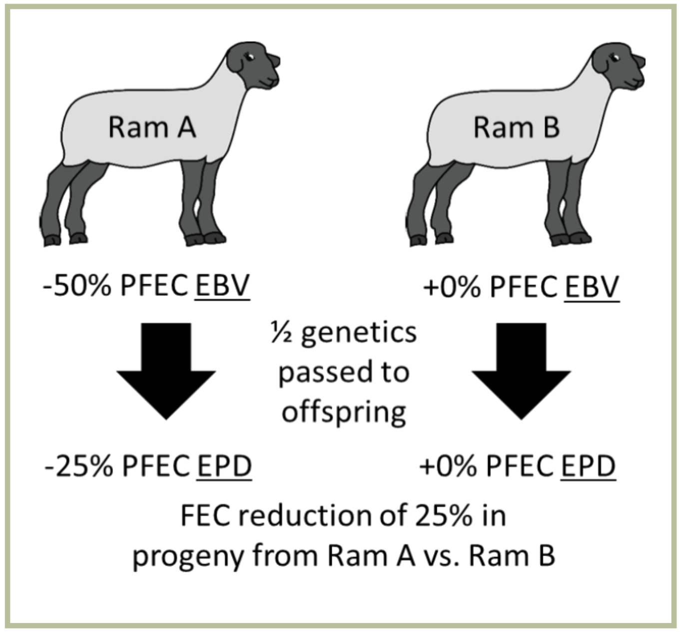


Figure 2: Using post-weaning FEC (PFEC) to select sires

If you were to mate these rams to a group of ewes then you could expect FEC of lambs sired by Ram A to be 25% lower than FEC of lambs sired by Ram B.

ESTIMATED BREEDING VALUES

Traits associated with parasite resistance (e.g. FEC) are best described as quantitative. This means they are typically controlled by many genes. Unlike a qualitative trait where a single gene is involved and selection is relatively simple with an understanding of an individual's pedigree. Scrapie resistance is a qualitative trait. RR parents have RR offspring and two QR parents will have QQ, QR and RR offspring (progeny genotypes can be determined with a Punnett Square). Traits like growth and parasite resistance are quantitative traits in which selection is most rewarded by using statistical methods. Fortunately, those statistical analyses are available to shepherds.

Quantitative genetic evaluation became available to the U.S. sheep industry in the late 1980's with the establishment of the National Sheep Improvement Program (NSIP). Now working with LAMBPLAN in Australia for genetic analysis, NSIP provides U.S. sheep and goat producers with estimated breeding values (EBVs) for a variety of reproductive, growth, carcass, wool and health-related traits. An EBV is simply a numerical estimate of an individual's genetic merit for a given trait. For those familiar with cattle expected progeny differences (EPDs), an EBV is twice the value of an EPD (a sire or dam passes on ½ of its genetic merit to its progeny). While an EPD estimates the difference between two individual's progeny performance, an EBV is a predictor of the individual itself. EBVs are calculated using individual performance data submitted by the producer as well as performance data from relatives and correlated traits. Traits are adjusted to standard ages and weights, and breeding values generated are comparable across flocks.

In the early 2000's, work by Dr. David Notter and his students at Virginia Tech provided the industry with the necessary parameters to generate EBVs on FEC. Since the nematode parasites of concern reside in the gastrointestinal tract of the host, adult worm counts cannot be obtained without sacrificing the animal. Consequently, FEC provide us with the best estimate of worm burden. Generating FEC EBVs gives us a genetic tool to begin selecting sheep or goats which are more resistant than others within the same breed.

Fecal egg count EBV is expressed as a percent change. For example, a FEC EBV of -50% indicates a reduction in FEC of 50% compared to an individual with a FEC EBV of 0% (Figure 2). Likewise, a FEC EBV

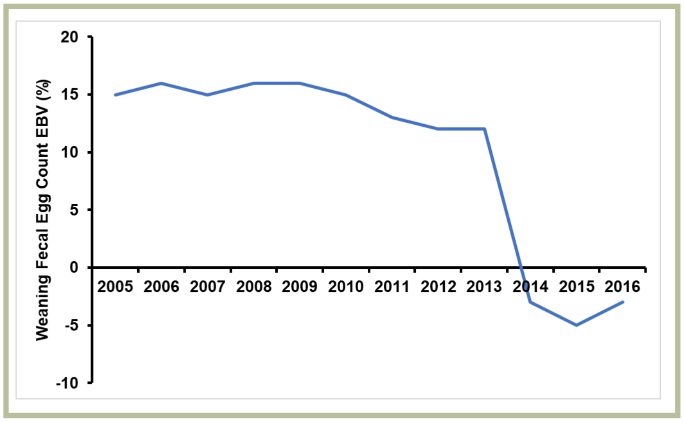


Figure 3: Effect of selection for lower WFEC EBV within the Katahdin breed

From 2005 to 2016 there has been a significant reduction in WFEC EBV averaged across the Katahdin breed. These data demonstrate the effect of selection for this trait by Katahdin producers.

of +50% indicates an increase in FEC of 50% compared to the same individual. Since an EPD is equivalent to ½ of an EBV, progeny from an individual with a -50% FEC EBV would be expected to have a FEC 25% lower than progeny from an individual with a FEC EBV of 0%. By selecting for negative FEC EBVs, FEC is reduced in resulting generations, thereby increasing parasite resistance in the flock.

The two most common time points to assess FEC for breeding value generation are at weaning (WFEC) and during the post-weaning period (PFEC). Generally, heritability for FEC ranges from 20 to 30%, meaning moderate genetic progress can be made through selection (similar to that of growth traits). Heritability indicates the proportion of the observed phenotype that can be explained by genetics. Great variability exists for FEC traits.

Using the Katahdin as an example, WFEC EBVs range from -100 to 769 and PFEC EBVs range from -100 to 1760. This means there is significant opportunity for genetic selection and breed improvement. Selection emphasis for WFEC in the Katahdin breed has resulted in a dramatic reduction in the WFEC EBV from 2005 to 2016 (Figure 3). Using FEC EBVs, some flocks now average a -60 to -70% WFEC.

GOAT RESISTANCE

Similar levels of variation in parasite resistance are observed in the goat breeds. Unfortunately, the goat industry has not adopted the genetic evaluation technology as quickly as the sheep industry has. Additionally, from an evolutionary perspective, goats are adapted to browsing where parasites are mostly absent. However, when goats graze mostly grasses they are exposed to a much higher number of parasites, and they are generally more susceptible than sheep. In general, the Myotonic, Kiko, and Spanish breeds tend to be more resistant than the Boer. However, like with the Katahdin, there are individuals within each breed which may be more resistant than others. In Kiko X Boer crosses, heritability for FEC was around 13%, so genetic progress is certainly possible.

With greater adoption of this genetic evaluation technology, more accurate breeding values could certainly be generated and identification of more "resistant" goats would be made easier. NSIP is available to goat producers as well but will require greater "buy-in" from producers to really become something that can be used across herds.

SUMMARY

There are many options available to combat the parasite challenge. Genetic selection has great potential to improve levels of resistance and reduce worm burden without drastic changes to management systems. Using EBVs as a selection tool provides increased assurance the sheep you are breeding meet the genetic merit you are striving for. Whether you are a purebred breeder using EBVs as a selection tool for both rams and ewes or a commercial breeder purchasing rams with EBVs to reduce parasite burden in your lamb crop, this technology is proven to help you achieve your selection goals.

See the NSIP Ram Buying Guide (nsip.org) for more information regarding EBVs and their use.

SELECTED REFERENCES

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National Sheep Improvement Program Searchable Database. nsipsearch.nsip.org.

Similar differences exist in goats Image by: Susan Schoenian

AUTHORS:

Scott Bowdridge, Ph.D.
West Virginia University,
Morgantown, West Virginia

Andrew Weaver, M.S.
West Virginia University,
Morgantown, West Virginia

REVIEWERS:

Ken Andries, Ph.D.
Kentucky State University, Frankfort, Kentucky

Joan Burke, Ph.D.
USDA-ARS, Dale Bumpers Small Farms Research Center, Booneville, Arkansas

Jim Morgan, Ph.D.
Round Mountain Consulting, Fayetteville, Arkansas

Susan Schoenian, M.S .
University of Maryland, Keedysville, Maryland

Niki Whitley, Ph.D.
Fort Valley State University, Fort Valley, Georgia

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