Winning strategies against *Hemonchus*

Meredyth Jones Cook, DVM, MS, DACVIM
Oklahoma State University, Stillwater, OK 74078
Large Animal Consulting & Education, Orlando, OK 73073

Key words: *Hemonchus*, sheep, goat, parasites

Hemonchus contortus is the most serious parasite facing small ruminant herds and flocks. Anthelmintic resistance and gastrointestinal parasitism due to this parasite have been identified as the greatest threats to small ruminant production worldwide (Waller 1997). Critical management areas for control of *Hemonchus* include refugia, environment, nutrition, genetics and drugs.

Contributors to resistance

The major contributors to anthelmintic resistance in cattle are identified as overuse of anthelmintics, use of drugs with persistent activity, inconsistent performance of pour-ons, lack of refugia and lack of effective quarantine treatments.[1] A meta-analysis of 131 studies in sheep identified the most significant risk factor to be high frequency of treatment followed by drench-and-shift pasture management, use of long-acting formulations and mixed-species grazing.[2]

Refugia

Refugia is a population of parasites that has not been exposed to a dewormer, reducing their likelihood of having resistant genetics. When building refugia protection into herd health plans, it's important to impress on clients that they are strategically breeding worms, just like they are strategically breeding their animal. The number one thing to know about refugia is that deworming all of the animals in the population removes refugia. This is where we went wrong for so long.

As problems with anthelmintic resistance have been investigated, the concept of individual animal susceptibility and the need for strategic selection of animals for deworming has been promoted and serves as the basis for the FAMACHA control scheme.[3] The goal of screening using the FAMACHA© system is to identify the small proportion of animals in a herd that require anthelmintic treatment while leaving the rest of the herd untreated, thereby leaving an anthelminthic-susceptible population of nematodes in the herd-mates and environment. Animals identified by FAMACHA screening have persistent clinical parasitism (i.e., fail to respond to anthelmintic treatment) are culled from the herd. This method for controlling parasitism in the face of anthelmintic resistance of nematodes has been validated for use in sheep and goats in the U.S., with strong correlation to fecal egg per gram count and packed cell volume.[4]

Fecal egg counts (FEC) performed by the Mini-FLOTAC or McMaster's methods[5-6] are important to perform periodically as a more quantitative method of monitoring, as well as determine other parasite genera that may be circulating in the herd or flock. Remember, FAMACHA only detects anemia, which is produced by *Hemonchus*.

Environment

It is important that we cease total reliance on dewormers to control parasite problems. Non-drug management along with proper drug usage is extremely important. Stocking density is an important consideration, but generic recommendations cannot be made, based on variations in climate and forage characteristics. A general place to start might be having no more than 5-7 sheep or goats per acre of pasture, with monitoring of parasite load and grass condition. Native grassland and improved pastures, which form a dense canopy or are overgrown keep moisture down close to the ground and shade fecal pellets, protecting nematode eggs from desiccation and heat destruction. Sparse brush, however, allows heat and air flow around fecal pellets, with temperatures for 155° F recorded in sun-exposed pellets. Rotation of pasture is also important to prevent overgrazing, both from a nutritional standpoint and parasite burden on that land. Environmental conditions should also be considered, with rains (0.5-1") producing increases in larval burdens within 2-3 weeks and high heat, as well as low temperatures (< 50 ° F) being unsuitable for larval development. Knowledge of these criteria should guide the use of anthelmintics such that they are only administered when the risk of larval development is high.

It is important to keep in mind who is contaminating the environment. Animals with low immunity to parasites, periparturient animals, young animals and new or returning animals either amplify or introduce parasites with the potential to carry resistance. For these reasons, it is important to protect the home environment by monitoring FEC in these groups and managing them accordingly. For new or returning animals, a quarantine period, FEC and triple class combination deworming (a benzimidazole, an avermectin and levamisole) is likely to achieve the greatest reduction in egg counts to then be carried onto pasture after release from quarantine.

The concept of "safe pastures" is important when designing pasture rotation strategies. Safe pastures include pastures which have been harvested, grazed by horses or cattle, or not grazed by small ruminants for 3 months in the warm season and 6 months in the cool season. Intensive pasture rotation is generally performed to maximize forage utilization, but can be extremely useful for parasite control. Rotation schemes ranging from 1 month to 2-3-month patterns have been devised, dependent mostly on climate conditions. Drylots are also safe areas, with no grass for larval development and can serve as emergency housing in times of extreme parasite burden.

Nutrition

Every herd or flock investigation I have performed has always turned up holes in nutritional management. This is an expansive topic, but we know that immunity is closely related to protein nutrition. Individual production classes must be fed a protein concentration that is consistent with their stage or production and growth. This can be monitored by body condition scoring (BCS) and assessment of muscle mass. Optimum protein nutrition has been documented to animals having reduced parasite burdens and increases in abomasal mast cell protease activity, which inhibits worm establishment in the abomasum.

A loose, palatable, high-quality trace mineral should be available to all production classes at all times. The benefits of optimal trace and macro mineral nutrition are many but we know specifically that phosphorus inhibits worm establishment, cobalt deficiency is related to reduced immunity to GI nematodes, that adequate copper is required for development of immunity against GI nematodes and that molybdenum can reduce worm burdens in lambs.[7]

Genetics

Although exposure to nematodes varies with season and environment, it appears that exposure to nematodes is fairly uniform within a herd. Nevertheless, some sheep and goats in the same environment are severely affected by nematodes whereas others are not clinically affected. This suggests a genetic component for susceptibility to parasitism. Heritability has been explored as a potential basis for the phenotypic variation in parasite susceptibility of goats,[8-10] where it has been concluded that parasite resistance may be improved in herds through genetic selection. Gene transcription profile studies have been performed in sheep to assess immunologic response to HC infection[11] and an ovine microarray has been created to compare gene expression between resistant and susceptible lambs.[12]

These susceptible animals can be readily identified over time using a combination of BCS, FAMACHA scoring, FEC and good record keeping. A common omission is the end point of the FAMACHA method which is to cull repeat offenders. Maintaining these animals in the herd for flock only serves to further contaminate pastures, increase input costs into nonproductive animals and produce offspring that are also susceptible.

Drugs

Once general herd management has been outlined, you'll need to determine the efficacy of anthelmintics for that premise. There are 2 main methods for determining which classes of dewormers have retained their efficacy in worm populations. The fecal egg count reduction test (FECRT) (Coles et al 1992) involves performing a fecal egg per gram (EPG) test, deworming with the chosen dewormer and then re-running an EPG test post treatment. Post treatment intervals for fecal sampling are: nonavermectins – 10-14 days, avermectins – 14-17 days, moxidectin – 17-21 days. If combination treatment is used, 14 days should be observed. Interpretation of FEC has been outlined.[13] Fecal Egg Count Reduction Test will demonstrate a 90% reduction in EPG for efficacious dewormers. Any dewormer without a 90% reduction in EPG has had a reduction in efficacy due to resistant parasites. Samples should be obtained from 10 animals or 10% of each pen, whichever is greater. In large groups, multiple drugs can be tested concurrently by testing 10-15 animals per dewormer. Alternatively, the Drenchrite® larval development assay can provide in vitro results. Here, larvae are developed and tested against all available classes of dewormers. This is done on a pooled fecal of 10-20 animals per group and, in some flocks or herds is less expensive than multiple fecals for the fecal egg count reduction test.

When a drug or drug fails on a farm, that does not necessarily mean that anthelmintic resistance is present. Other possibilities exist and should be considered. These include: incorrect spectrum of the drug for the target parasite, insufficient drug activity (expired, improper storage – heat/sun/cold, reinfection, improper dosing (settled suspension, spit out, calculation error), weight estimation inaccuracy, and flotation inaccuracy (1+, 2+, 3+...).

Regarding weight estimation, we found that people underestimate weights in goats 65.2% of the time and are within 10% only 36.6% of the time (Gibbons et al., unpublished data 2015).

One of the greatest departures from traditional thinking has been the discovery that rotating dewormers regularly speeds resistance rather than avoiding it. The current recommendation is that an effective dewormer be used until resistance to that dewormer is documented and then a new drug initiated, again with proper attention to good management practices. Newly purchased animals should be "cleared" of internal parasites before introduction to new herd. It is recommended that these animals be quarantined and have a EPG count done, held off feed for 24 hours, then dewormed with all 3 classes of dewormers, such as moxidectin, levamisole and albendazole on the same day. Fourteen days later, a repeated EPG count should be at or near zero and then the animal should be placed on a contaminated pasture, as any surviving worms will be triple-drug-resistant and there will be no refugia on any clean pasture.

Drug classes

It is important to have an understanding of the pros and cons of each anthelmintic we have available to us. First, the anthelmintic classes and drugs we have are:

- Benzimidazoles
- Albendazole, fenbendazole, oxfendazole
- Macrocyclic lactones
- Ivermectin, doramectin, moxidectin, eprinomectin
- Imidazothiazoles, tetrahydropyrimidines
- Levamisole, pyrantel, morantel

Benzimidazoles

The benzimidazoles bring with them several positive attributes, including no residual activity (recall that long action promotes anthelmintic resistance), they are very safe; albendazole is also effective against flukes and tapeworms, they are effective against lungworms and whipworms at high doses, cross the blood brain barrier for cases of CNS *P. tenuis* and have immunomodulatory effects.

Potential negative attributes of benzimidazoles include widespread, long-lasting *Hemonchus* resistance in small ruminants, potential for teratogenicity in early pregnancy and reduced conception.[14,15] Updated dosing charts for the benzimidizoles can be found at **wormx.info.** .

Macrocyclic lactones

The macrocyclic lactones have a moderate margin of safety, demonstrate efficacy against a wide variety of parasites, including nematodes, ticks, flies, mites and lungworms, and are effective against pre-CNS *P. tenuis* when administered parenterally. The cons of use of macrocyclic lactones include their residual activity (moxidectin > doramectin > ivermectin), limited activity against *Nematodirus,*[16] toxicity to dung beetles (except moxidectin), longstanding resistance once it develops, the need to be protected from light and potential toxicity to farm dogs (white-footed herding breeds). Updated dosing charts for the macrocyclic lactones can be found at **wormx.info**.

In addition to oral and injectable options, the macrocyclic lactones come in pour on form. These should never be used in small ruminants due to erratic and likely sub therapeutic absorption. If a topical insecticide is needed, a pure insecticide, rather than a dewormer, should be used.

Imidazothiazoles/tetrahydropyrimidines

This class of dewormers is a group of "throwback" dewormers that were widely used many years ago and have come back into fashion. They exhibit almost no residual activity, are effective against most GI nematodes and lungworms, any anthelmintic resistance is lost very quickly,[17] they have immunodulatory effects and morantel is labelled for lactating does – no other dewormer is.

The weaknesses of this class are that because they have no residual activity, relapses can occur after 1-2 lifecycles if management is not corrected; they are better at killing adults and have varied efficacy against larvae, they are inconsistent against whipworms and have no efficacy against flukes, tapeworms or protozoa, and have a narrower safety margin than the other classes of anthelmintics, with neurologic effects seen.[18] Updated dosing charts for the imidazothiazoles and tetrahydropyrimidines can be found at **wormx.info**.

Food product withholding

Remember that anthelmintics are drugs just like antimicrobials and do have an assigned withdrawal time. Moxidectin is frequently found as a violative residue in sheep and goat carcasses. Recall that for any drug used in an extra label fashion (dose, route, frequency, etc.), the tolerance will be zero and the label withdrawal is void. Always get updated withdrawal times from **FARAD.org**.

Combination deworming

Combination deworming differs from rotational deworming in that multiple drug classes are administered at the same time, rather than going class to class to class over a period of time. With this method, there is an additive effect to the dewormers, the spectrum becomes broader and there are fewer resistant survivor parasites.[19] Rotating dewormers on the other hand, has been shown to result in high-level resistance. When combination deworming is used, techniques to maintain refugia in the population must be used.

No matter the deworming strategy selected, Smart Drenching guidelines should be used. This set of recommendations seeks to improve efficacy of dewormers when they are used and prevent anthelmintic resistance. Dewormers, with the exception of levamisole and moxidectin should be dosed at twice the cattle dose for the heaviest animal in the group. All products, including injectable products, should only be used orally. Pour-on and in-feed products should not be used in sheep and goats.

Products should be placed in pharynx using drenching guns, rather than being placed in the mouth to ensure that the full dose is captured in the rumen.[20] When using benzimidazoles, animals should be held off-feed for 24 hours prior to treatment assuming animals are healthy enough for this and doses should be repeated 12 hours later.[21] This decreases the flow rate of digesta, increasing availability and efficacy of the drug. It is also useful to hold animals in a working pen for 24-72 hours after deworming before placing them on a new pasture. Finally, only animals that require treatment should be treated and efficacy of treatment should be monitored and dewormers should be administered when the parasites are expected to be in the animal, not in the environment. *Hemonchus* is a warm season parasite, so the focus should be on that time of year when temperatures are 60 to 95° F (15.5 - 35° C).

Complementary treatments

In response to the concerns with drug overuse, complementary treatments have been studied for properties that may reduce parasite burden in herds and flocks. Concentrated tannins, as available in many plant sources including *Sericea lespedeza*, have been shown to suppress internal parasites and provide bypass protein to boost nutrition.[22] Copper oxide wire particles have been shown to reduce FEC in lambs.[23] *D. flagrans*, the nematode-trapping fungi, has been shown to reduce larvae burden on pasture. This product is fed daily and does not function as an antiparasitic in the animal but rather is passed out in the feces where the fungi wrap up and kill larvae on the pasture. Despite being strongly touted by many livestock producers, diatomaceous has been shown to have very limited to no anthelmintic effect and therefore cannot be recommended.[24-27]

Management summary

- Evaluate pasture management, identify safe pastures
- Evaluate protein and trace mineral nutrition
- Determine breeding goals
- Identify all animals with tags
- Get parasite control history, especially with regard to drug use
- Implement non-drug parasite control strategies based on risk factors
- Train client to implement FAMACHA© scoring, EPG sample collection, BCS and record keeping
- Prepare clients for culling
- Deworm only animals who require it based on FAMACHA© score or egg per gram fecal counts
- Use short acting products, especially in growing animals and small ruminants
- Administer appropriate dose for species, weight, route
- Move pastures 48-72 hours after treatment
- Monitor drug efficacy with FECRT
- Provide high quality protein and loose trace minerals with copper
- Cull animals that require multiple treatments

References

1. Sutherland IA, Leathwick DM. Anthelmintic resistance in nematode parasites of cattle: a global issue? *Trends Parasit* 2011;27(4):176-181.

2. Falzon LC, O'neill TJ, Menzies AS. A systematic review and meta-analysis of factors associated with anthelmintic resistance in sheep. *Prev Vet Med* 2014;117(2):388-402.

3. Bath GF, Malan FS, Van Wyk JA. The FAMACHA Ovine Anemia Guide to assist with the control of haemonchosis. In: *Proceedings of the 7th Annual Congress of the Livestock Health and Production Group of the South African Veterinary Association*, Port Elizabeth, South Africa. 1996:5.

4. Kaplan RM, Burger JM, Terrill TH, et al. Validation of the FAMACHA eye color chart for detecting clinical anemia in sheep and goats on farms in the southern United States. *Vet Parasitol* 2004;123:105-120.

5. Alowanou GG, Adenile AD, Bossou AC, et al. A comparison of Mini-FLOTAC and McMaster techniques in detecting gastrointestinal parasites in West Africa Dwarf sheep and goats and crossbred rabbits. *J Appl Anim Res* 2021;49(1):30-38.

6. Silva JND, Lima MDLO, Paiva RRLT, et al. Comparing McMaster and Mini-FLOTAC for endoparasites diagnostic in goats. *Acta Vet Brasilia* 2020;14(4).

7. Sykes AR. Environmental effects on animal production: the nutritional demands of nematode parasite exposure in sheep. *Asia-Aus J Anim Sci* 2001;13:343-350.

8. Mandonnet N, Aumont G, Fleury J, et al. Assessment of genetic variability of resistance to gastrointestinal nematode parasites in Creole goats in the humid tropics. *J Anim Sci* 2001;79(7):1706-1712.

9. Gunia M, Phocas F, Arquet R, et al. Genetic parameters for body weight, reproduction, and parasite resistance traits in the Creole goat. *J Anim Sci* 2011;89(1):3443-3451.

10. Olayemi ME, Bolormaa S, van der Werf JHJ, et al. Estimates of genetic and phenotypic parameters for production, haematological and gastrointestinal nematode-associated traits in Australian cashmere goats. *Anim Prod Sci* 2011;51(2):123-134.

11. Rowe A, Gondor C, Emery D, Sangster N. Sequential microarray to identify timing of molecular responses to Haemonchus contortus infection in sheep. *Vet Parasitol* 2009;161(1-2):76-87.

12. Keane OM, Zadissa A, Wilson T, et al. Gene expression profiling of naïve sheep genetically resistant and susceptible to gastrointestinal nematodes. *BMC Genetics* 2006;7(1):1-12.

13. Kaplan RM. Biology, epidemiology, diagnosis, and management of anthelmintic resistance in gastrointestinal nematodes of livestock. *Vet Clin N Am Food Anim Pract* 2020;36:17-30.

14. JECFA. Albendazole. In: JECFA Food Additives Series 25. Prepared by the Thirty-fourth Meeting of the Joint WHO/FAO Expert Committee on Food Additives, WHO, Geneva. 1989:3-29.

15. Theodorides VJ, Carakostas MC, Colaianne JJ, et al. Safety of albendazole in developing bovine fetuses. *Am J Vet Res* 1993;54(12):2171-2174.

16. Flochlay A, Deroover E. Efficacy of four endectocides against *Nematodirus helvetianus* in cattle: moxidectin, ivermectin, doramectin 1% injectable solutions and moxidectin 0.5% pour-on solution. *Rev Med Vet* 1997;148:229-234.

17. Martin PJ, McKenzie JA. Levamisole resistance in *Trichostrongylus colubriformis*: a sex-linked recessive character. *Int J Parasitol* 1990;20(7):867-872.

18. Sahagun AM, Teran MT, Garcia JJ, et al. Oral bioavailability of levamisole in goats. *J Vet Pharm Therap* 2001;24:439-442.

19. Waller PJ. Anthelmintic resistance. *Vet Parasitol* 1997;72:391-405.

20. Sangster NC, Rickard JM, Henessey DR, et al. Disposition of oxfendazole in goats and efficacy compared with sheep. *Res Vet Sci* 1991;51(3):258-263.

21. Zajac AM, Gipson T. Multiple anthelmintic resistance in a goat herd. *Vet Parasitol* 2000;87:163-172.

22. Min BR, Hart DP, Miller D, et al. The effect of grazing forage containing condensed tannins on gastro-intestinal parasite infection and milk composition in Angora does. *Vet Parasitol* 2005;130(1-2):105-113.

23. Schweizer NM, Foster DM, Knox WB, et al. Single v. double dose of copper oxide wire particles (COWP) for treatment of anthelmintic resistant *Haemonchus contortus* in weanling lambs. *Vet Parasitol* 2016;229;68-72.

24. Bernard G, Mulumebet W, Ahmedna M. The effects of diatomaceous earth on parasite-infected goats. *Bull Georgian Natl Acad Sci* 2009;3:129-135.

25. Osweiler G, Carson T. Evaluation of diatomaceous earth as an adjunct to sheep parasite control in organic farming. Leopold Center Completed Grant Reports 1997;102:21-23.

26. Fernandez MI, Woodward BW, Stromberg BE. Effect of diatomaceous earth as an anthelmintic treatment on internal parasites and feedlot performance of beef steers. *Anim Sci* 1998;66(3):635-641.

27. McLean B, Frost D, Evans E., et al. The inclusion of diatomaceous earth in the diet of grazing ruminants and its effect on gastrointestinal parasites burdens. *ADAS Agricultural Res Cons Report* 2005:277-280.