PRACTICAL MANAGEMENT OF INTERNAL PARASITES IN GOATS

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INTRODUCTION

Internal parasitism is one of the biggest problems in the small ruminant industry. Internal parasite infestations of herds can cause major health issues, which have a major effect on the animal's performance and cause great economic loss to the producer. In fact, most of the economic losses caused by internal parasites are actually not due to mortality but production loss (Waller, 2004). The proper management of internal parasites is extremely important to the success of the goat producer. The ability to detect the clinical signs of a major infection, to properly treat the herd, and to effectively reduce the herds exposure to parasites are all very important aspects of internal parasite management. As the goat producer faces issues like the rise of anthelmintic resistance among parasites, the knowledge of how to properly manage internal parasites becomes necessary for the survival and the economic viability of his or her herd.

One of the first things that producers should realize, especially those in tropical and subtropical environments, is that goats are naturally browsers in contrast to sheep and cattle, which are grazers. Additionally, goats have traditionally been raised in dry-arid climates in extensive production systems, and they simply have not had the opportunity to adapt to the warm-moist conditions of a humid subtropical climate like Florida. Most production systems require them to graze intensively on improved pasture lands, and producers in the tropics and subtropics normally practice year round grazing. All of these factors in addition to the fact that many of the parasites that affect goats thrive in warm, moist conditions and live close to the ground, simply expose goats raised in tropical regions to more parasites than they are naturally accustomed to, even though they are known to be highly adaptable (Waller, 2004). Since many goats would not naturally survive in the production systems of Florida, proper management is necessary for the success of a herd.

Figure 1. Goats at the FAMU Research and Extension Center in Quincy, FL.

COMMON INTERNAL PARASITES IN FLORIDA

The frequency and type of parasites that affect goats vary by region. Factors such as climate, season, and rainfall affect the types of parasites that may be present in a herd. The first five parasites that will be discussed - the barber pole worm, coccidia, the tapeworm, the intestinal threadworm, and the intestinal threadneck worm - are parasites that have been commonly observed in fecal samples taken from goats in the north Florida area by Florida A&M University. The last parasite, the liver fluke, is also found in Florida but it is not widely dispersed.

A. Barber pole worm

Although illness caused by internal parasitism usually results from infestations of multiple parasites, the most pathogenic in small ruminants is *Haemonchus contortus*, or the barber pole worm. *H. contortus* is extensively dispersed, and it tends to thrive especially well in the warm, moist conditions of tropical and subtropical environments like Florida. *H. contortus* is haematophagous, which means that it feeds on the blood of its host. It lives in the abomasum, where it attaches with its mouth to feed, mature, and reproduce. *H. contortus* is a very fertile species. The female lays about 5000 eggs per day, which are expelled through the feces. After the eggs hatch, the larvae inhabit the water that develops on blades of grass from dew or rain. Then the host, such as a goat, ingests the larvae while grazing on the contaminated pastures continuing the cycle. It takes about 3 weeks to complete the life cycle of the worm, but if the worm enters the survival stage of arrested development, it could survive for months. Arrested development involves the larvae remaining in the abomasums of the animal without maturing until months afterwards. This allows the worm to survive the winter months when the egg and larvae do not thrive well on the ground. The survivability of the free-living stage of *H. contortus* is short; in fact, most infective larvae vanish from the pasture within 4-6 weeks in a wet tropical environment (Waller, 2004).

B. Coccidia

In Florida, coccidia and the barber pole worm are the two major parasites that cause problems in goats. Many of the important coccidia, which are protozoan (single-celled organisms), belong to the genera Eimeria. In goats, coccidiosis tends to be a problem in the young because they have not had the opportunity to develop immunity to these parasites. Kids between 3 weeks and four months are the most susceptible to this disease. The parasite invades the cells in the lining of the intestine, reproduces and causes the cells to rupture and die. The scarring of the intestine caused by this disease usually means that recovery will be slow and may result in an animal that is permanently unthrifty. The disease normally takes about 3 weeks after the initial infection to develop and includes symptoms like soft stool, decreased appetite, and poor weight gains. When a farm has coccidia, the mature animals carry around the parasites and may not show signs because they have developed immunity. A more serious manifestation of the disease may develop in the young, animals that had not been exposed previously, or those with a poor immune system. These symptoms include bloody diarrhea, straining, dehydration and possibly death (Heath & Harris, 1991; Luginbuhl, 1998; Mowlen, 2000; Schoenian, 2003).

C. Tapeworm

The tapeworm, or *Monezia expansa*, is not a major cause of disease. Animals may appear unthrifty or have an upset stomach under heavy infestations but infestation is normally not a major problem or concern since these parasites are relatively nonpathogenic. Yellow or white segments or “oocytes” can be seen with the naked eye in the feces or around the anus (Kahn, 2005).

D. Intestinal threadworm

Symptoms of infection by the intestinal threadworm, or *Strongyloides papillosus*, is similar to other stomach worms and may include diarrhea with mucous and blood, loss of appetite, and weight loss. The eggs can be seen by microscope in the feces and

infection can occur through the skin or the milk. Most infections are not a major cause of concern (Kahn, 2005).

E. Intestinal threadneck worm

The symptoms caused by an infestation of the intestinal threadneck worm, or *Nematodirus spathiger*, are characterized by their sudden manifestation, unthriftiness, profuse diarrhea, dehydration, sunken eyes, "tucked stomach", and death in as soon as 2-3 days after it is first observed (Kahn, 2005).

F. Liver fluke

The liver fluke is a problem for pastures that are in low areas or around lakes or streams because it is limited by the distribution of its intermediate host, the snail. The flukes infect the liver of the goat and can remain there for months or years. Although the fluke infects the liver, it can cause other problems such as growth and production lost. Since the snail that carries liver flukes only lives in wet areas, it is important to drain those areas or keep goats away from those areas using fencing (Heath & Harris, 1991; Dunn, 1999; Kahn, 2005).

CLINICAL SIGNS OF INFECTION

In order to properly manage the herd, it is important to be able to recognize the signs of parasitism. Diagnosis is usually done by observing the clinical signs, performing a fecal egg count test, or using the FAMANCHA© system to determine the level of infection. It is also important to consult with a veterinarian in order to obtain an accurate diagnosis since some symptoms are similar for multiple diseases.

A. Observing the clinical signs

Observe the herd daily for signs of abnormality. Sick animals usually isolate themselves from the herd and do not eat normally. A good time to check your animals is during feeding times. A daily visual inspection is usually sufficient to monitor for parasite infestation. However, other diagnostic methods such as fecal egg counts must also be routinely done since the biggest impact of internal parasites occur in the sub-clinical level (not easily detected by visual observation) (Waller & Thramsborg, 2004).

Many of the clinical signs for parasites were mentioned in the previous section. In this section, some general signs that normally point to internal parasite infection will be discussed. One should be able to recognize these signs in order to make a proper diagnosis and they will also be helpful when the problem is discussed with the veterinarian. Some of the observable clinical signs of a heavy internal parasite infection are anemia, bottle-jaw, and wasting away or poor weight gain. Anemia results from parasites sucking the blood. It can be observed in the mucous membranes, particularly those around the eyes and the gums. The membranes appear white or pale in contrast to the normal bright pink color that should be observed. Bottle-jaw is swelling, or edema, in the lower jaw of a goat. A gastrointestinal parasite infection causes a deficiency of proteins in the blood due to an increase demand for proteins and a

Figure 2. An animal with severe diarrhea (scours) because of a coccidial infection.

decrease in the nutrient supply because of a lack of appetite (Ashraf & Nepote, 1990; Min et al., 2005). When there is not a sufficient amount of proteins, which hold fluid in the blood, the fluids leak into areas like the lower jaw region and the lower area of the abdomen. In heavy infections and in young animals, a wasting away can be observed, in which the animal has a low body conditioning score, a dull coat, and appear unenergetic. Diarrhea, or scours, may also develop as a consequence of infestation (Figure 2) (Eysker & Ploeger, 2000).

B. Fecal analysis

Diagnosis of internal parasite infections is normally done by fecal analysis. The eggs of all of the parasites discussed above can be seen by microscope. The fecal analysis can be sent to a lab, performed at home, or by a veterinarian. Fecal egg counts can indicate the level of pasture contamination and the need to treat with anthelmintics.

It is suggested that fecal samples be collected from 10% of the herd or at least five goats to obtain an adequate representation (Luginbuhl, 1998). At Florida A&M University, fecal samples are collected from the entire herd in order to obtain a more accurate representation of the level of infection. Use a latex glove to collect the fecal samples. The fecal samples should be fresh and collected from the anus of the goat. A sample of about two to five grams is normally sufficient to do an accurate fecal analysis. The glove can be inverted to serve as a container for the sample or the sample can be placed in a plastic container or a small glass jar.

1. Diagnostic laboratory

If the fecal samples are sent to a diagnostic lab, the lab will send a report, which will show the number of worm eggs present. A veterinarian should be consulted in order to interpret the numbers because of the complexity of the information that a simple worm count can give. The veterinarian will also be able to give advice on what actions if any should be taken. If a severe parasite infection is suspected, it may be advantageous to treat the affected animals before the results are received because the time that it takes to receive the results shortens the window of opportunity to treat the animal before the disease progresses to a serious state (Eysker & Ploeger, 2000).

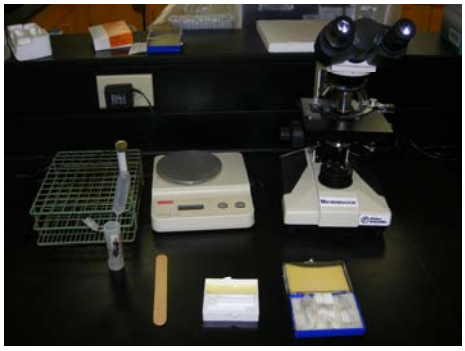

Figure 3. Equipment that can be used to do a fecal analysis includes a graduated test tube, a scale, a microscope, cover slips, microscope slides, a stirrer, and a plastic container (clockwise from top left corner).

2. Home

If the fecal analysis is done at home, a microscope, flotation solution, a spoon or stirrer for the fecal slurry, a straining device, test tube, microscope slides, and cover slips are need (Figure 3). A simple microscope with 200X magnification would be sufficient. Flotation solutions can be bought or they can be simple saturated salt or sugar solutions. In order to make a flotation solution, simply mix salt or sugar into boiling water until no more will dissolve then cool and store at room temperature. Weigh the pellets. Place pellets in a small container. The amount of flotation solution (in ml) that is added to the small container should be 10 subtract the weight of the pellets (in grams). For example, if the fecal pellets weigh 2 grams then 8 ml of flotation solution should

be added (10 – 2 = 8) or if the fecal pellets weigh 6.4 grams then 3.6 ml of flotation solution should be added to the container with the pellets (10 - 6.4 = 3.6). Mix thoroughly, being sure to disintegrate the pellets, and let it sit for three to five minutes. Mix the solution again and strain it to remove any large particles. Pour the strained solution into the test tube until it almost spills over and forms an elevated dome on top. Place the slide over the top of the tube and let it sit for 15-20 minutes. Carefully lift the slide off of the tube and place it (wet side up) on the microscope stand. Then place the cover slip over the slide and center it over the fluid. Examine the entire slide, moving from edge to edge – left to right to bottom. Count the eggs and use the following formula to determine eggs per gram of feces (EPG).

$$\textbf{EGGS PER GRAM (EPG)} = \frac{\textbf{Gram of FECES + ml of Flotation Soln.}}{\textbf{Gram of FECES}} \times \textbf{NO. OF EGGS X 1/3}$$

Remember, that the numerator of the fraction (the gram of feces + the ml of flotation solution) should equal 10. Once you have the EPG, use the following chart as a guide to determine if treatment is needed.

100-250 EPG – Not a significant amount
250-500 EPG – Low infection level
500-1000 EPG – Moderate infection level
>1,000 EPG – High infection level

A moderate to high level of infection indicates the need to treat the animal. A McMaster slide can also be used to determine EPG while regular slides are used to determine the general level of infection like low, medium, and high. It should be noted that the results from a fecal analysis are no more than estimations of the level of infestation of the animal or the herd (Hunter, 1994; Eysker & Ploeger, 2000; Schoenian, 2003).

C. The FAMACHA© system

The FAMACHA© system involves checking the color of the mucous membrane of the eye in order to determine the extent of anemia (Figure 4); and thus, the level of infestation by internal parasites (Luginbuhl, 2002; Waller, 2004; Gaskin, 2006). The technique was developed in South Africa and validated by studies in the United States. The system categorizes animals on a scale of 1 to 5, with 5 being reserved for the most anemic animals. FAMACHA© is only effective for the diagnosis of *H. contortus*. One of the advantages of the FAMACHA© system is that it decreases the number of animals

Figure 4. When conducting a FAMACHA test on an animal, remember to do it in an area with plenty of light and to always use the card.

that are treated by targeting animals that show physical signs of infection. This system of diagnosis lowers production cost, identifies worm susceptible animals that should be culled, and slows the development of anthelmintic resistance. Although the procedure is simple, quick, and easy to do, it is important that the producer is trained by a veterinarian or other trained animal health professional to use the FAMACHA© system accurately (Waller, 1999; Eysker & Ploeger, 2000; Schoenian, 2003; Kaplan et al., 2004; Hale, 2006).

TREATMENT

Treatment of parasitic worm infections is usually done with chemical dewormers, or anthelmintics. Although there are non-chemical treatments like diatomaceous earth and herbal remedies, there is not sufficient published research that confirms their effectiveness. It is important to consult with a veterinarian concerning treatment because improper treatment techniques could result in major problems.

A. Anthelmintics

Anthelmintics (anti-helminthes) are chemical dewormers used to treat infections of parasitic worms (helminths). There are a few types of anthelmintics that are commonly used for goats although there are only three (Ivomec©, Valbazen©, and Tramisol©) that are approved for use in goats. For anthelmintics that require "extra-label' use, a veterinarian should be consulted. The different classes or families of anthelmintics use different modes to kill the parasites. Table 1 contains the three classes of anthelmintics with brand names that are commonly used in goat production.

Coccidiosis is normally treated with sulfa drugs (Albon©) and amprolium (Corid©). The sulfa drugs do not directly cure the coccidiosis but instead prevent secondary bacteria diarrhea. In serious cases, the kid may need to be treated for dehydration and lack of electrolytes. To check for dehydration, perform the skin-tent test, which involves pulling a flap of the skin upwards and allowing the skin to fall back in place. If the skin takes more than a few seconds to fall, then the animal is dehydrated. To prevent dehydration, Gatorade© could be given by nursing bottle or stomach tube at a rate of 15-20% of their body weight per day (Heath & Harris, 1991; Schoenian, 2003).

1. How to administer properly

Anthelmintics can be given either by drenching (Figure 5), injection, in the feed, or in the water. The preferred method is to give the anthelmintics orally. Oral treatments can be done with a drenching gun. It involves holding the goat's muzzle with the fingers in the backside of the mouth to open it. Place the gun in the back of the mouth, tilt the head back, and administer the medication. Although the aim should be to reduce spillage, some spillage may still result (Dunn, 1999).

Figure 5. The anthelmintic can be administered with a drenching gun as shown. Hold the head up, open the mouth with your fingers and insert the gun into the back of the mouth.

B. Treatment strategies

Three common treatment strategies that are employed are tactical, salvage and strategic. A management scheme that incorporates aspects of all three strategies is recommended. Programs that involve treating the herd excessively are very much discouraged and can be costly.

Tactical treatment involves treating the herd based on environmental conditions. The herd is treated when conditions such as weather (i.e. rain) has made the environment advantageous for the rise of parasite numbers. Tactical treatments might also be based on an increase in fecal egg counts. This treatment program usually involves a schedule that involves treating animals at the start of the grazing season, in the summer when parasite numbers are high, in the fall or winter after the first frost, and when moving the animals to a "clean" pasture. The entire herd is usually treated to prevent disease (Scarfe, 1993; Luginbuhl, 1998).

Salvage treatment involves treating the animals that are seriously affected by disease. The animals usually already show many of the symptoms of infestation including wasting away, rough coat, anemia, bottle jaw and diarrhea. This treatment is usually done to save the life of the animal. If the animal demonstrates the symptoms of a severely diseased animal, it should be treated quickly (Luginbuhl, 1998). At times, it may be required to treat the animal before a positive diagnosis from a lab test or a veterinarian can be made. Hopefully, the animal is managed in such a way as to not allow it to reach this stage of sickness, but since many goats do not show any symptoms until they are severely affected, this type of treatment may not always be possible to avoid.

Selective treatment involves treating only animals that are susceptible to parasite infection. Animals like females that are about to kid (2-4 weeks before kidding), young animals, and animals that are showing symptoms of infection based on visual observation or the FAMACHA© system are treated. It is probably the best program out of the three in the long-run because it decreases the number of animals that are treated. Although this sounds counterproductive, a program based on using the least amount of anthelmintics by leaving some animals untreated while still maintaining a healthy herd is the best approach especially to slow the rise of anthelmintic resistance (Luginbuhl, 1998; Sangster, 1999; Schoenian, 2003).

A management plan that incorporates aspects of all three treatment strategies is recommended. One aspect of tactical treatment that may be beneficial is to closely observed the herd both visually and evaluate them using fecal egg counts or the FAMACHA© system when environmental or seasonal conditions are favorable to parasite development. However, it is not suggested that the entire herd be treated based on environmental conditions alone. Salvage treatment is needed to save an animal that is severely affected and should be done accordingly. Selective treatment involves making smart decisions based on a method of selecting individuals either by the FAMACHA© system, individual fecal egg counts, or another factor that may show symptoms of a parasite infection.

Figure 6. A subcutaneous iron injection can also be given to severely anemic animals. A veterinarian should be consulted on the use and administration of iron.

C. Detecting resistance

Resistance is developing at an alarming rate all over the world. It occurs when an anthelmintic is no longer effective. When the parasites in a particular herd become resistant to one anthelmintic, they usually become resistant to all of the anthelmintics in that particular class. It is important to monitor and attempt to control resistance because many scientists predict that there will be no new class of anthelmintics discovered in the near future. If the parasites in a herd become resistant to all of the anthelmintics currently available, this could result in a disaster for the producer.

Since resistance is genetically transferred through a parasite population, resistance develops slowly at first in a herd. Then, it progresses quickly as the genes are dispersed throughout the population until the particular anthelmintic is no longer effective. To detect resistance in a herd, normal observation, the fecal egg count reduction test (FECRT), and the larval development assay can be used. If the physical condition of the herd or an animal does not appear to improve after anthelmintic treatment, the development of resistance should be suspected. Another evaluative tool that can be used to detect resistance is the fecal egg count reduction test (FECRT). A representative fecal sampling and analysis is performed at the time of treatment. About 10-14 days later, another fecal sampling and analysis is performed. If a reduction of 90% or more in the egg count is not observed, resistance should be suspected. It is suggested that some animals are left untreated in order to conduct the FECRT on them to determine if there is any environmental or seasonal factors that could affect the results. This test can be performed by the producer, the veterinarian, or the samples can be collected and sent to a diagnostic lab (Scarfe, 1993; Luginbuhl, 1998). Another test that can be performed is the larval development assay (Drenchrite©). Although it is more expensive than the FECRT, it is known to be more sensitive than the FECRT, requires only one sampling, and can detect resistance at an earlier stage (Sangster, 1999).

In a study conducted at Florida A&M University (FAMU), three anthelmintics (levamisole, avermectin, and albendazole) were evaluated on the herd at the Florida A&M University Research and Extension Center in Quincy, FL. The FECRT was used to evaluate the anthelmintics. The results of the evaluation suggested that the herd was resistant to levamisole. However, Scarfe (1993) suggests that a less than acceptable fecal egg count reduction could also indicate an inadequate dosage rate or that an improper technique is being used to administer the anthelmintic. After the first evaluation, the dosage of levamisole was increased and another FECRT was performed. This resulted in the increase in the reduction of fecal egg counts. However, to make a conclusion on the results obtained more research needs to be conducted. The other two anthelmintics, avermectin and albendazole, both resulted in an acceptable reduction of the fecal egg counts. However, one anthelmintic had a higher reduction rate than the other. The higher reduction rate observed in the evaluation did not imply that one anthelmintic was more effective or better than the other anthelmintic. Generally, the efficacy of the different common anthelmintics when used properly is trivial and should not be used to decide which anthelmintic to use. The FECRT is useful for detecting resistance in a herd, or the possibility of a problem with the dosage or technique used to administer a particular anthelmintic.

D. Techniques to slow the development of resistance

It is important to incorporate management techniques that will slow the development of resistance. One technique that may contribute the most to the development of resistance is under-dosing. It is extremely important that animals not be under-dosed. The animals should be weighed to determine the proper dosage. If all the animals can not be weighed, the dosage should be set according to the weight of the

heaviest animal instead of the average weight of the herd. A veterinarian should be consulted to determine the proper dosage for goats since many anthelmintics are not approved for use in goats and goats usually require a higher dosage rate than sheep or cows.

Another technique that should be employed is the rotation of the type of anthelmintic used. Anthelmintic rotation slows the development of resistance by not allowing a population to build up a significant tolerance or resistance to a particular anthelmintic by introducing the population to another anthelmintic, which insures that sensitivity remains high. It is important to not rotate anthelmintics less than on a yearly basis because a rotation scheme that is less than yearly may result in parasites that are resistant to multiple anthelmintics.

One last technique to slow the development of resistant on your farm is to stop the introduction of resistant parasites. New animals should be quarantine in a separate area for at least 4 weeks before they are introduced to the general herd. This allows the animals to shed the parasites that they might have picked up from their previous location. The animals should also be treated with anthelmintics from two separate classes of drugs while they are quarantined (Luginbuhl, 1998; Schoenian, 2003; Hutchens & Chappell, 2004).

B. Emerging research

There is a general consensus among parasitologists at this time that producers will not be able to completely stop the use of anthelmintics, but they are stressing the importance of finding methods of parasite control that will allow the producers to decrease their reliance on them. Some emerging methods that appear promising are the use of biological controls, copper oxide boluses, neutraceuticals, and nutrition.

1. Biological controls

Some biological methods of parasite control appear to be a viable alternative in the control of gastrointestinal parasites, which is important to producers that want to produce organic products. Predacious fungi, specifically *D. flagrans*, appear to be one of the most promising of these methods. The fungus is fed to the animal as a feed additive, passes through the animal with the feces, grows and traps the parasite larvae in the feces, which decreases contamination of the pasture. One disadvantage of the use of fungus is that it must be fed daily to allow the fungal spores to be continuously shed through the feces. At this time the only option of administration is to incorporate it into the feed because the use of lick blocks does not appear to have a sufficient effect. Research continues on the use of predacious fungus (Waller & Thramsborg, 2004; Hale, 2006; Waller, 2006).

2. Copper wire particles

In recent research, the administration of copper oxide wire particle boluses have been shown to decrease parasite numbers in lambs. One disadvantage to this method of treatment is the danger of copper toxicity. However, mature goats appear to be more resistant to copper toxicity than mature sheep. Additionally, copper wire particle treatment shows promise in the control of parasite load in goats. However, more work needs to be done to determine proper dosage levels and treatment schedules. Also, since the levels of the natural intake of copper vary significantly based on geographic location, it is difficult to make general recommendations on usage to producers (Burke et al., 2004; Hale, 2006).

3. Neutraceuticals

Neutraceuticals is a term that refers to plants that contain compounds (neutricines) that are considered important because of their health benefits rather than their nutritional value. These crops can be grazed, fed as a supplement to the animal, or become apart of a crop rotation plan in order to reduce parasite loads. It should be noted that medicinal plants were used to control and treat internal parasites before the synthetic chemical anthelmintics were introduced.

Although there are numerous compounds that are thought to have beneficial effects on parasite loads, condensed tannins have gained some attention recently. The compound can be found in leguminous plants like leucena and mimosa in addition to other plants like oak trees. Condensed tannins have been shown to reduce gastrointestinal parasite loads in goats by reducing worm fertility, eliminating adult worms, and retarding the establishment of incoming larvae. It is important to note that the results vary depending on the plant species. For example, condensed tannins from some plants appear to only be effective against parasites that affect the small intestine and not those that dwell in the abomasum such as the barber pole worm. Another plant that has compounds that have an effect on gastrointestinal parasites is chicory (*Cichorium intybus*). Research continues on these plants in order to find out the factors that affect the effectiveness of the compounds in addition to their effect on host nutrition (Waller & Thamsborg, 2004; Knox et al., 2006; Waller, 2006).

4. Nutrition

Research has proven that improved nutrition increases both the animal's resilience, which is the animal's ability to endure infection, and its resistance, which is the animal's ability to defend against infection. It is especially important to consider strategic feeding regimens that improve the nutrition of animals that are more susceptible to parasite loads like peri-parturient animals, lactating females, and the young. Increased protein supplementation also appears to improve the resilience of the host to gastrointestinal parasites. Further research is being done to discover optimal feeding regimes (Wallace, 1998; Schoenian, 2003; Waller & Thramsborg, 2004).

PREVENTION

One of the most significant aspects in the control of internal parasites is to prevent parasite infection by decreasing the animal's exposure to the parasites. If the producer is able to effectively decrease the exposure and thereby the infection of the herd, the need to treat the animals also decreases, which has many benefits that are both economical and practical.

A. Sanitation

The first thing that should be taken into consideration in order to decrease the exposure to parasites is sanitation. Feed should be placed in troughs that cannot be contaminated by feces. The goats should only be fed as much as they will eat at that time to reduce waste. The feed troughs can also be moved periodically to discourage the buildup of mud around the feeding area. Water troughs should also be kept clean and free of contamination. It is important to keep the housing facilities clean and to not let fecal material build up as this may encourage the growth of coccidia (Heath & Harris, 1991; Schoenian, 2003). Shelters with raised slotted floors are encouraged to allow the feces to pass underneath and not allow the goats to walk or lay in them. The slotted floors will also decrease the frequency that the houses need to be cleaned.

B. Pasture management

Pasture management is another important tool to decrease parasite exposure. Rotating goats to a clean pasture is a good technique to use. In tropical and sub-tropical regions, pastures that have not been used for four weeks are considered to be clean. Additionally, pastures that have been grazed by another species of animals such as cattle or horses are considered clean because another breed of animal is able to clean the contaminated pasture by "picking up" the parasites without being affected by them. Parasites are usually not able to affect multiple breeds. However, the use of sheep in a co-grazing system is not suggested since some parasites can affect both sheep and goats. Pastures that have been tilled or used to produce hay or row crops that were removed are also considered clean (Schoenian, 2003).

Results from the FAMU study suggested that stocking density and grass height has an effect on parasite load as the group with the higher stocking density and in the paddock where the grass was kept at a low level displayed a faster rate of re-infestation. The height of the grass in a pasture is important because most parasites are found in the first four inches of grass height (Lewadoski, 2006). If the pasture is overgrazed and the grass is very low, the goats may be exposed to a large number of parasites. Since parasites are found close to the ground, forage that requires browsing is usually free from parasites. A pasture management scheme that considers all of these factors will be a very effective tool in controlling parasites.

C. Selecting animals that are genetically more resistant to worms

It is also important to select animals that are more resistant to worm infections. It has been proven that the minority of the herd usually carries and sheds the majority of the parasites. If the animals that are less resistant to parasite infection are removed or culled, the entire herd will be healthier as the number and severity of parasite infections should decrease in the herd. Resistance and resilience to parasite infection has been shown to be in part genetically inherited. Animals that always have high fecal egg counts, high FAMACHA© scores, or always require treatment should be removed from the herd. It should also be noted that different breeds tend to be more resistant and resilient to parasite infestations. The common brush goat, the Spanish goat, and the Myotonic tend to be more resistant to parasite infestation than dairy goats and the Boer. The Kiko may also be able to better deal with parasites because of how and where the breed was developed (Schoenian, 2003; Waller & Thramsborg, 2004).

CONCLUSION

Although the control of parasites can be a daunting task, a management scheme that includes smart choices based on sound, science-based facts can lead to a healthy, profitable herd. With challenges like the rise of resistance of parasites to drugs and the high cost of these drugs, one of the most significant aspects in the control of parasites is to prevent parasite infestations by decreasing the animal's exposure to the parasites through management techniques like those discussed above. Lastly, it is important to consult with a veterinarian about proper diagnosis and treatment of infections since the symptoms of parasite infections are similar to other diseases and many drugs used to treat parasites are not approved for use in goats and require "extra-label" use.

Table 1. The common names, recommended dosage rates, efficacy by parasite species, and the recorded levels of resistance of the three classes of anthelmintics used in goat production.

Drug Class	Common Names/Brands	Dosage	Effective against				Recorded Level of Resistance
			H. contortus	Other gastrointestinal parasites	Tapeworms	Flukes	
Benzimidazoles							
	Albendazole (Valbazen©)	1mL/17lbs	X	X	X	X	High
	Fenbendazole (Safeguard©)	2.3mL/100lbs	X	X	X	X	High
Avermectin							
	Ivermectin (Ivomec©)	1mL/55lbs	X	X	.	.	Very high
	Moxidectin (Cydectin©)	1mL/20lbs	X	X	.	.	Rising
Imidazothiazoles							
	Levamisole (Tramisol©)	1mL/27lbs	X	X	.	.	Low to moderate

The recommended dosage described here are only suggestions. A general guideline for anthelmintics not approved for goats is to use two times the recommended dose for cattle except for levamisole, which should be given at 1.5 times the dose for cattle. A veterinarian should still be consulted to determine proper usage of the products. The recommended dosages for goats are higher than for sheep and cattle because goats metabolize the drugs differently and normally require a higher dose to be effective. After the initial treatment, it is suggested the animal is treated again two weeks later to kill any surviving parasites that were in a premature stage during the initial treatment. The recorded levels of resistance described in the table were taken from various reports worldwide. However, it is important to note that because a drug is reported to have high levels of resistance does not mean that it would not still be effective on a particular farm or in a particular area. Some anthelmintics have specific withdrawal times. Be familiar with them and do not sell animals or send them to slaughter until after the withdrawal time has passed. Be careful to not overdose when using albendazole and levamisole because they do not have a wide margin of safety and can result in toxicity. Also, albendazole should not be used in pregnant or lactating does (Sangster, 1994; Luginbuhl, 1998; Craddock et al., 1994; Mobley & McGowan, 2001; Schoenian, 2003; Hutchens & Chappell, 2004; Hale, 2006).

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