



An Introduction to Sheep and Goat Parasite Management in Hawai'i

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Introduction

Small ruminants (Figure 1) have been a part of Hawai'i's human and physical landscapes for over two hundred years, beginning with the introduction of goats on Ni'ihau by Captain Cook in 1778 and sheep on Hawai'i by Captain Vancouver in 1793 (Henke 1929). Flock numbers gradually fell during the twentieth century, but the last decade has seen a strong resurgence in small ruminant production on both large ranches and homesteads. In addition to commanding a strong market for cabrito and lamb, these animals help producers meet multiple land management objectives: fire fuel reduction, weed management, brush control, and others.

Management of parasites, gastrointestinal worms in particular, is often a primary animal health issue on many Hawai'i farms and ranches. Our tropical environment is an ideal habitat for parasite species, especially in wetter locations. Losses caused by heavy parasite burdens are both direct, in terms of death, poor gains, and reproductive inefficiency, and indirect, stemming from increased susceptibility to secondary infection and greater labor needs. Parasite control should form a central part of every small-ruminant health-management strategy in Hawai'i. This publication aims to provide general guidance and considerations for developing a parasite-control program. There are many excellent resources that are available on the Internet and in print that explore these issues in greater depth, some of which are listed at the end of this publication. The information presented is for general education purposes only, and a veterinarian should be consulted when making health treatment decisions specific to your situation.



Fig. 1. Healthy Big Island bucks sparring.

Symptoms

Animals with heavy internal parasite burdens will often have poor body condition relative to the feed available, rough hair coat, pale mucous membranes (eyes, mouth, vagina, and rectal area), nasal discharge, diarrhea (as evidenced by a soiled tail and area around the anus), or fluid build-up under the jaw called edema (Figure 2). In addition to parasitic worms, goats and sheep may also harbor coccidia, several species of the protozoa *Eimeria* that live in the gut and are passed in feces much like worm parasites. The clinical level of infection, called coccidiosis, is evidenced by diarrhea, often with flecks of blood or mucus; straining; rough hair coat; and loss of body condition. Young lambs and kids are particularly susceptible, while older animals develop immunity.



Fig. 2. Goat showing clinical signs of internal parasite infection: rough hair coat, poor body condition, and edema (fluid build-up under jaw). This goat also could not keep up with the rest of the flock when herded.



Fig. 3. Tapeworm segments are often visible to the naked eye, appearing like rice grains in feces. Simple microscopes are very helpful in identifying and quantifying other internal parasite eggs in feces.

Coccidiosis is a leading killer of small ruminants under 4 months of age (Harwood 2006). External parasites can often be easily detected by close examination of the skin and inside the ears. Ear mites will cause a waxy buildup inside the ear, and lice and mites will cause buildup in the coat. Some internal parasites are visible to the naked eye in feces (Figure 3), and most internal parasites of concern can be detected and quantified directly by a fecal egg count, which can be made in the field with relatively inexpensive equipment.

Prevention

As with all animal health issues, prevention is the starting point for keeping your animals healthy and productive. The chief approaches for keeping parasite loads in check are

- biosecurity
- resistance and resilience
- sanitation
- pasture management.

Biosecurity. Biosecurity, as it relates to parasite management, involves limiting exposure of the flock to heavily infected animals. As much as possible, keep a closed flock and limit new acquisitions to males or artificial insemination. If purchasing off-farm animals,

keep an image of a healthy sheep or goat in your mind as you evaluate potential purchases (Figure 4).

If buying animals, ask the seller about their parasite-management regime, and if necessary ask that animals be dewormed before bringing them onto your property. Otherwise, a good health practice is to keep newly purchased animals in a quarantine pasture or pen separate from your flock, where you can deworm and observe the group before mixing with the home flock.

Resistance and Resilience. Resistance and resilience are expressed on both the flock and individual animal levels. From an economic perspective, the flock level drives management decisions on the individual level. Resistance is the natural capacity of some animals to maintain lower parasite infections compared to a general population. Resilience is the ability of animals to produce and function normally in spite of parasite burdens. Both attributes are heritable genetic traits and should be selected for both in breed selection and breeding within the flock. Hair breeds of sheep (e.g., St. Croix, Dorper, and Katahdin) were developed in the tropics in part for resistance and resilience to parasite infection. Good recordkeeping, systematic parasite monitoring, and aggressive culling are key for consistently developing

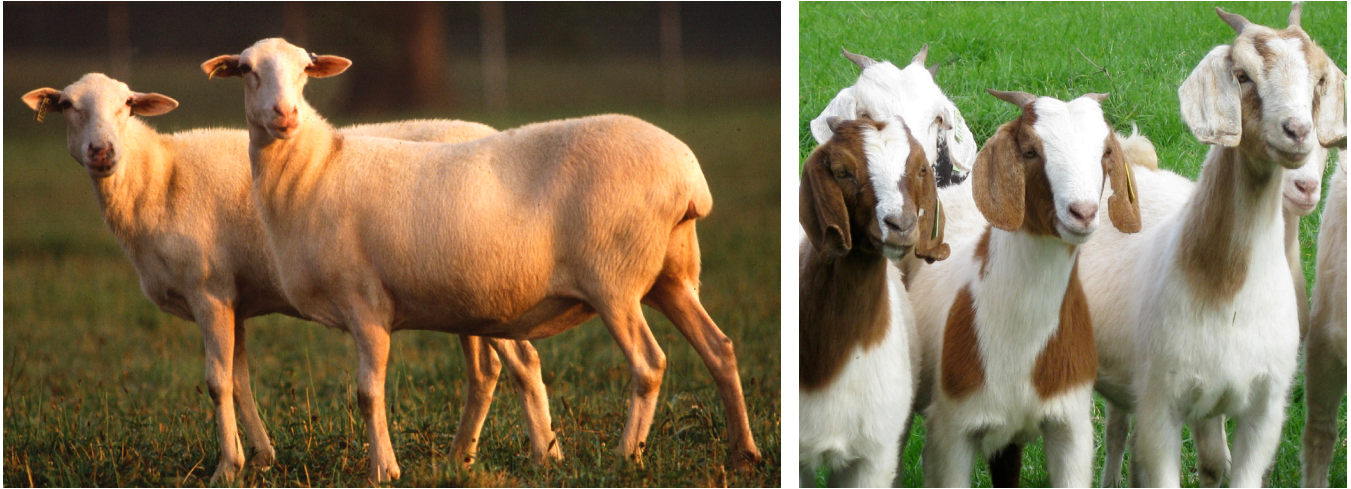


Figure 4. Healthy sheep and goats will be alert, active, tidy, and in good body condition relative to feed available (St. Croix sheep photo: USDA-ARS).

these traits in your flock regardless of breed. Culling individuals that are particularly susceptible to suffering heavy worm loads will reduce the number of worm larvae the rest of your flock will be exposed to.

Sanitation. Sanitation refers to reducing animal exposure to worm larvae and minimizing conditions favorable to external parasites. Take care to limit or move areas where animals will congregate frequently. Rain and shade shelters and birthing pens should be moveable or easily cleaned to prevent worm egg- and coccidia oocyst-containing feces buildup. Keeping tidy bedding in pens, raising feed and water off the ground, and separating age groups can also help reduce young animals' exposure to infectious coccidia oocysts.

Structures, particularly those made of wood, should be inspected for mites and periodically sanitized with an insecticidal dust if mites are a problem. Avoid locating loafing areas, watering sites, and other concentration sites in areas that are frequently wet or boggy, as these can be good conditions for both internal and external parasite breeding. In the tropics, hair sheep breeds are preferred to wool breeds when used in meat production. If wool production is desired, shear as necessary to prevent fly strike and secondary infections, particularly during wet times of the year. If animals are kept in confinement, keep feed and water well off the ground to avoid fecal contamination and frequently clean out feces and unused feed on the floor.

Pasture Management. Good pasture management helps control internal parasites in two ways: animals with good nutrition are more resistant to effects from parasite loads, and animals are less exposed to infectious larvae (see Figure 5 for parasite life cycle). Internal parasite larvae only move up to 12" from feces and can only climb up to about 2" height (Hale 2006). If enough pasture is available, goats and sheep will avoid grazing around droppings. Heavy stocking rates, or many animals in a small area or grazing an area for a long time, increase the probability of exposure to infectious larvae. Grazing close to the ground also increases this probability. Therefore, moving animals out of a pasture when the average grass height is no less than 3" and maintaining stocking densities, or numbers of animals per area, that prevent overly concentrating animals can help reduce exposure to infectious larvae (Wells 1999). Browse, or shrubs, are an excellent feed for goats in particular for these reasons.

For pasture health and optimal animal nutrition, paddocks should be sized to allow for up to a week's worth of forage for the number of goats or sheep they will hold. Do not return animals to a particular paddock for at least 45–90 days, depending on growing conditions and forage species, to allow for adequate recovery from grazing. Portable electric fencing is an excellent low-cost tool for flexibility in paddock design. Periodically shredding a paddock immediately after moving animals out can kill parasite larvae and eggs with the resulting

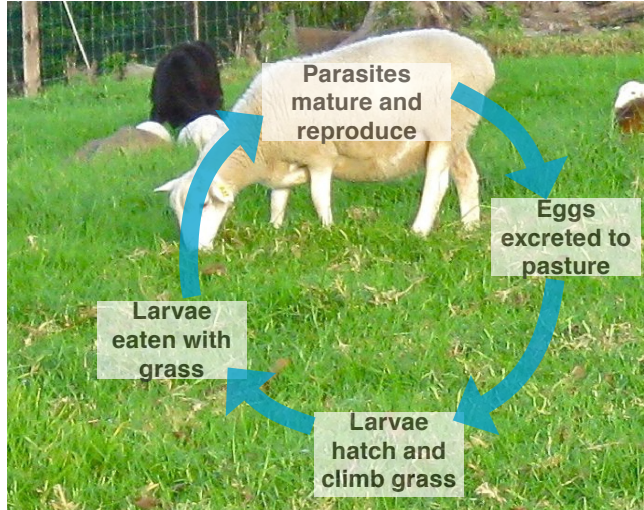


Fig. 5. Generalized depiction of the life cycle of many internal parasites.

heat and UV exposure and also removes old vegetation and weeds, thereby improving pasture quality as well (Schoenian 2008). For a detailed description of grazing management planning and how to estimate forage production for determining stocking rates, see “Foraging Behavior and Grazing Management Planning” (CTAHR PRM-2, www.ctahr.hawaii.edu/oc/freepubs/pdf/PRM-2.pdf) and “Stocking Rate: The Most Important Tool in the Toolbox” (CTAHR PRM-4, www.ctahr.hawaii.edu/oc/freepubs/pdf/PRM-4.pdf).

For goats, improving pastures to make them more suitable to their foraging behavior can be time and resource consuming but ultimately pays off very well over the long run. Modern goat breeds, as well as their wild ancestors, developed in landscapes dominated by brush. One Maui goat producer used portable electric fence to isolate areas newly planted with shrubs and trees. Basing pasture rotations on the use of the shrubs, this producer ensured goats spent more time browsing woody plants than grazing grass in the worm zone. This producer reports the reduced exposure to worm larvae and consequent reduced need for deworming justified the cost and effort of planting the shrubs.

Treatment

Even with strategic breed selection, flock breeding, sanitation, and pasture management, you will need to treat some of your flock at some point. Before discussing

treatment, an important note is that total elimination of all parasites from all animals all the time should not be a management goal. Not only is this goal impractical, expensive, and unnecessary; some level of infection likely helps the development of the immune system of growing and adult animals (Schoenian 2008). Treatment is usually only necessary for a certain portion of your flock during critical points in the breeding year or under certain environmental conditions. A multifaceted control program, often called integrated pest management, is the best approach to lowering your flock’s risk of widespread clinical infection. One Big Island goat producer has developed the above strategies so well that he has only dewormed a fraction of his flock of over a thousand does a few times in two years. But even with prevention steps in place, he reports that kids are still very susceptible to internal parasites and most are dewormed at weaning. At one Maui ranch, a majority of the goats culled are those that require treatment. The ranch reports that it rarely needs to treat for worms.

Dewormers, or anthelmintic drugs, are incredible tools in preventing losses from internal parasites. They should be used as a treatment and not a preventative. Overuse of dewormers quickly builds drug-resistant populations of internal parasites, while losses and costs will increase with continued heavy use (Hale 2006). Parasite resistance to drugs is a concern worldwide, especially in the tropics (Zajac and Gipson 2000). Effective treatment involves the following components:

- accurate diagnosis
- drug selection and rotation
- efficient administration
- monitoring.

Accurate Diagnosis. An important step that will help maintain dewormer efficacy is accurately identifying animals with heavy worm burdens. The obvious signs are those described in the Symptoms section. However, by the time animals show some of these signs it can often be too late for deworming to prevent severe problems, including death. Other health issues unrelated to parasites can also cause similar symptoms. Furthermore, animals may be harboring a heavy worm load without showing obvious outward signs. For small flocks, diagnosis through fecal egg counts is the most direct assessment of degree of infection. Where this is not practical owing to scale, an

indirect assessment method known as FAMACHA was developed in South Africa and is widely used to identify animals needing treatment (Kaplan, Burke et al. 2004; Hale 2006). The method involves comparing eyelid color to a standardized chart to identify anemic individuals, which receive treatment (Figure 6).

This method is promoted for the tropics and is effective against especially damaging blood-feeding worms; however, intestinal tract parasites such as tapeworms may escape detection. The driving principle behind diagnosis is to treat only the animals that need treatment. Blanket deworming on a set schedule is a recipe for quickly creating resistant parasite populations, resulting in ineffective anthelmintic drugs.

Drug Selection and Rotation. Accurately identifying the type of parasite your animals have will help you choose the appropriate dewormer. Anthelmintic drugs are classified in groups, and some groups are more effective against certain worms than others. Regardless of which drug you use, it is important to change periodically (e.g., each year) the type of dewormer applied (Wells 1999). Rotating dewormers again helps to maintain drug efficacy and prevents worm resistance. However, there are only three dewormer classes, and sometimes variety is hard to find on hand when you need it in Hawai'i.

Efficient Administration. Most small-ruminant dewormers are designed to be administered orally using a drenching gun. Determining the appropriate dose is critical in delivering any medicine. Animals are dosed according to body weight; therefore, when a scale is not available, estimating livestock weight as accurately as possible is important for efficient drug administration. Too high a dose is wasteful and can injure the animal, and too low a dose compounds the resistance problem without effectively treating the infection.

Research has established a predictable relationship between an animal's heart girth measurement and its body weight for average animals. Extremely emaciated, obese, or pregnant animals' weights will likely vary from predictions from heart girth measurements. Commercially available measuring tapes are calibrated to display weights, or one can use the following table. To estimate body weight, snugly encircle the animal's girth with a cloth measuring tape or rope just behind the withers on top and behind the elbows at the bottom



Fig. 6. Sheep producers employing the FAMACHA system for identifying animals needing treatment.

(Figure 7). Compare this length in inches to Table 1 to determine body weight. The Southern Consortium for Small Ruminant Parasite Control (SCSRPC) has developed dewormer dosage recommendations for sheep and goats based on body weight. The SCSRPC manual gives an in-depth treatment of effective internal parasite control and is available online at www.scsrpc.org/FlashF/pdf/manual.pdf. See other references listed at the end of this publication for more information.

Monitoring. Monitoring parasite loads should be a critical part of a small-ruminant management plan regardless of treatment approach. Effective monitoring is consistently applied on a time scale that will pick up changes without being too onerous or expensive to conduct. One method is to count worm eggs under a low-power microscope to determine the number of eggs per gram of feces. There are several different methods of estimating eggs per gram, and many require minimal equipment and training. As mentioned above, the FAMACHA system is used as an indirect, low-cost, and relatively fast method to monitor animals for anemia. Several producers use one or some combination of direct and indirect internal parasite-monitoring techniques. Publications listed in the References section give full details on methods for monitoring parasites in your flock.

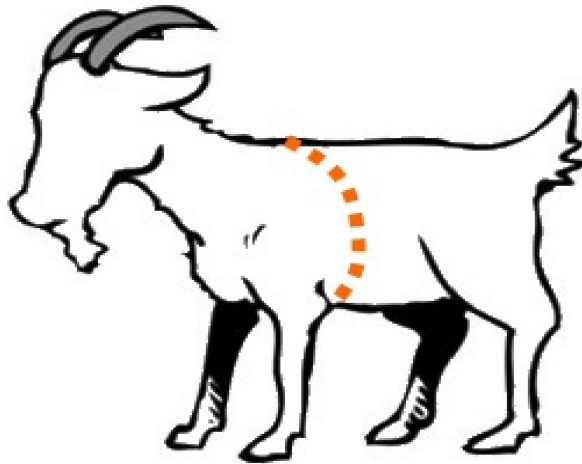


Fig. 7. The heart girth measurement should be taken snug around the chest at the orange dotted line and the length compared to the table below to determine approximate weight for average animals.

Regardless of what method you select, consistently apply that method and keep written or computerized records so you can recognize trends and guide your management.

A retired Maui goat producer noted that customer feedback is also an important monitoring tool. Many goat consumers use the entire animal, including the intestinal tract. While wholesaling through a dealer, the producer learned that his goats were highly sought after because of their lack of worms. He made it a point to follow up with customers to make sure his parasite-control program was continuing to meet their needs.

Alternative Treatment Approaches

There is no catchall system of parasite management that will work for everyone, all the time, in all places. An active area of research in Hawai'i and abroad is the development of new treatments and management systems to give small-ruminant producers more options. Driving this research is the readily apparent wide-scale increase of parasite resistance to pharmaceutical dewormers (Zajac and Gipson 2000; Howell, Burke et al. 2008). A multifaceted approach to integrated parasite management can greatly help to maintain dewormer efficacy on your ranch. Note that the following approaches are currently under development. They are mentioned here for information purposes and not necessarily as

Table 1. Estimating body weight can be done by taking the heart girth measurement and comparing to this chart. Chart adapted from Faerber et al. (2004).

Heart girth (inches)	Body weight (pounds)	Heart girth (inches)	Body weight (pounds)
10¾	5	24	50
14¼	10	25	56
14¾	11	26	62
15¼	12	27	68
16	14	28	73
17	16	29	80
18	22	30	85
19	26	31	90
20	30	32	100
21	34	33	105
22	38	34	115
23	43	35	125

an endorsement. The degree of their efficacy over the long term, their cost- effectiveness and unintended consequences, and the ways these methods could be practically applied on larger scales are still topics for further research.

Anthelmintic Forages. Several naturally occurring and cultivated plants are being evaluated for anthelmintic, or anti-parasitic, qualities. Plants containing high levels of condensed tannins have shown considerable promise for maintaining low internal parasite loads. Lab and field studies show that condensed tannins directly impact the animal parasite load as well as retarding larval development in the pasture (Min and Hart 2003; Min, Hart et al. 2005). The most studied forages are sericea (*Lespedeza cuneata*), birdsfoot trefoil (*Lotus corniculatus*), big trefoil (*Lotus uliginosus*), sainfoin (*Onobrychis viciifolia*), and sulla (*Hedysarum coronarium*). Condensed tannins are widely distributed in the plant kingdom, and many plants already naturalized in Hawai'i may have potential as anthelmintic forages. Black wattle (*Acacia mearnsii*) was introduced



Fig. 8. Big Island goats browsing Christmas berry (left). The after-effects (right) show substantial debarking and leaf removal as high as the animals can reach.

Table 2. Strongyle-type worm eggs per gram of feces as determined by a modified McMaster egg-count method from three goats in the Wailua Homestead area of Kaua'i receiving periodic cassava and ti leaf supplements. Goats were treated using commercial dewormer in May 2011 and December 2011. Dewormer treatment is often recommended when the number of eggs per gram exceeds 1,000–3,000.

Date	Goat 1	Goat 2	Goat 3
7/11/11	150	50	0
8/12/11	650	150	0
11/15/11	1700	0	150
5/24/12	800	150	0
7/6/12	600	100	100
9/20/12	550	50	100

to Hawai'i specifically for its tannin content, and a Big Island rancher reports low parasite loads when goats graze the pastures that have it. Several studies have used commercially available condensed tannins extracted from the quebracho tree (*Schinopsis* sp.) with success against parasite burdens (Lisonbee, Villalba et al. 2009; Villalba, Provenza et al. 2010). Leaves from cultivated cassava (*Manihot esculenta*) have also received attention for their efficacy against parasites owing to condensed tannins

(Sokerya, Waller et al. 2009). One Guam goat producer has used cassava leaves exclusively for internal parasite control for at least three years. On Kaua'i, a Wailua Homestead goat producer has periodically supplemented fresh cassava leaves and ti (*Cordyline fruticosa*) since March 2011. The producer used commercial dewormer once in May 2011 and once in December 2011 on three goats each time. Standard deworming in the area usually occurs once a month. Using a modified McMaster fecal egg count method, the producer found worm burdens as displayed in Table 2. The data suggest that even in a handful of goats on the same pasture, variation in worm susceptibility can be apparent.

Aside from condensed tannins, other plant compounds such as terpenes and alkaloids have shown anthelmintic effects. Researchers have focused on chicory (*Cichorium intybus*), wormwood (*Artemisia absinthium*), and tobacco (*Nicotiana* sp.) as having potential against parasites with these compounds. In Hawai'i, a Big Island ranch reports that terpene-containing Christmas berry (*Schinus terebinthifolius*) and alkaloid-containing indigo (*Indigofera suffruticosa*) may have anthelmintic effects in goats. After grazing a Guinea grass (*Panicum maximum*) pasture for some weeks without Christmas berry, the flock of several hundred goats had noticeably heavy worm loads. When turned back into pastures with Christmas berry, the goats intensively browsed it for weeks almost exclusively (as in Figure 8). As their

condition improved, gradually their foraging included greater quantities of other species.

There are likely more reports of this nature for other plant species found in Hawai'i. Further research is needed locally to determine which plants, if any, may be effective against parasites and how they can best be incorporated into a system for efficient control. Even if forages alone do not replace pharmaceuticals as a treatment, plants that help reduce how often small ruminants need deworming would be a great improvement in control.

Copper Wire Particles. Researchers have found copper oxide wire particles, originally developed to treat copper deficiency in cattle, can have anthelmintic effects in sheep and goats (Hale, Burke et al. 2007). The particles can be administered as boluses with a balling gun. While this form of copper absorbs slowly, sheep are particularly susceptible to copper toxicity, and care should be taken if using this method with sheep. See Hale, Burke et al. (2007) for details on this area of research.

Nematode-Trapping Fungus. Researchers have evaluated fungus spores fed to goats and sheep for reducing parasitic worms (Terrill, Larsen et al. 2004; Silva, Araujo et al. 2009). The fungus appears to arrest the development of the worm at the larval stage, thereby interrupting the life cycle. This is an active area of research with some potential.

Conclusion

Effective parasite control is crucial for efficient small ruminant production and welfare in Hawai'i. Deworming the entire flock on a set schedule using a handful of pharmaceuticals is not sufficient control over the long term. An integrated pest management approach which focuses on techniques that reduce animal exposure to parasites, improve livestock resistance and resilience, and effectively administer treatment will better protect your animals. Monitoring parasite loads through the production cycle will help you determine when your animals need treatment. Research is revealing many alternative approaches with great potential.

A wealth of information is available on this subject in the library, online, and across the fence. Talk with sheep and goat producers with experience in Hawai'i or the tropics to get an idea of what approach is best for

your conditions. Also, contact the University of Hawai'i Cooperative Extension Service for advice and assistance in parasite management planning or other livestock topics. A directory of County Extension Agents and Extension Specialists is available online at www.ctahr.hawaii.edu.

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Helpful Websites

Hawaii Sheep and Goat Association: sites.google.com/site/hawaiisheepandgoatassociation/

Langston University E. Kika de la Garza American Institute for Goat Research Extension: www.luresext.edu/goats/index.htm

Maryland Small Ruminant Page, maintained by Susan Schoenian, University of Maryland Cooperative Extension Service: www.sheepandgoat.com

National Center for Appropriate Technology (NCAT), Appropriate Technology Transfer for Rural Areas (ATTRA) publications: attra.ncat.org/attra-pub/livestock/livestock.html#sheep_goat

Southern Consortium for Small Ruminant Parasite Control (SCSRPC): www.scsrpc.org