Biology of Parasites

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Sheep and goats in the U.S. and around the world are infected with a wide range of internal and external parasites. In many regions of the world, the most important parasites are gastrointestinal nematode worms. The most important of these worms all belong to the same taxonomic group and are often referred to collectively as "trichostrongyles". All grazing sheep and goats are infected with a community of trichostrongyle parasites that can contribute to disease and production loss. With the recent development of high levels of parasite resistance to commercial dewormers, successful control of these parasites now requires integrated management programs that incorporate basic knowledge of the biology of trichostrongyle parasites.

Although all grazing sheep and goats are infected with some level of trichostrongyles, low worm numbers will usually have little impact on animal health. As worm numbers increase, however, reduced weight gain and decreased appetite may occur. The most severely affected animals will show signs that can include weight loss, diarrhea, anemia and bottle jaw (hypoproteinemia). Camelids (llamas and alpacas) can also be infected with these parasites and suffer the same signs of disease when parasite numbers are high. Adult cattle and horses, however, do not become infected with most sheep and goat trichostrongyles and usually kill any ingested infective larvae.

While all the trichostrongyle parasites can contribute to disease in sheep and goats, there is one worm that dominates in importance in the eastern and midwestern U.S. and in many other countries. This parasite is *Haemonchus contortus,* known as the barber (or barber's) pole worm or wireworm. The remainder of this presentation focuses on the biology of *H. contortus,* but the details of the life cycle of other trichostrongyle parasites (*Teladorsagia*, *Trichostrongylus*, etc) are very similar.

Haemonchus contortus adults are found in the abomasum, or true stomach, of small ruminants. In camelids, the parasites are found in C3, the camelid equivalent of the abomasum. Female worms reach about 1 inch (3 cm) in length, making this species one of the largest of the trichostrongyles (Figure 1). Unlike other trichostrongyles that feed on intestinal tissue or fluids, barber pole worm feeds directly on host blood. The parasite has a small "tooth" that is used to lacerate the stomach and cause surface bleeding, with the worm ingesting released blood. When large numbers of parasites are present significant loss of red blood cells and blood proteins occurs resulting in anemia and bottle jaw, which may be fatal if untreated. Severe infections are most likely to occur in young sheep and goats before immunity has developed.

Once barber pole worm or other trichostrongyle larvae infect a sheep or goat host they complete their development to the adult stage; this process usually takes two to three weeks. Once male and female worms are mature they mate and females begin to produce eggs. Barber pole worms are remarkably prolific and each female worm can

Figure 1. Heavy infection with *Haemonchus contortus* in the abomasum of a sheep. Individual worms reach a maximum size of about 1 inch.

produce up to 10,000 eggs/day. It is not unusual for sheep or goats to be infected with hundreds or thousands of parasites that could daily produce millions of eggs. Individual adult worms have a limited life span and usually survive for only a few months.

Eggs of *H. contortus* and other trichostrongyles are shed in the manure of infected sheep and goats (Figure 2). Development of eggs occurs in the manure, which provides some protection from environmental conditions. The cells inside the egg form a larva (first stage or L1) that hatches out of the egg. After hatching, larvae feed on bacteria and go through two molts to reach the infective third larval stage (L3). These third-stage larvae make their way out of the fecal material and onto the forage where they are ingested by sheep and goats (Figure 3).

Environmental conditions determine the rate of development of trichostrongyle larvae, their survival in the environment and ultimately impact the level of infection in sheep and goats. Different trichostrongyle parasites have different environmental preferences, which also determines their relative importance in different regions of the U.S. and the world. In general, development of trichostrongyle eggs and larvae occurs in a temperature range of approximately 50°F -96°F. One of the main reasons that *Haemonchus contortus* is so important in small ruminants in the U.S, is that the climate in much of the country has a period of warm, moist conditions that are highly favorable for development and survival of infective larvae. The southeastern U.S., in particular, with its hot, humid summers and long grazing season, is very well suited to *H. contortus.* Optimum conditions for transmission of *H. contortus* were found from mid-March to mid-October in Columbus, Georgia. *Haemonchus contortus* eggs and larvae do not tolerate cold and freezing temperatures well. However, members of ASRPC have found that even in New England, *H. contortus* is the predominant parasite egg in fecal samples in the summer grazing season. Although in western states cold winters and dry summers make *H. contortus* less important, irrigation can make conditions suitable for transmission. The minimum length of time required for the development of *H. contortus* L3 in hot summer weather is about 3-4 days. However, in cool spring or fall weather it may take several months for L3 to develop.

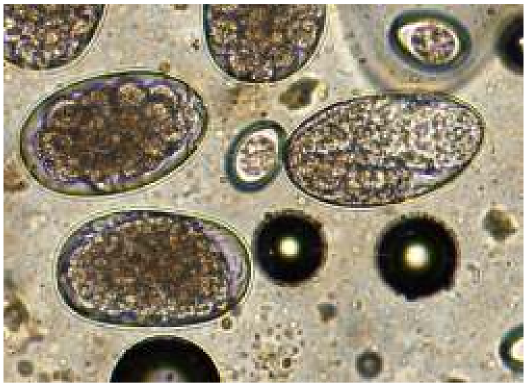

Figure 2. Three trichostrongyle eggs are shown in this photo. The egg on the right is developing and the basic shape of the larva has begun to form. *Haemonchus contortus* and most other trichostrongyles produce eggs similar in appearance that cannot be easily and consistently differentiated. The two smaller oval structures in the photo are coccidia oocysts.

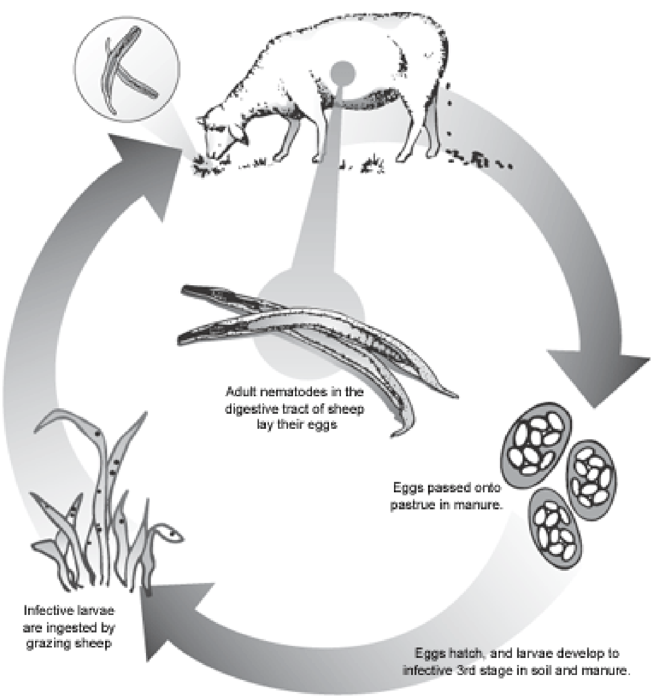

Figure 3. Life cycle of trichostrongyle parasites. Figure from Whittier et al. 2009. Control of Internal Parasites of Sheep. Virginia Cooperative Extension, Virginia Tech.

Once L3 larvae have formed and moved out of the fecal pellets, their ability to migrate on forage is affected by air temperature, soil moisture, and relative humidity. Larvae usually remain within inches of the fecal pellets and also do not migrate more than a few inches vertically on grass blades.

The length of time that L3 larvae can survive on pasture is also dependent on environmental conditions. Infective larvae are unable to feed and survive on existing metabolic reserves. Once those are exhausted, the larvae die. The hotter the weather, the faster they use their reserves and die. In the temperate portions of the U.S., a pasture may need to be rested for 6 months during cool weather to remove most parasite larvae. In hot weather, most larvae may be cleared from pasture in 3 months.

A final element of parasite biology that plays a major role in the successful transmission and survival of trichostrongyles is arrested development (hypobiosis). Following infection of a sheep or goat, a larva may go into a state of "arrest" where it does not continue development and is metabolically inactive for a period that may last several months. Following this period of arrest, the parasite larva resumes development and becomes an adult. Usually, the greatest proportion of arrested larvae is found in animals during times of the year when eggs and larvae do not survive well in the environment and thus allows worms to delay adulthood and egg production to a more favorable time of year for their offspring. In areas with cold winters, *Haemonchus* survives the winter months primarily as arrested larvae in animals. In lambs examined in Ohio, Maine, and Virginia more than 80% of *Haemonchus* were present as arrested larvae in winter. Where winters are very mild, hypobiosis appears to be less important in the epidemiology of parasite transmission. In Louisiana, levels of hypobiotic larvae were never substantial, although the highest proportion of hypobiotic larvae tended to be in the fall.

In areas where winter arrest of parasite larvae occurs, emergence and development of adult worms in late winter and spring are followed by an increase in fecal eggs counts. The rise in egg counts is magnified in lambing ewes by a relaxation of immunity around lambing called the Periparturient Egg Rise (PPR). The PPR is well documented in sheep, but may not be as important epidemiologically in goats.

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