ENVIRONMENT

Development and Persistence of Parasites

PARASITE PRIMER—PART 7

BY KAREN BRIGGS, WITH
CRAIG REINEMEYER, DVM, PHD;
DENNIS FRENCH, DVM, MS, DIPL. ABVP;
AND RAY KAPLAN, DVM, PHD

Back in January, in our first installment of this series, we described what makes a parasite different from other kinds of infectious organisms. One of those factors is that the offspring of adult parasites must return to the environment outside the horse in order to become capable of infecting a second animal, or re-infecting the original host.

So while discussing the environment might seem esoteric when we're talking about equine parasites, it's really one of the most critical elements to consider if you're going to construct an effective anti-parasite strategy. Equine parasites must undergo some change away from the horse—so the environment presents unique opportunities for disrupting transmission. That's a tremendous advantage compared with diseases that are directly contagious from one horse to the next.

The key to exploiting environmental events is understanding when and how Mother Nature works—for us or against us—in our perpetual battle against worms.

PAULA DA SILVA

The key to exploiting environmental events is understanding when and how Mother Nature works–for us or against us–in our perpetual battle against worms.

Environmental Factors

So what qualifies as "environment" for your horses? In the case of most domestic horses, the answer would be stalls, pastures, and paddocks. These are the battlefields on which we wage war against our major parasitic enemies—strongyles (bloodworms), ascarids (roundworms), and tapeworms.

Environment in a broader sense includes literally anything outside of the equine host. So, for certain equine parasites such as stomach worms and *Onchocerca* (which we discussed in the May issue), the flies that transmit them also must be considered a part of the environment.

Let's briefly review the changes undergone by each of the three major parasites during their sojourn in the environment.

Strongyles, ascarids, and tapeworms all produce an egg stage that passes from the horse in manure. Ascarids (as we discussed in the March 2004 issue) lay eggs that can develop to the infective stage in two to four weeks. The potential new roundworm is protected within the egg, and it can remain infective for perhaps as long as a decade. Strongyle eggs (see the April 2004 issue) hatch over a wide range of temperatures, and the rate of development varies with thermal conditions. The first-stage larva that emerges from the egg feeds in the environment, and it eventually molts to a second- (L2) and a third-stage (L3) larva. Only the third stage is potentially infective to another horse.

Tapeworm eggs (February 2004 issue) must be eaten by free-living mites found on pasture. They then develop into the infective stage (cysticercoid) inside the mite. All three parasites are transmitted into your horse when he inadvertently ingests the infective stage while grazing in the pasture.

Microenvironmental Variables

Temperature, moisture, and the availability of oxygen all have the potential to affect parasite development in the environment. Let's take a detailed look at each one.

Temperature—Ascarid and strongyle eggs are capable of developing or hatching over a wide range of environmental temperatures. As a general rule, the rate of development increases in direct proportion to the environmental temperature. Thus, strongyle eggs can hatch at 45°F, but it could take several weeks for them to reach the infective (L3) stage. At 80°F, however, strongyle larvae can become fully infective within five days of eggs leaving the horse.

There are two dynamic processes going on here. The first is development, which is the formation of new infective stages from a reproductive product (egg). The environmental conditions that favor parasitic development are virtually identical to those required for germination of a plant seed. Both respond to the same conditions—they will germinate (hatch) and grow above some critical temperature, but the rate of growth is accelerated in warmer conditions.

Development is only half of the picture for parasite transmission. The other factor is persistence, or how long infective stages survive in the environment. Persistence has a greater impact on the cumulative numbers of parasites acquired, and thus on the likelihood of associated disease (see "The Power of Persistence" above).

The environmental conditions that influence persistence are nearly the opposite of those required for development. Let's return to our gardening analogy. After the successful germination and growth of a tomato plant, the gardener can harvest and enjoy the ripe, red fruits. But what conditions would allow her to preserve that tomato for the longest period of time—or in terms of parasites, what conditions would allow them to persist for the longest time in the environment? If the tomato were stored in a refrigerator, it would remain fresh longer than if it were placed out in the sun.

This analogy applies directly to the infective stages of many common parasites because they persist far longer at cold temperatures than in warm ones. This difference shouldn't be a huge surprise to us because equine parasites probably evolved along with their warm-blooded hosts in temperate, rather than tropical, climates. Accordingly, the environmental stages of most equine parasites are more at home on the steppes of Siberia than in the steamy jungles of India or on the sands of Saudi Arabia.

Let's examine this phenomenon by using strongyles as our model. After a strongyle egg hatches, the first- (L1) and second-stage (L2) larvae feed actively in the environment, ingesting organic material and bacteria from the manure. The third-stage

HOW MANY WORMS ARE OUT THERE?

The Power of Persistence

What's the difference between development and persistence in terms of disease risk? Development essentially describes the numbers of new larvae that appear in the environment, whereas persistence determines how long they stick around.

For example, if 10,000 new larvae appeared on a pasture each day, but they only lived for 24 hours, the maximum daily risk would be 10,000 larvae. The previous conditions could be described as favoring development, but not persistence. Alternatively, if only 1,000 new larvae arrived each day, but they were able to survive for months, it would only take about two weeks before the maximum daily risk would exceed the previous example. Thus, conditions that favor persistence are more important for determining the likelihood of parasitic disease.

In continental North America, conditions during autumn and spring favor both development and persistence. Southern horses face a much greater risk of strongyle infection during winter than in summer. Northern horses at pasture are challenged almost perennially, and stabling them during the winter months might be the only practical respite from strongyle exposure.

Regardless of climatic influences, the most effective strategy is to maintain low fecal egg counts in horses. Eggs turn into larvae, and larvae turn into parasites. Once the cycle has entered the environment, we have few control options other than confining our horses. Therefore, the most logical approach is to minimize contamination with eggs in the first place. Upcoming articles will describe the implementation of this strategy in greater detail.

—Karen Briggs with Craig Reinemeyer, DVM, PhD; Dennis French, DVM, MS, Dipl. ABVP; and Ray Kaplan, DVM, PhD

larvae (L3), however, which are infective, are covered by a membrane that protects them from desiccation (drying out). This flexible coat of armor contains one major design flaw. It has no mouth opening, so an L3 can no longer feed. It must survive by using stored energy reserves. You'll never see a nematode with love handles, because they have no organs of energy storage. Their sole energy reserves are stored within tiny intestinal cells, and those are very limited in quantity. The rate of consumption of those finite energy reserves is directly proportional to environmental temperature, meaning that their energy is used up more rapidly in hot weather. Just as in high school chemistry lab, firing up a Bunsen burner and applying heat often sped up a reaction. So, too, worms burn energy faster at higher temperatures—and they die when their energy reserves are depleted.

At colder temperatures, energy consumption by third stage strongyle larvae is nil. That is why they survive for months in a refrigerator, and they can persist happily all through winter in most North American climates. Remember that these larvae are cold-blooded invertebrates. They aren't killed by freezing, they don't shiver when they get cold, and they don't need any mechanisms to burn energy in order to stay warm. They just take the weather as it comes and expend their energy in response to thermal conditions.

In comparison, ascarids and tapeworms are less susceptible to environmental conditions. Ascarid eggs still need warmth to develop to an infective stage, but a viable egg can survive for up to a decade. Tapeworm eggs might be killed by freezing, but it is certain that their mite vectors only feed actively during the warmer months of the year. This means mites can only ingest eggs (and acquire new infections) during spring, summer, and autumn in most parts of North America. We don't know how long mites can survive once infected, but it is reasonable to assume that they make it through winter conditions just fine.

Moisture—Because larval stages are more dependent on moisture than worm eggs, we'll use strongyles again to explore this environmental variable. Sufficient moisture is usually present in equine manure to support the hatching of strongyle eggs and promote development to the L3 stage if temperatures are warm enough. But when development is slowed, additional moisture might be required to complete development.

Because all grazing animals demonstrate some degree of fecal avoidance behavior (see "Lawns and Roughs" on page 5), larvae have a better chance of becoming successful parasites if they migrate away from manure and onto forage where they will be consumed. Larvae can be disseminated by mechanical disruption of fecal piles, but the most common method is through heavy rainfall (anything in excess of a half-inch). Parasite transmission is hindered by drought, but helped along by frequent precipitation.

After they leave the fecal pile, most strongyle larvae set up shop in the thatch layer on pasture. This is the dense mat of vegetative detritus (debris) at the root level of pasture grasses, directly on top of the soil. The relative humidity within the thatch layer is considerably higher than in other areas of the vegetation, especially during dry weather.

Because of the critical requirement for a moist microenvironment, strongyle transmission occurs almost exclusively on pastures. Infection from stalls or dry-lot paddocks is negligible—clean horse stalls are simply too dry to allow strongyle larvae to develop or persist, and even in a filthy, damp stall, strongyles are unlikely to develop because the ammonia that comes with urine accumulation is extremely toxic to strongyle larvae. Clean and dry or wet and stinky, horses rarely acquire new strongyle infections in confined conditions.

Oxygen—Because parasite offspring only become infective in an aerobic environment, they all require oxygen for development and growth. However, sufficient oxygen is uniformly available in all but a few extreme circumstances. The relatively loose structure of equine manure ensures that air can penetrate to all areas of the fecal pellet, especially as it dries out.

The Bigger Picture

Your horse's relative risk of exposure to parasitic infection varies in different management situations. A few parasites, such as ascarids and pinworms, can be transmitted in stalls, but pastures are the main battleground for strongyle control. And because pastures are affected greatly by climatic variation, horse owners in Manitoba, Canada, face a different set of challenges than those in Florida.

Across North America, spring and autumn present nearly optimal conditions

ANNE EBERHARDT

Any third-stage strongyle larvae present on pasture in autumn will probably survive just fine through the whole winter, even under six inches of ice and snow.

SHAWN HAMILTON

Spreading fresh manure on pastures is a common management practice that can have a ruinous impact on your pastures. Equine manure should be composted prior to spreading.

for generating wormy pastures. Average daily temperatures facilitate the hatching of eggs and development of larvae without shortening the life span of infective stages.

In northern temperate climates (roughly above the latitude of the Ohio River), summer conditions are favorable for both development and persistence of strongyles, but the cold northern winters do not support hatching of eggs or development of larvae from November through March. Despite that, any third-stage larvae present on pasture in autumn will probably survive just fine through the whole winter, even under six inches of ice and snow. In fact, rested pastures can be an important source of strongyle infection for northern horses when they are first turned out in the spring. The larvae that successfully over-wintered eventually die off, but not until early summer when rising daily temperatures (with the energy expenditure they trigger) do them in.

In southern temperate regions, strongyle eggs hatch very rapidly during summer, but the high daily temperatures are unfavorable for larval survival. The infectivity (numbers of available infective larvae) of southern pastures is at its lowest level of the annual cycle during summer. Southern winters, on the other hand, are cool enough to promote larval persistence, but strongyle eggs can also hatch and develop slowly into new larvae whenever daily temperatures rise above 45°F.

A few years ago in Tennessee, a study monitored the numbers of available larvae on pastures occupied by horses (at approximately one horse per acre) enrolled in various parasite control programs. On the pasture grazed by untreated horses, larval numbers during summer never exceeded 2,000 per kilogram of forage. However, worm numbers increased during autumn, and more than 60,000 larvae per kilogram of forage were recovered during December.

Some aspects of pasture usage are determined by the horses themselves. Left to their own devices, grazing horses segregate pastures into two distinct areas, which have been described as roughs and lawns. Roughs are areas of taller forage, where horses preferentially defecate, but do not graze. The lawns are areas of shorter forage that have been grazed down by feeding horses and are characterized by a relative paucity of manure. In the 1980s, Dr. Rupert Herd of The Ohio State University demonstrated that the levels of strongyle infectivity (numbers of available larvae) were about 15 times higher in roughs than in lawns. So, by not grazing in the roughs, horses naturally practice a behavior that significantly reduces their exposure to parasite infection!

However, we humans are irresistibly compelled to tame our environment,

ANNE EBERHARDT

With a greater density of horses on your pastures, more parasites will be shed that can further infest them. Also, more horses eat more grass, forcing horses to graze closer to parasite-rich defecation areas.

HOW HORSES MANAGE THEIR PASTURES

Lawns and Roughs

All grazing animals practice some degree of fecal avoidance behavior. (Ever seen a new father holding a dirty diaper at arm's length? This response is apparently exhibited by some non-grazers as well.) If you look at an occupied cattle pasture, for instance, you'll see numerous tufts of tall grass distributed at irregular intervals over the entire field. Closer inspection reveals a fecal pat at the base of each of these tufts. The grass in these clumps is not tall because it's being fertilized by the manure, it's high because it's not being grazed. Cattle avoid the manure as well as the grass growing around and through it. Horses do something similar, but they don't defecate as indiscriminately as cattle. Equids deposit their manure in distinct areas known as roughs, and subsequently avoid grazing in those contaminated patches. The closer-clipped areas they do graze are termed lawns.

The behavioral basis of fecal avoidance in horses is unknown, a fascinating phenomenon that awaits further scientific investigation. Why do horses avoid fecally challenged roughs? Is it due to olfactory (smell) cues, visual stimuli, or other, unknown factors? And if one could determine the behavioral basis of fecal avoidance, is it possible that this behavior might be exploited? Could horses be trained to defecate in certain areas of a pasture, perhaps where the forage wasn't so desirable?

In the future, perhaps the equine proclivity for forming roughs and lawns could be manipulated to improve pasture utilization.

—Karen Briggs with Craig Reinemeyer, DVM, PhD; Dennis French, DVM, MS, Dipl. ABVP; and Ray Kaplan, DVM, PhD

ANNE EBERHARDT

Owners should never drag pastures that are currently occupied. For optimal parasite control, pastures should be left vacant for a minimum of two weeks in the south, or four weeks in the north, after dragging in summer months.

including horse pastures, so we use a bush hog to cut down the taller forage. Clipping pastures probably doesn't affect parasite exposure very much, because the horses still know where the manure is concentrated and graze elsewhere. But dragging or harrowing pastures totally disrupts Mother Nature's system for segregating infected from clean areas. Dragging disseminates fecal material, along with its larval passengers, from an isolated area of concentration and spreads it uniformly across the entire pasture. It contaminates the previously pristine lawns with larvae, and exposes horses to more parasites than if the pastures had been allowed to look ragged.

(As a general rule, owners should never drag pastures that are currently occupied. For optimal parasite control, pastures should be left vacant for a minimum of two weeks in the south, or four weeks in the north, after dragging during the summer months. Pastures dragged after Oct. 1 will remain infective until the following July in nearly all regions of the United States.)

Spreading fresh manure on pastures is a common management practice that can have the same ruinous impact as dragging if the manure contains strongyle eggs. Equine manure should be composted prior to spreading. (Look for more specifics on the impact of dragging, spreading manure, and other pasture management techniques in the final two installments of this year-long series.)

The number of horses on your pasture also has a significant impact on the risk of exposure to parasites. Fecal avoidance is a dominant behavior, but it can be overwhelmed by hunger.

Horses on overcrowded pastures extend their grazing farther into the roughs and thereby presumably increase their risk of parasitism. They also increase their exposure by grazing available forages to ever shorter lengths (remember that the infective larvae tend to be concentrated in the thatch layer at the base of the grass). Part of the reason for high larval numbers on pastures (measured on the basis of a unit weight of forage) during winter months is that grass is often grazed down to the root during winter. In contrast, the lush growth of spring and summer tends to dilute horses' exposure to infective larvae.

In any season, grazing horses should be managed so that forage height remains at a reasonable level, and supplemental hay should be supplied whenever necessary to minimize over-grazing.

Future Directions

If the environment is so critical in the transmission of equine parasites, why don't scientists just develop some silver bullets that can kill or remove the infective stages from pastures?

It would be wonderful if it were that simple.

Even though parasites with infective egg stages (ascarids and pinworms) can be transmitted in confinement, disinfectants aren't very effective against them. And as we've discussed, strongyles are transmitted almost exclusively on pastures. However, strongyle larvae are far from alone out there. They dwell among a veritable jungle of living organisms, including soil nematodes, free-living mites, beneficial insects, and the pasture grasses themselves. Scientists have not yet discovered any exclusive chemicals or worm-specific viruses that could kill strongyle larvae without disrupting the entire ecosystem. You don't want to kill off the good "bugs" along with the bad ones. So for now, adopt some of the management controls discussed here.

A future installment of this series on parasites will discuss the recent developments that hold some promise for environmental control. But for the time being, the most common approach is the appropriate use of dewormers (which will be discussed next month) to prevent horses from contaminating their environments with worm eggs.