Introduction
Parasites live in a host from which they obtain food and protection. They may harm but usually do not benefit the host. The word “parasite” is derived from the Latin and Greek languages meaning, in general, “one who eats at the table of another.” It is said that a “good” parasite does not overtly harm or kill its host. It is theoretically possible that a more benign parasite (e.g. *Gasterophilus* spp.) is much “older in eons of time” and it and its host have adjusted better to each other than a conceivably “newer” parasite (e.g. *Strongylus* spp.) which may be more harmful to its host.

Taxonomy
Horses can harbor over 100 species of internal parasites. About one half of these species are nematodes in the strongyle group (family Strongylidae Baird, 1853). They are separated taxonomically into two categories—large strongyles (subfamily Strongylinae Railliet, 1893) and small strongyles (cyathostomes) (subfamily Cyathostominae Nicoll, 1927). Historically, large strongyles included only those strongyles in the genus *Strongylus* Müller, 1780. In this discourse, the latter designation will be used for large strongyles i.e. it includes only *Strongylus* spp. More recently in revision of the taxonomy of the strongyles, based on morphology, large strongyles include, besides, *Strongylus* spp., the genera *Bidentostomum* Tshoijo in Popova, 1958, *Craterostomum* Boulenger, 1920, *Oesophagodontus* Railliet et Henry, 1902, and *Triodontophorus* Looss, 1902. The latter four genera are much less important because, unlike *Strongylus* spp., they do not migrate outside the intestinal tract.

Life Cycle
**Outside the Horse**
Strongyles live as adults in the large intestine (cecum, ventral colon, and dorsal colon) of the horse and lay eggs that are voided in the feces (Figures 1 and 2). In the environment, an egg embryonates to the first stage larva (L₁) which hatches and then develops to the second stage larva (L₂), and finally to the third stage larva (L₃) which is the infective stage (Figure 3). The L₁ and L₂ feed on organic matter, but the L₃ does not feed but subsists on internal nutrients. The L₃ is the infective stage which typically crawls up on pasture vegetation, especially under moist conditions which make movement easier than dry situations, and is then accidentally ingested by the grazing horse (Figure 4). Inside the horse the L₃ develops to the fourth (L₄) and then fifth (L₅) (adult) stage.

**Figure 1.** Strongyle life cycle.
Inside the Horse

Within the genus *Strongylus* are four species—*S. asini, S. edentatus, S. equinus, and S. vulgaris.* These species are the most pathogenic of the strongyles because they can cause colic and even death of horses. *Strongylus vulgaris* is the most damaging of the four species. Detrimental effects of these parasites usually are most evident during migration of immature stages in organs outside the gastrointestinal tract.

*Strongylus vulgaris* will be highlighted because it is the most pathogenic parasitic nematode species in horses. When L3 are ingested they penetrate the intestinal mucosa, mainly of the posterior part of the small intestine, cecum, and ventral colon, and enter arterioles in the walls of these organs. About two weeks later they begin arriving and accumulating primarily in the cranial mesenteric artery (CMA) (Figures 5 and 6). There they undergo development to the L4 and L5. Their presence stimulates the immune system
to “repel” these invaders. Upon initial infection, this action is a negative feature because the host reaction produces cellular debris which may result in thrombi and emboli that can block blood flow. Thus resulting in chronic or acute colic and possible death of the horse because of lessened or lack of blood supply to the intestine. In addition, there is a condition called a “verminous aneurysm” which is enlargement and thickening of the CMA and adjoining arteries. Acquired immunity to *S. vulgaris* is typical in varying degrees. The preponderance of literature states that the L₄ and L₅ come back to the large intestine via arteries. Some researchers wonder how such large larvae can get back through the small arterioles. They hypothesize that maybe the L₅ that actually come back to the intestine are ones that do not migrate to the CMA. Possibly, L₃ penetrate through the large intestinal wall and undergo development to L₄ and L₅ there on the serosa surface before returning. In any event, L₅ coming back (assuming they left) can be found encysted in the mucosa of the cecum, ventral colon and dorsal colon. After L₅ excyst they locate primarily in the cecum, but also in the ventral colon, which are the usual locations for mature adults that attach to and feed on the mucosa of these organs (Figures 7, 8, and 9). The prepatent period, the time since acquisition of L₃ until females begin laying eggs, is about six months. Future improved methodology may allow more exact determination of the route of migrating larval *S. vulgaris*.

**Small Strongyle (Cyathostome) Group**

The small strongyle group includes more than 50 species worldwide. Only 10 or 12 species are the most common. Virtually, 100 percent of horses are infected with at least some species of small strongyles. Numbers of these worms are usually lower in older horses that have had time to develop some immunity to them. They are much less harmful than *Strongylus* spp. because the infective third stage (L₃) penetrates only into the lining of the large intestine where it encysts (Figure 10). Here they develop to the fourth (L₄) and sometimes young...
fifth (L5, adult) stages which excyst usually by trickling out into the intestinal lumen and maturing (Figure 11). Also they may remain encysted for long periods. In a recent study, the earliest prepatent period for a small strongyle species (Cylicostephanus longiburatus) was about two months. There is great variation in the fecundity of species of strongyles. Under poorly understood circumstances, massive numbers of larval stages can excyst and emerge in a short time, causing severe damage to the intestinal lining, resulting in extensive fluid and protein loss. The condition is called “larval cyathostomiasis,” and has been reported more commonly in Europe than the United States. Death can occur from this disease situation. This can be related seasonally, especially in late winter or early spring, and also after deworming. Overall the small strongyles are not considered very pathogenic, except under certain conditions, but they should not be overlooked as disease entities.

**Treatment/Drug Resistance**

Over several centuries various methods have been advocated for control of internal parasites of horses. It was not until the early 1900s that scientific methods were begun to detect actual efficacy of antiparasitic compounds against horse parasites. The first compound so-tested was carbon disulfide which was proven to be efficacious against horse bots (Gasterophilus spp.) and ascarids (Parascaris equorum). Since the early 1900s until presently (2015), more than 25 products have become commercially available for control of endoparasites in horses. These compounds are in only a few chemical classes including benzimidazoles (BZs) (e.g. thiabendazole), phenylguanidines (Pro-BZ) (e.g. febantel); imidazothiazoles (e.g. levamisole + piperazine), macrocyclic lactones (e.g. ivermectin and moxidectin), organophosphates (e.g. dichlorvos), pyrimidines (e.g. pyrantel) and others (carbon disulfide, phenothiazine, and piperazine). No new classes of equine parasiticides have been marketed in the past 25 years except praziquantel, which only has activity on tapeworms in horses. Currently, both of the commercially available benzimidazoles (fenbendazole and oxibendazole) and pyrantel pamoate are ineffective on small strongyles (cyathostomes). The macrocyclic lactones (ivermectin and moxidectin) are now less effective against small strongyles then initially. It was established that these compounds now have lower activity on luminal stages (especially fourth stages) of small strongyles so the life cycle is shortened.

At the present time, in Kentucky and world-wide, *S. vulgaris* is uncommon any more in horses on farms with frequent deworming programs. In other words, drug resistance for these parasites has not been demonstrated like it has with the small strongyles. Constant monitoring needs to be done to determine if parasiticides remain efficacious against this nematode species.

Treatment of all horses in a herd with chemical compounds every six to eight weeks for parasite control has been done for several decades. In later research, it has been found that as horses age, only a few in a herd are shedding...
“high” numbers of strongyle eggs. Current opinion is to establish a profile of strongyle eggs per gram (EPG) for older horses and then only treat those with “high” EPG values. Recent research at the University of Kentucky has shown that under most conditions one strongyle EPG count is sufficient to establish this profile for a horse. Thus, only treatment of “necessary” select horses saves money, and also may help prolong drug effectiveness. Even though small strongyles are resistant to the benzimidazoles and pyrantel pamoate, it may still be beneficial to use them, because of their activity on some of the other parasites. Use of ivermectin and moxidectin twice a year (in the spring and fall) is recommended for treatment of older horses. There is no absolute strongyle EPG value that should be used to determine whether it seems necessary to treat a horse. Some recommend treatment for horses with strongyle EPGs of 200, 500, or higher, but this can be decided on an individual basis. In general, there is not a direct relationship between strongyle EPG counts and worm counts. With S. vulgaris being rare, there is much more leeway in chemotherapy for parasite control. It is difficult to prove that small strongyle larvae, while they are encysted, and larvae and adults in the lumen of the large intestine cause clinical problems. However, in the future there may be insidious negative effects found that are not detected by current methods. At this time, it is believed that the major benefit of reduction of small strongyle numbers in a horse is lowering of egg deposition on pastures; thus lessening development of infective stages to enter horses. It is obvious that much more research on management practices needs to be done to reduce or supplement use of parasiticides. These might include, for example, removal of feces from pasture, chain harrowing, rotation on pasture with ruminants, fungicidal activity on parasite eggs/larvae and other innovative ideas.

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References


