

Sustainable Equine Parasite Control

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In 1966, Drudge and Lyons (1966) were first to describe a modern equine anthelmintic program based on suppressive treatments. The first benzimidazole-type drugs had recently entered the market, and with these modern, safe, and broad-spectrum drugs, a whole new approach could be taken. Drudge and Lyons used the best scientific evidence available at the time to suggest a protocol involving treatment of all horses every other month year-round. The primary target parasite was *Strongylus vulgaris*, but the protocol was designed to control other relevant parasite species as well. It has since been termed the interval dose regimen and has been widely implemented.

While this approach was highly successful in controlling *S. vulgaris*, it quickly led to a new problem: anthelmintic resistance (Kaplan, 2004). Although mechanisms of anthelmintic resistance are not yet fully understood, it is clear that frequent anthelmintic treatments applied to all horses with regular intervals year-round provides a heavy selection pressure for development of anthelmintic resistance. Thus, parasite control programs are now being designed to be more sustainable and to maintain efficacy of the available drug classes as long as possible.

The key components of any parasite control program are to use available diagnostic tools to monitor parasite levels and drug efficacy, and to tailor the program to the conditions on the given farm. This paper provides an overview of the diagnostic methods currently available and outlines general principles for equine parasite control.

Diagnostic Methods

Parasitic diagnostic information can be collected for three different purposes, although the current techniques are not equally reliable for all three. The three purposes are as follows: (1) clinical diagnosis in an individual horse suspected of suffering from a parasitic clinical condition; (2) surveillance of parasite levels throughout the herd as part of a parasite control program; and (3) screening for anthelmintic resistance with the fecal egg count reduction test (FECRT).

Clinical Diagnosis

While information about present intestinal parasite burdens can be obtained by performing fecal egg counts, it is not as simple to diagnose parasitic disease as one may assume. There are several reasons for this, but first and foremost it is important to recognize that mere presence of parasites such as strongyles, ascarids, or tapeworms does not necessarily lead to disease. These parasite categories should be considered ubiquitous in equine establishments, but actual parasitic disease is the rare event rather than the rule. In other words, parasites are likely to be present in a horse with colic or diarrhea without a causal relationship. Second, the adult egg-shedding parasites are not necessarily the stages causing disease in the horse. A couple of examples are cyathostomin larvae causing larval cyathostominosis or migrating stages of *Strongylus vulgaris* causing thromboembolic colic. The adult strongyles are considered only mild pathogens, and currently there are no diagnostic methods for detecting the larval stages.

Moreover, strongyle-type eggs cannot be told apart by size or morphological characteristics. In principle, a strongyle egg could represent any of the over 50 different strongyle species known to infect horses. The large strongyles (including *Strongylus vulgaris*, *S. edentatus*, and *S. equinus*) can

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be diagnosed by culturing fecal samples and subsequently identifying the third stage larvae to the species level. Recent validations using retrospective data have shown that egg counts and larval cultures generally have high positive predictive values (>0.90) but that the negative predictive values were more moderate (about 0.75) (Nielsen et al., 2010). This underlines the fact that a horse with a negative fecal egg count or larval culture may still harbor adult strongyle parasites. The same study illustrated that horses in the 0-500 strongyle egg count range had significantly smaller worm burdens compared to horses with higher egg counts. This supports the use of fecal egg counts for treatment decisions. However, there were no direct linear relationships between egg counts and worm burdens.

Parasite Surveillance

Fecal egg counts are generally useful for performing routine parasite surveillance on a farm and designing a parasite control program based on the findings. Several studies have illustrated that adult horses are capable of maintaining their level of strongyle egg shedding over time, even with little or no anthelmintic treatment (Nielsen et al., 2006; Becher et al., 2010). Each horse can be said to possess a certain strongyle contaminative potential (SCP), and a few egg counts performed over time will allow classification of any given herd into low (often <200 EPG), medium (often 200-500 EPG), and high shedders (>500 EPG). This knowledge can then be used to treat horses according to their SCP. It should be noted that in any given herd of mature horses, the large majority of horses will belong to the low or moderate category.

Fecal egg counts will also generate useful information about the occurrence of *Parascaris equorum* in young horses. Given the levels of ivermectin and moxidectin resistance often encountered in *P. equorum*, it has become crucial to know whether this parasite is present or not in order to select the most appropriate drug for treatment (see Table 1).

Table 1. Current levels of resistance by major nematode parasites to three anthelmintic classes in managed horse herds.

Drug class	Cyathostomins	Large strongyles	<i>P. equorum</i>
Benzimidazoles	Widespread	None	None
Pyrimidines	Common	None	Early indications
Avermectin/milbemycins	Early indications	None	Widespread

Anthelmintic Resistance

The most important reason for performing fecal egg counts is to screen for anthelmintic resistance. Resistance to anthelmintic drugs in equine parasites has been described since the late 1950s. Today, levels of resistance have reached a point where some degree of reduced anthelmintic efficacy is to be expected on every managed horse establishment (Kaplan, 2004; Lyons et al., 2009, 2010). Therefore, it is of paramount importance to routinely evaluate the efficacy of the anthelmintic treatments applied to ensure that the parasite control program is working satisfactorily.

For cyathostomin parasites, benzimidazole resistance has been reported to be widespread over several continents, while pyrantel resistance appears to occur at a somewhat lower level, but also on multiple continents. Most recently, there have been reports of early signs of resistance to ivermectin and moxidectin. The egg reappearance period (ERP) is defined as the number of weeks from

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the day of treatment until strongyle eggs can again be detected in the feces. For ivermectin and moxidectin, the ERP is now markedly reduced compared to when the drugs were initially introduced, and this has been associated with survival of immature luminal stages of cyathostomin (Lyons et al., 2009, 2010). A summary of current occurrences of anthelmintic resistance in equine parasites is presented in Table 1. All types of resistance are not necessarily present on every farm, but the table can be used as a guide to the parasites that are most likely to be resistant to a particular drug on any given farm.

Detection of Anthelmintic Resistance

The only practical method currently available for determining anthelmintic efficacy is the fecal egg count reduction test (FECRT). There are several ways to perform this test, but the basic principle is to measure the percent reduction of fecal egg counts after anthelmintic treatment. FECRTs can only be performed on the farm level, where an average anthelmintic efficacy is calculated across a group of horses. Based on this result, the farm can be classified as having no signs of resistance, suspected resistance, or convincing signs of resistance. The percent reductions are calculated with the following formula:

$$\%FECR = \left(\frac{FEC_{pre} - FEC_{post}}{FEC_{pre}} \right) \times 100\%$$

Individual FECRs are calculated for each horse, and the farm FECR is then reached by averaging these values. There are no internationally accepted general guidelines for classifying farms based on these findings, but a guideline committee has been formed and useful thresholds for determining resistance can be expected in the near future. In the meantime, guideline thresholds for determining resistance are provided in Table 2. Among other things, the selected thresholds depend on the efficacy the drug had when it was first introduced to the market. It should be noted that due to levels of variability known to occur in FECR data, it is recommended to include a “gray zone” in which farms are categorized as suspected resistance and results are inconclusive. If a farm gets classified as suspected resistance, it is recommended to repeat the test or collect more data by including more horses.

Table 2. Guideline thresholds for classifying anthelmintic resistance on farms based on the fecal egg count reduction test. Percent fecal egg count reductions (FECR) should be calculated across a group of horses in each farm.

Anthelmintic	No signs of resistance	Suspect resistance	Clear signs of resistance
Benzimidazoles	>90%	90-80%	<80%
Pyrantel	>90%	90-80%	<80%
Macrocyclic lactones	>95%	95-85%	<85%

On a given farm, a minimum of six horses should be chosen for the test. It is preferable to use horses with moderate to high fecal egg counts, and pre-treatment egg count levels below 200 EPG should generally be avoided. Similarly, the choice of egg-counting technique is critical. The key feature is the detection limit of the technique. Detection of early reduction in efficacy requires a technique capable of detecting low numbers of eggs in the post-treatment samples, and this

is especially important when pre-treatment egg counts are not overly high (i.e., above 500 EPG). However, the large majority of adult horses will have egg counts below this level. For this reason, a technique with a minimum detection limit of 50 EPG or above is not useful for the FECRT. It is generally recommended to use egg count techniques with detection limits of 25 EPG or below, but lower is always better. The lower detection limit, however, comes with a cost in terms of more time and effort required to perform the egg counts. This is most often because of one or more centrifugation steps involved with these methods.

Tapeworm Diagnosis

Diagnosing tapeworm infections remains a challenge despite the availability of several techniques. Fortunately, tapeworm diagnostic methods have been well validated, so their weaknesses and strengths can be evaluated precisely.

Fecal Examination for Tapeworm Eggs

Any qualitative or quantitative fecal examination technique is capable of detecting tapeworm eggs. However, cestode eggs are distributed unevenly in feces as proglottids disintegrate, which makes the sensitivity of most techniques too low to make a reliable diagnosis. If eggs are found, they should be regarded as the tip of the iceberg, and many more could be recovered with a modified technique.

The basic modification employed for detecting tapeworms is to increase the amount of feces examined (Proudman and Edwards, 1992). Whereas a routine McMaster procedure typically uses 4 g of feces, 30-40 g of feces are examined to increase the likelihood of finding tapeworm eggs. Furthermore, the more effective tapeworm methods use enhanced flotation with cover slips sitting on top of centrifuge tubes. This often requires a centrifuge with a closed swing-bucket rotor to prevent cover slips from being dislodged. Some studies have reported that examination of fecal samples 24 hours after tapeworm treatment yielded higher *Anoplocephala* egg counts and a higher percentage of positive samples (Elsener and Villeneuve, 2011). Presumably, segments from dead tapeworms disintegrate within the host gut and release eggs into the feces. The highest diagnostic sensitivity reported for an egg counting technique for detection of tapeworm eggs is 61%. This, however, means that the method has a 39% chance of a false negative result. However, these findings were based on detection of cestode burdens of all sizes. If this threshold were adjusted to detect 20 or more tapeworms, the diagnostic sensitivity increases to about 90%. In other words, only 10% of tapeworm burdens of 20 or more worms would be missed with this method. The choice of 20 tapeworms as a cutoff level is supported by the fact that no or very little mucosal pathology is observed with tapeworm burdens of fewer than 20 worms (Kjaer et al., 2007).

In summary, the modified egg count method has proven useful for diagnosing moderate and large tapeworm burdens, while the smaller worm burdens may go undetected. The method is relatively easy to perform in most laboratories, but does require a centrifuge and is more time-consuming than the simple McMaster.

These shortcomings indicate that antibody titers reflect exposure rather than contemporaneous infection. The serum ELISA remains a very useful test for investigating historical *Anoplocephala* exposure in a herd, but a positive result for an individual animal may not be a reliable indicator of current infection (Kjaer et al., 2007).

Principles for Equine Parasite Control

Recommendations given for equine parasite control used to consist of relatively simple calendar-

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based recommendations with anthelmintic treatments administered at regular intervals year-round. There is no doubt that this has led to the current levels of anthelmintic resistance, and it is now recommended to decrease the treatment intensity to further delay the development of resistance as much as possible, while still achieving satisfactory control over relevant parasites. Parasite control recommendations should be tailored to the conditions on each farm, and a “one size fits all” program no longer exists. However, it is possible to identify and define a number of elements, which should always be part of any parasite control program. These elements should be implemented taking into account farm-specific conditions, such as climate, length of grazing season, stocking rate, and age range of horses. The following section presents the major elements to include in a parasite control program.

Evaluation of Drug Efficacy

No matter the anthelmintic treatment regimen, drug efficacy should be evaluated every year with the FECRT. It is of utmost importance to perform the FECRT in foals and weanlings as they are likely to harbor both strongyles and ascarids capable of developing resistance to different anthelmintic drug classes.

Basic Foundation of Treatments

A majority of adult horses appear to maintain low egg count levels over time, despite no or very few anthelmintic treatments. For these horses, one or two yearly treatments will be sufficient to avoid reemergence of large strongyle parasites, particularly *S. vulgaris*. All drugs work against large strongyles at the intestinal stage, but it is preferred to use a drug with efficacy against migrating larvae as well. Effective drugs include ivermectin, moxidectin, and the five-day regimen of double-dose fenbendazole. If there is evidence of tapeworm transmission in the area, these foundation treatments could be combined with praziquantel or pyrantel.

Targeting High Strongyle Egg Shedders

Fecal egg counts will identify horses that are prone to return to higher levels of egg shedding after anthelmintic treatment, and it will be beneficial to target these with some additional treatment, while the constant low shedders should be covered by the foundation treatments defined above. Options for additional treatment include moxidectin, which suppresses egg shedding for a longer time period post treatment compared to other drugs. With this approach, an adult high strongyle shedder (>1000 EPG) can receive three or four yearly treatments at most. An alternative is daily in-feed supplementation of pyrantel, which can be used if there is no sign of resistance to this drug.

Defining the Grazing Seasons

Most geographical and climatic locations feature a distinct grazing season with a clearly defined off-season when horses are instead fed roughage in barns and/or paddocks. In a northern temperate climate, the off-seasons will occur during the colder winters, while in subtropical and tropical climates, the summers may be too hot for grazing. During such off-seasons, there will be very little or no parasite transmission, and there is no justification for rigorous anthelmintic treatments during this period. Some climates allow year-round transmission and no off-season can be defined.

Anthelmintic Treatments During the Horse's First Year of Life

When a foal hits the ground, there is a certain order of parasites that it encounters during its first

year of life. As each parasite category requires its own treatment considerations, it is worth keeping this order of appearance in mind.

1. *Strongyloides westeri*. Foals acquire this parasite through the mother's milk during the first weeks of life. However, it is rarely encountered nowadays and there is little evidence that suggests any pathogenic effects. Therefore it is not recommended to treat foals or mares for *S. westeri*.

2. *Parascaris equorum*. This is the primary parasitic pathogen of foals. Treatments should be carried out at two to three months of age with a benzimidazole drug to minimize the risk of small intestinal impaction.

3. Cyathostomins. Foals begin to acquire a strongyle burden as they start grazing during the first months of life. The time to consider treatment of this burden is around the time of weaning, which is often at the age of six months. However, *P. equorum* can still be predominating at this age, so fecal samples are recommended to investigate the presence of this parasite. Ivermectin is the drug of choice for strongyles, but other drug classes can be used if there are no signs of resistance against them. Benzimidazoles are still the recommended drug type for *P. equorum*, but they cannot be expected to work against strongyles without performing a FECRT clearly showing a satisfactory efficacy.

4. Tapeworms. Foals are likely to encounter tapeworms when they start grazing, but there may be considerable differences in the levels of exposure between individual farms. It is most often recommended to include tapeworm treatment once or twice yearly.

In summary, the foundation treatment for a foal during its first year of life would be four treatments: 1) at 2 to 3 months targeting *P. equorum*; 2) at about 6 months targeting *P. equorum* and/or strongyles; 3) at about 9 months targeting strongyles and possibly tapeworms; and 4) at about 12 months targeting the same parasite groups. Local circumstances such as clinical problems due to parasites, high stocking rates, or high levels of traffic in and out of the farm can justify including more than four treatments, but in most cases it will not be needed. It is very important to routinely monitor anthelmintic efficacy against both strongyles and *P. equorum* using the FECRT.

Horses in the age group of 1 to 4 years of age are likely to harbor larger worm burdens and have higher egg counts than adult horses. In addition, horses in this age group are more likely to develop clinical disease due to parasite infection. Therefore, they should receive more treatments than the adult horses. The decision regarding the number of treatments will depend on conditions on the given farm, but 3 to 4 annual treatments should be the guideline foundation. It can be recommended to include a larvicidal treatment towards the end of the grazing season to reduce the size of the encysted worm burden. It is of utmost important to routinely monitor anthelmintic efficacy in this age group.

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