Guidelines for the control of worms in equines

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1. Background

Parasitic worms commonly infect horses that graze. While most of these animals do not display visible symptoms of infection, a significant worm burden can lead to health issues in certain horses, particularly younger ones. Symptoms can vary from mild colic and weight loss to severe conditions that may cause intense colic or diarrhoea. The increased vulnerability in younger horses is attributed to the time required for their immune systems to mount a robust defence against these parasites.

The key to successful worm control lies in preventing the accumulation of heavy worm burdens in horses that are prone to infection. It is crucial to reduce contamination on pasture using diagnostic testing to target horses excreting higher levels of worm eggs, to use management approaches to avoid worm stages developing on pasture and to specifically target certain worm types or life cycle stages in those individuals that need treatment to avert illness. With the widespread issue of wormer resistance, it is vital to use wormers judiciously, avoiding unnecessary treatments. The effectiveness of these strategies is supported by the fact that, typically, most horses in a group carry low worm burdens and exhibit low rates of egg shedding into their environment, and therefore do not need regular worming treatments.

This guide has been written to provide up-to-date information on;

1. common types of worms
2. wormers used to control worms
3. wormer resistance
4. sustainable worm control strategies.

This information provides essential knowledge to support implementation of sustainable parasite control in horses.

2. Worms that infect horses in the UK

Horses and other equids can be infected with a range of parasitic worms (known as 'helminths'); these include roundworms ('nematodes'), tapeworms ('cestodes') and flatworms ('trematodes'). All of these parasites are found world-wide.

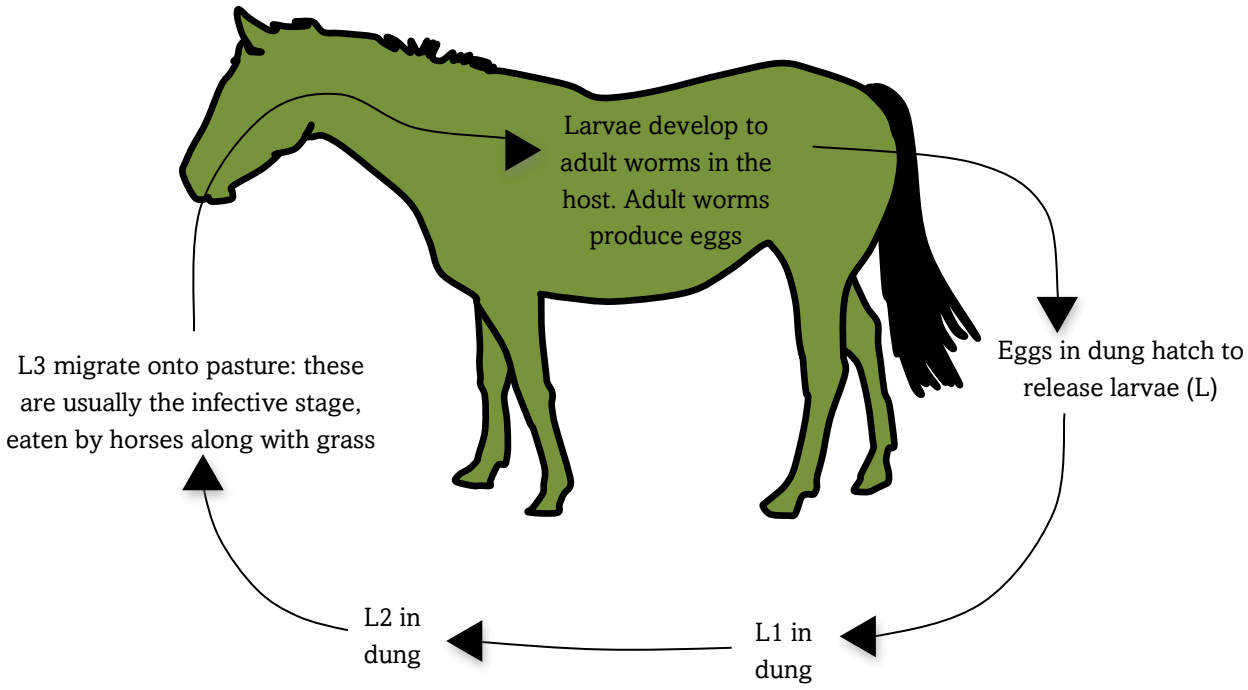
Common worms that can infect equines, their site of infection, the type of stock most likely to be infected, clinical manifestations and time between infection until eggs are found in dung

Worm (common name)	**Where adults worms are found**	**Type of stock *most likely* to be affected**	**Possible clinical signs**	**Time from first infection to eggs in dung (prepatent period)**
Roundworms				
Strongyloides westeri ('threadworm')	Small intestine	Young foals (i.e. < 6 months)	Uncommon but include diarrhoea and dermatitis, especially lower limb.	1-2 weeks
Parascaris spp. ('roundworm', 'ascarid')	Small intestine	Youngsters, to 2 years-old	Unthriftiness, potbelly, poor hair coat, slow growth and, sometimes, colic. Some cases have a nasal discharge and cough due to migrating larvae in the lungs.	10-12 weeks
Cyathostomins ('small redworms', 'small strongyles')	Large intestine	All ages, but high burdens are more likely in animals aged 1-4 years	Weight loss, diarrhoea and/or colic. Severe signs are associated with mass emergence of immature worms (larvae) from gut wall (larval cyathostominosis).	2-3 months (but may be extended to 2 years)
Strongylus vulgaris ('large redworm')	Large intestine (larvae live in blood vessels)	All ages, but high burdens more likely in 1-3 year-olds	Colic, anaemia, ill thrift.	6-7 months
Oxyuris equi (pinworm)	Large intestine, rectum	6 months and over	Itching around the tail head.	5 months
Dictyocaulus arnfieldi (lungworm)	Lungs	6 months and over	Occasional cause of respiratory signs in horses that co-graze with donkeys. Chronic cough, poor condition.	5-6 weeks. Worms do not fully mature in adult horses. Cycle develops fully in foals and donkeys, who act as source of infection

Tapeworms				
Anoplocephala perfoliata	Junction of large and small intestine. Worms found at other sites in animals with larger burdens.	6 months and over	Colic.	6-10 weeks
Flatworms				
Fasciola hepatica	Liver and bile ducts	6 months and over	Weight loss, anaemia, swelling under chin, chest or abdomen. Sometimes, colic or diarrhoea.	10-12 weeks

Non-worm parasites such as bots are sometimes observed; these do not usually cause clinical issues in horses.

The way in which worms are spread and how they develop and persist in the host is crucial to understanding how to prevent transmission, control infection and prevent clinical disease. Life cycles also govern the clinical signs that worms cause in the host. A typical roundworm life cycle is shown below.



Generally, adult worms live in the small or large intestine. Some worms travel through or live in other organs (e.g., the lungs and liver) but are less commonly found than intestinal worms. In most cases, adult worms release eggs that pass into the environment via dung. In the egg are larvae which then undergo several larval (L) stages (L1-L5). In most cases, L1 hatch from eggs and develop to L3 in dung. L3 are motile and move from dung onto blades of grass on a film of water. Usually, L3 are infective and are transmitted by ingestion. The warmer the temperature, the faster larval stages develop to L3. In warm weather (i.e., 30^{o}C plus), eggs hatch and develop to L3 in as short as 2-3 days, although only a small proportion of larvae survive if these temperatures persist. Larval development takes several weeks when it is cooler and pauses at <8^{o}C. L3 are surrounded by the 'skin' of the L2, which protects them from drying out. This prevents L3 from feeding and they survive on a limited amount of energy stored in cells of their intestines. Once the energy is used up, L3 stages die. How quickly this occurs is proportional to environmental temperature. In warm weather, stores are used up quicker as L3 move around faster. These aspects of larval development and survival affect how long contaminated pasture should be rested before it is considered 'safe'. For some types of worms (pinworm, *Parascaris* spp.*)*, larvae do not hatch from eggs but develop in the egg. These eggs are resistant and can be difficult to clear from contaminated paddocks.

Upon ingestion, worm larvae may either mature entirely into adults within the gastrointestinal tract or travel through various tissues within the host. The following summarizes these factors for each common worm type, emphasizing their influence on transmission dynamics and the manifestation of clinical signs. Comprehending these elements is crucial for developing effective sustainable control measures.

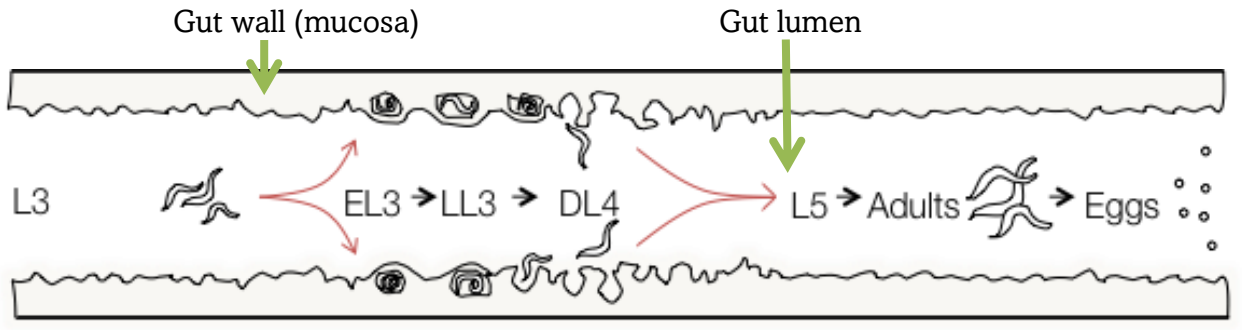
a. Roundworms (nematodes)

Strongyles

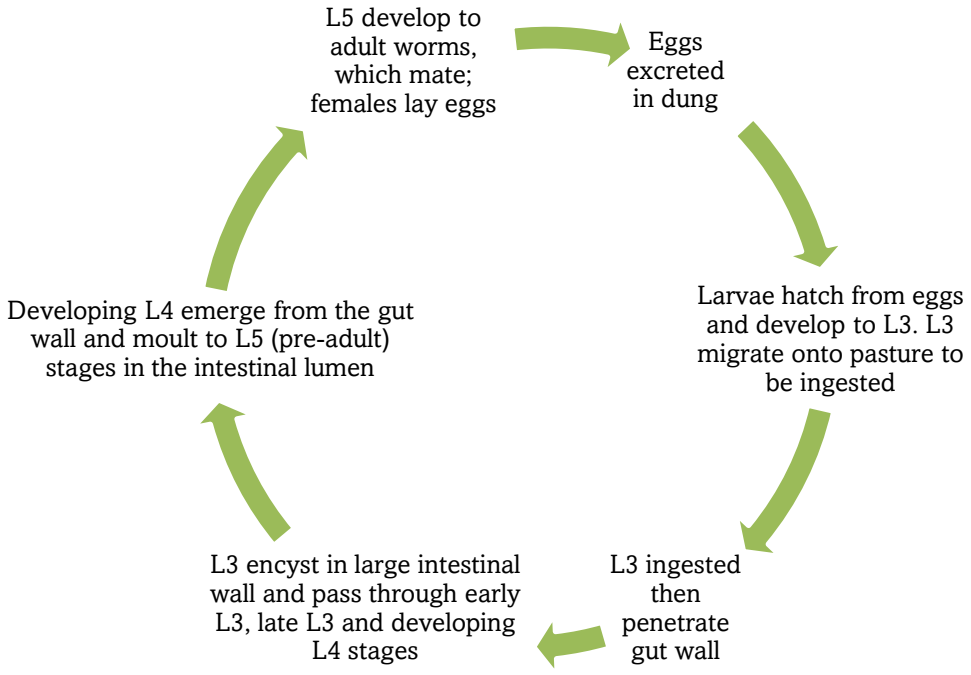
Strongyles are extremely common parasites of horses. Adult worms are found in the large intestine (caecum, colon) and are 1-5 cm long. There are two main types of strongyles: small strongyles (cyathostomins) and large strongyles (the most important being *Strongylus* species). These parasites are a common cause of weight loss and intestinal conditions in horses kept under poor management.

Cyathostomins (small redworm, small strongyles)

These are the most common equine worms worldwide. Most grazing horses have cyathostomins. Adult worms are hair-like (~1 cm long). There are ~50 cyathostomin species; however, the life cycle and epidemiology of these are similar such that they can be considered as a single entity. Shortly after ingestion, larvae invade the wall (mucosa) of the large intestine, where a capsule develops around each worm which develops within a cyst; hence the term 'encysted larva'. The length of time this takes is variable (a few weeks to many months). Encysted larvae can build up in high numbers (up to several million in some individuals). The larva that first enters the intestinal wall is the early third stage larva (EL3). After EL3 become encysted, they mature progressively to late third stage larvae (LL3), then developing fourth-stage larvae (DL4). EL3 can pause in development for extended periods. This figure summarises the cyathostomin host stages (image, H. McWilliam).

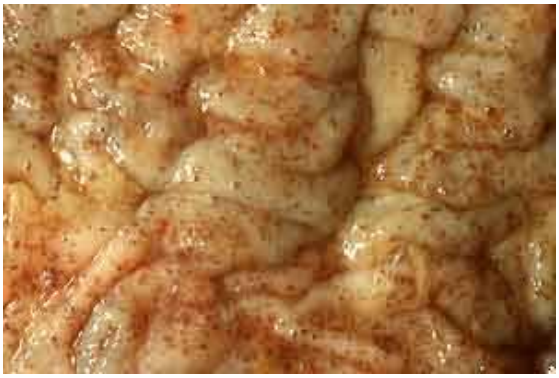


Factors that determine larval duration in the intestinal wall are unknown, but are likely associated with host age, immunity, season, and/or total burden. Within weeks of emergence, larvae mature to adults, which mate and females lay eggs that are excreted in dung.



Encysted larvae are important because, if they emerge in large numbers, they cause larval cyathostominosis. This can lead to severe inflammation of the intestinal lining, with impaired motility and diarrhoea, weight loss and colic, and usually occurs from late autumn to spring. In rare cases, horses die without showing signs. Larval

cyathostominosis has a poor prognosis and is considered a serious parasite-related disease. Horses of all ages can be infected with cyathostomins, although younger horses (1-4-years-old) are more susceptible to higher burdens and clinical disease.



Large intestinal wall sample from a larval cyathostominosis case at post-mortem demonstrating large numbers of encysted larvae (brown dots) on the large intestinal wall surface.

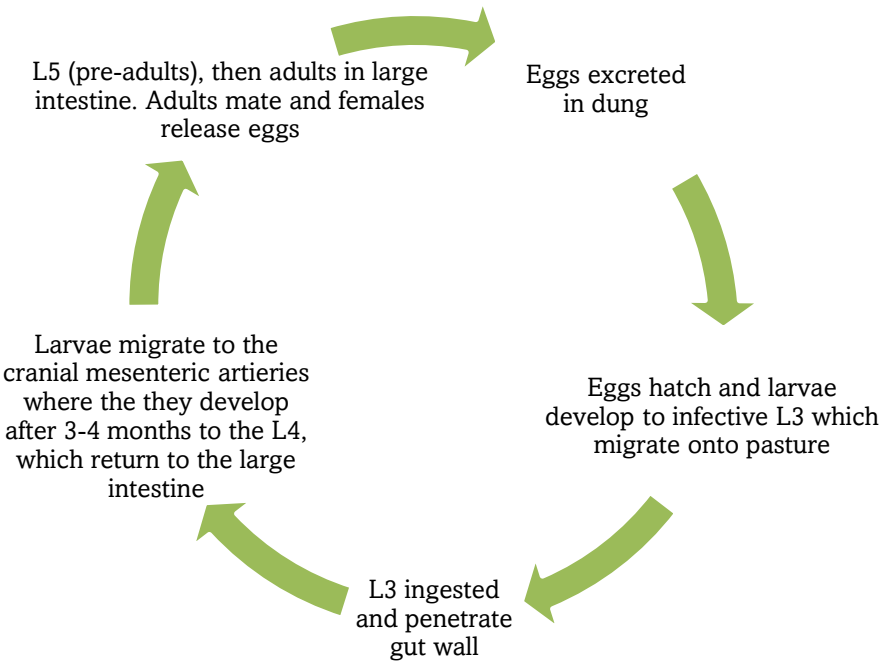
Foals acquire infection when they start grazing. Although immunity starts to develop after exposure, its rate of development is slow and varies amongst individuals. Most adult horses eventually develop immunity and have low cyathostomin burdens; however, a small proportion (usually <20%) can remain more susceptible and harbour higher burdens. This distribution is reflected in worm egg shedding patterns within groups. Horses can thus be classified as low strongyle egg shedders (excreting <200 eggs per gram [epg] in dung), moderate egg shedders (200-500 epg) and high egg shedders (>500 epg). This means that, on well-managed paddocks, many horses consistently have low faecal egg counts (FEC), even in the absence of worming, and a small proportion has high FEC. The latter are responsible for the majority of pasture contamination. This is demonstrated in the figure below, where horses shaded in grey represent the moderate-high strongyle egg shedding sub-group and those in black, the low egg shedding group. If a 200 epg threshold is selected for worming, this results in reductions in anthelmintic

use compared to an all-group treatment approach, which leads to lower selection for anthelmintic resistance (see below).

Typical negative binomial distribution of intestinal worms in horses which is reflected in the pattern of egg shedding within a group; usually, 20% of the group are responsible for >80% of the total eggs being shed in dung onto paddocks.

Large strongyles

Large strongyle adult worms are thicker than cyathostomins, reaching up to 5 cm in length. Large strongyle larvae leave the intestine after infection and migrate through various tissues for 6-11 months. The migratory route depends on the large strongyle species. The species, *Strongylus vulgaris*, is most associated with clinical disease. The life cycle of *S. vulgaris* is summarised below.

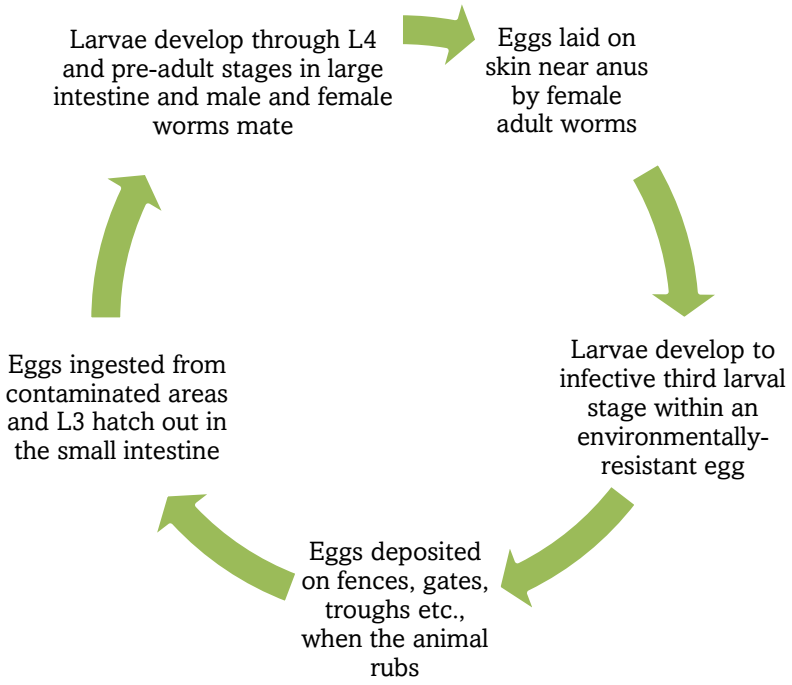


Larvae in cranial mesenteric arteries can lead to disease because this vessel provides the main blood supply to the intestine. When larvae cause damage to the arterial wall, this can lead to a malformed artery (aneurysm). This causes abnormal blood flow, which can lead to the formation of blood clots, which attach to artery walls but can break free and block blood flow to the intestine. This causes thromboembolic colic, which is life-threatening if not treated promptly by surgery. *S. vulgaris* is uncommon in regions with frequent use of broad-spectrum macrocyclic lactone wormers.

Oxyuris equi

This is the equine pinworm. The adults are white/grey and live in the colon near the rectum. The worms have a long tale that tapers and females can reach up to 10 cm long. Horses of all ages can be infected. Most horses do not have a clinical issue, but some

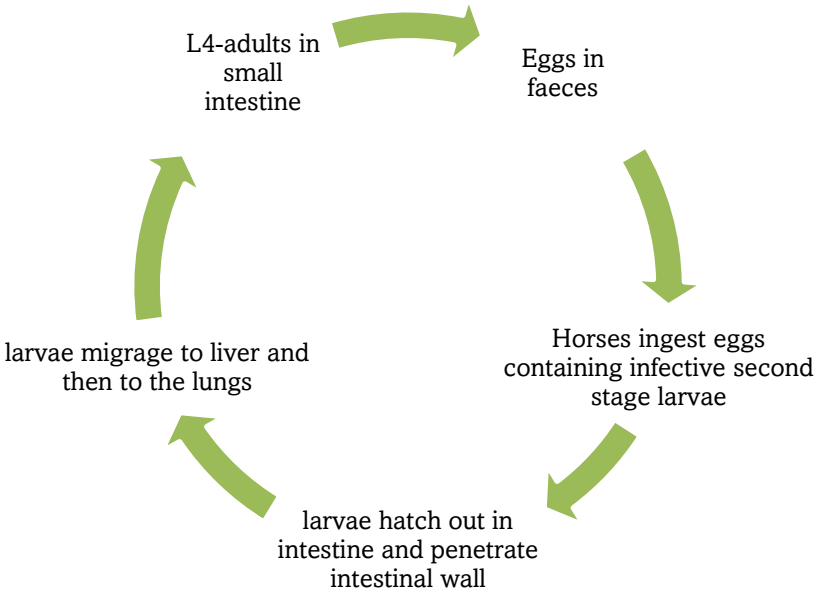
animals are susceptible to repeated infections which can lead mild to intense itching of the tail head. The life cycle is shown below.



When female worms migrate onto skin, they lay eggs in yellow-grey gelatinous masses. Larvae develop to infective L3 in the egg in as short as 3-5 days. Horses are infected when they ingest eggs containing L3. These mature to adults 45-60 days after infection. Increased reports of pinworm infections in the UK may be due to animals being treated inappropriately, wormers not working effectively due to a lack of access of active anthelmintic in the rectum and skin, drug resistance, increased persistence/survival of infective stages in the environment or more awareness of the condition in owners. Key to control of pinworm is the effective *removal of eggs from the environment* by disinfecting and rinsing *all* areas where an infected animal may rub (i.e. gates, fence posts, troughs etc.) as well as from the affected area of the horse. If a horse or pony is identified as a persistent or repeated pinworm case, advice should be sought from a veterinary surgeon.

Parascaris spp.

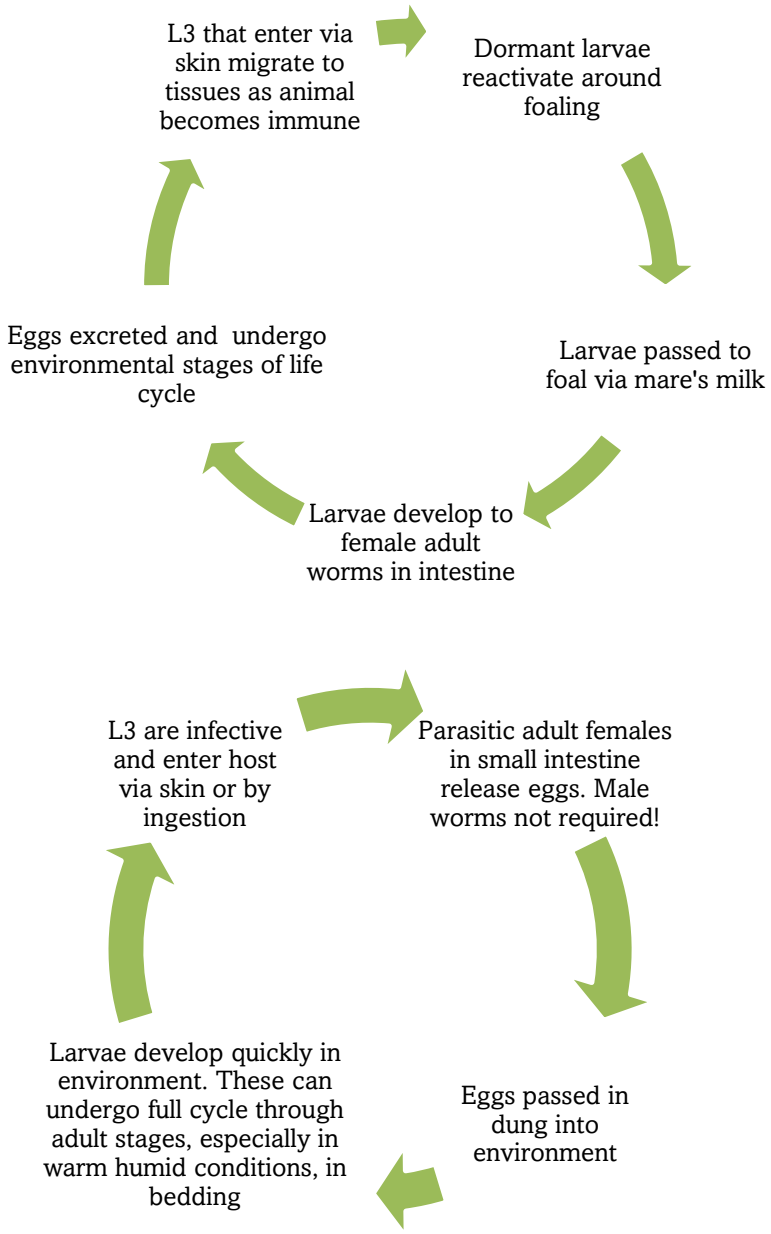
Adult worms are large (females reach ~38 cm long) and are found in the small intestine. Females lay environmentally-resistant eggs, which are excreted in dung and develop to contain infective larvae. Once eggs are ingested, larvae are released in the intestine and migrate through the liver and lungs. Larvae reach the lungs ~7 days after infection. They migrate through lung tissue to be coughed up and swallowed into the gastrointestinal system ~4 weeks after infection, and develop to adult worms. The latter mate; eggs are excreted ~10 weeks after infection.



This is a common and important parasite of foals and yearlings. It is unusual to see clinical problems in adult animals because most horses develop immunity between 18 and 24 months of age. Donkeys do not seem to develop the high levels of immunity and adult donkeys can have positive ascarid egg counts. High burdens can cause a nasal discharge, coughing, weight loss and poor coat condition. In severe infections, youngsters can develop colic which may be fatal.

Strongyloides westeri

This small threadworm has an unusual life cycle, and can be completed in the environment as well as within the host.

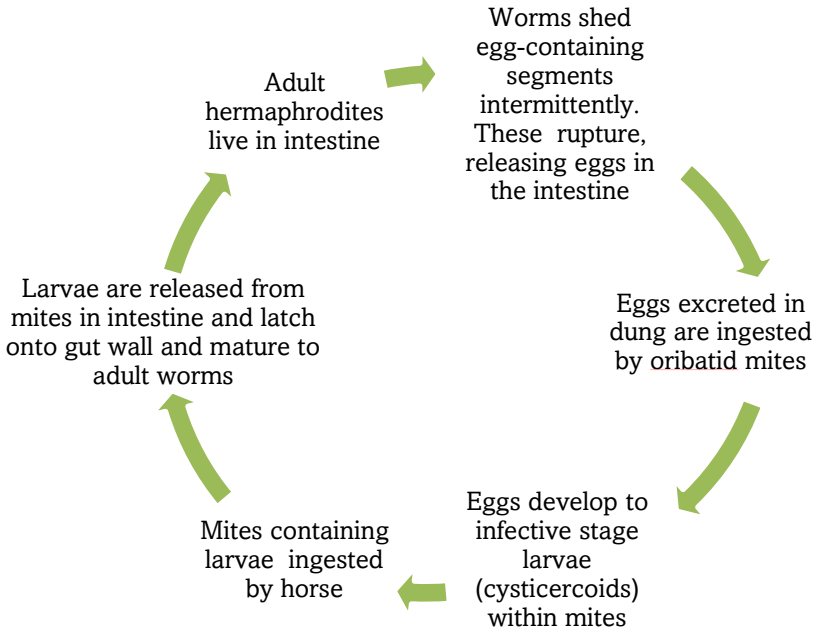


In the free-living cycle, eggs hatch in bedding and worms develop to males and females which reproduce. Female worms lay eggs which develop to infective stages in bedding. In the parasitic cycle, female worms reproduce asexually in the intestine. Females lay

eggs which pass out in dung before hatching. In dung, larvae develop to L3 which migrate onto bedding to infect via skin penetration or ingestion. As horses develop immunity, larvae persist in tissues and, in mares, can reactivate at foaling and pass to foals in milk. When larval challenge is high, this parasite may cause diarrhoea. Dermatitis of the lower limb/coronary band can occur under high environmental challenge, which is more common when bedding is not changed regularly. Signs are rare in animals >6 months.

b. Tapeworms (*Anoplocephala perfoliata*)

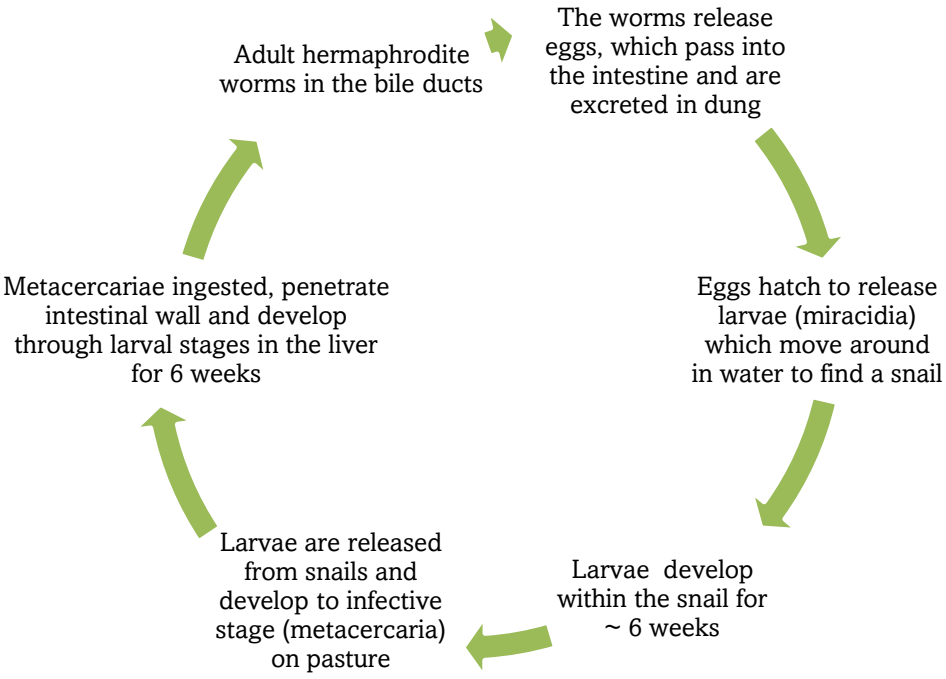
Anoplocephala perfoliata is the most common tapeworm. Adult worms are usually found at the junction of the small and large intestine and measure 4-8cm long, are flattened and creamy. At higher burdens, tapeworm can be found at other sites in the intestine. Tapeworm can cause intestinal blockage and colic; individuals with higher burdens are more likely to develop signs of colic. Most horses have a few tapeworms and do not develop disease. The life cycle involves an intermediate host (mite) and final host (horse).



Adult tapeworms produce many eggs within segments and release these at irregular intervals into the intestine. The period from infection to excretion of eggs is 6-10 weeks.

c. Flatworms (liver fluke)

Liver fluke (*Fasciola hepatica*) adults live in liver bile ducts where they cause damage. These worms are hermaphrodite and the 2-3 cm long adults are flat, leaf-shaped and pale brown. Infection is relatively in sheep and cattle in the UK, and the parasite can also infect horses. It is found in marshy areas as it requires a snail intermediate host, which lives in these environments. Therefore, horses that graze pasture previously/concurrently grazed by ruminants in marshy areas are at risk. Liver fluke can be carried by rivers or heavy rain run-off, so infection can occur where there has not been direct contact with ruminants.



Liver fluke can be difficult to diagnose in horses as signs of infection are non-specific. Some studies indicate that horses (especially adult horses) can develop some immunity

to liver fluke, but develop clinical signs due to the damaging effects of the migrating larvae and developing adults in the liver and bile ducts. Liver fluke can infect humans if they eat contaminated raw vegetables. Humans cannot catch fluke directly from animals.

Establishing a control programme that prevents the accumulation of large numbers of infective worm stages on pasture is key to limiting parasite burdens in horses

Historically, control was based on the regular administration of wormers (anthelmintics) to all horses. Frequent treatments have led to the development of drug resistance in all common parasitic worms of horses and is an increasing threat to equine welfare.

Control programmes must address the threat of anthelmintic resistance and these medicines must be used responsibly.

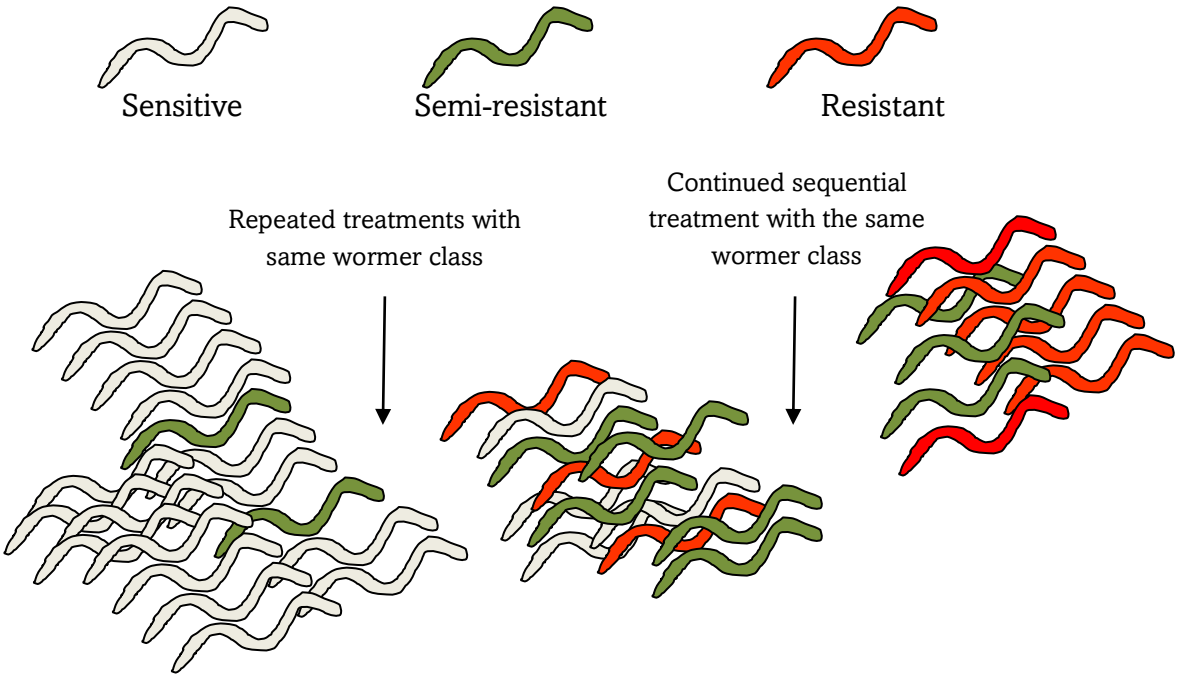
3. Wormers (anthelmintics)

Nearly all anthelmintics are marketed as 'broad-spectrum' wormers, meaning that they are effective against several types of worms. Four anthelmintic 'classes' are licenced for use in equids in the UK. Three were developed for controlling roundworms; Class 1. benzimidazoles (active ingredient: fenbendazole; roundworms only), Class 2. tetrahydropyrimidines (active ingredient: pyrantel embonate; roundworms and tapeworm [when administered at a 'double dose']), Class 3. macrocyclic lactones (active ingredients: ivermectin or moxidectin; roundworms only). A further class, isoquinoline

pyrazines (active ingredient: praziquantel) was developed for control of tapeworm species, including *A. perfoliata*. In general, wormers with label claims against strongyles are effective against adult egg-laying stages, but only some are effective against migrating large strongyles or all stages of cyathostomins that reside in the intestinal wall.

4. Anthelmintic resistance

Resistance develops when worms are able to survive treatment with an anthelmintic that was previously effective against that population. Resistance is due through mutations in parasite DNA that lead to an alteration in worm molecules that are targets of the anthelmintic, or in worm proteins that help parasites withstand the presence of the anthelmintic. These alterations allow parasites to survive treatments that would otherwise be lethal to them. Mutations are passed from one generation to the next, so with repeated treatments with the same anthelmintic over time, the proportion of population with the mutations increases as indicated below.



Anthelmintic resistance is a significant concern in equine medicine as resistance has now been reported in all common worms that affect horses: cyathostomins, *Parascaris* spp. and *A. perfoliata* (Nielsen MK. Int J Parasitol Drugs Drug Resist. 2022:20;76-88). Anthelmintic resistance is very common in cyathostomins, particularly resistance to fenbendazole and pyrantel compounds. Cyathostomin populations that are resistant to both fenbendazole and pyrantel anthelmintics have been observed in many countries, including the UK. Of concern, cyathostomin resistance to ivermectin and moxidectin is now also documented, with many reports of shortened strongyle egg reappearance periods observed after treatment with these anthelmintics. It is therefore likely that resistance to all three anthelmintics licensed for use against cyathostomins exists on some premises in the UK.

Parascaris spp. resistance to macrocyclic lactone compounds is commonly reported across regions, including the UK, with emerging reports of resistance to pyrantel and fenbendazole in these species. More recently, resistance in *A. perfoliata* to both pyrantel and praziquantel compounds was reported in mares and foals based on a stud farm in the US (Nielsen MK. Int J Parasitol Drugs Drug Resist. 2023:22;96-101). There have also been several reports of ivermectin and moxidectin resistance in pinworm, albeit in small studies (Nielsen MK. Int J Parasitol Drugs Drug Resist. 2022:20;76-88). For all of these common worms, the possibility of multi-drug resistance is therefore a real possibility and, with no new equine anthelmintics in development by pharmaceutical companies, the threat of anthelmintic resistance to equine health and welfare is a serious one.

As yet, there have been no published reports of wormer resistance in large strongyle worms or in *S. westeri* populations. The table below summarises the anthelmintic classes available for treating equine worms in the UK along with anthelmintic resistance status for each class.

Class – active compound	***S. westeri***	***Parascaris* spp.**	**Cyathostomins**	***S. vulgaris***	***A. perfoliata***
Benzimidazole – fenbendazole[1]	+	+ (**resistance emerging**)	+ (**resistance common**)	+	-
Tetrahydropyrimidine – pyrantel salts[2]	-	+ (**resistance emerging**)	+ (**resistance common**)	+	+ (**resistance emerging**)
Macrocyclic lactone (avermectin) – ivermectin[3]	+	+ (**resistance common**)	+ (**resistance emerging**)	+	-
Macrocyclic lactone (milbemycin) – moxidectin[4]	+	+ (**resistance common**)	+ (**resistance emerging**)	+	-
Isoquinoline-pyrazine – praziquantel[5]	-	-	-	-	+ (**resistance emerging**)

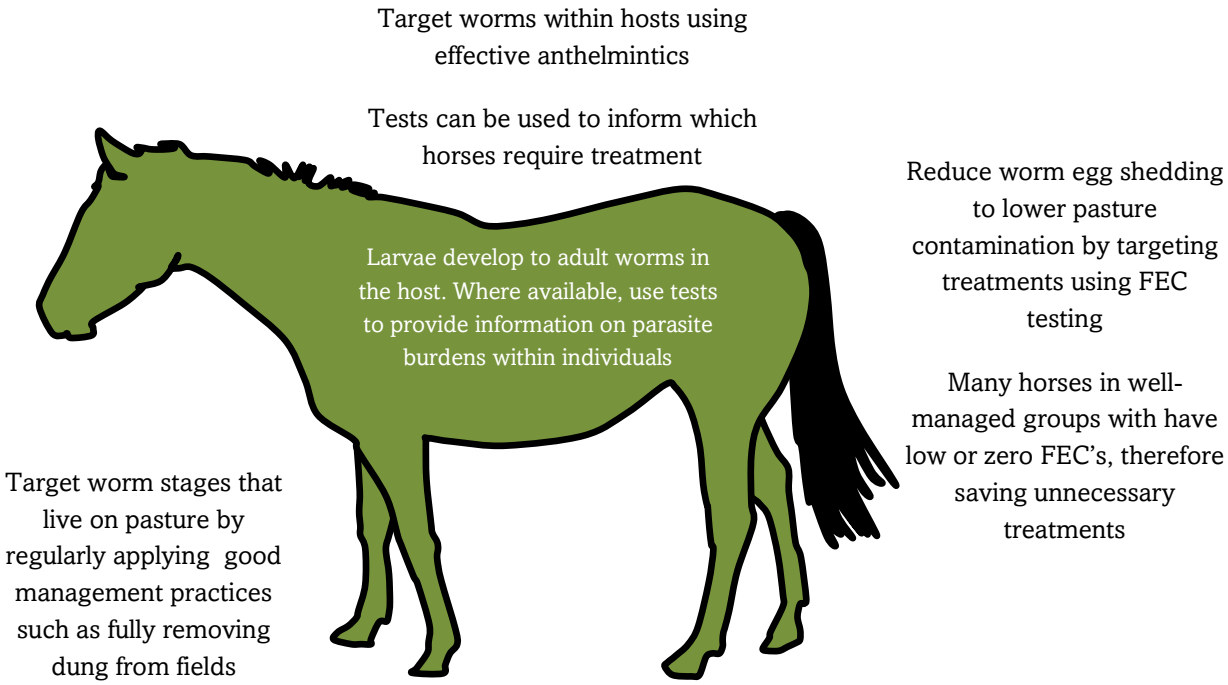
Information extracted from the UK Veterinary Medicines Directorate database in 2024: available at https://www.vmd.defra.gov.uk/ProductInformationDatabase/. Footnotes: [1]Pioneer product (fenbendazole) licensed for foals and pregnant mares. Licensed efficacy against benzimidazole-sensitive adult small redworm when administered as single dose and encysted mucosal fourth (L4) and third stage larvae (L3), including EL3, when administered at standard dose daily for 5 consecutive days. Licensed efficacy against adult and immature ascarid spp. [2]Pioneer product (pyrantel embonate) licensed for foals >4 weeks and pregnant/lactating mares. Licensed efficacy against adult small redworm and adult ascarid spp. Efficacy against adult tapeworm when used at double dose used for non-tapeworm species. [3]Pioneer product (ivermectin) licensed for horses of all ages, including pregnant mares. Licensed efficacy for lumenal adult and L4 of small redworm. Licensed efficacy against larval and adult ascarids. [4]Pioneer product (moxidectin) licensed for foals 4 months+ and pregnant/lactating mares. Licensed efficacy against intramucosal small redworm L4. At 8 weeks post treatment, small redworm EL3 eliminated. Licensed efficacy against larval and adult ascarids. [5]In UK, a single-active extemporaneous praziquantel preparation can be prescribed by veterinarians (recommendations cannot be made regarding the minimum age for safe use), otherwise available as a combination product with ivermectin or moxidectin.

The most serious consequence of resistance is complete treatment failure, with a particular anthelmintic no longer effective leading to persistent infection and, if high burdens persist, clinical disease. Anthelmintic resistance is irreversible; however, resistance to a particular anthelmintic in one species does not necessarily mean that there will be resistance to the same anthelmintic in a different species, so it is important to test the effects of anthelmintics at yard level to assess which products work against the different parasites that are present.

To reduce further selection for resistance, it is important to use anthelmintics only when they are needed and to combine strategic or diagnostic-led treatments with management practices that reduce the overall parasite burden on paddocks.

5. Sustainable control strategies

Worms can be targeted in the environment by using pasture management strategies and within hosts by worming treatments. As many animals are likely to have low parasite burdens, not all will require regular treatment with anthelmintics. Diagnostic tests can be used to identify those animals that require treatment and those that do not.



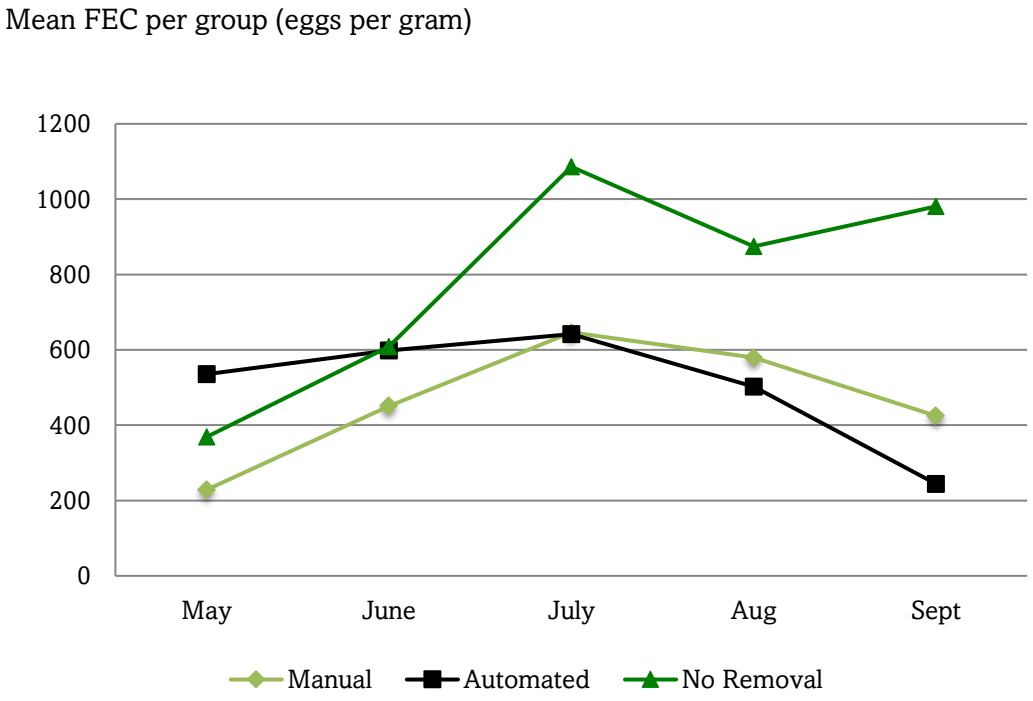
The main objective of control is to limit levels of infection so that horses remain healthy and clinical disease does not develop. Frequent wormer administration should be

avoided since this promotes resistance. It is impossible to eradicate all parasites from all animals and trying to do so only selects for resistance. For these reasons, all programmes must include good pasture management to reduce infection levels in the environment.

Management approaches that support sustainable worm control

Dung removal

Dung removal must be done to break worm life cycles and reduce pasture contamination. In the UK, remove dung at least twice a week, especially in summer. This graph demonstrates the impact of dung removal in reducing strongyle egg counts in donkeys on fields where pasture hygiene was practiced compared to fields where it was not.



Adapted from: Corbett CJ, Love S, Moore A, Burden FA, Matthews JB, Denwood MJ. Parasit Vectors. 2014;7:48.

In addition to removing dung, or where it is not logistically possible to do this regularly, pastures should not be overgrazed. Stocking density should be restricted to a maximum of 1 horse per 1 acre (0.4 hectares). Ideally, especially in the absence of dung removal, pastures should be fully rested from horses. Infective strongyle L3 can survive a few weeks in hot weather, but for 6-9 months in cooler weather. Therefore, seasonal and local weather conditions must be considered when calculating how long pastures should be rested for before being deemed 'safe'. Resting for a full season will have a significant impact on strongyle egg and larval contamination; however, oribatid mites containing tapeworm cysticercoid larvae and ascarid eggs may persist for periods beyond a year.

Alternating and/or mixed grazing with ruminants can reduce pasture infection load with equine parasites. A roundworm species that lives in the stomach (*Trichostrongylus axei*) is capable of infecting cattle, sheep, pigs and horses, but this is not considered a clinical threat to horses. Liver fluke can cross between hosts if pastures include areas where the fluke intermediate snail host can live. Disease results from damage to liver tissue caused by migration of immature fluke, and/or from the presence of adult worms in bile ducts. Horses with liver fluke often show no or vague signs of disease such as weight loss, lethargy or poor performance, especially older horses. In more severe cases, diarrhoea, anaemia and jaundice are observed, with increases in liver enzymes in the blood suggesting hepatic damage. Co-grazing with ruminants, or being on land previously grazed by ruminants, are strong risk factors for liver fluke infection. Sedimentation-based FEC methods can be performed to detect excretion of heavy fluke eggs in ruminants. These FEC methods have poor sensitivity for detecting infection in horses, likely due to sporadic shedding of eggs from adult worms or because infections may not reach the fully mature stage (Quigley A, Sekiya M, Egan S, Wolfe A, Negredo C, Mulcahy G. Equine Vet

J. 2017;49:183-188). Instead, an antibody-based blood test is available for detecting liver fluke infection in horses (Liver fluke in horses - Liverpool Veterinary Parasitology Diagnostics - University of Liverpool). This test is more sensitive than FEC analysis and a positive result indicates current or recent infection.

Harrowing is commonly used in the UK. However, under weather conditions that prevail, harrowing will only act to disseminate infection by breaking up egg-contaminated dung and spreading parasites across the grazing area. If dry hot conditions prevail, strongyle larvae may die in weeks, but if these conditions are not encountered, L3 survive for months. If harrowing is performed, pasture should be rested until considered safe and should not be grazed in the same season.

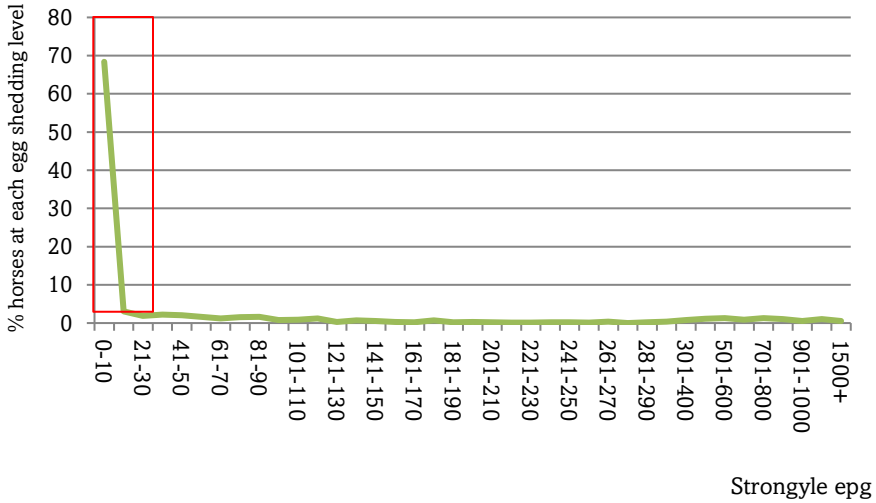
Summary

- Remove dung at least twice weekly
- Limit stocking density to one horse per acre
- Pastures should be rested from grazing. In the UK, to reduce strongyle infection risk, rest pastures for 6-12 months
- Practice alternate and/or mixed grazing with ruminants, but be aware of possible cross-infection with liver fluke
- If harrowing, rest pasture after harrowing until at least the middle of the following season

Diagnostic tests that support sustainable worm control

Targeting treatments against nematodes based on faecal egg count tests

FEC-directed treatment protocols work well because nematode egg shedding is unevenly distributed in horses; in groups of adult animals, ~20% of individuals excrete ~80% worm eggs shed at any given time. This is demonstrated below, where the majority of 1,200 FEC test results were negative or low (highlighted by the red box).



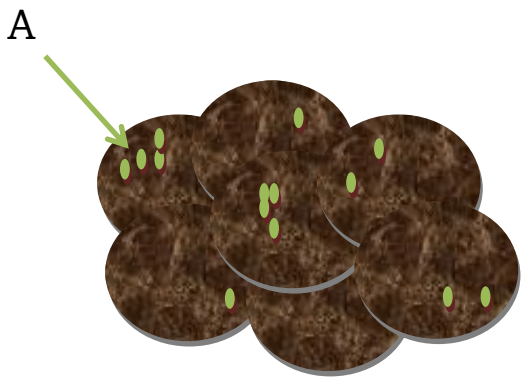
Adapted from: Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. Parasitology 2013;140:641-52

When using FEC tests, horses identified as shedding eggs at and above a threshold strongyle epg (e.g., 200 epg) receive wormer, whilst FEC-negative horses or those excreting eggs below this level are left untreated. This reduces unnecessary treatments, lowering selection pressure for resistance, but has a significant effect on the number of eggs shed into the environment and, therefore, pasture contamination. In some cases, FEC-directed treatment protocols can be financially beneficial. One analysis of 14 UK yards showed that anthelmintic use was reduced by 82% on the basis of strongyle FEC testing when treating at a 200 epg threshold and, considering test cost (based on an average charge of several FEC service providers), a mean saving of £294/year per yard compared to an interval treatment programme (Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Stratford CH, Matthews JB. Vet Rec. 2013;173:371).

FEC tests provide an estimate the number of worm eggs per gram in dung. Different protocols are available, however all work on the principle of taking a proportion of dung, cleaning it up, separating out worm eggs (usually by flotation in salt solution) and examining and counting eggs under a microscope. Some tests have higher sensitivity than

others; the higher the sensitivity, the more valuable the information the test provides. Therefore, it is recommended to choose a test service that offers a method with higher sensitivity (i.e. one can detect a low numbers of worm eggs per gram of dung).

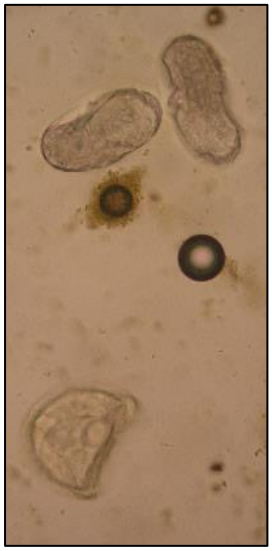
Worms eggs are not evenly distributed in dung heaps. This figure depicts how worm eggs can be spread across a heap. If only ball A was sampled and counted, it would indicate a higher number of eggs than is representative of the entire sample.



Adapted from: Lester HE, Matthews JB. Equine Vet J. 2014;46:139-145.

Therefore, when obtaining a sample, always ensure that it is representative across the heap by collecting sub-samples from 3-4 balls (or different parts of the heap), mix together, and collect at least 5 grams. Because eggs can hatch within a day when it is warm, samples must be collected fresh and transported in a sealable container or bag. It is important to have no air in the container or bag, as air promotes hatching. Samples should be transported at a cool temperature. The same principles apply at the laboratory to ensure that the sample count is representative. The FEC test must be performed within 5 days of sample collection.

Examples of worm eggs identified using FEC testing.



The image on the left shows a dung sample examined under a microscope. The two oval eggs are strongyle eggs. Large and small strongyle eggs cannot be discriminated, but UK FEC samples will primarily contain small strongyle eggs. The single D-shaped egg is a tapeworm egg. Tapeworm egg shedding is intermittent and FEC tests are not sensitive for detecting tapeworm infection; other types of tests are available for this purpose (see below).

The egg shown here is a *Parascaris* spp. egg. These are most commonly seen in samples from foals and yearlings. FEC tests can be used to inform treatments in young horses and are useful in detecting which worm infections individuals harbour; this will help to determine the type of wormer to administer.

The eggs shown here are smaller than those shown above. These are *S. westeri* eggs. These are commonly found in young foals and are only a clinical issue if found in very high numbers.

Strongyle infections can be discriminated by hatching eggs and culturing the larvae to L3. These stages are distinctive between large and small strongyle species. Most strongyle eggs detected are likely to be small strongyle eggs. Where there is concern regarding large strongyle infections (i.e., in circumstances where macrocyclic lactones have not

been used for an extended period), samples can be sent to a specialist parasitology laboratory for larval culture and differentiation.

Standard FEC tests cannot detect liver fluke eggs. As indicated above, an antibody-based blood test is available for detecting liver fluke infection. When there is concern regarding this parasite, owners must consult their veterinary surgeon regarding diagnosis and treatment as no anti-fluke wormers are licenced for use in horses in the UK.

Targeting treatments against tapeworm based on measurement of parasite-specific antibodies

FEC methods demonstrate low sensitivity (3-61%) for detecting tapeworm infection (Gasser RB, Williamson RM, Beveridge I. Parasitology 2005;131:1-13; Matthews JB, Peczak N, Lightbody KL. Pathogens 2023;12:1233). This is because adult *A. perfoliata* worms release egg-containing segments intermittently increasing the rate of false negative results. The low sensitivity of FEC methods for tapeworm is also due to the presence of non-egg bearing immature and sterile worms within individuals (Meana A, Pato NF, Martín R, Mateos A, Pérez-García J, Luzón M. Vet. Parasitol. 2005;130:233-240). Instead, antibody-based blood or saliva tests can be used to diagnose tapeworm infection in horses. Levels of antibodies measured in these tests show strong positive correlations with tapeworm burdens (infection intensity), with both blood- and saliva-based tests shown to be similarly accurate in detecting infection (Proudman CJ, Trees AJ. Parasite Immunol. 1996;18;499-506; Lightbody KL, Davis PJ, Austin CJ. Vet. Clin. Path. 2016;45:335-46). These tests (marketed as the EquiSal Tapeworm Saliva test and the Tapeworm Blood test by Austin Davis Biologics Ltd, https://www.austindavis.co.uk/) incorporate a calibration curve that acts as an internal quality control, with each result

reported as a serum or saliva score. The scores are categorised as 'low', 'borderline' or 'moderate/high', depending on the level of antibody measured. Tapeworm treatment is advised for horses that have a borderline or moderate/high score. Both types of tests have been demonstrated to accurately identify all horses with clinically-relevant burdens of >20 tapeworms (Lightbody KL, Davis PJ, Austin CJ. Vet. Clin. Path. 2016;45:335-46).

In the UK, horses should be tested for tapeworm infection in spring and autumn. Assessment in spring helps identify horses with tapeworm burdens that are likely to act as a source of egg contamination during the optimal period of oribatid mite activity in summer. Effective worming of these horses will help break the transmission cycle and result in lower mite infections on pasture. Testing in autumn will detect tapeworm burdens in horses that have become infected over the summer grazing period. Effective treatment of horses that test positive will help reduce the risk of tapeworm-associated colic at a time of year when tapeworm burdens are likely to be higher. All horses in a group should be tested at the same time to identify those that are a source of contamination onto pasture. In cases where many horses test positive in these antibody-based assays, it is likely that paddocks are very contaminated, and due to the fact that anti-tapeworm anthelmintics are only effective for a short period, horses may become rapidly reinfected. In such cases, it is important to ensure that infection risk is reduced by improving pasture management by regular removal of all dung from paddocks and, where indicated, reducing stocking density.

Groups considered at low risk of infection can be tested annually, in spring or autumn. Such groups would be horses where previous testing has indicated no, or minimal, levels of tapeworm infection, or adult horses where there is a detailed history of excellent pasture management with no previous indications of tapeworm-related disease.

When used to inform treatment decisions, tapeworm testing can reduce anthelmintic use significantly compared to blanket treatments; for example, in one study using EquiSal Tapeworm Saliva testing across a year in 237 horses kept on a welfare establishment, 85% of tests reported as below the treatment threshold (Lightbody KL, Matthews JB, Kemp-Symonds JG, Lambert PA, Austin CJ. Eq Vet J. 2018;50:213-219). Analysis of Austin Davis Biologics' commercial saliva test dataset demonstrates the scale of reduction in treatments that can be achieved compared to blanket worming; of 164,002 samples tested from 2015-2022, 68.2% fell below the treatment threshold, a saving of 111,927 worming doses (Matthews JB, Peczak N, Engeham S. In Practice 2024;46:34-41).

Targeting treatments against cyathostomins by measuring parasite-specific antibodies

Horses accumulate burdens of cyathostomin mucosal larvae that can comprise a high proportion of an individual's total burden. As these stages are immature, they will not be detected by FEC testing. Strongyle FEC's also show poor correlations with cyathostomin adult worm numbers as they do not account for the presence of male parasites and variable egg release by female worms. This means that it is difficult to assess cyathostomin burdens to assess whether or not horses require treatment to target worm stages present within the host. To account for this gap in the diagnostic toolbox, it has *previously* been recommended to administer a 'larvicidal' worming treatment to *all* horses at the end of the grazing season so that horses with potentially damaging burdens are treated to reduce the risk of developing disease (AAEP Guidelines 2019). Such practices are strongly selective for anthelmintic resistance. A test that helps identify horses that do

not require this larvicidal treatment provides an option for reducing resistance selection against wormers such as moxidectin.

With Horse Trust funding, an antibody-based blood test has been developed (Tzelos T, Geyer K, Mitchell M, McWilliam, Kharchenko VO, Burgess STG, Matthews JB. Int J Parasitol. 2020;50:289-298), and subsequently optimised, validated and commercialised by Austin Davis Biologics. The test (the Small Redworm Blood test, https://www.austindavis.co.uk/small-redworm-blood-test), available through veterinary practices in the UK and EU, is based on the measurement of antibodies specific to three cyathostomin recombinant proteins detectable in mucosal larval and luminal larval/adult stage worms (Lightbody KL, Austin A, Lambert PA, von Samson-Himmelstjerna G, Jürgenschellert L, Krücken J, Nielsen MK, Sallé G, Reigner F, Donnelly CG, Finno CJ, Walshe N, Mulcahy G, Housby-Skeggs N, Grice S, Geyer KK, Austin CJ, Matthews JB. Int J Parasitol. 2024. 54:23-32). The proteins are derived from the three commonest cyathostomin species and, similar to the tapeworm tests above, the Small Redworm Blood test includes a calibration curve that acts as an internal quality control and is used to generate a serum score result. The test informs on cyathostomin burdens above/below three cyathostomin thresholds, 1,000, 5,000 and 10,000 worms, and is recommended for informing worming treatments in horses kept in *low infection-risk* circumstances. Horses managed in higher infection risk situations are likely to harbour cyathostomin burdens that are above these thresholds and, in these cases, it is advisable to administer cyathostomin larvicidal treatments in late autumn/winter as previously recommended. The table below summarises all of the factors that need to be considered when deciding whether or not to use the Small Redworm Blood test for informing treatment decisions in horses.

Risk categories (combine responses to individual factors to calculate overall risk level		
	LOW INFECTION RISK	HIGH INFECTION RISK
Management factors	• Closed herd, dung removed at least 2 times a week, low stocking density (≤1 horses/acre), no young stock (<5 years-old) in group • Horses with limited grazing time such as race/sport horses	• Open herd, no/ineffective quarantine measures, dung not removed/removed less than once a week, high stocking density (>1 horse/acre), young stock (<5 years-old) in group, anthelmintic resistance previously identified/efficacy not tested
FEC results of the individual and horses that it grazes with	Concurrent/recent individual or group FEC test results consistently <200 strongyle eggs per gram	Concurrent/recent individual or high proportion of group FEC results ≥ 200 strongyle eggs per gram
Apply the Small Redworm Blood test?	YES Test when considering applying an all-group larvicidal treatment in late autumn or at the end of the grazing season to avoid unnecessary worming of horses with low burdens	NO Many horses will return a positive result in the test as cyathostomin burdens are likely to be >10,000 worms in high infection-risk circumstances. Consider applying a larvicidal treatment late autumn/winter

The veterinary surgeon will interpret the reported serum score(s) in light of a herd risk assessment and will base the decision to worm at a serum score cut-off of either the 1,000, 5,000 or 10,000 cyathostomin burden threshold.

Applying the test using this guidance can result in considerable anthelmintic treatment reductions compared to previously-recommended blanket worming programmes. Data from a low infection-risk sport horse cohort (n=981) demonstrated that the percentage of horses that returned serum scores below the 1,000 and 10,000 total cyathostomin burden thresholds were 62% and 81%, respectively, promoting to reductions in anthelmintic use compared to an all-group treatment approach (Matthews JB, Peczak N, Engeham S. In Practice 2024;46:34-41).

Detecting pinworm infection to inform treatment decisions

Adult pinworm infection can be detected using a 'tape' test. Sticky tape is used to take an impression from skin under the horse's tail, where female pinworms come out and lay eggs. To increase sensitivity of detection, it is recommended to apply three separate strips to the skin and examine each under the microscope for pinworm eggs.

6. Testing for wormer resistance

It is important to establish whether or not anthelmintics demonstrate efficacy by reducing FEC's by an appropriate amount. When treating with an effective wormer, adult worms die and egg production stops. The FEC reduction test (FECRT) is invaluable for establishing the effectiveness of anthelmintic treatments and should be applied annually to test efficacy against strongyle (primarily, cyathostomin) and *Parascaris* spp. populations. The test is generally a group level test. To assess efficacy, two dung samples are collected; the first on the day of treatment (day 0) and the second, 14-17 days after treatment (only from animals measured as ≥200 EPG on day 0). Samples should be handled as described for FEC testing. Strongyle or *Parascaris* spp. egg counts before and after treatment are compared to calculate the mean percentage reduction in eggs counted after treatment. Cut-off values for considering efficacy are a mean reduction in FEC of >95% when treating with ivermectin or moxidectin, and a mean reduction in FEC of >90% when treating with fenbendazole or pyrantel. If the percentage reduction in FEC is above these values, no further action is required. If the percentage reduction is below these value, resistance is suspected and further investigation is required.

The effect of anthelmintics can be monitored by evaluating strongyle egg reappearance periods (ERP). This is the time after treatment when worm eggs should not be observed in dung or their number reduced by >90% compared to levels measured at treatment. Strongyle ERP values were established when the products were launched. The expected strongyle ERP for each wormer type is shown below.

Anthelmintic	Minimum strongyle ERP that would indicate effectiveness
Fenbendazole	6-8 weeks*
Pyrantel	4-6 weeks*
Ivermectin	6-8 weeks*
Moxidectin	13 weeks*

* ERP/treatment interval cited on UK Veterinary Medicines Directorate (http://www.vmd.defra.gov.uk/ProductInformationDatabase/) for fenbendazole (Panacur Equine Granules 22.2% w/w), pyrantel (Strongid - P Paste 43.90% w/w), ivermectin (EQVALAN Oral Paste for Horses) and moxidectin (EQUEST ORAL GEL, 18,92 mg/g, oral gel for horses and ponies).

A shortened ERP may be an early indicator of resistance. Monitoring can be performed, especially in relation to ivermectin or moxidectin, by performing FEC tests every 2-3 weeks after treatment and identifying when the first positive FEC's occur or when the mean FEC after treatment reaches 10% the level counted at treatment. Although labour intensive, ERP monitoring can be performed where there has been high use of ivermectin or moxidectin. If a product is found to fail, further repeated use is not recommended. In the UK, treatment failures must be reported to the Veterinary Medicines Directorate: https://www.vmd.defra.gov.uk/adversereactionreporting/Product.aspx?SARType=Animal.

7. Putting targeted worming protocols into practice

Owners should always discuss parasite control with their prescriber before purchase of a wormer to decide if a treatment is necessary and, if so, which product should be selected.

A risk assessment of likely worm transmission should be performed, considering the resident population, grazing management, history of wormer use, clinical history and the results of diagnostic tests. Below are recommendations for control programmes, based on animal age. These are based on UK seasons.

Adult horses: 5 years and over

i. Apply FEC-directed treatments spring till autumn. Pyrantel or ivermectin are recommended for FEC-directed treatments. Use an epg treatment threshold of 200 epg*
ii. The interval for follow-up FEC testing is 6-8 weeks after pyrantel treatment or 8-10 weeks after ivermectin treatment
iii. A FECRT should be included each year to test wormer effectiveness
iv. Depending on the risk of *A. perfoliata* transmission, blood or saliva tests should be carried out once (low risk, autumn) or twice (unknown risk or high risk, spring and autumn). Tapeworm-positive animals should be treated with praziquantel** or pyrantel (at twice the dose recommended for roundworms)
v. In high-risk circumstances, administer a larvicidal treatment (moxidectin***) in late autumn/early winter. This should be given at least 4-6 weeks after the previous pyrantel treatment or 6-8 weeks after the last ivermectin treatment
vi. In low-risk circumstances, consider not administering a larvicidal treatment or use the Small Redworm Blood test to assess cyathostomin burden category
vii. FEC testing should be performed 12-14 weeks after moxidectin treatment to monitor egg shedding in late winter/early spring, especially if horses are grazing parts/all day and the weather is mild.

Good pasture management, especially dung removal, should be performed to reduce contamination of pasture with worms

* The EPG threshold for treatment can be adapted depending on the risk of environmental contamination and class of stock. No guidelines are published for the acceptable number of *P. equorum* eggs for treatment thresholds; if these eggs are detected (more likely in horses 2 years-old and under), treatment is recommended.

** Praziquantel is no longer available as a single active in the UK, but can be prescribed by a veterinary surgeon as an extemporaneous formulation.

*** Most anthelmintics do not have high efficacy against cyathostomin EL3. Five-day fenbendazole treatment has licensed efficacy against these stages, but resistance is almost ubiquitous in cyathostomin in developed regions. Use this compound if efficacy confirmed by FECRT

A FEC-directed worming programme can be used in younger animals. The FEC interval is likely to be shorter than that for older horses. This is because younger horses usually shed higher levels of strongyle eggs and tend to have a shorter ERP. In high risk situations,

after an all-group moxidectin treatment in late autumn/early winter, a second treatment may be necessary in late winter. Application of a second treatment should be based on FEC test results and on risk assessment of the likely levels of contamination on grazing.

1–4-year-old horses

i. Apply FEC-directed treatments spring till autumn. Pyrantel or ivermectin are recommended for FEC-directed treatments. Use an epg treatment threshold of 200 epg.
ii. This age group is more likely to have higher burdens and hence shed more parasite eggs. The interval for follow-up FEC testing is 4-6 weeks after pyrantel treatment or 6-8 weeks after ivermectin treatment
iii. Depending on the risk of *A. perfoliata* transmission, blood or saliva tests should be carried out once (low risk, autumn) or twice (unknown risk or high risk, spring and autumn). Tapeworm-positive animals should be treated with praziquantel* or pyrantel (at twice the dose recommended for roundworms)
iv. Administer an all-group moxidectin treatment in late autumn/early winter. A second moxidectin treatment may be necessary 12-14 weeks later, based on FEC testing and a risk assessment of likely levels of contamination on pasture. Youngsters are more likely to require a second treatment if grazing all day in mild winters, especially if kept at higher stocking density on paddocks not subject to regular pasture hygiene.

Good pasture management, especially dung removal, should be prioritised on pastures grazed by youngsters to reduce contamination with worms. Avoid using the same paddocks for young horses year after year; rest and rotate where possible.

*Praziquantel is no longer available as a single active in the UK, but can be prescribed by a veterinary surgeon as an extemporaneous formulation.

The routine treatment of young foals for *S. westeri* is not recommended unless the parasite has been identified as a clinical problem. A widespread practice has been to worm mares with ivermectin before foaling; however, if mares have been treated in the previous 6 months with a macrocyclic lactone, there is little justification for this.

The main focus for worm control in foals is *Parascaris*. Larvae of this worm can cause disease and there are no diagnostic tests to detect the immature stages. As a result,

wormer treatments at 2-3 months (during the migratory phase) and at 5-6 months of age are advised, especially on farms where the infection risk may be higher. Because of high levels of macrocyclic lactone resistance in this species, fenbendazole or pyrantel should be administered. FEC tests can be performed at 6 months to identify if foals are shedding eggs and to identify the type of worm eggs being excreted. A FECRT should be performed on worm egg-positive foals to ensure that the treatment reduces the mean FEC by >90%. If the FECRT indicates lower efficacy, change to another compound (e.g., change from fenbendazole to pyrantel or *vice versa*). Where macrocyclic lactones are known to be effective (by previous FECRT), these anthelmintics can be used. Moxidectin is not licensed for use in foals under 4 months.

FEC testing should be performed at 8 months to identify worm eggs/excretion levels. Timing may however coincide with the need to apply an all-group cyathostomin larvicidal treatment, but concurrent infection with *Parascaris* spp. will also need to be assessed. FEC testing should be performed 2 weeks after treatment to assess effectiveness of the treatment against cyathostomins and *Parascaris* spp. If foals are fully weaned, a tapeworm saliva test can be performed to inform treatment in autumn (note: tapeworm specific antibody in mare's milk contaminates foal saliva which can result in false positive tests). Alternatively, non-weaned foals >6 months can be tapeworm blood tested. Recently weaned foals should be turned onto the cleanest pastures.

Foals

i. Administer anthelmintic at 2-3 months-old and at 5-6 months-old. Seek veterinary advice as the anthelmintic prescribed depends on previous use and FEC test results on-site. Options are fenbendazole, pyrantel or ivermectin. Note that macrocyclic lactone resistance in *Parascaris* spp. is common.

ii. Depending on the last treatment applied, FEC test foals between 7 and 8 months to identify if treatment should be directed against a. *Parascaris* (treat

FEC-positive foals with fenbendazole or pyrantel), b. strongyles (treat FEC-positive foals with ivermectin or moxidectin) or c. *Parascaris* spp. and strongyles (treat FEC-positive foals with ivermectin [if *P. equorum* population ivermectin-sensitive] or pyrantel). If timing coincides with late autumn and if foals are > 4 months-old, administered a cyathostomin larvicidal dose of moxidectin. A 2-week FECRT should be performed to ensure that the product is effective.

iii. Foals can be tested (blood or saliva) for tapeworm from 6 months onwards. Tapeworm-positive foals should be treated with praziquantel* or pyrantel (at twice the dose recommended for roundworms).

Optimal pasture management and dung removal should be prioritised on foal pastures. Recently weaned foals should be turned out on grazing that is likely to have the lowest risk of infection. Maintaining foals on the same pasture year-after-year is not recommended.

*Praziquantel is no longer available as a single active in the UK, but can be prescribed by a veterinary surgeon as an extemporaneous formulation.

Recommendations for quarantine

New acquisitions that will graze with permanent residents should be treated with moxidectin (+/- praziquantel or tapeworm tested) and kept off pasture for three days. A post-treatment FECRT should be performed 14 days after treatment to assess effectiveness of moxidectin against nematodes. If horse comes from a low infection-risk herd, a Small Redworm Blood test can be used to inform whether or not a cyathostomin-targeted treatment with moxidectin is required.

Best Practice Control

1. Always work with a prescriber to risk assess likely parasite infection levels on site
2. Ensure all horses within the herd or group are on the same programme
3. Use weight tapes or, preferably, weigh scales to determine body weights to ensure appropriate anthelmintic dosing. Ensure that the full dose is swallowed. Store anthelmintics according to the information on the packaging
4. Remove dung at least twice a week. Place well away from paddocks and water courses
5. Practice appropriate quarantine measures based on the risk of infection in the newcomer
6. Do not dose and move to clean pasture; this selects for resistance
7. Only use anthelmintic products licensed for use in equids and according to products instructions for use

Notes: Targeted treatment protocols have not been rigorously evaluated in foals/young equids and the impact of reduced treatment frequencies also needs to be fully assessed for tapeworm, ascarid, and large strongyle infections. The choice of strongyle epg threshold for treatment is based more on tradition than science; further studies need to be performed to ensure that recommendations have a true evidence basis. These guidelines will be updated when further evidence-based recommendations become available.

Acknowledgements

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